Espacenet Meine Patentliste am 16-12-2016 13:13

8 Dokumente in "Meine Patentliste"
Anzeige ausgewählte Publikationen

Veröffentlichung	Titel	Seite
WO2007009424 (A1)	METHOD FOR PRODUCING A TEXTILE MATERI...	2
DE102005033107 (B3)	Multiaxial textile semifinished produ...	13
US2006019093 (A1)	ANTISTATIC POLYMER MONOFILAMENT, METH...	16
EP3002367 (A1)	WET PAPER WEB TRANSFER BELT, PAPERMAK...	20
EP2902545 (A1)	Wet paper web transfer belt	41
US4675229 (A)	Spiral coil corrugator belt	59
WO9617125 (A1)	PAPERMAKER'S FABRIC CONTAINING FIBERS...	69

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(71) Anmelder *(für alle Bestimmungsstaaten mit Ausnahme von US)*: **SAERTEX GMBH & CO. KG** [DE/DE]; Brochterbecker Damm 52, 48369 Saerbeck (DE).

(72) Erfinder; und
(75) Erfinder/Anmelder *(nur für US)*: **LAMMERS, Bruno** [DE/DE]; Veltrup 20, 48282 Emsdetten (DE).

(74) Anwalt: **HABBEL & HABBEL**; Am Kanonengraben 11, 48151 Münsfter (DE).

(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Veröffentlicht:
— *mit internationalem Recherchenbericht*
— *vor Ablauf der für Änderungen der Ansprüche geltenden Frist; Veröffentlichung wird wiederholt, falls Änderungen eintreffen*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(54) Title: METHOD FOR PRODUCING A TEXTILE MATERIAL FROM SYNTHESIS FIBRES AS A SEMIFINSIHED PRODUCT FOR MULTIAXIAL STRUCTURES AND A MULTIAXIAL TEXTILE MATERIAL

(54) Bezeichnung: VERFAHREN ZUR HERSTELLUNG EINES TEXTILS AUS SYNTHESEFASERN ALS HALBZEUG FÜR MULTIAXIALE GELEGE UND MULTIAXIALES TEXTIL

(57) Abstract: The invention relates to a method for producing a textile material from synthesis fibres as a textile semifinished product for multiaxial textile materials. According to the invention, fibres, rovings or fibre strands are arranged in a unidirectional manner and assembled into meshes by means of sewing thread or binding thread. The invention also relates to a textile material produced by the inventive method.

(57) Zusammenfassung: Die Erfindung bezieht sich auf ein Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für multi- axiale Textilien , wobei Fasern, Rovings oder Faserbündel uni- direktional angeordnet sind und durch Näh- oder Bindefäden in Maschen gefaßt werden. Die Erfindung bezieht sich weiterhin auf ein Textil, das nach dem vorgenannten Verfahren hergestellt ist.

WO 2007/009424 A1

„Verfahren zur Herstellung eines Textils aus Synthesefasern als Halbzeug für multiaxiale Gelege und multiaxiales Textil“

Die Erfindung bezieht sich auf ein Verfahren zur Herstellung eines Textils aus Synthesefasern als Halbzeug für multiaxiale Gelege und auf ein multiaxiales Textil.

Historisch werden multiaxiale Textilien durch das Zusammenfügen von zwei Geweben hergestellt, wobei die beiden Gewebe einen sehr leichten Kettfadenanteil und einen hohen Schußfadenanteil aufweisen. Die beiden Gewebe werden in die benötigten Winkel verzogen, z. B. + 45° und – 45°. Diese verzogenen Gewebe werden dann durch Vernähen miteinander verbunden.

Später gab es Maschinen, welche Fadenscharen in den einzelnen Winkeln ablegten. Diese wurden über einen seitlich mitlaufenden Halterahmen fixiert und anschließend miteinander vernäht.

Bei beiden Herstellvarianten ist es nicht möglich, das Gewicht stufenlos in der Fläche zu varieren. Ferner ist es nicht gewebetypisch, daß das Gewebe einzig nicht mit einer Achse gebildet werden kann, sondern in der weiteren Achse mindestens Verstärkungsfäden vorhanden sind, welche die Drapierfähigkeit mindern. Weiterhin war es bisher nicht möglich, gezielte und regelmäßige Lücken in das flächige Textil einzubringen.

In der DE 30 03 666 A1 wird ein Gelege zur Herstellung einer Verstärkung von im wesentlichen aus Flächen bestehenden Bauteilen und eine Vorrichtung zur Herstellung desselben beschrieben. Auch in der DE 100 61 028 A1 wird ein Verfahren zum Herstellen von mehrschichtigen FTP-Preforms mittels schmelzbaren Fixierfäden beschrieben. Bei beiden Verfahren basiert die Maschenbildung bzw. das Vernähen der textilen Halbzeuge auf einer Sticktechnologie, wobei bei dieser Herangehensweise jeweils der Stickgrund mitgeführt wird bzw. muß dieser vor Formgebung entfernt werden.

Der Erfindung liegt daher die Aufgabe zugrunde, ein Verfahren zur Herstellung eines Textils aus Synthesefasern als Halbzeug für ein multiaxiales Gelege vorzuschlagen, bei welchem das Gewicht stufenlos in der Fläche variabel gestaltet werden kann und das eine hohe Drapierfähigkeit aufweist. Außerdem soll es möglich sein, gezielte und regelmäßige Lücken in das flächige Textil einzubringen.

Diese der Erfindung zugrundeliegende Aufgabe wird durch die Lehre des Hauptanspruches gelöst.

Vorteilhafte Ausgestaltungen der Erfindung sind in den Unteransprüchen erläutert.

Gemäß der Erfindung bezieht sich die Erfindung auch auf ein nach dem Verfahren hergestelltes Textil, das in den Ansprüchen 6 bis 8 definiert ist.

In der vorliegenden Anmeldung wird für die Maschenbildung der einzelnen textilen Halbzeuge keine Unterlage, d. h. kein Stickgrund benötigt, so daß ein Stickverfahren und sticktechnisch verbundene Halbzeuge durch die vorliegende Anmeldung nicht unter Schutz gestellt werden sollen.

Gemäß der Erfindung werden Fasern, Faserbündel oder Rovings unidirektional und parallel durch Bindefäden gefaßt und zusammengehalten. Diese Bindefäden laufen üblicherweise quer zu den zu fassenden Fasern, Faserbündeln oder Rovings. Hierbei werden die Fasern, Faserbündel oder Rovings durch einen Bindefaden, welcher sogenannte Maschen bildet, gebunden, d. h. alle Bindefäden umschlingen immer nur einen Faden bzw. ein Faserbündel oder einen Roving und fixieren diesen dann durch die Masche.

Die Maschengröße oder auch Stichlänge ist frei wählbar.

Wenn nun ein Roving oder Faserbündel mit einer bestimmten Textur genutzt wird, ist das Gewicht des Textils durch ein Verändern der Maschengröße oder Stichlänge variabel zu gestalten.

Weiterhin können auch Leermaschen, also nicht mit Rovings oder Faserbündeln belegte Maschen produziert werden. Der

Sinn und Zweck dient zur Kanalbildung, die für ein leichtes Einfiltrieren von Faserverbundbauteilen hilfreich ist.

Patentansprüche:

1. Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für multiaxiale Gelege, **dadurch gekennzeichnet**, daß Fasern, Rovings oder Faserbündel unidirektional angeordnet werden und jeweils durch Bindefäden in Maschen gefaßt werden, wobei alle Bindefäden immer nur einen Faden, einen Roving oder ein Faserbündel umschließen und fixieren und mindestens zwei textile Halbzeuge anschließend in unterschiedlichen Winkeln zueinander übereinandergelegt miteinander verbunden werden, wobei für die Maschenbildung der einzelnen textilen Halbzeuge keine Unterlage benötigt wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß die Stich- oder Maschenlänge des textilen Halbzeugs in einem Rapport variabel groß ist.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß auf normale, voll eingezogene Maschen sogenannte Leermaschen folgen.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß die Verbindung der wenigstens zwei Halbzeuge mechanisch, z. B. durch Vernähen, erfolgt.

5. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß die Verbindung der wenigstens zwei Halbzeuge durch einen chemischen Binder erfolgt.

6. Multiaxiales Textil, **dadurch gekennzeichnet**, daß Fasern, Rovings oder Faserbündel unidirektional angeordnet und durch Bindefäden in Maschen gefaßt sind, wobei alle Binfäden immer nur einen Faden bzw. ein Faserbündel oder einen Roving umschlingen und fixieren und mindestens zwei der textilen Halbzeuge anschließend in unterschied-

lichen Winkeln zueinander übereinandergelegt und miteinander verbunden sind, wobei für die Maschenbildung der einzelnen textilen Halbzeuge keine Unterlage vorhanden ist.

7. Multiaxiales Textil nach Anspruch 6, **dadurch gekennzeichnet**, daß die Stich- oder Maschenlänge des textilen Halbzeugs in einem Rapport variabel ist.

8. Multiaxiales Textil nach Anspruch 6 oder 7, **dadurch gekennzeichnet**, daß auf normale, voll eingezogene Maschen sogenannte Leermaschen folgen können.

INTERNATIONAL SEARCH REPORT

International application No
PCT/DE2006/001168

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29C70/20 D04H13/00 D04H3/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B29C D04H D04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 691 197 A2 (BAYERISCHE MOTOREN WERKE AG [DE]; STOLL & CO H [DE]) 10 January 1996 (1996-01-10)	1,5,6
Y	page 3, line 14 - line 24; figure 1	4
Y	US 5 445 693 A (VANE JEFFREY A [GB]) 29 August 1995 (1995-08-29) abstract; figure 1	4
A	WO 02/063083 A (RHODIA IND YARNS AG [CH]; LANG BRUNO [CH]; KURT MAX [CH]) 15 August 2002 (2002-08-15) page 5, line 18 - page 6, line 9; figures 1,2	1-8
A	GB 1 275 705 A (VLAM PETER HUBERTUS MARIA DE [NL]) 24 May 1972 (1972-05-24) page 3, line 42 - line 52; figures 2,6	1-8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2006	23/11/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Pierre, Nathalie

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/DE2006/001168

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0691197 A2	10-01-1996	DE 4423739 A1	11-01-1996
US 5445693 A	29-08-1995	NONE	
WO 02063083 A	15-08-2002	NONE	
GB 1275705 A	24-05-1972	CA 922089 A1	06-03-1973
		DE 2032423 A1	28-01-1971
		FR 2048071 A5	19-03-1971
		NL 7008333 A	13-12-1971

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/DE2006/001168

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. B29C70/20 D04H13/00 D04H3/10

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
B29C D04H D04B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X Y	EP 0 691 197 A2 (BAYERISCHE MOTOREN WERKE AG [DE]; STOLL & CO H [DE]) 10. Januar 1996 (1996-01-10) Seite 3, Zeile 14 - Zeile 24; Abbildung 1	1,5,6 4
Y	US 5 445 693 A (VANE JEFFREY A [GB]) 29. August 1995 (1995-08-29) Zusammenfassung; Abbildung 1	4
A	WO 02/063083 A (RHODIA IND YARNS AG [CH]; LANG BRUNO [CH]; KURT MAX [CH]) 15. August 2002 (2002-08-15) Seite 5, Zeile 18 - Seite 6, Zeile 9; Abbildungen 1,2	1-8
A	GB 1 275 705 A (VLAM PETER HUBERTUS MARIA DE [NL]) 24. Mai 1972 (1972-05-24) Seite 3, Zeile 42 - Zeile 52; Abbildungen 2,6	1-8

☐ Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen ☒ Siehe Anhang Patentfamilie

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"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
16. November 2006	23/11/2006

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Pierre, Nathalie

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/DE2006/001168

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
EP 0691197 A2	10-01-1996	DE 4423739 A1	11-01-1996
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		DE 2032423 A1	28-01-1971
		FR 2048071 A5	19-03-1971
		NL 7008333 A	13-12-1971

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 10 2005 033 107 B3** 2007.01.11

(12) # Patentschrift

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B32B 5/10 (2006.01)
B32B 7/12 (2006.01)
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(73) Patentinhaber:
SAERTEX GmbH & Co. KG, 48369 Saerbeck, DE

(74) Vertreter:
Habbel & Habbel, 48151 Münster

(72) Erfinder:
Lammers, Bruno, 48282 Emsdetten, DE

(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:
DE 100 61 028 A1
DE 30 03 666 A1

(54) Bezeichnung: **Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für multiaxiale Gelege und multiaxiales Textil**

(57) Zusammenfassung: Die Erfindung bezieht sich auf ein Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für multiaxiale Textilien, wobei Fasern, Rovings oder Faserbündel unidirektional angeordnet sind und durch Näh- oder Bindefäden in Maschen gefaßt werden. Die Erfindung bezieht sich weiterhin auf ein Textil, das nach dem vorgenannten Verfahren hergestellt ist.

Beschreibung

[0001] Die Erfindung bezieht sich auf ein Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für multiaxiale Gelege und auf ein multiaxiales Textil.

[0002] Historisch werden multiaxiale Textilien durch das Zusammenfügen von zwei Geweben hergestellt, wobei die beiden Gewebe einen sehr leichten Kettfadenanteil und einen hohen Schußfadenanteil aufweisen. Die beiden Gewebe werden in die benötigten Winkel verzogen, z. B. +45° und –45°. Diese verzogenen Gewebe werden dann durch Vernähen miteinander verbunden.

[0003] Später gab es Maschinen, welche Fadenscharen in den einzelnen Winkeln ablegten. Diese wurden über einen seitlich mitlaufenden Halterahmen fixiert und anschließend miteinander vernäht.

[0004] Bei beiden Herstellvarianten ist es nicht möglich, das Gewicht stufenlos in der Fläche zu varieren. Ferner ist es nicht gewebetypisch, daß das Gewebe einzig nicht mit einer Achse gebildet werden kann, sondern in der weiteren Achse mindestens Verstärkungsfäden vorhanden sind, welche die Drapierfähigkeit mindern. Weiterhin war es bisher nicht möglich, gezielte und regelmäßige Lücken in das flächige Textil einzubringen.

Stand der Technik

[0005] In der DE 30 03 666 A1 wird ein Gelege zur Herstellung einer Verstärkung von im wesentlichen aus Flächen bestehenden Bauteilen und eine Vorrichtung zur Herstellung desselben beschrieben. Auch in der DE 100 61 028 A1 wird ein Verfahren zum Herstellen von mehrschichtigen FTP-Preforms mittels schmelzbaren Fixierfäden beschrieben. Bei beiden Verfahren basiert die Maschenbildung bzw. das Vernähen der textilen Halbzeuge auf einer Sticktechnologie, wobei bei dieser Herangehensweise jeweils der Stickgrund mitgeführt wird bzw. dieser vor der Formgebung entfernt werden muß.

Aufgabenstellung

[0006] Der Erfindung liegt daher die Aufgabe zugrunde, ein Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für ein multiaxiales Gelege sowie ein multiaxiales Textil vorzuschlagen, bei welchem das Gewicht stufenlos in der Fläche variabel gestaltet werden kann und das eine hohe Drapierfähigkeit aufweist. Außerdem soll es möglich sein, gezielte und regelmäßige Lücken in das flächige Textil einzubringen.

[0007] Diese der Erfindung zugrundeliegende Aufgabe wird durch die Lehre der Ansprüche 1 und 6 gelöst.

[0008] Vorteilhafte Ausgestaltungen der Erfindung sind in den Unteransprüchen erläutert.

[0009] Gemäß der Erfindung bezieht sich die Erfindung auch auf ein nach dem Verfahren hergestelltes Textil, das in den Ansprüchen 6 bis 8 definiert ist.

[0010] In der vorliegenden Anmeldung wird für die Maschenbildung der einzelnen textilen Halbzeuge keine Unterlage, d. h. kein Stickgrund benötigt, so daß ein Stickverfahren und sticktechnisch verbundene Halbzeuge durch die vorliegende Anmeldung nicht unter Schutz gestellt werden sollen.

[0011] Gemäß der Erfindung werden Fasern, Faserbündel oder Rovings unidirektional und parallel durch Bindefäden gefaßt und zusammengehalten. Diese Bindefäden laufen üblicherweise quer zu den zu fassenden Fasern, Faserbündeln oder Rovings. Hierbei werden die Fasern, Faserbündel oder Rovings durch einen Bindefaden, welcher sogenannte Maschen bildet, gebunden, d. h. alle Bindefäden umschlingen immer nur einen Faden bzw. ein Faserbündel oder einen Roving und fixieren diesen dann durch die Masche.

[0012] Die Maschengröße oder auch Stichlänge ist frei wählbar.

[0013] Wenn nun ein Roving oder Faserbündel mit einer bestimmten Textur genutzt wird, ist das Gewicht des Textils durch ein Verändern der Maschengröße oder Stichlänge variabel zu gestalten.

[0014] Weiterhin können auch Leermaschen, also nicht mit Rovings oder Faserbündeln belegte Maschen produziert werden. Der Sinn und Zweck dient zur Kanalbildung, die für ein leichtes Einfiltrieren von Faserverbundbauteilen hilfreich ist.

Patentansprüche

1. Verfahren zur Herstellung eines Textils aus Synthesefasern als textiles Halbzeug für multiaxiale Gelege, **dadurch gekennzeichnet**, daß Fasern, Rovings oder Faserbündel unidirektional angeordnet werden und jeweils durch Bindefäden in Maschen gefaßt werden, wobei alle Bindefäden immer nur einen Faden, einen Roving oder ein Faserbündel umschließen und fixieren und mindestens zwei textile Halbzeuge anschließend in unterschiedlichen Winkeln zueinander übereinandergelegt miteinander verbunden werden, wobei für die Maschenbildung der einzelnen textilen Halbzeuge keine Unterlage benötigt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Stich- oder Maschenlänge des textilen Halbzeugs in einem Rapport variabel groß ist.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß auf normale, voll eingezogene Maschen sogenannte Leermaschen folgen.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Verbindung der wenigstens zwei Halbzeuge mechanisch, z. B. durch Bindefäden erfolgt.

5. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Verbindung der wenigstens zwei Halbzeuge durch einen chemischen Binder erfolgt.

6. Multiaxiales Textil, dadurch gekennzeichnet, daß Fasern, Rovings oder Faserbündel unidirektional angeordnet und durch Bindefäden in Maschen gefaßt sind, wobei alle Binfäden immer nur einen Faden bzw. ein Faserbündel oder einen Roving umschlingen und fixieren und mindestens zwei der textilen Halbzeuge anschließend in unterschiedlichen Winkeln zueinander übereinandergelegt und miteinander verbunden sind, wobei für die Maschenbildung der einzelnen textilen Halbzeuge keine Unterlage vorhanden ist.

7. Multiaxiales Textil nach Anspruch 6, dadurch gekennzeichnet, daß die Stich- oder Maschenlänge des textilen Halbzeugs in einem Rapport variabel ist.

8. Multiaxiales Textil nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß auf normale, voll eingezogene Maschen sogenannte Leermaschen folgen können.

Es folgt kein Blatt Zeichnungen

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(54) ANTISTATIC POLYMER MONOFILAMENT, METHOD FOR MAKING AN ANTISTATIC POLYMER MONOFILAMENT FOR THE PRODUCTION OF SPIRAL FABRICS AND SPIRAL FABRICS FORMED WITH SUCH MONOFILAMENTS

(76) Inventors: **Heping Zhang**, Summerville, SC (US); **William Harwood**, Gulf Breeze, FL (US); **Gilbert Ross**, Waycross, GA (US)

Correspondence Address:
CAESAR, RIVISE, BERNSTEIN, COHEN & POKOTILOW, LTD.
11TH FLOOR, SEVEN PENN CENTER
1635 MARKET STREET
PHILADELPHIA, PA 19103-2212 (US)

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(57) **ABSTRACT**

An antistatic polymer monofilament of this invention comprises a polymer composite of a thermoplastic polymer as a matrix and carbon nanotubes as a conductive filler. A process of this invention for manufacturing an antistatic polymer monofilament comprising the steps of blending in an extruder a thermoplastic polymer and carbon nanotubes and extruding monofilaments from said blend. An industrial fabric of this invention, which is usable in nonwoven and papermaking machines, said fabric comprising monofilaments for dissipating static charges, said monofilaments including a thermoplastic polymer matrix and a filler of carbon nanotubes.

ANTISTATIC POLYMER MONOFILAMENT, METHOD FOR MAKING AN ANTISTATIC POLYMER MONOFILAMENT FOR THE PRODUCTION OF SPIRAL FABRICS AND SPIRAL FABRICS FORMED WITH SUCH MONOFILAMENTS

BACKGROUND OF THE INVENTION

[0001] 1. Field of Invention

[0002] This invention relates to an antistatic polymer monofilament, a method for making an antistatic polymer monofilament for the production of spiral fabrics and spiral fabrics employing such monofilaments.

[0003] 2. Description of Related Art

[0004] Industrial fabrics used as non-woven lay down conveyer belts in machines for making non-woven fabrics and paper machine clothing employed at the final dryer sections of paper making machines require antistatic properties. That is, they must dissipate or prevent the build up electrical charges to prevent such charges from accumulating to a point where high energy sparking may occur when the belts or clothing contact grounded objects. Such high energy sparking can create an undesired safety hazard. Permanent antistatic monofilaments are frequently included in industrial fabrics to prevent the undesired build up of static charges.

[0005] Current antistatic fabrics are very similar to conventional polyester dryer fabrics with the exception that they contain carbon filled polyamide antistatic yarns and conductive edging. The seams are either loop seams or endless. There is a disadvantage to both seam styles. The loop seam is weaker than the main body of the fabric and also can put an undesired seam mark onto the finished product. An endless seamed fabric is very time consuming to install, which also is undesirable.

[0006] British Patent GB 21 01 559 discloses a fabric that has metal wires woven together with polymer monofilaments, where the metal wires are capable of discharging electrostatic charges from the fabric. The disadvantage of this structure is that the stretching behavior of the metal wire differs significantly from that of the remaining fabric. This can easily lead to breakage of the metal wires. An additional risk is that the metal wires normally corrode in air, which creates points of interruption for discharging the static charges.

[0007] To overcome the above-identified problems of utilizing metal wires in conjunction with polymer monofilaments in the fabric, fabrics have been made with surface coated monofilaments, with the surface coating including conductive particles to dissipate undesired static charges. Thus, the conductive coating on the polymeric monofilaments renders the monofilaments antistatic without losing the benefit of monofilament mechanical properties. Examples of such coating treatments are disclosed in EP 0327227A2 (1989) to Xerox, EP 0308234 A1(1989) to Courtaulds, EP 0294504 B1(1987) to BASF, and U.S. Pat. No. 5,935,706 (1999) to Dupont. In the prior art coating processes a polymer monofilament typically is first treated to make it receptive for receiving the conductive coating. Thereafter, the conductive coating, e.g., carbon black or a layer of metal particles, are then suffused onto the treated surface of the polymer monofilament. Though this approach maintains most of the polymer monofilament properties, the antistatic sheath or coating tends to wear away, due to the fact that the coated monofilaments frequently are subject to strong mechanical abrasion. In particular, during the fabric weaving process, friction between the coated monofilaments and mechanical parts of the weaving machine tend to abrade the coated sheath and cause serious housekeeping problems. Moreover, the monofilament treatment and coating process involves complicated chemical processing, thereby undesirably increasing the cost of the formed fabric.

[0008] Another prior art practice has been to incorporate antistatic particles into polymer bodies instead of employing a surface coating. A variety of materials, including carbon fibers, metallic fibers and carbon blacks can be used as polymer additives for making antistatic or conductive polymer compositions. Such approaches are disclosed in, e.g., U.S. Pat. No. 6,083,562 (2000) to Sterling Chemicals International and EP 0399397 A2 (1990) to Dupont. The desired electrical conductivity in the polymer composite is achieved when an adequate network of conductive particles or fibers is established within the polymer. Large amounts of carbon black or metal particles, typically in an amount >10 wt %, need to be incorporated into the polymer to form the desired network for dissipating static charges.

[0009] The above-described polymer composites including conductive additives have not been reported for use in polymer monofilaments. This is largely due to the fact that the composite does not have good compatibility between the polymer matrix and the highly loaded, large particle-sized antistatic fillers. In particular, carbon black, carbon fibrils and metal particles, typically in a dimension of microns, lead to severe phase separation during formation (i.e., extrusion and orientation in the solid state) of monofilaments, resulting in very brittle filaments having unacceptable variations in diameter along their length. Such monofilaments would be unsuitable for use in applications of this invention, which require the monofilaments to have a high degree of structural integrity to maintain their mechanical properties and close dimensional tolerances along their length.

[0010] Graphite nanotubes as a conductive medium are a relatively new entry in this general area. Compared to carbon blacks, which typically have a particle size on the order of several microns, the multiple wall nanotubes have a diameter between 10-20 nm and an aspect ratio of greater than 100, making them sub-micron in size. The surface area of these nanotubes typically can be about 250 m^2/g and can establish a conductive network in a polymer matrix at very low loadings, resulting in minimal degradation of polymer physical properties. EP 1054036 A1 (2000) to Fina Research S.A. discloses partially oriented fibers made of polyethylene and polypropylene with carbon nanotubes. WO 02/076724 (2002) to Eikos disclosed electrically conductive polymer films containing carbon nanotubes. These disclosures, however, are not readily applicable to, nor do they suggest forming monofilaments.

[0011] Polymer monofilaments, which are the subject of the instant invention, differ from fibers and films of the type disclosed in EP 1054036 and WO 02/076724 in that the primary purpose of the carbon nanotubes in the present invention is to provide a network capable of dissipating a static charge, and that the diameter of a round cross sectional

area of the formed monofilament is greater than 0.05 mm. Any fillers in the polymer matrix can easily cause phase separation in the monofilament orientation process as the monofilament exits the extruder.

[0012] It is an object of this invention to develop polymer monofilaments that exhibit permanent static dissipative properties with long lasting effect and good mechanical properties.

[0013] All references cited herein are incorporated herein by reference in their entireties.

SUMMARY OF THE INVENTION

[0014] A monofilament in accordance with this invention includes a thermoplastic polymer matrix and a filler of carbon nanotubes as a conductive medium for dissipating static charges.

[0015] The monofilaments of this invention preferably have a diameter between 0.1 mm to 1.0 mm; (b) a surface resistivity between 10^4 to 10^9 ohms/square; (c) a static dissipation rate less than 200 μs; (d) a tensile tenacity greater than 1.5 g/d; and (e) a tensile elongation at break greater than 20%.

[0016] A monofilament in accordance with this invention is formed by blending in an extruder a thermoplastic polymer and carbon nanotubes and extruding monofilaments from said blend. A wide variety of thermoplastic polymers may be employed in this invention, such as polyesters, polyamides, polyethylene, polypropylene and polyphenylene sulfide (PPS). The preferred polymers are polyesters and polyamides, with the most preferred polymer being polyethylene terephthalate (PET), such as PET "Crystar" Merge 5147 sold by Dupont in Wilmington Del., USA. Preferred nanotubes are "Fibril" nanotubes supplied as product MB6815-00, which is a 15% masterbatch of the nanotubes in PET, sold by Hyperion Catalysis International Inc., 38 Smith Place, Cambridge, Mass. 02138.

[0017] An industrial fabric usable in nonwoven and papermaking machines also constitutes a part of this invention. The fabric comprises monofilaments for dissipating static charges, said monofilaments including a thermoplastic polymer matrix and a filler of carbon nanotubes.

[0018] In a preferred embodiment of a fabric in accordance with this invention the monofilaments for dissipating static charges are woven with filaments of other thermoplastic polymers. Most preferably the other filaments are monofilaments of polyethylene terephthalate (PET).

[0019] Preferably the fabric is of a spiral construction including monofilaments of this invention as stuffer elements, said fabric including conductive edging.

DETAILED DESCRIPTION OF THE INVENTION

[0020] A monofilament in accordance with this invention includes a thermoplastic polymer matrix and a filler of carbon nanotubes as a conductive filler for dissipating static charges. These nanotubes are known in the art. They have a diameter of between 10-20 nm and an aspect ratio of greater than 100. Typically the surface area of the nanotubes is 250 m^2/g and can establish a conductive network in a polymer matrix at very low loadings, resulting in minimal degradation of polymer physical properties. The nanotubes disclosed in EP 1054036 A1 (2000) and WO 02/076724 (2002), are usable in this invention. These latter-two publications already have been incorporated by reference herein.

[0021] Preferably the thermoplastic polymer employed as the matrix of the monofilaments of this invention is a polyester, but as noted earlier, the use of other thermoplastic polymers is contemplated to be within the scope of the broadest aspects of this invention. Also, as noted earlier the preferred polymers are polyesters and polyamides, with the most preferred polymer being polyethylene terephthalate (PET), such as PET "Crystar" Merge 5147 sold by Dupont.

[0022] Also, as noted earlier the preferred nanotubes are "Fibril" nanotubes supplied as product MB6815-00, which is a 15% masterbatch of the nanotubes in PET, sold by Hyperion Catalysis International Inc.

[0023] In accordance with the broadest aspect of this invention the carbon nanotubes are present in a weight percent of less than 15%, based on the weight of the monofilament. More preferably the carbon nanotubes are present in a weight percent of less than 10% and even more preferably in a weight percent of less than 5%.

[0024] The monofilaments of this invention preferably have a diameter between 0.1 mm to 1.0 mm; (b) a surface resistivity between 10^4 to 10^9 ohms/square; (c) a static dissipation rate less than 200 μs; (d) a tensile tenacity greater than 1.5 g/d; and (e) a tensile elongation at break greater than 20%. The monofilament in accordance with this invention is formed by blending in an extruder a thermoplastic polymer and carbon nanotubes and extruding monofilaments from said blend.

[0025] An industrial fabric usable in nonwoven and papermaking machines, said fabric comprising monofilaments for dissipating static charges, said monofilaments including a thermoplastic polymer matrix and a filler of carbon nanotubes.

[0026] In a preferred embodiment of a fabric in accordance with this invention the monofilaments for dissipating static charges are woven with filaments of other thermoplastic polymers. Most preferably the other filaments are monofilaments of polyethylene terephthalate (PET) and the monofilaments for dissipating static charges are woven into the fabric as stuffer filaments.

[0027] Preferably the fabric is of a spiral construction including monofilaments of this invention as stuffer elements, said fabric includes an edge sealing polymer incorporating sufficient carbon black to provide anti-static properties, thereby forming a network of static dissipating material within the fabric.

[0028] Industrial fabrics including the antistatic polymer monofilaments of the present invention can be quickly and easily installed onto a non-woven machine. Moreover, these fabrics will have a very smooth surface and a non-marking seam. Furthermore, the antistatic material does not shed during its manufacture or in its end use in the industrial fabrics of this invention.

[0029] As the monofilaments of the present invention are impregnated with the static dissipating material, and not coated, the fabrics derived from said monofilaments have smooth surfaces that will not generate dust during manu-

facturing and in use, and also are easy to seam. It is unnecessary to cantilever the machine as with an endless seam. As an added benefit, if the fabric is damaged it is possible to remove or replace the damaged section.

[0030] The inventive, antistatic monofilament is handled in the same manner as any conventional monofilament. It does not cause a dusting problem of the type that occurs with carbon black coated monofilament. Moreover the monofilament of the present invention is cheaper to make than the market-available products.

[0031] The following table shows the properties of monofilaments within the scope of this invention. However, this is just illustrative of the invention and is not intended as a limitation on the broadest aspects of the invention.

[0032] The formulation of the monofilaments is as follows:

[0033] Du Pont Crystar Merge 5147 PET—68%

[0034] Hyperion MB6815-00-29%

[0035] Compatabilizer—3% FUSE 100 supplied by Polymer Dynamix, 665 Martin St, Rahway, N.J. 07065.

Sample #	Draw Ratios	Total Draw	Tenacity (g/den)	Elongation @ Break (%)	Young's Mod. (g/den)	Shrinkage (%)	Surface Resistance (Ω/sq)	Denier (g/9000 m)
Extrudate								
1	3	3	1.4	42	57	13.6	1×10^{9}	3085
2	3.5	3.5	1.75	35	70	15.5	1×10^{12}	2605
3	4	4	2.2	10	85	17.1	2×10^{12}	2168
4	3 × 1	3	1.55	42	58	11.4	1×10^{12}	2954
5	3 × 1.05	3.15	1.7	32	67	13.5	2×10^{11}	2721
6	3 × 1.1	3.3	1.65	25	65	13.8	1×10^{11}	2757
7	3 × 1.2	3.6	1.95	10	77	15.6	6×10^{11}	2424
8	3 × 1.05 × 1	3.15	1.75	23	65	10.1	6×10^{8}	2776
9	3 × 1.05 × .9	2.84	1.5	26	53	6.9	3×10^{9}	2908
10	3 × 1.05 × .85	2.68	1.4	42	43	2.7	1×10^{8}	3215
11	3 × 1.1 × .875	2.89	1.7	27	53	4.7	2×10^{11}	2738
12	3 × 1.05 × .95	2.99	1.6	30	57	7.0	4×10^{8}	2730
13	3 × 1 × .95	2.85	1.62	35	62	6.8	2×10^{7}	2786

[0036] The draw ratios represent the degree of stretching of the filament during processing. For example, in sample 12 3×1.05×0.95 denotes that the yarn was stretched by 3× in the first drawing step then by 1.05× in the second stage, and finally relaxed by 0.95× in the final stage. This is achieved by changing the godet roll speeds, so that in this case if the 1st roll speed is 30 feet/min, then the second would be 30×3=90 feet/min (i.e., a 3× stretch), the third would be 90×1.05=94.5 feet/min (i.e., 1.05× stretch)and the last would be 94.5×0.95=89.8 feet/min (i.e.,.0.95×).

[0037] Mechanical properties tested according to ASTM D2256-97. Thermal shrinkage test carried out according to ASTM D204 with the temperature modified to 204° C. Surface resistance measured using a Trek 152 meter with a 2P probe according to ASTM D4496.

[0038] While the invention has been described in detail and with reference to specific examples thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof.

1. An antistatic polymer monofilament comprising a polymer composite of (a) a thermoplastic polymer as a matrix and (b) carbon nanotubes as a conductive filler, said monofilament having a diameter between 0.1 mm to 1.0 mm, a surface resistivity between 10^4 to 10^9 ohms/square, a static dissipation rate less than 200 μs, a tensile tenacity greater than 1.5 g/d and a tensile elongation at break greater than 20%.

2-17. (canceled)

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(71) Applicant: **Ichikawa Co., Ltd.**
Tokyo (JP)

(72) Inventor: **TAMURA, Ai**
Tokyo (JP)

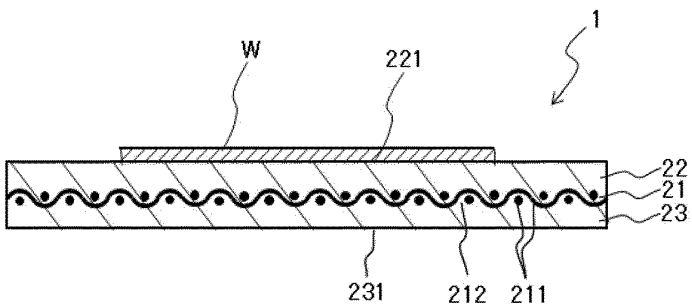
(74) Representative: **Gassner, Wolfgang et al**
Dr. Gassner & Partner mbB
Patentanwälte
Marie-Curie-Strasse 1
91052 Erlangen (DE)

(54) WET PAPER WEB TRANSFER BELT, PAPERMAKING SYSTEM, PAPERMAKING METHOD AND METHOD FOR PRODUCING A WET PAPER WEB TRANSFER BELT

(57) The object of the present invention is to provide a wet paper web transfer belt having excellent wet paper web transfer properties wherein the paper robbing phenomenon in the press part is prevented, a papermaking system having excellent operational stability comprising said wet paper web transfer belt, a papermaking method having excellent operational stability using said wet paper web transfer belt, and a method for producing said wet paper web transfer belt.

This is achieved by a wet paper web transfer belt 1 for transferring a wet paper web; wherein it comprises a wet paper web carrying surface 221 carrying a wet paper web W, which is made of a resin layer 22, and wherein the skewness Rsk of the roughness curve of the wet paper web carrying surface 221 is -0.5 or less.

Fig. 1



EP 3 002 367 A1

Description

Technical Field

[0001] The present invention relates to a wet paper web transfer belt, a papermaking system, a papermaking method and a method for producing a wet paper web transfer belt.

Description of the Related Art

[0002] Papermaking machines removing moisture from the source material of paper are generally equipped with a wire part, a press part and a dryer part. These parts are arranged in the order of wire part, press part and dryer part in the wet paper web transfer direction.

[0003] Regarding the passing of the wet paper web in the press part, at present, closed-draw papermaking machines are known in which the wet paper web is passed in a closed draw. In the press part of the closed-draw papermaking machine, the wet paper web is transferred while being placed on a papermaking felt or a wet paper web transfer belt; therefore, there are no places in which the wet paper web travels on its own and the occurrence of web breaks can be prevented. Thus, closed-draw papermaking machines are advantageous with regard to high operating speeds and operational stability.

[0004] On the other hand, when the wet paper web is passed between wet paper web transfer belts or felts in the press part of such a closed-draw papermaking machine, the "paper robbing" phenomenon may occur in which the wet paper web gets stuck at a wet paper web transfer belt or felt and is not passed to the next wet paper web transfer belt or felt. When the paper robbing phenomenon occurs, operations need to be stopped and the setting of the device needs to be changed so that the wet paper web is passed as it should be.

[0005] A number of studies have been carried out regarding wet paper web transfer belts in order to improve the wet paper web transfer properties and to prevent the paper robbing phenomenon in the press part (for example, patent documents 1 to 4). In patent documents 1 to 3, belts are studied in which the wet paper web transfer properties have been improved by setting the belt surface roughness Ra or Rz within a predetermined range. In patent document 4, a belt is studied in which the wet paper web transfer properties have been improved by providing a porous outer layer of the belt.

[Prior Art Documents]

[Patent Documents]

[0006]

Patent Document 1: JP 2014-62337 (A)
Patent Document 2: JP 2014-62338 (A)
Patent Document 3: JP H06-57678 (A)
Patent Document 4: EP 1069235 (A)

SUMMARY OF THE INVENTION

Problems to be solved by the Invention

[0007] Nevertheless, further improvements of the wet paper web transfer properties are required as the operating speeds of papermaking machines increase.

[0008] Therefore, the object of the present invention is to provide a wet paper web transfer belt having excellent wet paper web transfer properties wherein the paper robbing phenomenon in the press part is prevented, a papermaking system having excellent operational stability comprising said wet paper web transfer belt, a papermaking method having excellent operational stability using said wet paper web transfer belt, and a method for producing said wet paper web transfer belt.

Means for solving said Problems

[0009] The present inventor, as a result of intensive studies to achieve the above object, found out that the adhesive properties of the wet paper web in relation to the wet paper web transfer belt are important when the wet paper web transfer belt receives the wet paper web and that said adhesive properties are improved when the smoothness of the

wet paper web carrying surface of the wet paper web transfer belt is high, and that the release properties of the wet paper web in relation to the wet paper web transfer belt are important when the wet paper web transfer belt passes the wet paper web and that said release properties are improved when the wet paper web carrying surface is relatively rough, and have thus achieved said object.

[0010] Then, the present inventor, as a result of having further studied the complementary of the conflicting roughness conditions of the wet paper web carrying surface relating to the adhesive and release properties, found out that excellent adhesive properties and release properties of the wet paper web can both be achieved by setting the skewness of the roughness curve of the wet paper web carrying surface within a predetermined range, and have thus completed the invention.

[0011] In other words, the present invention relates to the following:

(1) A wet paper web transfer belt for transferring a wet paper web; wherein it comprises a wet paper web carrying surface carrying a wet paper web, which is made of a resin layer, and wherein the skewness Rsk of the roughness curve of the wet paper web carrying surface is -0.5 or less.
(2) The wet paper web transfer belt according to (1); wherein Rsk is between - 2.7 and -0.5.
(3) The wet paper web transfer belt according to (1) or (2); wherein the arithmetic average roughness Ra of the wet paper web carrying surface is between 2.0 and 12.0 μm.
(4) A papermaking system comprising a press part squeezing moisture from a wet paper web; wherein the press part is configured so that, in at least one part thereof, a wet paper web transfer belt according to any one of (1) to (3) is used in a closed draw so as to pass a wet paper web.
(5) The papermaking system according to (4); wherein the press part is configured so that, in at least one part thereof, the wet paper web is passed in a closed draw between a wet paper web transfer belt and felt.
(6) A papermaking method comprising a step of squeezing moisture from a wet paper web which is formed by dewatering a pulp slurry; wherein a wet paper web transfer belt according to any one of (1) to (3) is used in said step for passing a wet paper web in a closed draw.
(7) The papermaking method according to (6); wherein, in the step of squeezing moisture, the wet paper web is passed in a closed draw between a wet paper web transfer belt and felt.
(8) A method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises

a step of forming a resin layer, and
a step of polishing the surface of the resin layer in two stages successively using a 1st abrasive and a 2nd abrasive of a finer grit than the 1st abrasive, to form a wet paper web carrying surface for carrying a wet paper web.

(9) A method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises

a resin layer forming step of forming a resin layer,
a 1st polishing step of polishing the surface of said resin layer using an abrasive having a grit of #120 or less, and
a 2nd polishing step of polishing said surface using an abrasive having a grit of #240 or more.

(10) The method for producing a wet paper web transfer belt according to (9); wherein the 1st polishing step and the 2nd polishing step are performed consecutively.
(11) A method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises

a resin layer forming step of forming a resin layer,
a 1st polishing step of polishing the surface of said resin layer using a 1st abrasive, and
a 2nd polishing step of polishing said surface using a 2nd abrasive of a finer grit than the 1st abrasive; wherein the 1st polishing step and the 2nd polishing step are performed consecutively, and
the difference between the grit of the abrasive used in the 1st polishing step and the grit of the abrasive used in the 2nd polishing step is #120 or more. (12) A wet paper web transfer belt produced by a method for producing a wet paper web transfer belt according to any one of (8) to (11).

ADVANTAGES OF THE INVENTION

[0012] By means of the constitution described above, it is possible to provide a wet paper web transfer belt having excellent wet paper web transfer properties wherein the paper robbing phenomenon in the press part is prevented, a papermaking system having excellent operational stability comprising said wet paper web transfer belt, a papermaking method having excellent operational stability using said wet paper web transfer belt, and a method for producing said wet paper web transfer belt.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a sectional view in the cross machine direction showing one example of a wet paper web transfer belt relating to a preferred embodiment of the present invention.

Fig. 2 is a schematic enlarged sectional view in the cross machine direction showing one example of a wet paper web carrying surface comprised in the wet paper web transfer belt shown in Fig. 1.

Fig. 3 is a schematic diagram explaining a preferred embodiment of a method for producing a wet paper web transfer belt according to the present invention.

Fig. 4 is a schematic diagram explaining a preferred embodiment of a method for producing a wet paper web transfer belt according to the present invention.

Fig. 5 is a schematic diagram showing one example of one part of the press part in a preferred embodiment of a papermaking system according to the present invention.

Fig. 6 is a schematic diagram showing an evaluation device of a wet paper web transfer belt.

BEST MODES FOR CARRYING OUT THE INVENTION

[0014] Hereinafter, preferred embodiments of the wet paper web transfer belt, the method for producing a wet paper web transfer belt, the papermaking system, and the papermaking method according to the present invention will be explained in detail by referring to the drawings.

[0015] Firstly, the wet paper web transfer belt according to the present invention will be explained.

[0016] Fig. 1 is a sectional view in the cross machine direction showing one example of a wet paper web transfer belt relating to a preferred embodiment of the present invention; Fig. 2 is a schematic enlarged sectional view in the cross machine direction showing one example of a wet paper web carrying surface comprised in the wet paper web transfer belt shown in Fig. 1. It should be noted that, in Fig. 1, a wet paper web W to be transferred is shown to facilitate understanding; however, it goes without saying that this is not the constitution of wet paper web transfer belt 1. Moreover, in the drawings, each member is suitably emphasized to facilitate explanation and their size and proportion do not correspond to the real members. Furthermore, hereinafter, the planned machine direction in the papermaking system will be referred to as "MD" and the planned cross machine direction in the papermaking system will be referred to as "CMD".

[0017] The wet paper web transfer belt 1 shown in Figs 1 and 2 is used for transferring and passing the wet paper web W in the press part of a papermaking machine. The wet paper web transfer belt 1 forms an endless band-shaped body. In other words, the wet paper web transfer belt 1 is an annular belt. Then, the longitudinal direction of the wet paper web transfer belt 1 is generally disposed along the machine direction (MD) of a papermaking system.

[0018] The wet paper web transfer belt 1 comprises a reinforcing fiber base material layer 21, a 1st resin layer (wet paper web carrying resin layer) 22 provided on one main surface at the outer surface side of the reinforcing fiber base material layer 21, and a 2nd resin layer (roll side layer) 23 provided on the other surface of the reinforcing fiber base material layer 21; these layers are formed by laminating. Moreover, the 1st resin layer is the layer that forms the outer surface (outer circumferential face) of the annular shape forming the wet paper web transfer belt 1.

[0019] The reinforcing fiber base material layer 21 is made of a reinforcing fiber base material 211 and a resin 212. The resin 212 is present in the reinforcing fiber base material layer 21 so as to fill the gaps of the fibers in the reinforcing fiber base material 211. In other words, one part of the resin 212 impregnates the reinforcing fiber base material 211 while the reinforcing fiber base material 211 is embedded in the resin 212.

[0020] There are no particular limitations with regard to the reinforcing fiber base material 211; however, for example, fabrics woven by a weaving machine and the like from warp and weft yarns are commonly used. Moreover, it is also possible to use a grid-like web material of superimposed rows of warp and weft yarns without weaving.

[0021] The fineness of the fibers constituting the reinforcing fiber base material 211 is not particularly limited, for example, 300 to 10000 dtex, and preferably 500 to 6000 dtex may be used.

[0022] Moreover, the fineness of the fibers constituting the reinforcing fiber base material 211 may be different depending on the part in which the fibers are used. For example, the fineness of the warp and weft yarns in the reinforcing fiber base material 211 may be different.

[0023] As reinforcing fiber base material 211, it is possible to use one or a combination of two or more polyesters (polyethylene terephthalate, polybutylene terephthalate, and the like), aliphatic polyamides (polyamide 6, polyamide 11, polyamide 12, polyamide 612, and the like), aromatic polyamides (aramid), polyvinylidene fluoride, polypropylene, polyether ether ketone, polytetrafluoroethylene, polyethylene, wool, cotton, metals, and the like.

[0024] As resin 212, it is possible to use one or a combination of two or more of thermosetting resins such as urethane, epoxy, acryl, and the like, or thermoplastic resins such as polyamide, polyarylate, polyester, and the like; preferably, urethane resin may be used.

[0025] The urethane resin used in the resin 212 is not particularly limited; however, for example, urethane resin obtained by curing a urethane prepolymer having a terminal isocyanate group, which was obtained by reacting an aromatic or aliphatic polyisocyanate compound and polyol, together with a curing agent having an active hydrogen group may be used. Moreover, it is possible to use an anionic, nonionic or cationic aqueous urethane resin of the self-emulsification type or forced emulsification type. In this case, for improving the resistance to water, it is also possible to crosslink the aqueous urethane resin by using a cross linking agent of melamine, epoxy, isocyanate, carbodiimide, and the like, together with the aqueous urethane resin.

[0026] In addition, the resin 212 may also comprise one type or a combination of two or more types of inorganic fillers such as titanium oxide, kaolin, clay, talc, diatomaceous earth, calcium carbonate, calcium silicate, magnesium silicate, silica, mica, and the like.

[0027] Further, the type and composition of the resin 212 in the reinforcing fiber base material layer 21 may be different in each part of the reinforcing fiber base material layer 21 or it may be the same.

[0028] The 1st resin layer 22 is provided on one main surface of the reinforcing fiber base material layer 21 and is mainly made of a resin material.

[0029] The 1st resin layer 22 constitutes a wet paper web carrying surface 221, which is in contact with the wet paper web W and carries the wet paper web W on the main surface at the opposite side of the main surface that is joined to the reinforcing fiber base material layer 21. In other words, the wet paper web transfer belt 1 carries the wet paper web W on the wet paper web carrying surface 221 of the 1st resin layer 22 and can transfer the wet paper web W.

[0030] The skewness Rsk of the roughness curve of the wet paper web carrying surface 221 is -0.5 or less.

[0031] Here, the roughness curve of the skewness Rsk is the parameter defined according to JIS B0601:2001 (or the corresponding ISO 4287:1997). Rsk can express the degree of asymmetry of the height distribution in relation to the mean line of the roughness curve. If Rsk=0, it means that the height distribution of the roughness curve is symmetrical in relation to the mean line of the roughness curve; if Rsk<0, it means that the height distribution of the roughness curve tends towards the upper side of the mean line; and if Rsk>0, it means that the height distribution of the roughness curve tends towards the lower side of the mean line. Since the height distribution of the roughness curve tends towards the upper side of the mean line when Rsk<0, the region of the convex portions protruding from the mean line is wide, while the region of the concave portions recessed from the mean line is narrow. Moreover, the depth of the convex portions is greater than the height of the concave portions of the wide region.

[0032] Fig. 2 is a schematic enlarged sectional view in the cross machine direction showing one example of the wet paper web carrying surface 221 of the wet paper web transfer belt 1. Fig. 2 shows, as an example, the schematic view of a case in which Rsk is -2.7 and the arithmetic average surface roughness Ra is 12.0. As shown in Fig. 2, since Rsk is negative and sufficiently small, the convex portions 222, which are higher than the mean line, account for a relatively flat and wide region, wherein the web paper web W can adhere to the convex portions 222. On the other hand, the concave portions 223, which are deeper than the mean line, form holes of a relatively large volume as relatively steep valleys. When the wet paper web W is released, such concave portions 223 are advantageous for rupturing the water film between the wet paper web W and the wet paper web carrying surface 221 and for introducing air between the wet paper web W and the wet paper web carrying surface 221 and contribute to the improvement of the release properties of the wet paper web W from the wet paper web carrying surface 221.

[0033] Then, if Rsk is -0.5 or less, the convex portions 222 contributing to the improvement of the adhesive properties of the wet paper web W with the wet paper web carrying surface 221 and the concave portions 223 contributing to the improvement of the release properties of the wet paper web W from the wet paper web carrying surface 221 are thus disposed on the wet paper web carrying surface 221 in an appropriate ratio, and the wet paper web transfer belt 1 at the same time excels in the adhesive and release properties of the wet paper web W, which were conflicting properties in conventional belts. The result thereof is that the wet paper web transfer belt 1 has excellent wet paper web transfer properties wherein the paper robbing phenomenon is prevented when the wet paper web W is passed in the press part.

[0034] Thus, Rsk may be -0.5 or less; however, -2.7 to -0.5 is preferred, -2.5 to -0.8 is even more preferred, and -2.3 to -1.1 is still more preferred.

[0035] Due to this, the excellent adhesive and release properties of the wet paper web W described in relation to the wet paper web transfer belt 1 can be more reliably established.

[0036] Furthermore, it is preferred that 50% or more of the area of the wet paper web carrying surface 221 are within the above-mentioned Rsk ranges, even more preferred are 80% or more, still more preferred are 90% or more.

[0037] Moreover, the arithmetic average roughness Ra of the wet paper web carrying surface 221 is not particularly limited; however, it is preferably between 1.0 and 20 μm, 2.0 to 12.0 μm are even more preferred, and 2.5 to 9.0 μm are still more preferred. Due to this, the excellent adhesive and release properties of the wet paper web W described in relation to the wet paper web transfer belt 1 can be more reliably established.

[0038] Furthermore, the term average roughness Ra as it is used in the present specification is defined according to JIS B0601.

[0039] Moreover, it is possible to measure the above-mentioned Rsk and Ra for any curved surface and line of the

wet paper web carrying surface 221; however, in case polishing marks are formed on the wet paper web carrying surface 221, measuring preferably perpendicular to the direction of the polishing marks is also possible so as to perform measurement in the transverse direction of the polishing marks.

[0040] As resin material constituting the 1st resin layer 22, it is possible to use one type or a combination of two or more types of the resin materials that can be used in the reinforcing fiber base material layer 21, as described above. The type and composition of the resin material constituting the 1st resin layer 22 and the resin constituting the reinforcing fiber base material layer 21 may be the same or may be different.

[0041] From the point of view of mechanical strength, wear resistance and flexibility, in particular urethane resins are preferred as resin material constituting the 1st resin layer 22.

[0042] Moreover, the 1st resin layer 22 may also comprise one or more inorganic fillers in the same way as the reinforcing fiber base material layer 21.

[0043] Further, the type and composition of the resin materials and the inorganic fillers in the 1st resin layer 22 may be different in each part of the 1st resin layer or it may be the same.

[0044] Moreover, the 1st resin layer 22 preferably has the property of not letting water pass. In other words, the 1st resin layer 22 is preferably water-impermeable.

[0045] The 2nd resin layer (roll side layer) 23 is provided on one main surface of the reinforcing fiber base material layer 21 and is mainly made of a resin material.

[0046] The 2nd resin layer 23 constitutes a roll contacting surface 231 for contacting a roll, described hereinafter, on the main surface at the opposite side of the main surface that is joined to the reinforcing fiber base material layer 21. For transferring the wet paper web, the wet paper web transfer belt 1 can be driven during use via a roll by bringing the roll contacting surface 231 in contact with the roll.

[0047] As resin material constituting the 2nd resin layer 23, it is possible to use one type or a combination of two or more types of the resin materials that can be used in the reinforcing fiber base material layer 21, as described above. The type and composition of the resin material constituting the 2nd resin layer 23 and the resin material constituting the 1st resin layer 22 or the reinforcing fiber base material layer 21 may be the same or may be different.

[0048] From the point of view of mechanical strength, wear resistance and flexibility, in particular urethane resins are preferred as resin material constituting the 2nd resin layer 23.

[0049] Moreover, the 2nd resin layer 23 may also comprise one or more inorganic fillers in the same way as the reinforcing fiber base material layer 21.

[0050] Further, the type and composition of the resin materials and the inorganic fillers in the 2nd resin layer 23 may be different in each part of the 2nd resin layer or it may be the same.

[0051] The dimensions of the wet paper web transfer belt 1 described above are not particularly limited, as they may be suitably set according to the use of the wet paper web transfer belt.

[0052] The width of the wet paper web transfer belt 1 is not particularly limited, however, it may, for example, be 700 to 13,500 mm, or preferably 2,500 to 12,500 mm.

[0053] Further, the length (circumferential length) of the wet paper web transfer belt 1 is not particularly limited, however, it may, for example, be 4 to 35 m, or preferably 10 to 30 m.

[0054] Moreover, the thickness of the wet paper web transfer belt 1 is not particularly limited, however, it may, for example, be 1.5 to 7.0 mm, or preferably 2.0 to 6.0 mm.

[0055] Further, the wet paper web transfer belt 1 may have a different thickness in each place or it may have the same thickness everywhere.

[0056] A wet paper web transfer belt 1 as described above may be produced by the method for producing a wet paper web transfer belt according to the present invention described hereinafter.

[0057] The wet paper web transfer belt 1 according to the above embodiment has excellent wet paper web transfer properties, wherein excellent adhesive and release properties of the wet paper web W are obtained because the wet paper web carrying surface 221 has a predetermined Rsk, and the paper robbing phenomenon is prevented when the wet paper web W is passed in the press part. In particular, the excellent adhesive and release properties of the wet paper web W in relation to the wet paper web transfer belt 1 are more reliably established because the arithmetic average roughness of the wet paper web carrying surface 221 is within the range described above.

[0058] As a modified embodiment of the wet paper web transfer belt 1 described above, an embodiment can, for example, be mentioned in which the roll side layer is not a layer constituted by a resin material, but by a batt fiber layer formed by needling batt fiber. Further, as still another modified embodiment of the wet paper web transfer belt according to the present invention, an embodiment can, for example, be mentioned which comprises a layer in which the above-mentioned batt fibers are impregnated by resins such as those mentioned above. In either of these modified embodiments, except for the roll side layer, the same constitution as in the above-mentioned wet paper web transfer belt 1 may be adopted.

[0059] Moreover, as material of the batt fibers, it is possible to use one or a combination of two or more of the materials that can be used in the reinforcing fiber base material 211.

[0060] Furthermore, in the embodiments described above, it is explained that the wet paper web carrying surface 221 in the wet paper web transfer belt 1 is provided on the outer circumferential surface of the 1st resin layer 22; however, the invention is not limited thereto; it is also possible that only the region destined to carry the wet paper web as wet paper web carrying surface has the predetermined skewness Rsk.

[0061] Moreover, a tab or the like may be provided in a suitable wet paper web transfer belt to match the constitution of the papermaking machine that is being used.

[0062] Next, a preferred embodiment of a method for producing a wet paper web transfer belt according to the present invention will be explained. Fig. 3 is a schematic diagram explaining a preferred embodiment of a method for producing a wet paper web transfer belt according to the present invention, and Fig. 4 is a schematic diagram explaining a preferred embodiment of a method for producing a wet paper web transfer belt according to the present invention.

[0063] The method for producing the wet paper web transfer belt relating to the 1st embodiment of the present invention is a method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises a resin layer forming step of forming a resin layer, a 1st polishing step of polishing the surface of said resin layer using an abrasive having a grit of #120 or less, and a 2nd polishing step of polishing said surface using an abrasive having a grit of #240 or more.

[0064] First, the resin layer is formed in the resin layer forming step. In this step, specifically, a laminated body 1 a is formed in which a reinforcing fiber base material layer 21 in which an annular and band-shaped reinforcing fiber base material 211 is embedded in a resin material, and on both sides thereof, a 1st resin layer precursor 22a as resin layer and a 2nd resin layer 23 are laminated.

[0065] Such a laminated body 1 a may be formed by any method; however, in the present embodiment, the reinforcing fiber base material layer 21 is formed by coating a resin material onto the reinforcing fiber base material 211 so that the resin material penetrates the reinforcing fiber base material 211, and at the same time, the 1st resin layer precursor 22a and the 2nd resin layer 23 are formed on both sides of the reinforcing fiber base material layer 21.

[0066] Specifically, first, as shown in Fig. 3(a), the annular and band-shaped reinforcing substrate 211 is installed so as to be in contact with two rolls 38 which are disposed in parallel.

[0067] Next, as shown in Fig. 3(b), a resin material is applied to the outer surface of the reinforcing fiber base material 221. The resin material may be applied by any method; however, in the present embodiment, the resin material is applied to the reinforcing fiber base material 211 by discharging the resin material from the resin discharge opening 40 while rotating the rolls 38. Moreover, at the same time, the applied resin material is uniformly coated onto the reinforcing fiber base material 211 by using a coating bar 39. The resin material coated at this time can penetrate the reinforcing fiber base material 211. Therefore, in the present embodiment, it is possible to apply the resin comprised in the reinforcing fiber base material 211 and, at the same time, the resin material constituting the 1st resin layer precursor 22a and the 2nd resin layer 23.

[0068] Moreover, the resin material may also be applied as a mixture with the above-mentioned inorganic filler. Further, the type and composition of the resin material and the inorganic filler for forming the layers may be different or may be the same for each layer.

[0069] Next, the coated resin material is cured. By this means, the laminated body 1 a, in which the layers are laminated from the outer surface in the order of the 1st resin layer precursor 22a, the reinforcing fiber base material layer 21 and the 2nd resin layer 23, is obtained. The method for curing the resin material is not particularly limited; however, the curing may, for example, be performed by heating, UV irradiation, and the like.

[0070] Moreover, in case the resin material is cured by heating, for example, a far infrared heater or other method may be used.

[0071] Further, in case the resin material is cured by heating, the heating temperature of the resin material is preferably 60 to 150° C, and still more preferably 90 to 140° C. Furthermore, the heating time can, for example, be 2 to 24 hours, and preferably 3 to 20 hours.

[0072] Next, in the 1st polishing step, the surface of the resin layer is polished by using an abrasive having a grit of #120 or less. Specifically, the outer surface of the 1st resin layer precursor 22a is polished by the above-mentioned abrasive as the resin layer that is to become the wet paper web carrying surface 221. Thus, by polishing the surface of the resin layer with a relatively coarse abrasive, it is possible to form relatively great unevenness on the surface of the resin layer.

[0073] The grit of the abrasive may be #120 or less, as described above; however, #100 or less is preferred, and #40 to #80 is even more preferred. By this means, it is possible to more reliably adjust the skewness Rsk of the roughness curve of the wet paper web carrying surface 221 that is to be formed in the end.

[0074] The abrasive used may be abrasive particles in the form of powder or slurry; however, coated abrasive cloth or paper to which the abrasive particles have been attached is preferable.

[0075] Specifically, this step is performed by bringing a polishing device 41 fitted with an abrasive in contact with the laminated body 1 a which is installed on the 2 rolls 38, as shown in Fig. 4.

[0076] As method of using the polishing device 41, for example, the entire outer surface 221 a of the 1st resin layer

precursor 22a is polished. Further, it is preferred that the polishing in this step adjusts the thickness of the 1st resin layer precursor 22a to approximately the thickness of the 1st resin layer 22 that is to be obtained in the end. The grit of the abrasive in this step is small; therefore it is possible to efficiently adjust the thickness.

[0077] Moreover, it is possible to omit the polishing of the outer surface 221 a corresponding to the vicinity of the end parts of the 1st resin layer precursor 22a. Nevertheless, in consideration of the load from the roll edges, it is preferred to perform the machining so that the thickness at the vicinity of the end parts of the wet paper web transfer belt 1 is thinner than the thickness in other parts.

[0078] Moreover, in this step, a plurality of polishing processes using abrasives of a grit within the ranges described above may also be performed. In this case, abrasives of different grit may also be used for each polishing process.

[0079] Next, in the 2nd polishing step, the surface of the resin layer, in other words, the outer surface 221 a of the 1st resin layer precursor 22a, is polished by using an abrasive having a grit of #240 or more. Thus, by using abrasives of a grit that greatly differs from the abrasive used in the 1st polishing step, relatively flat convex portions are formed by polishing the convex portions of the relatively great unevenness on the outer surface of the 1st resin layer precursor 22a formed in the 1st polishing step. By this means, the wet paper web carrying surface 221 having relatively deep concave portions and convex portions which are relatively flat over a wide region, in other words, having the desired skewness Rsk of the roughness curve described above, is formed. By this means, the wet paper web transfer belt 1 is obtained.

[0080] The grit of the abrasive may be #240 or more, as mentioned above; however, a grit of #280 or more is preferred and a grit between #320 and #800 is even more preferred. By this means, it is possible to more reliably adjust the skewness Rsk of the roughness curve of the wet paper web carrying surface 221 that is to be formed in the end in the desired range, and, at the same time, to adjust the arithmetic average roughness Ra in the preferred range.

[0081] Moreover, the difference of the abrasive grit used in the 1st polishing step and the abrasive grit used in the 2nd polishing step is not particularly limited; however, it is preferably #180 or more and even more preferably #240 or more. By this means, it is possible to more reliably form relatively deep and narrow concave portions and relatively flat convex portions over a wide region on the outer surface 221 a (wet paper web carrying surface 221) and to more reliably adjust the skewness Rsk of the roughness curve of the wet paper web carrying surface 221 that is to be formed in the end in the desired range.

[0082] The abrasive used may be abrasive particles in the form of powder or slurry; however, coated abrasive cloth or paper to which the abrasive particles have been attached is preferable.

[0083] Specifically, this step is performed by bringing a polishing device 41 fitted with an abrasive into contact with the laminated body 1 a which is installed on the 2 rolls 38, in the same way as in the 1st polishing step.

[0084] Moreover, the places polished in this step are places corresponding to the wet paper web carrying surface 221 that is to be formed and comprise at least the parts polished in the 1st polishing step.

[0085] Moreover, in this step, a plurality of polishing processes using abrasives of a grit within the ranges described above may also be performed. In this case, abrasives of different grit may also be used for each polishing process.

[0086] Furthermore, it is preferred to perform this step after the 1st polishing step without performing other polishing or buffing operations of places corresponding to the wet paper web carrying surface 221 to be formed. In other words, it is preferred to consecutively perform the 1st and the 2nd polishing steps.

[0087] Moreover, as a modified embodiment of the method for producing a wet paper web transfer belt 1 described above, there is an embodiment in which, instead of the reinforcing fiber base material 211 described above, a reinforcing fiber base material in which batt fibers have been needled is used. By this means, the above-mentioned wet paper web transfer belt having, as roll side layer, a batt fiber layer, or the wet paper web transfer belt comprising a roll side layer in which the batt fibers have been impregnated by resin can be obtained.

[0088] Next, a method for producing the wet paper web transfer belt relating to the 2nd embodiment according to the present invention will be explained.

[0089] The method for producing the wet paper web transfer belt according to this embodiment is a method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises a step of forming a resin layer, and a step of polishing the surface of the resin layer in two stages successively using a 1st abrasive and a 2nd abrasive of a finer grit than the 1st abrasive, to form a wet paper web carrying surface for carrying a wet paper web.

[0090] The step for forming the resin layer may be performed in the same way as the resin layer forming step of the 1st embodiment described above.

[0091] In the next step, the surface of the resin layer is polished in two stages by successively using a 1st abrasive and a 2nd abrasive of a finer grit than the 1st abrasive, and a wet paper web carrying surface for carrying a wet paper web is formed. By this means, the wet paper web carrying surface is formed on the resin layer (1st resin layer) and a wet paper web transfer belt is obtained.

[0092] In the polishing step for forming a wet paper web carrying surface in the prior art, in general, 4 or more types of abrasive having different grits are used with the aim of uniformly polishing the surface, and the polishing is performed in stages according to the number of types of abrasives. In contrast, in the present embodiment, by polishing the surface of the resin layer in only two stages by intentionally using 2 types of abrasive, it is possible to increase the asymmetry

of the heights of the wet paper web carrying surface formed and to reduce the skewness Rsk of the roughness curve of the wet paper web carrying surface.

[0093] Moreover, as long as the relationship of the grits described above is satisfied, the 1st abrasive and the 2nd abrasive are not particularly limited. Nevertheless, it is preferred that the 1st abrasive and the 2nd abrasive, respectively, have a grit corresponding to the abrasive used in the 1st embodiment, described above, for the abrasive used in the 1st polishing step and the abrasive used in the 2nd polishing step. By this means, it is possible to more reliably adjust the skewness Rsk of the roughness curve of the wet paper web carrying surface that is to be formed in the end in the desired range, and, at the same time, to adjust the arithmetic average roughness Ra in the preferred range.

[0094] Moreover, the specific polishing methods in this step may be the same as the 1st polishing step and the 2nd polishing step in the 1st embodiment described above.

[0095] Next, a method for producing the wet paper web transfer belt relating to the 3rd embodiment according to the present invention will be explained.

[0096] The method for producing a wet paper web transfer belt according to the present embodiment is a method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises a resin layer forming step of forming a resin layer, a 1st polishing step of polishing the surface of said resin layer using a 1st abrasive, and a 2nd polishing step of polishing said surface using a 2nd abrasive of a finer grit than the 1st abrasive; wherein the 1st polishing step and the 2nd polishing step are performed consecutively, and the difference between the grit of the abrasive used in the 1st polishing step and the grit of the abrasive used in the 2nd polishing step is #120 or more.

[0097] The resin forming step may be performed in the same way as the resin forming step in the 1st embodiment described above.

[0098] Next, in the 1st polishing step, the surface of the above-mentioned resin layer is polished by using a 1st abrasive. The specific polishing method in this step may be the same as the 1st polishing step in the 1st embodiment described above.

[0099] The grit of the 1st abrasive used in this step is not particularly limited; however, preferably, it may be the same as the grit of the abrasive used in the 1st polishing step of the 1st embodiment.

[0100] Next, in the 2nd polishing step, the surface of the resin layer is polished by using a 2nd abrasive of a finer grit than the 1st abrasive. By this means, the wet paper web carrying surface is formed on the resin layer (1st resin layer) and a wet paper web transfer belt is obtained.

[0101] Moreover, this step, in other words the 2nd polishing step, is performed consecutively to the 1st polishing step, and the difference between the grit of the abrasive used in the 1st polishing step and the grit of the abrasive used in the 2nd polishing step is #120 or more. Thus, in contrast to conventional methods in which the grit of the abrasives is finely set in stages, in the present embodiment, the difference of the grit of the 1st abrasive and 2nd abrasive is intentionally set at a relatively large value, and by performing these polishing steps consecutively, it is possible to increase the asymmetry of the heights of the wet paper web carrying surface formed and to reduce the skewness Rsk of the roughness curve of the wet paper web carrying surface.

[0102] Moreover, the difference of the abrasive grit used in the 1st polishing step and the abrasive grit used in the 2nd polishing step may be within the range described above; however, it is preferably #180 or more and even more preferably #240 or more. By this means, it is possible to more reliably form relatively deep and narrow concave portions and relatively flat convex portions over a wide region on the outer surface and to more reliably adjust the skewness Rsk of the roughness curve of the wet paper web carrying surface that is to be formed in the end in the desired range.

[0103] The grit of the 2nd abrasive used in this step is not particularly limited; however, preferably, it may be the same as the grit of the abrasive used in the 1st polishing step of the 2nd embodiment.

[0104] Moreover, the specific polishing methods in this step may be the same as the 2nd polishing step in the 1st embodiment described above.

[0105] Next, a papermaking system according to the present invention will be explained by referring to the preferred embodiments. Fig. 5 is a schematic diagram showing one example of one part of the press part in a preferred embodiment of a papermaking system according to the present invention.

[0106] The papermaking system according to the present invention comprises a press part squeezing moisture from a wet paper web; wherein the press part is configured so that, in at least one part thereof, a wet paper web transfer belt according to the present invention is used in a closed draw so as to pass a wet paper web.

[0107] Moreover, in the present embodiment, the papermaking system 2 comprises a wire part (not shown in the drawing) forming a wet paper web by dewatering a pulp slurry, a press part 3 squeezing moisture from the wet paper web, and a dryer part 4 drying the wet paper web from which moisture has been squeezed. These parts are arranged in the order of wire part, press part 3 and dryer part 4 in the wet paper web W transfer direction (the direction of arrow B) in the order of the steps performed by these parts.

[0108] The wire part is configured to dewater the pulp slurry supplied from a head box while it is carried and transferred so as to form a wet paper web. The wet paper web formed is transferred to the press part 3. In the present embodiment, the constitution of a publicly known wire part can be used; therefore, the detailed description is omitted.

[0109] Next, the press part 3 is configured so as to squeeze moisture from the wet paper web transferred from the

wire part. In general, press parts are publicly known, and, in the present embodiment, a publicly known constitution can be used for certain parts of the press part 3; therefore, the detailed description of the publicly known parts of the constitution of press part 3 is omitted.

[0110] The press part 3 comprises a press felt (also simply referred to as felt) 5, a press felt 6, a wet paper web transfer belt 1, guide rollers 8 for guiding and rotating the press felts 5, 6 and the wet paper web transfer belt 1, and a press section 12. The press felt 5, the press felt 6 and the wet paper web transfer belt 1 are each a band-shaped body configured to form an endless shape and are supported by the guide rollers 8. The press felts 5, 6, the wet paper web transfer belt 1 and a dryer fabric 7, respectively, support and transfer the wet paper web W in the direction of the arrow B. At this juncture, the wet paper web W is passed from the press felt 5 to the press felt 6 and from the press felt 6 to the wet paper web transfer belt 1.

[0111] The wet paper web W is passed through the press section 12 in a closed draw from the press felt 6 to the wet paper web transfer belt 1.

[0112] Hereinafter the press section 12 will be described. The press section 12 is a compression means constituted by a shoe press mechanism 13 and a press roll 10 arranged in a position facing the shoe press mechanism. The shoe press mechanism 13 comprises a concave shoe 9 facing the press roll 10 and a band-shaped shoe press belt 11 surrounding the shoe 9. Together with the press roll 10, the shoe 9 constitutes the press section 12 via the shoe press belt 11. In the press section 12, the wet paper web W is pressed by the shoe 9 via the shoe press belt 11 and the press roll 10 while being sandwiched between the press felt 6 and the wet paper web transfer belt 1. As a result thereof, moisture is squeezed from the wet paper web W. The press felt 6 is configured to have high water permeability, and the wet paper web transfer belt 1 is configured to have low water permeability. Therefore, in the press section 12, the moisture in the wet paper web W moves to the press felt 6. In this way, in the press part 3, water is squeezed from the wet paper web W and the surface of the wet paper web is smoothed.

[0113] Immediately after exiting the press section 12, the wet paper web W, the press felt 6, and the wet paper web transfer belt 1 swell in volume because they are suddenly released from pressure. Due to this swelling and because of the capillary action of the pulp fibers constituting the wet paper web W, the so-called "rewetting phenomenon" occurs in which part of the moisture in the press felt 6 moves to the wet paper web W. Nevertheless, since the water permeability of the wet paper web transfer belt 1 is low, the amount of moisture held inside it is small. Therefore, there is hardly any rewetting due to moisture moving from the wet paper web transfer belt 1 to the wet paper web W, and the wet paper web transfer belt 1 contributes to improving the smoothness of the wet paper web W.

[0114] For passing the wet paper web W in the press section 12 in such a manner, it is required of the wet paper web transfer belt 1 that, immediately after exiting the press section 12, the wet paper web W is released from the press felt 6 and positively adheres to the wet paper web carrying surface 221 of the wet paper web transfer belt 1. In general, it is in such places that the "paper robbing" phenomenon tends to occur. The "paper robbing" described here indicates a phenomenon, in case a common wet paper web transfer belt is used, in which the adhesive force of the wet paper web carrying surface is weak and the wet paper web passing the press section remains on the press felt without being moved from the press felt to the wet paper web transfer belt. Nevertheless, in the wet paper web transfer belt 1, which has a suitable degree of adhesiveness of the wet paper web carrying surface 221 with the wet paper web W, as described above, the paper robbing phenomenon by the press felt 6 is prevented because it has excellent wet paper web transfer properties.

[0115] Moreover, the wet paper web W, having passed the press section 12, is carried and transferred by the wet paper web transfer belt 1 and is passed in a closed draw from the wet paper web transfer belt 1 to the dryer fabric 7 of the dryer part 4. The suction roll 14 of the dryer part 4, provided to support the dryer fabric 7, releases the wet paper web W adhering to the wet paper web transfer belt 1 by suction and causes it to adhere to the surface of the dryer fabric 7. The wet paper web transfer belt 1 has suitable properties for releasing the wet paper web W from the wet paper web carrying surface 221; therefore, in this case too, the "paper robbing" phenomenon is prevented when the wet paper web is passed.

[0116] The dryer part 4 is configured to dry the wet paper web W. In the present embodiment, a publicly known constitution can be used as dryer part 4; therefore, the detailed description is omitted. The wet paper web W is dried and becomes base paper by passing through the dryer part 4.

[0117] Thus, according to the papermaking system of the present invention, by using a wet paper web transfer belt with excellent wet paper web transfer properties, it is possible to suppress the paper robbing phenomenon and to improve production stability.

[0118] Next, a papermaking method according to the present invention will be described by referring to a preferred embodiment.

[0119] The papermaking method according to the present invention comprises a step of squeezing moisture from a wet paper web formed by dewatering a pulp slurry; in this step, the wet paper web is passed in a closed draw by using a wet paper web transfer belt according to the present invention.

[0120] Moreover, the papermaking method according to the present embodiment comprises a step of forming a wet

paper web by dewatering a pulp slurry (dewatering step), a step of squeezing moisture from the wet paper web (moisture squeezing step), and a step of drying the wet paper web (drying step).

[0121] Further, the dewatering step and the drying step can each be performed by a publicly known method; therefore, the detailed description will be omitted. For example, the dewatering step and the drying step can be performed by using the above-mentioned wire part and dryer part 4, respectively.

[0122] In the water squeezing step, water is further squeezed from the wet paper web obtained in the dewatering step.

[0123] In the present embodiment, in the water squeezing step, the wet paper web is passed in a closed draw by using the above-described wet paper web transfer belt according to the present invention. By using a wet paper web transfer belt according to the present invention having excellent wet paper web transfer properties, the paper robbing phenomena are prevented.

[0124] In particular, it is preferred to move the wet paper web in a closed draw from a felt to the wet paper web transfer belt. In this case, problems such as the above-mentioned paper robbing phenomenon are more reliably prevented.

[0125] Moreover, the moisture squeezing step may be performed by using the press part 3 described above.

[0126] Thus, according to the papermaking method of the present invention, by using a wet paper web transfer belt with excellent wet paper web transfer properties, it is possible to suppress the paper robbing phenomenon and to improve production stability.

[0127] Above, the present invention has been described in detail based on preferred embodiments; however, the present invention is not limited by this. Each constitution may be substituted as desired, or a constitution may be added as desired, as long as a similar function can be obtained.

EXAMPLES

[0128] Hereinafter, the present invention will be described even more specifically by means of the Examples; however, the present application is not limited to these Examples.

1. Production of the Wet Paper Web Transfer Belt

[0129] The wet paper web transfer belts of Examples 1 to 9 and Comparative Examples 1 to 3 were produced according to the method hereinafter.

(1) Resin Layer Forming Step

[0130] Firstly, the reinforcing fiber base material of the constitution hereinafter was prepared.

[0131] The Reinforcing Fiber Base Material

Upper warp yarn: twisted monofilament of 2000 dtex made from nylon 6
Lower warp yarn: twisted monofilament of 2000 dtex made from nylon 6
Weft yarn: twisted monofilament of 1400 dtex made from nylon 6
Weave: double warp weave of 40 upper/lower warp yarns/5 cm and 40 weft yarns/5 cm

[0132] The reinforcing fiber base material was made by entangling and integrating batt fibers of 20 dtex made from nylon 6 with the woven fabric of the above constitution by needling 200 g/m^2 of the batt fibers to the roll side of the woven fabric.

[0133] Next, as shown in Fig. 3(a), the reinforcing fiber base material was installed on 2 rolls so that the batt fiber side is disposed at the inner side.

[0134] Next, as shown in Fig. 3(b), urethane resin was coated so as to form a resin layer of 1.1 to 1.2 mm thickness from the surface of the reinforcing fiber base material by impregnating so that the liquid urethane resin penetrated the fabric of the reinforcing fiber base material from its wet paper web carrying surface side.

[0135] Next, the coated resin was cured and the semi-finished product of a wet paper web transfer belt was obtained, wherein a reinforcing fiber base material layer in which the reinforcing fiber base material is impregnated by urethane resin, a 1st resin layer precursor formed at the outer circumference of the reinforcing fiber base material layer, and a 2nd resin layer formed at the inner circumference of the reinforcing fiber base material layer are laminated.

(2) Polishing Step

[0136] The outer circumferential surface of the obtained semi-finished product of the 1st resin layer precursor was polished as shown in Fig. 4.

[0137] As polishing, rough grinding (1st polishing step), adjusting the thickness of the resin layer precursor to about

1.0 mm by using a relatively coarse abrasive, and finishing (2nd polishing step), adjusting the roughness of the wet paper web carrying surface to be formed in the end, were performed.

[0138] In the rough grinding (1st polishing step) and the finishing (2nd polishing step) of the Examples and Comparative Examples, coated abrasives of the grits given in Table 1 were used as abrasive. Moreover, in Examples 1 to 9 and Comparative Examples 2, 3, polishing was performed in two stages by using two types of coated abrasives. In Comparative Example 1, on the other hand, polishing was performed in four stages by using four types of coated abrasives.

[0139] By going through the above polishing steps, a wet paper web carrying surface having a predetermined skewness of the roughness curve and arithmetic average roughness was formed and a wet paper web transfer belt with a 1st resin layer having said wet paper web carrying surface was obtained. The production conditions of the wet paper web transfer belts obtained in the Examples and Comparative Examples are shown in Table 1 together with the skewness of the roughness curve and the arithmetic average roughness. Moreover, the values for the skewness or the roughness curve and the arithmetic average roughness were obtained by measuring in the width direction, in other words perpendicular to the polishing marks, by using a Surftest SJ-210 (manufactured by Mitutoyo Corporation).

Table 1

	Grit of the coated abrasives		State of the wet paper web carrying surface	
	Rough grinding (1st polishing step)	Finishing (2nd polishing step	Rsk	Ra (μm)
Example 1	#120	#400	-0.6	2.1
Example 2	#80	#320	-0.6	6.5
Example 3	#60	#240	-0.6	11.5
Example 4	#100	#600	-1.6	2.1
Example 5	#80	#400	-1.6	6.5
Example 6	#60	#320	-1.6	11.5
Example 7	#100	#800	-2.5	2.1
Example 8	#80	#600	-2.5	6.5
Example 9	#60	#400	-2.5	11.5
Comparative Example 1	#100	#180	-0.35	2.1
	#120	#240		
Comparative Example 2	#120	#180	-0.35	6.5
Comparative Example 3	#100	#100	-0.35	11.5

2. Evaluation of the Transfer

[0140] The evaluation device of wet paper web transfer belts shown in Fig. 6 was used to evaluate the adhesive and release properties between wet paper web W and the wet paper web transfer belt after the wet paper web W had passed the press nip 12 under the conditions hereinafter. Further, the evaluation device shown in Fig. 6 is identical to the device in Fig. 5, except that the constitution upstream of the press felt 6 has been omitted from the constitution of the press part 3. Moreover, the pressing conditions, the constitution of the press felt 6 and the constitution of the wet paper web were as described hereinafter.

[0141] The Pressing Conditions

Papermaking speed: 1200 m/min
Pressing pressure: 1050 kN/m

[0142] The Constitution of the Press Felt 6

[0143] In the press felt 6 used, an intermediate layer batt fiber layer (outer circumferential side) and a rear layer batt

fiber layer (inner circumferential side) were formed by needling batt fibers to both sides of a base fabric, and a front layer batt fiber layer was formed by needling batt fibers to the outer circumferential side of the intermediate layer batt fiber layer. Moreover, the constitution and the conditions for forming the batt fiber layers were as described hereinafter. Furthermore, felts with three types of front layer batt fibers of different fineness were provided as press felt 6. The fineness of the front layer batt fibers of the press felts were 3.3 dtex, 6.6 dtex and 11 dtex, respectively.

[0144] Base fabric: laminated base fabric

Upper Fabric Base Fabric
Warp yarn: monofilament of 1400 dtex made from nylon 6
Weft yarn: monofilament of 500 dtex made from nylon 6
Weave: 1/1 plain weave of 50 warp yarns/5 cm and 40 weft yarns/5 cm
Lower Fabric Base Fabric
Warp yarn: twisted monofilament of 2000 dtex made from nylon 6
Weft yarn: twisted monofilament of 1400 dtex made from nylon 6
Weave: 3/1 broken weave of 40 warp yarns/5 cm and 40 weft yarns/5 cm

[0145] Batt Fibers Needled to the Base Fabric

Front layer batt fiber: 200 g/m^2 batt fiber made from nylon 6
Center layer batt fiber: 300 g/m^2 batt fiber of 20 dtex made from nylon 6
Rear layer batt fiber: 100 g/m^2 batt fiber of 20 dtex made from nylon 6

[0146] Moreover, in the evaluation, the moisture content of the felt 6 was set by using a shower and a suction box (not shown in the drawing).

Felt moisture: felt moisture weight / (felt moisture weight + felt weight per unit area) = adjusted to 30 %
Wet Paper Web (Handsheet)
Pulp: LBKP 100% csf 450 mL
Basis weight: 60 g/m^2
Wet paper web moisture before pressing: wet paper web moisture weight before pressing / (wet paper web moisture weight before pressing + wet paper web bone dry weight) = adjusted to 60% (moisture control by sandwiching with filter paper)
Wet paper size: 200 mm length by 200 mm width

[0147] Under the above conditions, the adhesive property of the wet paper web transfer belts was evaluated by judging whether or not the wet paper web W adhered to the wet paper web transfer belt after the wet paper web W had passed the press nip 12. Moreover, the adhesive property of the wet paper transfer belts was evaluated by using press felts 6 with a front layer batt fiber of different fineness according to the criteria for evaluation hereinafter. Furthermore, the evaluation of the adhesive property of the wet paper web transfer belts was performed immediately after installing the wet paper web transfer belt and after the evaluation device had been operated for three days while water was being supplied.

A: The wet paper web W adhered to the wet paper web transfer belt in the case of all front layer batt fibers of different fineness.
B: The wet paper web W adhered to the wet paper web transfer belt in the case of front layer batt fibers of 6.6 dtex and 11 dtex, while it did not adhere to the wet paper web transfer belt with front layer batt fibers of 3.3 dtex.
C: The wet paper web W adhered to the wet paper web transfer belt in the case of front layer batt fibers of 11 dtex, while it did not adhere to the wet paper web transfer belt with front layer batt fibers of 3.3 dtex and 6.6 dtex.
D: The wet paper web W did not adhere to the wet paper web transfer belt in the case of each of the front layer batt fibers of different fineness.

[0148] Moreover, the wet paper web transfer belts with the evaluation A to C above can be considered to have excellent adhesive property.

[0149] The release property of the wet paper web transfer belts was evaluated by judging whether or not the wet paper web W carried by the wet paper web transfer belt moved to the dryer fabric 7. Moreover, the evaluation was performed by confirming whether or not the wet paper web W had moved to the dryer fabric 7 while the degree of vacuum in the suction roll 14 was changed to -20 kPa, -30 kPa, -40 kPa, respectively. Furthermore, the evaluation of the release property of the wet paper web transfer belts was performed immediately after installing the wet paper web transfer belt

and after the evaluation device had been operated for three days while water was being supplied.

A: The wet paper web W moved to the dryer fabric in the case of every degree of vacuum in the suction roll 14.
B: The wet paper web W moved to the dryer fabric in the case of -30 kPa, -40 kPa vacuum in the suction roll 14, while it did not move to the dryer fabric in the case of -20 kPa vacuum in the suction roll 14.
C: The wet paper web W moved to the dryer fabric in the case of -40 kPa vacuum in the suction roll 14, while it did not move to the dryer fabric in the case of -20 kPa, -30 kPa vacuum in the suction roll 14.
D: The wet paper web W did not move to the dryer fabric in the case of each of the degrees of vacuum in the suction roll 14.

[0150] Moreover, the wet paper web transfer belts with the evaluation A to C above can be considered to have excellent release property.

[0151] The results of the evaluations above are shown in Table 2.

Table 2

	The state of the wet paper web carrying surface		Evaluation of the wet paper web transfer properties			
			Immediately after installation		After 3 days of operation	
	Rsk	Ra (μm)	adhesive	release	adhesive	release
Example 1	-0.6	2.1	C	C	B	C
Example 2	-0.6	6.5	C	A	C	B
Example 3	-0.6	11.5	C	A	C	A
Example 4	-1.6	2.1	B	C	B	C
Example 5	-1.6	6.5	B	A	B	A
Example 6	-1.6	11.5	C	A	C	A
Example 7	-2.5	2.1	A	C	A	C
Example 8	-2.5	6.5	A	A	A	A
Example 9	-2.5	11.5	A	A	A	A
Comparative Example 1	-0.35	2.1	D	C	C	D
Comparative Example 2	-0.35	6.5	D	A	D	C
Comparative Example 3	-0.35	11.5	D	A	D	B

[0152] As shown in Table 2, the wet paper transfer belts relating to Example 1 to 9 have excellent adhesive and release properties both immediately after installation and after three days of operation. Moreover, the release property of the wet paper web transfer belts relating to Examples 1 to 9 are better after three days of operation than immediately after installation of the wet paper web transfer belt.

[0153] On the other hand, the wet paper web transfer belts relating to Comparative Examples 1 to 3 did not have sufficient adhesive and release properties. In particular, compared to immediately after installation, the release property had deteriorated after three days of operation.

[0154] Thus, the wet paper web transfer belts relating to Examples 1 to 9 had excellent wet paper web transfer properties, wherein the adhesive and release properties were excellent at the same time and the paper robbing phenomenon of the wet paper web was prevented in the press part.

DESCRIPTION OF THE REFERENCE CHARACTERS

[0155] 1: Wet paper web transfer belt, 1 a: Laminated body, 2: Papermaking system, 3: Press part, 4: Dryer part, 5,6: Press felt (felt), 7: Dryer fabric, 8: Guide rollers, 9: Shoe, 10: Press roll, 11: Shoe press belt, 12: Press section, 13: Shoe

press mechanism, 14: Suction roll, 21: Reinforcing fiber base material layer, 211: Reinforcing fiber base material, 212: Resin, 22: 1st Resin layer, 22a: 1st Resin layer precursor, 221: Wet paper web carrying surface , 222: Convex portions, 223: Concave portions, 23: 2nd Resin layer, 231: Roll contacting surface, 38: rolls, 39: Coater bar, 40: Resin discharge opening, 41: Polishing device, W: Wet paper web.

Claims

1. A wet paper web transfer belt for transferring a wet paper web; wherein it comprises a wet paper web carrying surface carrying a wet paper web, which is made of a resin layer, and wherein the skewness Rsk of the roughness curve of the wet paper web carrying surface is -0.5 or less.

2. The wet paper web transfer belt according to claim 1; wherein Rsk is between -2.7 and -0.5.

3. The wet paper web transfer belt according to claim 1 or 2; wherein the arithmetic average roughness Ra of the wet paper web carrying surface is between 2.0 and 12.0 μm.

4. A papermaking system comprising a press part squeezing moisture from a wet paper web; wherein the press part is configured so that, in at least one part thereof, a wet paper web transfer belt according to any one of claims 1 to 3 is used in a closed draw so as to pass a wet paper web.

5. The papermaking system according to claim 4; wherein the press part is configured so that, in at least one part thereof, the wet paper web is passed in a closed draw between a wet paper web transfer belt and felt.

6. A papermaking method comprising a step of squeezing moisture from a wet paper web which is formed by dewatering a pulp slurry; wherein a wet paper web transfer belt according to any one of claims 1 to 3 is used in said step for passing a wet paper web in a closed draw.

7. The papermaking method according to claim 6; wherein, in the step of squeezing moisture, the wet paper web is passed in a closed draw between a wet paper web transfer belt and felt.

8. A method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises
a step of forming a resin layer, and
a step of polishing the surface of the resin layer in two stages successively using a 1st abrasive and a 2nd abrasive of a finer grit than the 1st abrasive, to form a wet paper web carrying surface for carrying a wet paper web.

9. A method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises
a resin layer forming step of forming a resin layer,
a 1st polishing step of polishing the surface of said resin layer using an abrasive having a grit of #120 or less, and
a 2nd polishing step of polishing said surface using an abrasive having a grit of #240 or more.

10. The method for producing a wet paper web transfer belt according to claim 9; wherein the 1st polishing step and the 2nd polishing step are performed consecutively.

11. A method for producing a wet paper web transfer belt for transferring a wet paper web; wherein it comprises
a resin layer forming step of forming a resin layer,
a 1st polishing step of polishing the surface of said resin layer using a 1st abrasive, and
a 2nd polishing step of polishing said surface using a 2nd abrasive of a finer grit than the 1st abrasive; wherein the 1st polishing step and the 2nd polishing step are performed consecutively, and
the difference between the grit of the abrasive used in the 1st polishing step and the grit of the abrasive used in the 2nd polishing step is #120 or more.

12. A wet paper web transfer belt produced by a method for producing a wet paper web transfer belt according to any one of claims 8 to 11.

Fig. 1

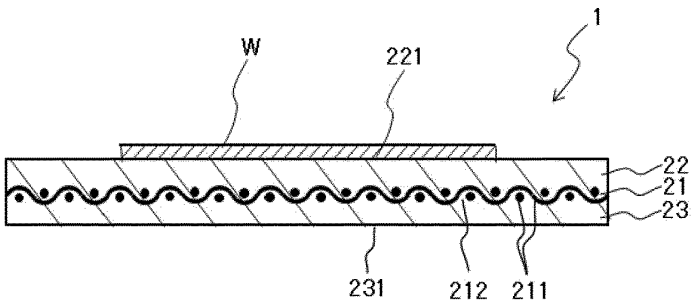


Fig. 2

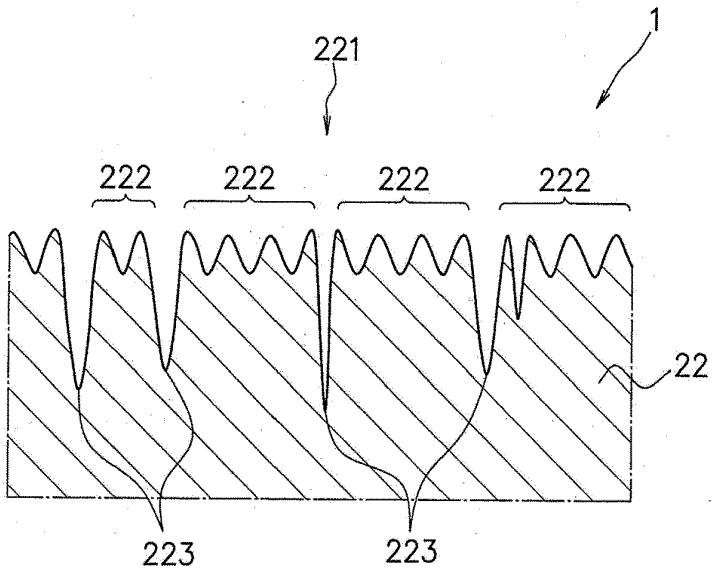


Fig. 3

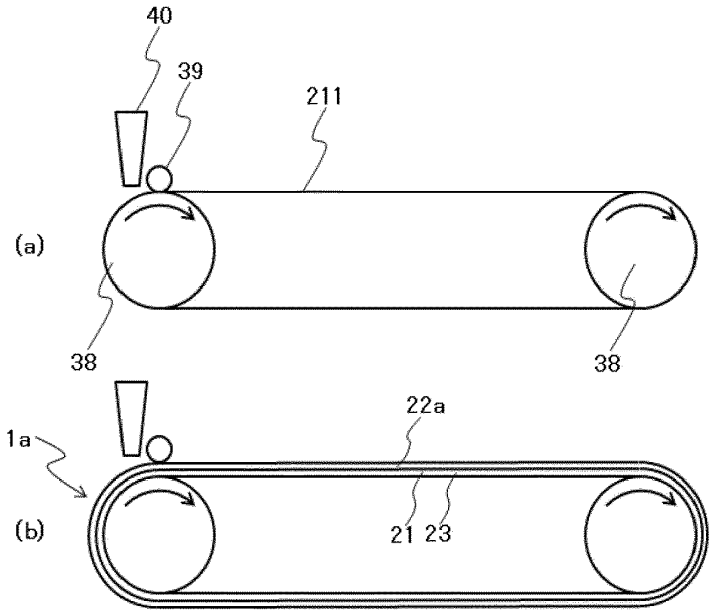


Fig. 4

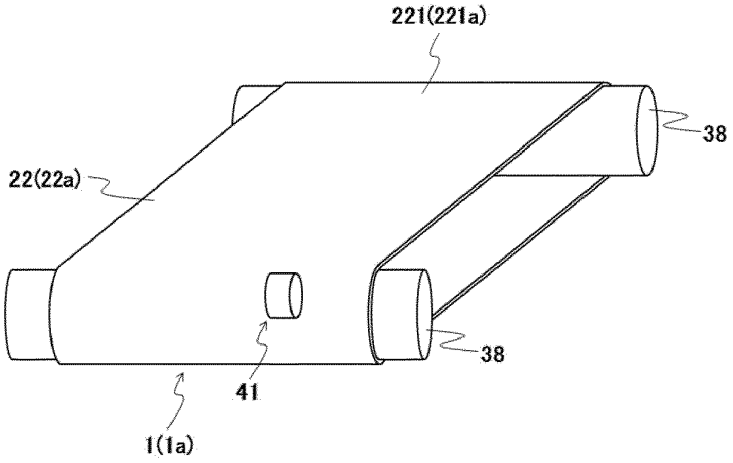


Fig. 5

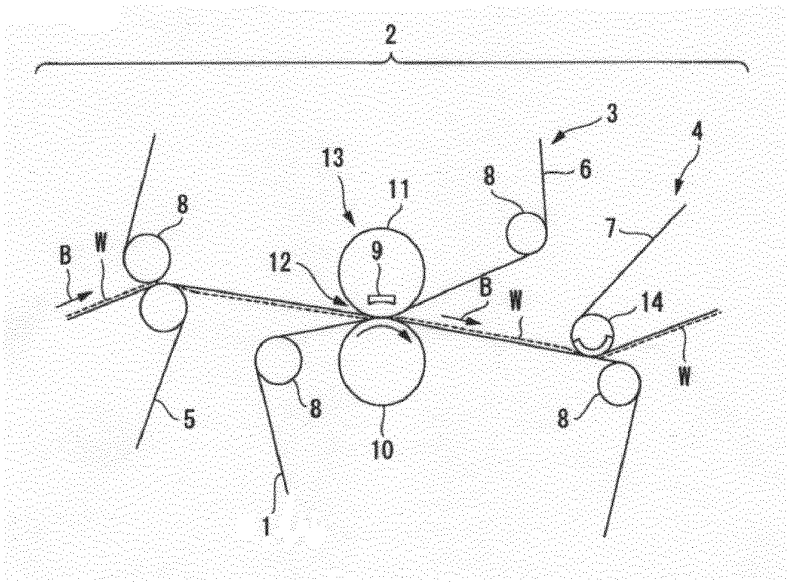

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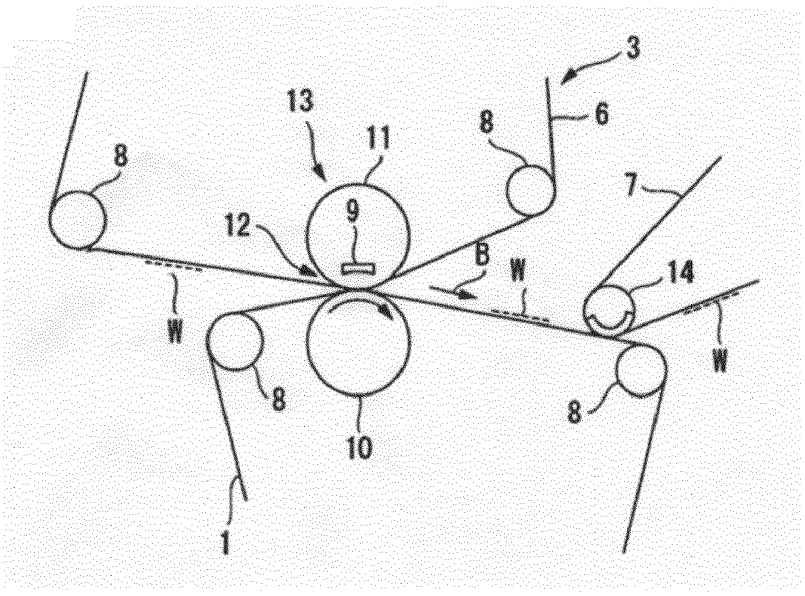
Fig. 6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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 3880

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X	EP 1 703 016 A1 (ICHIKAWA CO LTD [JP]) 20 September 2006 (2006-09-20) * paragraphs [0039], [0047], [0052], [0053], [0055] - [0058] *	1-12	INV. D21F7/08
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A	EP 2 711 458 A1 (ICHIKAWA CO LTD [JP]) 26 March 2014 (2014-03-26) * abstract *	1-12	

TECHNICAL FIELDS SEARCHED (IPC)

D21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 November 2015	Pregetter, Mario

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(19) Europäisches Patentamt
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(71) Applicant: **ICHIKAWA CO.,LTD.**
Tokyo (JP)

(72) Inventors:
- **Inoue, Kenji**
  Tokyo, (JP)
- **Umehara, Ryo**
  Tokyo, (JP)
- **Tamura, Ai**
  Tokyo, (JP)
- **Sugawara, Yuta**
  Tokyo, (JP)

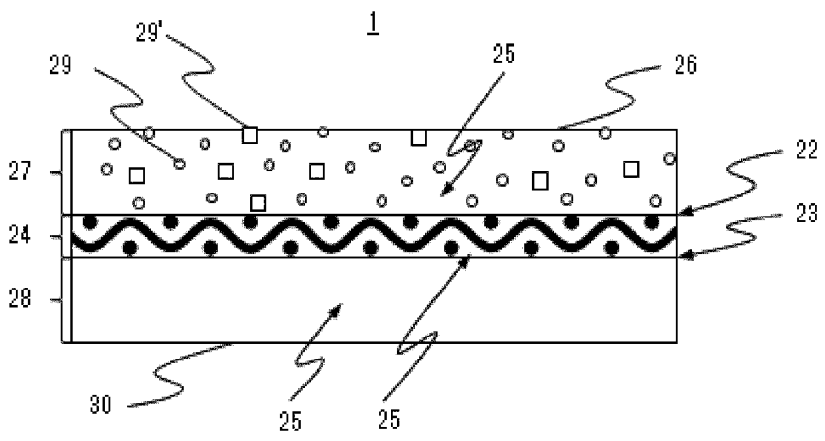
(74) Representative: **Gassner, Wolfgang et al**
Dr. Gassner & Partner mbB
Patentanwälte
Marie-Curie-Strasse 1
91052 Erlangen (DE)

(54) Wet paper web transfer belt

(57) The object of the present invention is to provide a wet paper web transfer belt wherein the adhesive properties and releasing properties of the wet paper web with the wet paper web contacting surface of conventional wet paper web transfer belts have been further improved and paper robbing and floating edges do not occur.

This is achieved by a wet paper web transfer belt (1) in which a polyurethane (25) is integrated with a reinforcing base material (24) comprising a wet paper web-side surface (22) and a machine-side surface (23), at least the wet paper web-side surface of the reinforcing base material is embedded in the polyurethane, an outer circumferential layer (27) comprising a wet paper web contacting surface (26) is constituted by some of the polyurethane; wherein at least the outer circumferential layer comprises two different types of fillers including a high-roundness filler (29) with a relatively high roundness and a low-roundness filler (29') with a relatively low roundness.

Fig. 1



EP 2 902 545 A1

Description

Technical Field

[0001] The present invention relates to a wet paper web transfer belt (also referred to as transfer belt) used in papermaking machines.

Description of the Related Art

[0002] A papermaking machine for removing moisture from the source material of paper generally comprises a wire part, a press part and a dryer part. The wire part, the press part and the dryer part are arranged along the transfer direction of a wet paper web.

[0003] In one type of papermaking machine, the wet paper web is passed from one part to another in an open-draw. In the press part of this open-draw papermaking machine, there are a number of places in which the wet paper web is not supported by any roll or by papermaking equipment such as a felt or a belt; in other words, places in which the wet paper web is travelling on its own. In these places, problems such as "web breaks" tend to occur. The risk of this problem occurring increases as the papermaking machine is operated at high speed; therefore, there are limitations to operating an open-draw papermaking machine at high speed.

[0004] In recent years, most papermaking machines have therefore come to be of the type in which the wet paper web is passed in a closed-draw. In the press part of this closed-draw papermaking machine, the wet paper web is transferred while being placed on a papermaking felt or a wet paper web transfer belt; therefore, there are no places in which the wet paper web travels on its own as in an open-draw papermaking machine. As a result, it has become possible to operate papermaking machines at still higher speed and to stabilize operations.

[0005] Hereinafter an example of the press part of a closed-draw papermaking machine will be explained in detail.

[0006] Fig. 7 is a schematic diagram of a closed-draw papermaking machine in which a wet paper web transfer belt according to the present invention is used. As shown in Fig. 7, a closed-draw papermaking machine 2 for removing moisture from a source material of paper comprises a wire part (not shown in the figure), a press part 3 and a dryer part 4. The wire part, the press part 3 and the dryer part 4 are arranged in the order of the processes they perform along the transfer direction of a wet paper web W (the direction indicated by arrow B).

[0007] The wet paper web W is transferred by being passed from the wire part to the press part 3 and from there to the dryer part 4. After dewatering the wet paper web in the press part 3, it is finally dried in the dryer part 4. A wet paper web transfer belt 1 is arranged in the press part 3 of the papermaking machine 2 for transferring the wet paper web W in the direction of arrow B.

[0008] The wet paper web W is transferred in the direction of arrow B while being supported by press felts 5, 6, the wet paper web transfer belt 1 and a dryer fabric 7, respectively. The press felts 5, 6, the wet paper web transfer belt 1 and the dryer fabric 7 are respectively endless belts supported by guide rollers 8.

[0009] In a typical closed-draw papermaking machine, a shoe press mechanism 13 is arranged in a position facing press roll 10. The shoe press mechanism 13 comprises a concave press shoe 9 facing the press roll 10; via a shoe press belt 11, the shoe 9 constitutes a press section 12 together with the press roll 10.

[0010] The wet paper web W is passed from the wire part (not shown in the figure) to the press part 3; thereafter, it is passed from the press felt 5 to the press felt 6. Then, the wet paper web W is transferred by the press felt 6 to the press section 12 of the shoe press mechanism 13. In the press section 12, the wet paper web W is compressed by the shoe 9 via the shoe press belt 11 and by the press roll 10 while being sandwiched by the press felt 6 and the wet paper web transfer belt 1. As a result thereof, the moisture in the wet paper web W is dewatered. Compared to the wet paper web transfer belt 1, the press felt 6 is configured to have high water permeability; therefore, in the press section 12, the moisture from the wet paper web W moves to press felt 6. In the press part 3, the wet paper web W is thus dewatered and its surface is smoothened.

[0011] Immediately after exiting the press section 12, the wet paper web W, the press felt 6 and the wet paper web transfer belt 1 swell in volume because they are suddenly released from pressure. Due to this swelling and because of the capillary action of the pulp fibers constituting the wet paper web W, the so-called "rewetting phenomenon" occurs in which part of the moisture in the press felt 6 moves to the wet paper web W. Nevertheless, since the water permeability of the wet paper web transfer belt 1 is low, the amount of moisture held inside it is small. Consequently, there is almost no rewetting phenomenon in which moisture moves from the wet paper web transfer belt 1 to the wet paper web W, and the wet paper web transfer belt 1 contributes to improving the dewatering of the wet paper web W.

[0012] Having passed through the press section 12, the wet paper web W is transferred by the wet paper web transfer belt 1 in the direction indicated by arrow B. Then, the wet paper web W is sucked up by a suction roll 14 and transferred by the dryer fabric 7 to the dryer part 4, where it is dried.

[0013] Here, the adhesive and releasing properties of the wet paper web contacting surface in relation to the wet paper

web are among important functions required by the wet paper web transfer belt. In other words, the wet paper web transfer belt 1 requires that the wet paper web W positively adheres to the wet paper web contacting surface of the wet paper web transfer belt 1 immediately after it exits from the press section 12, while allowing the wet paper web W to smoothly release (detach) from the wet paper web transfer belt 1 when it is passed to the dryer fabric. In case these requirements are not fulfilled, the phenomenon of paper robbing and floating edges (damp edges) can occur.

[0014] The phenomenon called paper robbing occurs, for example, when the adhesive force of the wet paper web contacting surface of the wet paper web transfer belt 1 is weak and the wet paper web W having passed through the press section 12 remains on the press felt 6 instead of being passed from the press felt 6 to the wet paper web transfer belt 1, or when the adhesive force of the wet paper web contacting surface of the wet paper web transfer belt 1 is strong and the wet paper web W remains on the wet paper web transfer belt 1 instead of being passed to the dryer fabric 7. The phenomenon called floating edges occurs when the end parts (edges) of the wet paper web detach from the wet paper web transfer belt 1 or the press felt 6 and become to float.

[0015] When paper robbing occurs, operations need to be interrupted and the setting of the device needs to be modified so that the wet paper web is appropriately transferred. Further, when the floating edges phenomenon occurs, it is possible that quality problems occur such as wrinkles in the wet paper web; moreover, the problem of a break in the wet paper web (sheet break) or operational problems may occur such as the need to reduce the operating speed of the papermaking machine so as to avoid a break in the wet paper web (or the occurrence of floating edges).

[0016] Further, another important function of the wet paper web transfer belt is the wear resistance of the wet paper web contacting surface and the machine contacting surface of the wet paper web transfer belt. In other words, it becomes possible to use the wet paper web transfer belt over an extended period of time by improving the wear resistance of the wet paper web contacting surface and the machine contacting surface of the wet paper web transfer belt 1.

[0017] Various wet paper web transfer belts have been proposed in the prior art to fulfill the above functions.

[0018] For example, JP 06-057678 A discloses a wet paper web transfer belt in which a wet paper web contacting surface formed on the upper surface of a base (wet paper web side) is formed by an impermeable polymer coating layer and a lower surface of the base (roll side) is formed by a fibrous web. Particles with a higher hardness than the polymer coating are mixed in the impermeable polymer coating layer and the particles are made to protrude from the surface by such means as polishing the wet paper web contacting surface. Furthermore, US 6962885, JP 2007-530800 and WO 2013/020745 similarly propose belts in which various fillers have been added to the resin layer.

[0019] The hydrophilic properties and the surface roughness of the wet paper web transfer belt surface are two major factors influencing the wet paper web adhesive properties of the wet paper web transfer belt. Adding a filler, as in the wet paper web transfer belts mentioned in the above-cited prior art, is an effective means for adjusting the hydrophilic properties and the surface roughness of the wet paper web transfer belt surface. However, further improvement has been desired in view of prevention of paper robbing and floating edges.

[Prior Art Documents]

[0020]

Patent Document 1: JP 06-057678
Patent Document 2: US 6962885
Patent Document 3: JP 2007-530800
Patent Document 4: WO 2013/020745

SUMMARY OF THE INVENTION

Problems to be solved by the Invention

[0021] The object of the present invention is to provide a wet paper web transfer belt, wherein the adhesive properties and the releasing properties of the wet paper web contacting surface with the wet paper web are improved and paper robbing and floating edges do not occur.

Means for solving the Problems

[0022] The present invention, in order to solve the above problems, has employed the technology described below in a wet paper web transfer belt, wherein a reinforcing base material comprising a wet paper web-side surface and a machine-side surface and a water-impermeable resin are integrated with each other, and wherein at least the wet paper web-side surface of the reinforcing base material is embedded in the water-impermeable resin, and an outer circumferential layer comprising a wet paper web contacting surface is constituted by some of the water-impermeable resin.

(1) A wet paper web transfer belt in which a reinforcing base material comprising a wet paper web-side surface and a machine-side surface and a thermosetting polyurethane are integrated with each other, at least the wet paper web-side surface of the reinforcing base material is embedded in the polyurethane, an outer circumferential layer comprising a wet paper web contacting surface is constituted by some of the polyurethane; wherein, at least the outer circumferential layer comprises two different types of fillers including a high-roundness filler with a relatively high roundness and a low-roundness filler with a relatively low roundness, the difference between the high-roundness filler and the low-roundness filler is 0.1 or more.

(2) A wet paper web transfer belt according to (1); wherein the roundness of the high-roundness filler is 0.6 or more and the roundness of the low-roundness filler is less than 0.6.

(3) A wet paper web transfer belt according to (1); wherein the roundness of the high-roundness filler is 0.7 or more and the roundness of the low-roundness filler is less than 0.7.

(4) A wet paper web transfer belt according to (1); wherein the roundness of the high-roundness filler is 0.8 or more and the roundness of the low-roundness filler is less than 0.8.

(5) A wet paper web transfer belt according to (1) to (4); wherein the specific surface area of the high-roundness filler is 10 m^2/g or less.

(6) A wet paper web transfer belt according to (1) to (5); wherein the specific surface area of the low-roundness filler is 12 m^2/g or more.

(7) A wet paper web transfer belt according to (1) to (6); wherein the low-roundness filler comprises one or more filler(s) selected from inorganic fillers.

(8) A wet paper web transfer belt according to (1) to (7); wherein the low-roundness filler comprises one or more filler(s) selected from inorganic fillers or carbon-based fillers.

(9) A wet paper web transfer belt according to (1) to (8); wherein the two different fillers are only comprised in the outer circumferential layer.

(10) A wet paper web transfer belt according to (1) to (9); wherein the content of the high-roundness filler is from 5 wt% or more to 55 wt% or less in relation to the total weight of the outer circumferential layer (the total weight of the polyurethane, the filler(s) and other additives), and the content of the low-roundness filler is from 5 wt% or more to 55 wt% or less in relation to the total weight of the outer circumferential layer (the total weight of the polyurethane, the filler(s) and other additives).

(11) A wet paper web transfer belt according to (1) to (10); wherein the total content of the two different fillers is from 10 wt% or more to 60 wt% or less in relation to the total weight of the outer circumferential layer (the total weight of the polyurethane, the fillers and other additives).

(12) A wet paper web transfer belt according to (1) to (11); wherein the low-roundness filler is one or more types of filler selected from amorphous particulate fillers, needle-like fillers, fibrous fillers, plate-like fillers.

(13) A wet paper web transfer belt according to (1) to (12); wherein the average particle diameter of the high-roundness filler is 1.0 to 100 μm.

(14) A wet paper web transfer belt according to (1) to (13); wherein the average particle diameter of the low-roundness filler is 1.0 to 100 μm.

(15) A wet paper web transfer belt according to (1) to (14); wherein the reinforcing base material is a composite reinforcing base material in which short fibers have been intertwiningly integrated by needle punching with at least the machine-side surface of the reinforcing base material.

(16) A wet paper web transfer belt according to (15); wherein an inner circumferential layer comprising a machine contacting surface is constituted by some of the short fibers integrated with the machine-side surface.

(17) A wet paper web transfer belt according to (1) to (15); wherein an inner circumferential layer comprising a machine contacting surface is constituted by some of the polyurethane.

[0023] By adopting the above-described constitution, the present invention can provide a wet paper web transfer belt wherein the adhesive properties and releasing properties of the wet paper web with the wet paper web contacting surface of conventional wet paper web transfer belts have been further improved, and paper robbing and floating edges do not occur.

Brief Description of the Drawings

[0024]

Fig 1 is a sectional view showing a wet paper web transfer belt according to the present invention.
Fig 2 is a sectional view showing another embodiment of a wet paper web transfer belt according to the present invention.
Fig 3 is a sectional view showing another embodiment of a wet paper web transfer belt according to the present invention.
Fig 4 is a sectional view showing another embodiment of a wet paper web transfer belt according to the present invention.
Fig 5 is a sectional view showing another embodiment of a wet paper web transfer belt according to the present invention.
Fig. 6 are schematic diagrams showing a method for impregnating and layering a wet paper web transfer belt according to the present invention with polyurethane.
Fig. 7 is a schematic diagram showing an example of the press part of a papermaking machine.
Fig. 8 is a schematic diagram relating to a wet paper web transfer test device.

Best Modes for Carrying out the Invention

[0025] Hereinafter, the embodiments of the present invention will be explained in detail while referring to the drawings. The present invention is a wet paper web transfer belt 1 used in the press part of the papermaking machine shown in Fig. 7. The wet paper web transfer belt 1 is an endless belt supported by guide rollers 8.

[0026] Fig. 1 is a sectional view in the width direction (in the Cross Machine Direction: CMD) of the wet paper web transfer belt 1 according to the present invention. The wet paper web transfer belt 1 is constituted by integrating a reinforcing base material 24 and a polyurethane 25 by impregnating with the polyurethane 25 and by layering and curing the polyurethane 25 so that the reinforcing base material 24 comprising a wet paper web-side surface 22 and a machine-side surface 23 is embedded in the thermosetting polyurethane 25, and so that an outer circumferential layer 27 comprising a wet paper web contacting surface 26 and an inner circumferential layer 28 comprising a machine contacting surface 30 are formed by some of the water-impermeable resin 25. A high-roundness filler 29 of a relatively high roundness and a low-roundness filler 29' of a relatively low roundness are included in the polyurethane 25 constituting the outer circumferential layer 27.

[0027] Figs 2 to 5 are sectional views in the width direction showing another embodiment of the wet paper web transfer belt 1 according to the present invention. A wet paper web transfer belt 1 shown in Fig. 2 is constituted by integrating a reinforcing base material 24 and a polyurethane 25 by impregnating with the polyurethane 25 and by layering and curing the polyurethane 25 so that the reinforcing base material 24 comprising a wet paper web-side surface 22 and a machine-side surface 23 is embedded in the polyurethane 25, and so that an outer circumferential layer 27 comprising a wet paper web contacting surface 26 and an inner circumferential layer 28 comprising a machine contacting surface 30 are formed by some of the polyurethane 25. A high-roundness filler 29 and a low-roundness filler 29' are included in the polyurethane 25 constituting the outer circumferential layer 27 and the inner circumferential layer 28 and the polyurethane 25 impregnating the reinforcing base material 24. In this way, due to the filler contained in the inner circumferential layer 28, it is possible to improve the wear resistance of the machine contacting surface 30 while also improving the crack resistance of the polyurethane.

[0028] A wet paper web transfer belt 1 shown in Fig. 3 is constituted by integrating a reinforcing base material 24 and a polyurethane 25 by impregnating with the polyurethane 25 and by layering and curing the polyurethane 25 so that the reinforcing base material 24 comprising a wet paper web-side surface 22 and a machine-side surface 23 is embedded in the polyurethane 25, and so that an outer circumferential layer 27 comprising a wet paper web contacting surface 26, an intermediate layer 31 formed between the outer circumferential layer 27 and the wet paper web contacting surface 22 of the reinforcing base material 24, and an inner circumferential layer 28 comprising a machine contacting surface 30 are formed by some of the polyurethane 25. A high-roundness filler 29 and a low-roundness filler 29' are included in

the polyurethane 25 constituting the outer circumferential layer 27. In this way, it is possible to prevent the wear of the reinforcing base material 24 due to a filler by not including a filler in the polyurethane 25 impregnating the reinforcing base material 24, the inner circumferential layer 28 and the intermediate layer 31 adjacent to the reinforcing base material 24.

[0029] A wet paper web transfer belt 1 shown in Fig. 4 is constituted by integrating a composite reinforcing base material 32, in which short fibers 33 have been intertwiningly integrated by needle punching in a machine-side surface 23 of a reinforcing base material 24 comprising a wet paper web-side surface 22 and a machine-side surface 23, and a polyurethane 25 by impregnating with the polyurethane 25 and by layering and curing the polyurethane 25 so that the composite reinforcing base material 32 is embedded in the polyurethane 25, and so that an outer circumferential layer 27 comprising a wet paper web contacting surface 26 and an inner circumferential layer 28 comprising a machine contacting surface 30 are formed by some of the polyurethane 25. A high-roundness filler 29 and a low-roundness filler 29' are included in the polyurethane 25 constituting the outer circumferential layer 27. In this way, by using the composite reinforcing base material 32, it is possible to improve the strength of the wet paper web transfer belt, adjust the impregnation speed of the polyurethane during manufacturing and also improve operability.

[0030] A wet paper web transfer belt 1 shown in Fig. 5 is constituted by integrating a composite reinforcing base material 32, in which short fibers 33 have been intertwiningly integrated by needle punching in a machine-side surface 23 of a reinforcing base material 24 comprising a wet paper web-side surface 22 and a machine-side surface 23, and a polyurethane 25 by impregnating with the polyurethane 25 and by layering and curing the polyurethane 25 so that at least the wet paper web-side surface 22 of the composite reinforcing base material 32 is embedded in the polyurethane 25, and so that an outer circumferential layer 27 comprising a wet paper web contacting surface 26 is formed by some of the polyurethane 25, and the inner circumferential layer 28 comprising a machine contacting surface 30 is formed by some of the short fibers 33. A high-roundness filler 29 and a low-roundness filler 29' are included in the polyurethane 25 constituting the outer circumferential layer 27. In this way, due to the use of short fibers in the inner circumferential layer 28, the flexibility of the wet paper web transfer belt is improved; the installation of the belt in a papermaking machine is made easy, while the wear of the guide rollers 8 is reduced.

[0031] The reinforcing base material 24 is generally a fabric woven with a weaving machine, or the like, from warp and weft yarns; however, a grid-like structure made by superposing warp and weft columns can also be used.

[0032] Examples of materials for the reinforcing base material 24 and the short fibers 33 include polyester (polyethylene terephthalate, polybutylene terephthalate, and the like), aliphatic polyamide (polyamide 11, polyamide 12, polyamide 612, and the like), aromatic polyamide (aramid), polyvinylidene fluoride, polypropylene, polyether ether ketone, polytetrafluoroethylene, polyethylene , wool, cotton, metal, and the like.

[0033] Examples of alternative materials for the polyurethane 25 include thermosetting resins such as epoxy, acrylic, and the like, or thermoplastic resins such as polyamide, polyarylate, polyester, and the like; preferably urethane resin is used.

[0034] The roundness (X) of the filler particles can be expressed by formula (1) below; wherein, A and B are respectively the particle projected area and the perimeter measured on an image taken of a filler particle by an electron microscope, B is the area of a perfect circle corresponding to the perimeter C, r is the particle radius, and n is the circular constant.

$$X = A / B = A / (\pi r^2) = A / \{\pi \times (C / 2\pi)^2\} = A \times 4\pi / C^2 \quad (1)$$

[0035] Examples of materials for the high-roundness filler 29 include inorganic fillers such as silica, glass, calcium carbonate, iron, stainless steel, alumina, aluminum, zinc, tin, titanium and the like; the average particle diameter can be in the range from 1.0 μm to 300 μm. The specific surface area of the high-roundness filler 29 can be 10 m^2/g or less.

[0036] Examples of materials for the low-roundness filler 29' include inorganic fillers such as silica, glass, kaolin, calcium carbonate, iron, stainless steel, alumina, aluminum, zinc, tin, titanium and the like, and carbon-based fillers such as carbon black. The specific surface area of the low-roundness filler 29' can be 12 m^2/g or more. Moreover, in view of giving the surface of the wet paper web transfer belt a degree of roughness via the shape of the low-roundness filler 29', it is also possible to use amorphous particulate fillers, needle-like fillers, fibrous fillers and plate-like fillers.

[0037] In case only one type of filler with a relatively high roundness (for example, a roundness of 1) is used as filler added to the outer circumferential layer of the wet paper web transfer belt, the surface of the wet paper web transfer belt may become too smooth because it is difficult to give the surface of the wet paper web transfer belt roughness by this filler, and the adhesive properties of the wet paper web may become excessive. Moreover, in case only one type of filler with a relatively low roundness (for example, a roundness of less than 0.6) is used as filler added to the outer circumferential layer of the wet paper web transfer belt, the surface of the wet paper web transfer belt may become too rough because this filler gives the surface of the wet paper web transfer belt too much roughness, and the adhesive properties of the wet paper web may be insufficient.

[0038] In the wet paper web transfer belt according to the present invention, the amount of high-roundness filler and low-roundness filler varies according to the type of paper to be made and according to the papermaking conditions; however, in order to ensure the sheet adhesion properties, it is preferred to introduce, into the outer circumferential layer 27, between 5 wt% or more and 55 wt% or less of the high-roundness filler and between 5 wt% or more and 55 wt% or less of the low-roundness filler in relation to at least the total weight of the outer circumferential layer (the total weight of the polyurethane, the fillers and other additives). Moreover, in order to prevent contamination in parts where lipophilic contaminants (from pitch, sizing agents, and the like) are abundant, it is necessary to make the surface hydrophilic by introducing a relatively large amount of fillers; however, if the amount of fillers exceeds 60 % of the total weight (the total weight of the polyurethane, the fillers and other additives), the wet paper web transfer belt becomes too hard and there is the risk of cracks occurring. Further, in parts where fine pulp fibers with high adhesiveness are used, there is the risk of malfunctioning occurring in which the fine pulp fibers adhere to the surface of the wet paper web transfer belt if too much filler is introduced. Consequently, the total amount of the high-roundness filler 29 and the low-roundness filler 29' in each layer is preferably 10 wt% to 60 wt% of the total weight of the layer (the total weight of the polyurethane, the fillers and other additives). Other additives such as pigments and anti-foaming agents can be appropriately added according to design.

[0039] Thus, by adopting the above-described constitution in the wet paper web transfer belt 1, it is possible to provide a wet paper web transfer belt in which the adhesive and releasing properties of the wet paper web with the wet paper web contacting surface of conventional wet paper web transfer belts are further improved and in which paper robbing and floating edges do not occur.

[0040] Hereinafter, a specific example of a production method of a wet paper web transfer belt according to the present invention will be explained.

[0041] Fig. 6 is a schematic diagram showing the layering of polyurethane of the wet paper web transfer belt 1 shown in Fig. 1. As shown in Fig. 6 (a), the reinforcing base material 24 is installed so that the machine-side surface 23 of the reinforcing base material 24 is in contact with the rolls 40, which are arranged in parallel. Then, the inner circumferential layer 28 of the wet paper web transfer belt 1 can be formed by coating polyurethane from a resin discharge opening 42 onto the wet paper web-side surface 22 of the reinforcing base material 24 while rotating the rolls 40, and by allowing the polyurethane to penetrate by a coater bar 41 from the wet paper web-side surface 22 of the reinforcing base material 24 to the machine-side surface 23 thereof and by curing the polyurethane (Fig. 6 (b)). The semi-finished product obtained in this step is installed so that the wet paper web-side surface 22 of the reinforcing base material 24 is in contact with the two rolls 40, which are arranged in parallel; then, the inner circumferential layer 28 of the wet paper web transfer belt 1 can be formed by coating polyurethane from the resin discharge opening 42 onto the machine-side surface 23 of the reinforcing base material 24 while rotating the rolls 40, and by layering the polyurethane onto the machine-side surface 23 of the reinforcing base material 24 by the coater bar 41 and by curing the polyurethane; it is also possible to perform this process by inversing the front and the back.

[0042] Next, the outer circumferential layer 27 of the wet paper web transfer belt 1 can be formed by again coating polyurethane from the resin discharge opening 42 onto the wet paper web-side surface 22 of the reinforcing base material 24 while rotating the rolls 40, and by layering the polyurethane by the coater bar 41 and by curing the polyurethane (Fig. 6 (c)). Now, the wet paper web transfer belt 1 shown in Fig. 1 can be obtained by including the two types of fillers, i.e., the high-roundness filler 29 with a relatively high roundness and the low-roundness filler 29' with a relatively low roundness, in the polyurethane constituting the outer circumferential layer 27. Further, the wet paper web contacting surface 26 and the machine contacting surface 30 of the wet paper web transfer belt 1 can be polished according to need and the desired surface roughness can be obtained.

[0043] Moreover, the wet paper web transfer belts 1 shown in Figs 2 to 5 can be obtained by optionally setting the constitution of the intermediate layer 31, not comprising the high-roundness filler 29 and the low-roundness filler 29', and the use of the composite reinforcing base material 32 as substitute for the reinforcing base material 24.

[0044] Hereinafter, the present invention will be described by means of the Examples and Comparative Examples. The Reinforcing Base Material

[0045] The reinforcing base materials of the wet paper web transfer belts according to Examples 1 to 9 and Comparative Examples 1 to 8 used the following constitution.

- Upper warp yarn: twisted monofilament of 2000 dtex made from polyamide 6
- Lower warp yarn: twisted monofilament of 2000 dtex made from polyamide 6
- Weft yarn: twisted monofilament of 1400 dtex made from polyamide 6
- Weave: double warp weave of 40 upper/lower warp yarns/5 cm and 40 weft yarns/5 cm

The Polyurethane

[0046] The polyurethane of the wet paper web transfer belts of Examples 1 to 9 and Comparative Examples 1 to 8 was obtained by reacting a mixture of tolylenediisocyanate (TDI) and polytetramethylene glycol (PTMG), as urethane prepolymer, with dimethylthiotoluenediamine (DMTDA), as curing agent.

[0047] In Examples 1 to 9, the wet paper web transfer belt shown in Fig. 1 was obtained by using the above-described reinforcing base material and polyurethane. Moreover, in Comparative Examples 1 to 8, the wet paper web transfer belt was produced by changing the filler shown in Fig. 1. The polyurethane curing conditions were identical for all wet paper web transfer belts; after curing the polyurethane, the wet paper web contacting surface was polished and the surface roughness Ra (arithmetic average surface roughness) of the wet paper web contacting surface was fixed at 1.5 μm for all belts.

[0048] The conditions of the fillers included in the outer circumferential layer of the wet paper web transfer belts of Examples 1 to 9 and Comparative Examples 1 to 8 are shown in Table 1.

[0049] The floating edges condition of the wet paper web after passing the nip and the occurrence of paper robbing due to the felt 6 or due to the wet paper web transfer belt after the wet paper web W had passed the press nip 12 under the conditions listed hereinafter and by using the device shown in Fig. 8 was evaluated regarding the wet paper web transfer belts of Examples 1 to 9 and Comparative Examples 1 to 8. The evaluation device shown in Fig. 8 has the constitution of the press part 3 shown in Fig. 7, in which the constitution upstream of the press felt 6 has been omitted. The press conditions, the constitution of the press felt 6 and the constitution of the wet paper web were as listed hereinafter.

[0050] The Pressing Conditions

- Papermaking speed: 1600 m/min
- Pressing pressure: 1050 kN/m

[0051] The Constitution of the Press Felt 6

[0052] Base Fabric

- Upper warp yarn: twisted monofilament of 2000 dtex made from polyamide 6
- Lower warp yarn: twisted monofilament of 2000 dtex made from polyamide 6
- Weft yarn: twisted monofilament of 1400 dtex made from polyamide 6
- Weave: double warp weave of 40 upper/lower warp yarns/5 cm and 40 weft yarns/5 cm

[0053] The Batt Fibers needle-punched to the Base Fabric

- Front layer batt fibers: 300 g/m^2 batt fibers of 6 dtex made from polyamide 6
- Rear layer batt fibers: 100 g/m^2 batt fibers of 6 dtex made from polyamide 6

[0054] The Wet Paper Web (Handsheet)

- Pulp: LBKP 100% csf 550 mL
- Basis weight: 40 g/m^2
- Wet paper web moisture before pressing: wet paper web moisture weight before pressing/(wet paper web moisture weight before pressing + wet paper web bone dry weight) = adjusted to 60% (moisture control through a filter paper, wet paper web moisture after pressing about 50%)
- Wet paper size: 700 mm length by 700 mm width

[0055] Further, the paper robbing due to the felt 6 or the wet paper web transfer belt after passing the nip was evaluated with the help of a video camera. The evaluation results are shown in Table 2.

[Table 1]

	High-roundness filler				Low-roundness filler			
	Material	Roundness	Average diameter	Added amount	Material	Roundness	Average diameter	Added amount
Example 1	Silica	0.75	5	5	Silica	0.55	5	55
Example 2	Silica	0.75	5	15	Silica	0.55	5	15
Example 3	Silica	0.75	5	55	Silica	0.55	5	5
Example 4	Silica	0.75	1	15	Silica	0.55	5	15
Example 5	Silica	0.75	100	15	Silica	0.55	5	15
Example 6	Silica	0.75	5	15	Silica	0.55	1	15
Example 7	Silica	0.75	5	15	Silica	0.55	100	15
Example 8	Silica	0.75	5	15	Kaolin	0.55	5	15
Example 9	Silica	0.85	5	15	Silica	0.55	5	15
Comparative Example 1	Silica	0.75	5	10	-	-	-	-
Comparative Example 2	Silica	0.75	5	30	-	-	-	-
Comparative Example 3	Silica	0.75	5	55	-	-	-	-
Comparative Example 4	Silica	0.75	100	15	-	-	-	-
Comparative Example 5	-	-	-	-	Silica	0.55	5	10
Comparative Example 6	-	-	-	-	Silica	0.55	5	30
Comparative Example 7	-	-	-	-	Silica	0.55	5	55
Comparative Example 8	-	-	-	-	Silica	0.55	100	15

[Table 2]

	Evaluated items Paper robbing	Floating edges	Wet paper web transfer belt paper robbing
	Observed	Observed	Observed
Example 1	No	No	No
Example 2	No	No	No
Example 3	No	No	No
Example 4	No	No	No
Example 5	No	No	No
Example 6	No	No	No
Example 7	No	No	No
Example 8	No	No	No
Example 9	No	No	No
Comparative Example 1	No	No	Sometimes
Comparative Example 2	No	No	Yes
Comparative Example 3	No	No	Yes
Comparative Example 4	No	No	Yes
Comparative Example 5	No	Sometimes	No
Comparative Example 6	No	Sometimes	No
Comparative Example 7	No	-	No
Comparative Example 8	No	Sometimes	No

[0056] As shown in Table 2, the adhesive and releasing properties of the wet paper web on the wet paper web contacting surface was further improved in the wet paper web transfer belts of Examples 1 to 9, in which paper robbing and floating edges did not occur.

Explanation of the Reference Characters

[0057] W: wet paper web, 1: wet paper web transfer belt, 2: closed-draw papermaking machine, 3: press part, 4: dryer part, 5, 6: press felt, 7: dryer fabric, 8: guide rolls, 9: shoe, 10: press roll, 11: shoe press belt, 12: press section, 13: shoe press mechanism, 14: suction roll, 22: wet paper web-side surface, 23: machine-side surface, 24: reinforcing base material, 25: polyurethane, 26: wet paper web contacting surface, 27: outer circumferential layer, 28: inner circumferential layer, 29: high-roundness filler, 29': low-roundness filler, 30: machine contacting surface, 31: intermediate layer, 32: composite reinforcing base material, 33: short fibers, 40: rolls, 41: coater bar, 42: resin discharge opening

Claims

1. A wet paper web transfer belt in which a reinforcing base material comprising a wet paper web-side surface and a machine-side surface and a thermosetting polyurethane are integrated with each other, at least the wet paper web-side surface of the reinforcing base material is embedded in the polyurethane, an outer circumferential layer comprising a wet paper web contacting surface is constituted by some of the polyurethane; wherein, at least the outer circumferential layer comprises two different types of fillers including a high-roundness filler with a relatively high roundness and a low-roundness filler with a relatively low roundness, the difference between the high-roundness filler and the low-roundness filler is 0.1 or more.

2. The wet paper web transfer belt according to claim 1; wherein the roundness of the high-roundness filler is 0.6 or

more and the roundness of the low-roundness filler is less than 0.6.

3. The wet paper web transfer belt according to claim 1; wherein the roundness of the high-roundness filler is 0.7 or more and the roundness of the low-roundness filler is less than 0.7.

4. The wet paper web transfer belt according to claim 1; wherein the roundness of the high-roundness filler is 0.8 or more and the roundness of the low-roundness filler is less than 0.8.

5. The wet paper web transfer belt according to any one of claims 1 to 4; wherein the specific surface area of the high-roundness filler is 10 m^2/g or less.

6. The wet paper web transfer belt according to any one of claims 1 to 5; wherein the specific surface area of the low-roundness filler is 12 m^2/g or more.

7. A wet paper web transfer belt according to any one of claims 1 to 6; wherein the low-roundness filler comprises one or more filler(s) selected from inorganic fillers.

8. A wet paper web transfer belt according to any one of claims 1 to 7; wherein the high-roundness filler comprises one or more filler(s) selected from inorganic fillers or carbon-based fillers.

9. A wet paper web transfer belt according to any one of claims 1 to 8; wherein the two different fillers are only comprised in the outer circumferential layer.

10. A wet paper web transfer belt according to any one of claims 1 to 9; wherein the content of the high-roundness filler is from 5 wt% or more to 55 wt% or less in relation to the total weight of the outer circumferential layer (the total weight of the polyurethane, the filler(s) and other additives), and the content of the low-roundness filler is from 5 wt% or more to 55 wt% or less in relation to the total weight of the outer circumferential layer (the total weight of the polyurethane, the filler(s) and other additives).

11. A wet paper web transfer belt according to any one of claims 1 to 10; wherein the total content of the two different fillers is from 10 wt% or more to 60 wt% or less in relation to the total weight of the outer circumferential layer (the total weight of the polyurethane, the fillers and other additives).

12. A wet paper web transfer belt according to any one of claims 1 to 11; wherein the low-roundness filler is one or more types of filler selected from amorphous particulate fillers, needle-like fillers, fibrous fillers, plate-like fillers.

13. A wet paper web transfer belt according to any one of claims 1 to 12; wherein the average particle diameter of the high-roundness filler is 1.0 to 100 μm.

14. A wet paper web transfer belt according to any one of claims 1 to 13; wherein the average particle diameter of the low-roundness filler is 1.0 to 100 μm.

15. A wet paper web transfer belt according to any one of claims 1 to 14; wherein the reinforcing base material is a composite reinforcing base material in which short fibers have been intertwiningly integrated by needle punching with at least the machine-side surface of the reinforcing base material.

16. A wet paper web transfer belt according to claim 15; wherein an inner circumferential layer comprising a machine contacting surface is constituted by some of the short fibers integrated with the machine-side surface.

17. A wet paper web transfer belt according to any one of claims 1 to 15; wherein an inner circumferential layer comprising a machine contacting surface is constituted by some of the polyurethane.

Fig. 1

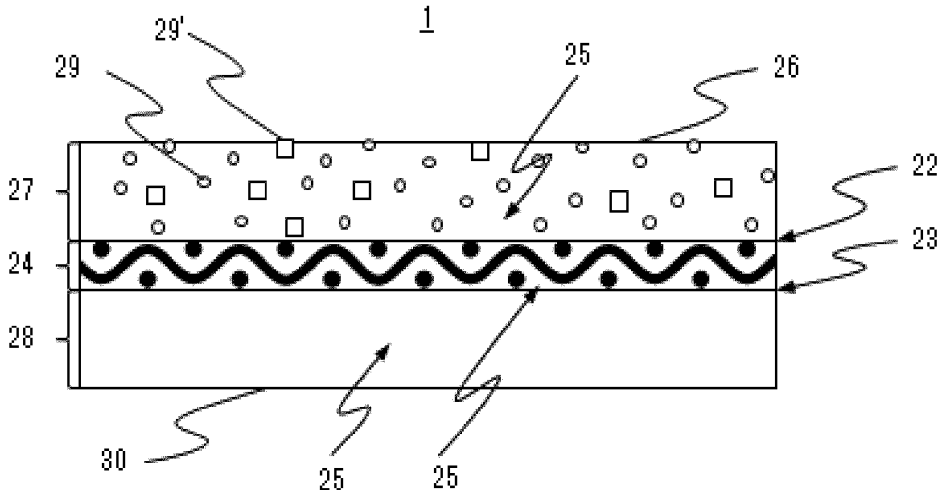

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Fig. 2

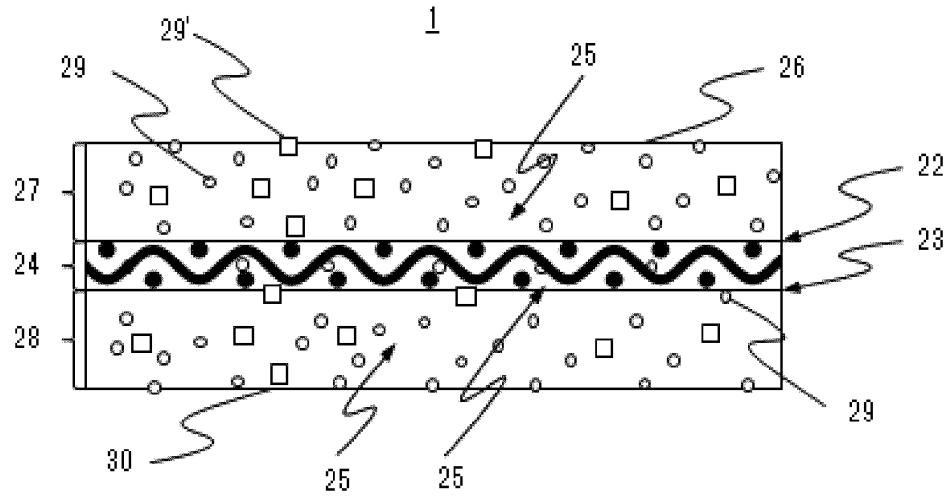
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Fig. 3

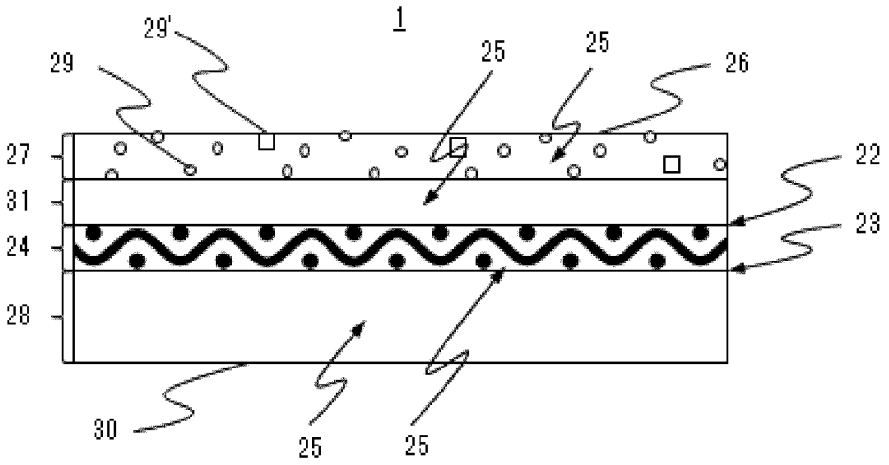


Fig. 4

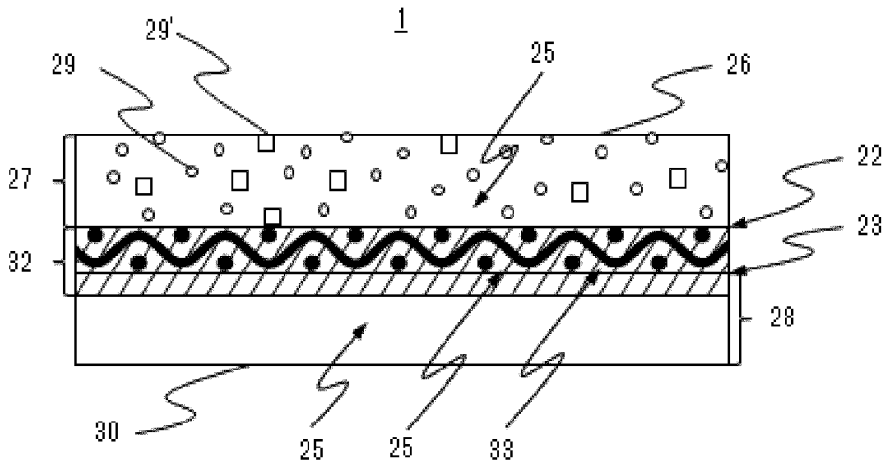


Fig. 5

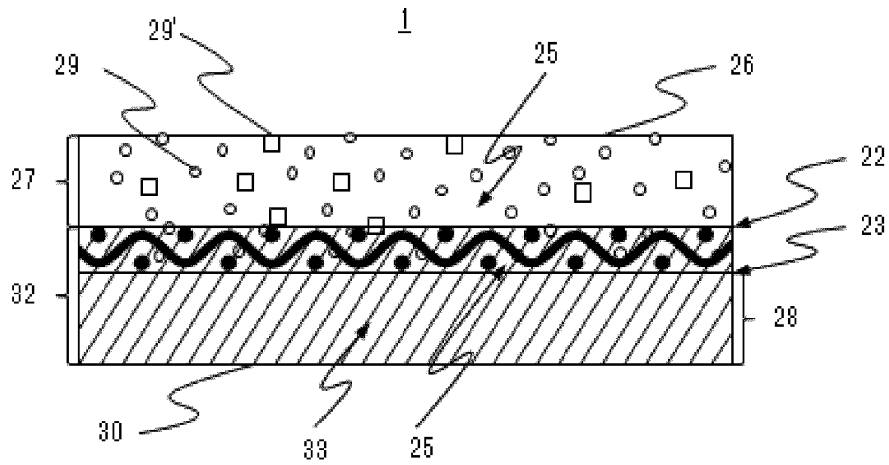
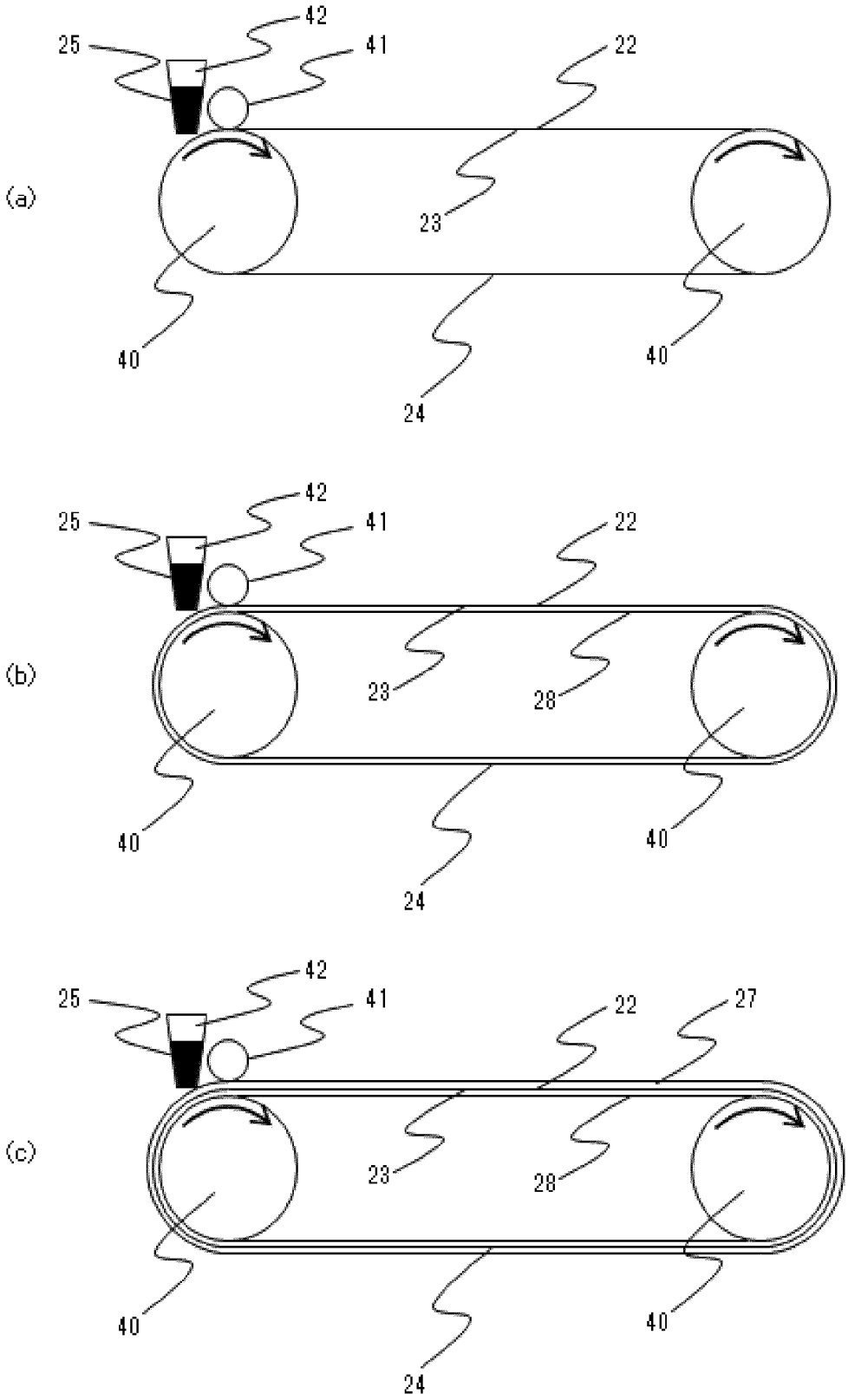


Fig. 6


(a)
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42
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Fig. 7

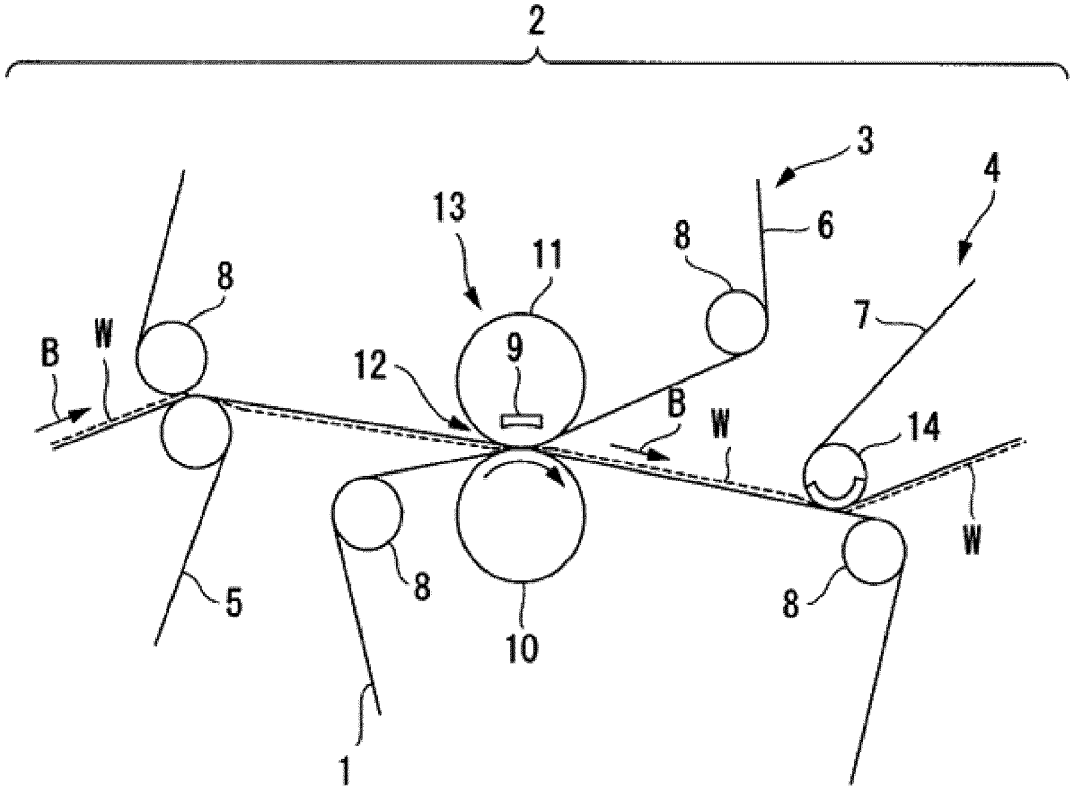
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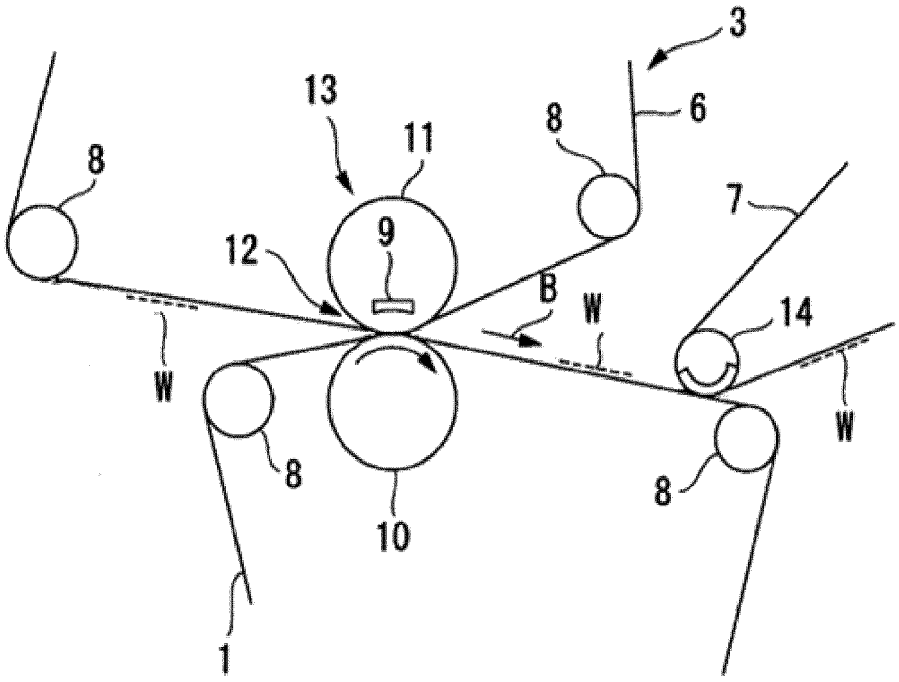
Fig. 8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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 2698

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X,D	WO 2013/020745 A1 (VOITH PATENT GMBH [DE]; MATUSCHCZYK UWE [DE]; DELMAS DELPHINE [DE]; RE) 14 February 2013 (2013-02-14) * page 3, line 6 - page 5, line 27 * * page 6, line 23 - page 7, line 8 * * pages 1a,1b *	1,5, 7-12,14, 15	
A	WO 01/27387 A1 (TAMFELT OYJ ABP [FI]; HAGFORS SATU [FI]; JERMO OLLI [FI]) 19 April 2001 (2001-04-19) * abstract *	1	

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D21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	8 June 2015	Maisonnier, Claire

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 15 2698

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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United States Patent [19]

Westhead

[11] **Patent Number: 4,675,229**

[45] **Date of Patent: Jun. 23, 1987**

[54] **SPIRAL COIL CORRUGATOR BELT**

[75] Inventor: **William T. Westhead**, Waycross, Ga.

[73] Assignee: **Scapa Inc.**, Waycross, Ga.

[21] Appl. No.: **822,210**

[22] Filed: **Jan. 24, 1986**

[51] **Int. Cl.**[4] **B32B 5/32**; B32B 7/00

[52] **U.S. Cl.** **428/222**; 428/234; 428/300; 428/311.1; 428/316.6

[58] **Field of Search** 428/222, 234, 300, 311.1, 428/316.6

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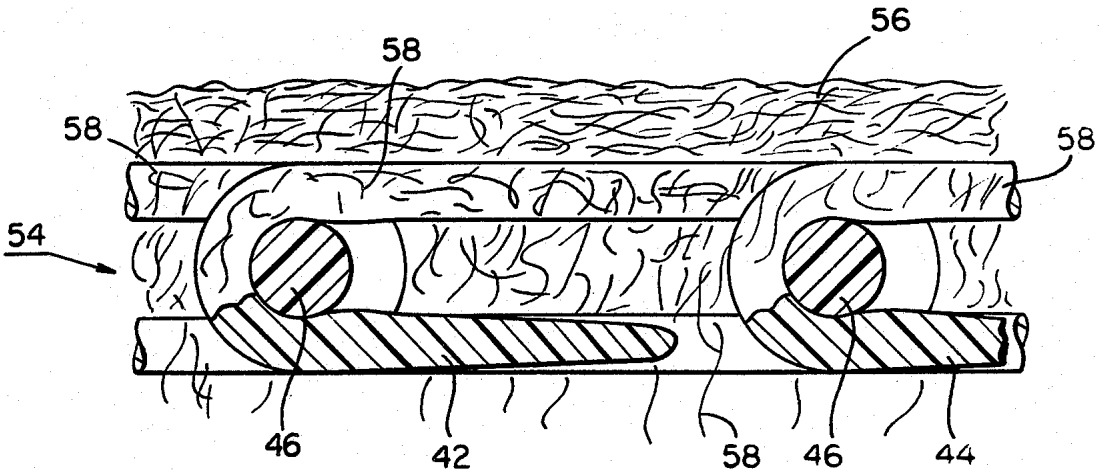
Primary Examiner—Marion C. McCamish

Attorney, Agent, or Firm—Fleit, Jacobson, Cohn & Price

[57] **ABSTRACT**

A belt structure including a carrier formed from a plurality of intermeshing spiral coils with adjacent coils interconnected by hinge yarns. The spiral coil carrier is plated under tension and heated to cause the spiral coils to extend longitudinally to define spaced upper and lower substantially flat surfaces. A yieldable, porous batt of synthetic fibrous material is needled into and onto one surface of the carrier. As an alternative structure, a yieldable, porous, open cell foam is applied to the spiral coil carrier to fill the interior thereof, and to extend outwardly from one surface to form an outer foam layer. The belts are particularly suitable as pressure and transporting belts in a corrugating machine, but can also be used in wet press and dryer sections of papermaking machines.

24 Claims, 8 Drawing Figures



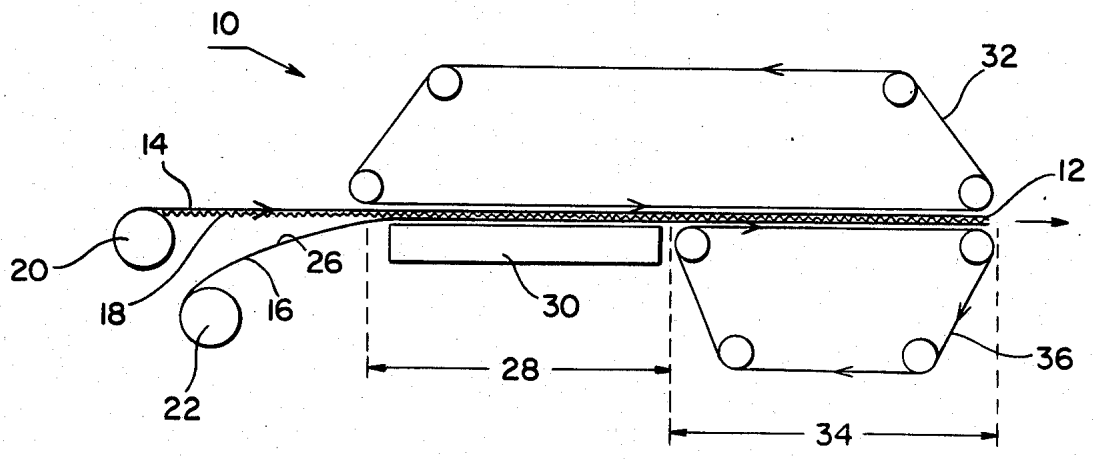


FIG. 1

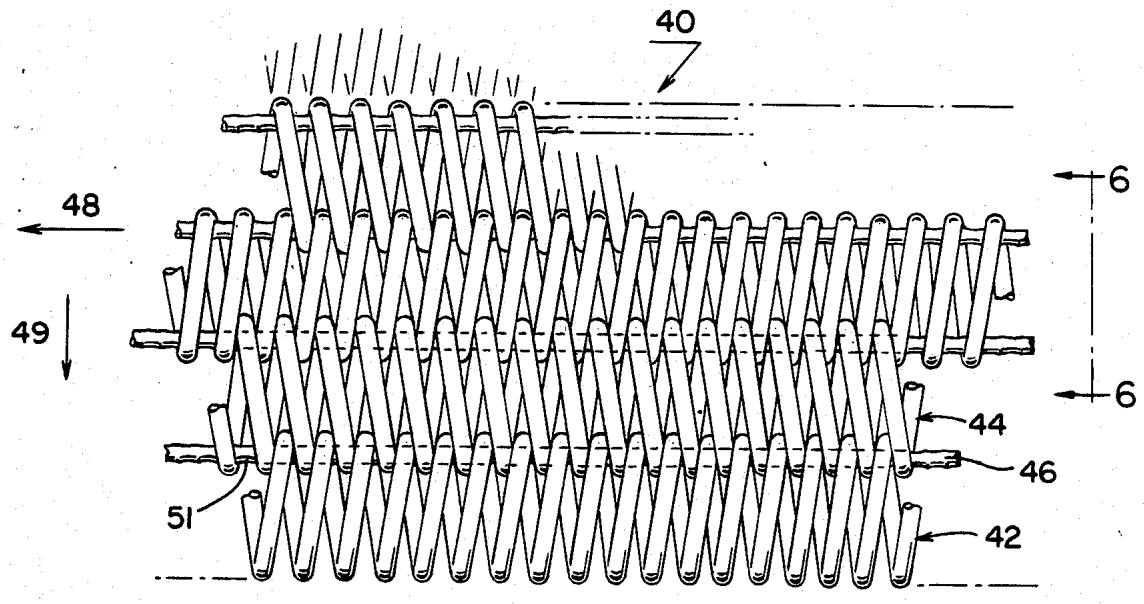


FIG. 2

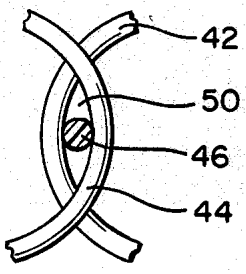


FIG. 3

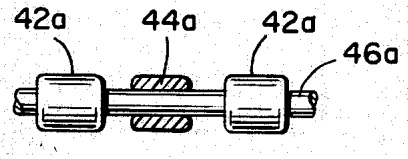


FIG. 4

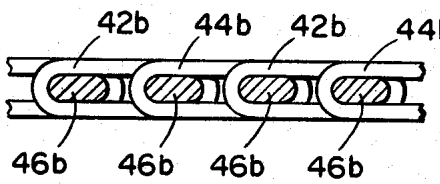


FIG. 5

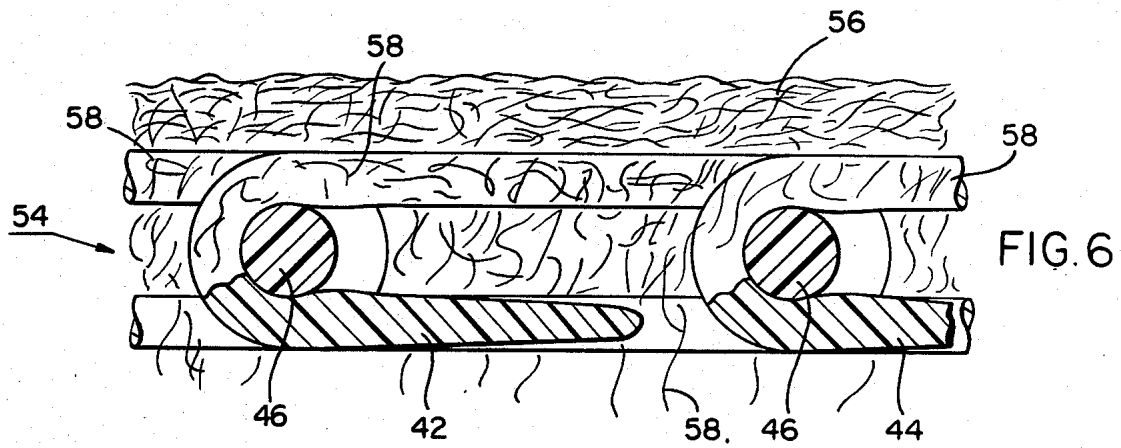


FIG. 6

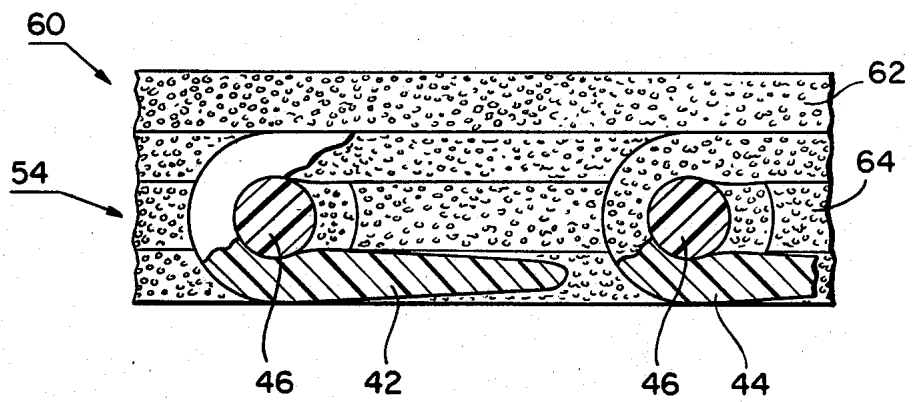


FIG. 7

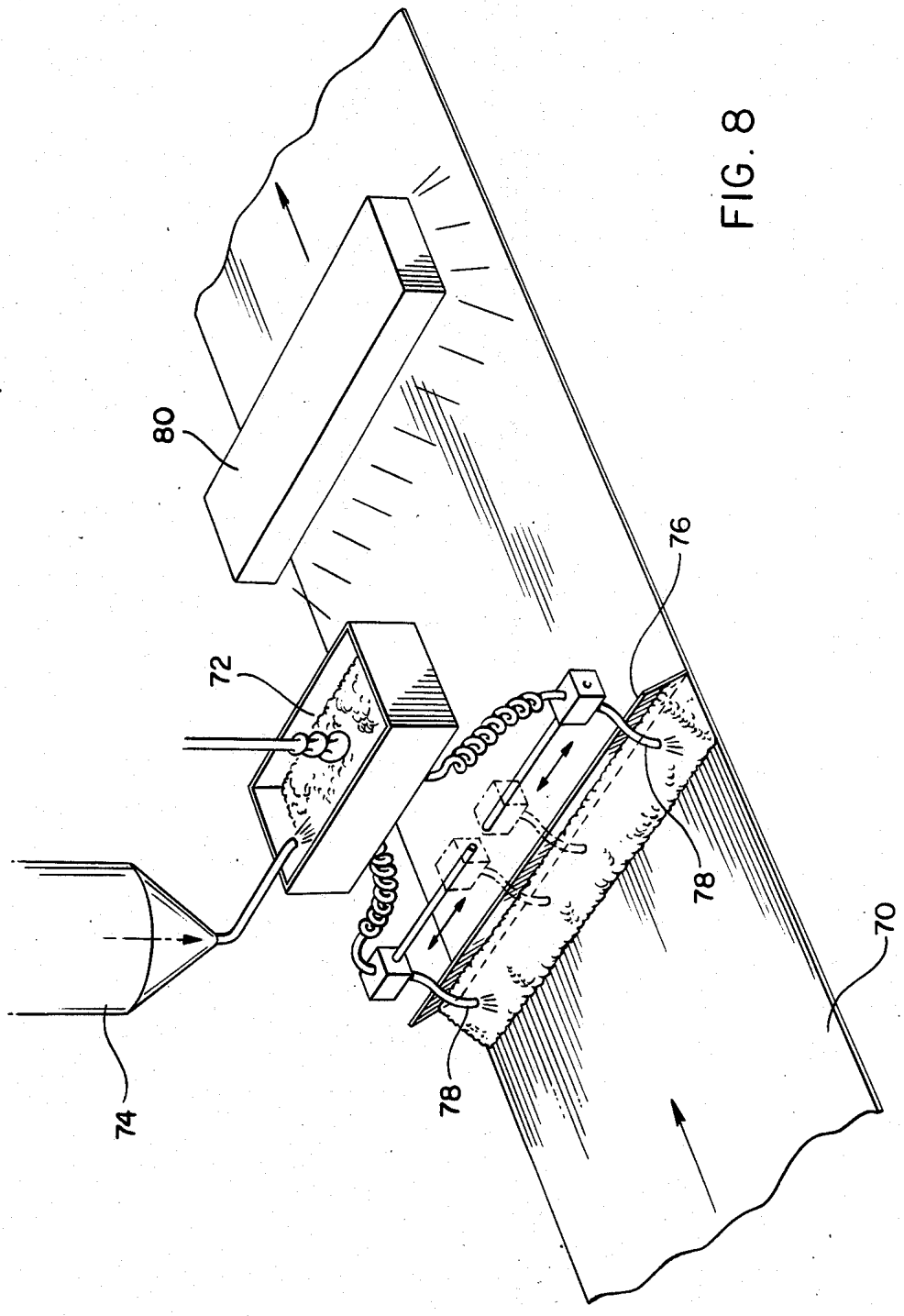


FIG. 8

SPIRAL COIL CORRUGATOR BELT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to corrugator belts, and more particularly to a corrugator belt structure incorporating a spiral coil carrier having either a fibrous batt secured thereto or having a foam coating thereon, for engagement with a surface of a corrugated sheet.

2. Description of the Prior Art

Corrugator belts are used in corrugating machines to feed sheet material through the machine, as well as to apply pressure to the sheet material to facilitate joining together of the several sheets of material forming a sheet of faced corrugated paperboard. Conventional corrugating machine belts are normally either a woven fabric or, alternatively, a woven fabric carrier that has a batt of fabric material needled thereto that is adapted to come into direct contact with and bear against a surface of the sheet material that passes through the corrugating machine. The conventional corrugator belts presently in use have a number of shortcomings. Included within those shortcomings is a tendency for the belts to wear at the outer edges thereof, when a narrow sheet of corrugated board is being formed, as a result of sagging of the belt edges and rubbing along the heater unit that is provided to dry the glue used to adhere the respective individual facing sheet or sheets that are combined to form a composite sheet of corrugated paperboard.

In addition to edge wear, the present corrugator belts also include heavy metal hooks that join together the ends of the belt to thereby form an endless belt structure. The hooks result in a seam in the belt that can cause a mark on the surface of the corrugated paperboard because of the reduced tendency of the belt to deflect in the seam area as compared with the more resilient surrounding portions of the belt.

Other problems that result from the use of present corrugator belts include poor frictional characteristics that result in slippage of the belt relative to the facing of the sheet of corrugated board that is being formed, stretching of the belt and sometimes breakage because of age of the fabric, and necking of the fabric, which is manifested as contraction widthwise of the belt if left stationary in contact with the heater plate of a corrugating machine. Further, conventional corrugator belts also sometimes run wet because of the absorption thereby of moisture, which leads to poor sheet drying, and possible sheet warping or curl, and they are also readily contaminated by glue or other materials and consequently require periodical removal for cleaning.

It is an object of the present invention to provide a corrugator belt structure that overcomes the deficiencies noted hereinabove with respect to the presently used corrugator belt structures.

SUMMARY OF THE INVENTION

Briefly stated, in accordance with one aspect of the present invention, a corrugator belt is provided having a spiral coil carrier, the coil structure including a plurality of hinge yarns, all of the hinge yarns extending in a common direction, and a plurality of spiral coils disposed in a common plane in a side-by-side relationship, each of the coils extending in the common direction, adjacent coils of the spirals being intermeshed and held together in intermeshing relationship by at least one of the hinge yarns. After assembly the fabric is first subjected to a controlled heat treatment. A batt of synthetic fibrous material is then needled to one surface of the carrier for contact with the surface of the sheet of corrugated board, in order to form a belt that permits the application to the corrugated sheet of substantially uniform friction and pressure for moving the sheet along a machine.

In accordance with another aspect of the present invention, a carrier is formed from a plurality of spiral coils, the coils being in intermeshing relationship and connected by respective hinge yarns to form a carrier structure that is subsequently flattened by applying heat and tension to the carrier sheet. The interior of the resulting carrier is filled with an open cell foam, and the foam extends beyond one surface of the carrier to provide an external foam layer that is adapted to contact the sheet of corrugated board.

If desired, a silicone based release treatment can be applied to the outer surface of the batt or foam to reduce the build-up of contaminants on and in the belt.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view showing a portion of a corrugating machine for forming a composite sheet including a corrugated sheet and one or more flat facing sheets adhered to the corrugated sheet.

FIG. **2** is a fragmentary plan view of a spiral coil carrier for a corrugator belt in accordance with the present invention, and in which the carrier is formed from monofilament yarns having a circular cross section.

FIG. **3** is a fragmentary view showing portions of two interengaged coils with a hinge yarn extending therethrough.

FIG. **4** is a cross-sectional view through a spiral coil carrier showing coil yarns having a non-circular cross section.

FIG. **5** is a fragmentary cross-sectional view through a spiral coil carrier wherein the hinge yarns interconnecting the coils are formed from non-circular yarns and the coils have been flattened.

FIG. **6** is a fragmentary cross-sectional view taken along the line **6—6** of FIG. **2** showing a spiral coil carrier, the carrier having a fiber batt needled so that fibers extend into the carrier and the batt protrudes above the surface of the carrier.

FIG. **7** is a fragmentary cross-sectional view similar to FIG. **6**, but showing a spiral coil carrier with a foam material within the coils and extending beyond one surface thereof to provide a foam layer on the carrier.

FIG. **8** is a fragmentary perspective view showing one form of apparatus that can be used to apply foam materials to a spiral coil carrier in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to FIG. **1** thereof, there is shown a portion of a machine **10** for forming a composite sheet of corrugated paperboard **12**. The portion of the machine shown is the part where the respective individual sheets are joined together to form the composite sheet.

The composite sheet of corrugated board **12** includes a flat top sheet **14**, a flat bottom sheet **16**, and an intermediate sheet **18** that is of corrugated configuration. Intermediate sheet **18** includes generally sinusoidal cor-

rugations that extend across the width of the sheet and is sandwiched between top sheet **14** and bottom sheet **16**. The respective sheets **14, 16** are typically made from kraft paper, and can have a thickness of about 0.016 inches and a basis weight of about 42 lbs/1000 sq ft., ranging from about 26 to about 90 lbs/1000 sq. ft. Intermediate sheet **18** of corrugated paperboard typically has a thickness of about 0.010 inches and a basis weight of about 26 lbs/1000 sg. ft., ranging from about 26 to about 42 lbs/1000 sq. ft. Intermediate sheet **18** of corrugated paper can either be secured to the top sheet in a separate operation, in which a roll **20** of board is provided wherein the board includes a flat facing sheet to which a corrugated sheet is adhered as shown in FIG. **1**, or alternatively, separate rolls (not shown) to provide the top sheet and the corrugated intermediate sheet can be provided. Bottom sheet **16** is supplied from a roll **22**, or the like, and a glue layer **24** is applied to the surface **26** of sheet **16** that is adapted to come into contact with the corrugated intermediate sheet **18**. The two sheets, or three, as the case may be, are fed to a heating zone **28** which includes a heater plate **30** that serves to heat and thereby dry the glue. Heater plate **30** includes a flat surface over which the sheets pass, and pressure is applied to the total sheet structure **12** by means of an upper belt **32** that is so positioned as to cause uniform pressure to be applied to the respective sheets of material to press them against the surface of heater plate **30**. Although illustrated and described herein as a three layer sheet of double faced corrugated board in the form of a corrugated inner sheet and flat facing sheets on each face of the corrugated sheet, it will be apparent to those skilled in the art that the corrugator belt herein described can also be used to make single faced corrugated board, multiple wall corrugated board, or other laminated board structures.

Downstream of heating zone **28** is a cooling zone **34**. The heated composite corrugated paperboard sheet is carried through cooling zone **34** between a lower belt **36** and upper belt **32** to permit the board to cool and the adhesive to set. Belts **32, 36** move together to carry the completed corrugated paperboard sheet to a downstream processing station (not shown) where the material is either die cut to a desired configuration in flat sheet form, or, alternatively, is rolled into rolls of suitable width and diameter for shipment to end users.

In transporting the corrugated paperboard sheet through the corrugating machine, the belts must have sufficient surface friction to convey the composite board through the machine without slippage, and they must also have good wear resistance to avoid the need for frequent replacement of the belts, which requires the machine to be shut down. Additionally, the belts should have good stability, particularly resistance to longitudinal and lateral stretching, so that they permit uniform tension across the belt to provide uniform drying of the glued corrugated board sheet. It is also desirable that the belts have sufficient permeability to allow escape of moisture, and thereby prevent curling or warping of the composite corrugated board sheets, that they be clean running in that they do not attract or retain foreign materials, and that they not cause undesired marks to be made in the resulting composite corrugated paperboard sheet.

Referring now to FIG. **2**, a portion of a belt in accordance with the present invention is shown and generally identified as carriers **40**. In that connection, it is to be understood that the drawing figures are in the nature of schematic representations and do not necessarily illustrate the elements of the carrier to any precise scale.

Carrier **40** basically comprises a plurality of spiral S-coils **42** joined together with a plurality of spiral Z-coils **44** through the use of hinge yarns **46** to define the carrier. The letters "S" and "Z" indicate the direction of twist of the spiral coils. A spiral coil has an S-twist if, when it is held vertically, the spirals or convolutions around its central axis slope in the same direction as the middle portion of the letter S, and a Z-twist if the spirals slope in the same direction as the central portion of the letter Z.

The spiral coils **42** and **44** each consist of lengths of spiral monofilament, i.e., a monofilament with the appearance of a spring coil. The monofilament is synthetic in nature and is typically made from polyester, although other materials, such as polyamide, polyolefin, polyetheretherketone, and the like, can also be used.

In constructing a spiral coil carrier, a spiral coil (in this case S-coil **42**) is first selected and laid out in what will eventually become the cross-machine direction, as indicated by arrow **48**. Thus it can be appreciated that the width of the carrier is determined by the length of the coil. A second spiral (in this case Z-coil **44**) is then intermeshed with the first spiral coil **42** in side-by side relationship to define a biconvex appearing hinge yarn-receiving opening **50** therebetween (see FIG. **3**). Opening **50** receives a hinge yarn **46**, which also extends in the cross-machine direction, and which is also typically a synthetic monofilament, and, like the spiral coils, may be made of polyester, polyamide, polyolefin, polyetheretherketone, and the like. When inserted into the adjacent intermeshed spiral coils, hinge yarn **46** acts as a pivot or hinge for interconnecting the adjacent coils.

The laying down of additional interengaged spiral coils in an alternating 'S' coil and 'Z' coil relationship with the subsequent insertion of a hinge yarn within the respective openings defined therebetween is continued until a carrier of desired length is produced. The spiral coils are alternately S-twist and Z-twist coils so as to reduce torque in the carrier.

Hinge yarns **46** can be of circular cross section, although yarns of non-circular cross section can also be employed, if desired. The overall size and shape of the hinge yarns depends on the size and shape of the spiral coil yarns and the yarn-receiving openings that the coils define when they are intermeshed, as well as the desired permeability of the carrier.

After the carrier has been formed through the intermeshing of the alternate S-twist and Z-twist coils and the insertion therewithin of the hinge yarns to form an endless carrier structure, the carrier is then subjected to heat treatment while it is under controlled tension. The tension is applied in what will become the machine direction (arrow **49** as seen in FIG. **2**). Under these circumstances, the spiral coils **42, 44**, which were originally circular or elliptical in transverse section, become flattened and their inner surfaces press up against the hinge yarns. At the same time, the controlled tensioning of the belt while being heated and the resultant flattening of the spiral coils causes crimping **51**, or surface undulations (see FIG. **2**), to occur in the hinge yarns. The crimp or undulations resulting from the heat treatment is desirable to stabilize the carrier and to ensure good runnability on a machine, i.e., no distortion or stretching. The crimping or undulations also ensures that the hinge yarns do not move laterally, which would cause separation of adjacent coils and would leave an

opening at either edge of the carrier. Thus, upon completion of the heating under controlled tension, a carrier results in which the hinge yarns all lie in a common plane. In like manner, the spiral coils are flattened, and the upper and lower surfaces of the coils lie in respective spaced parallel planes of the carrier.

The flatness of the upper sheet receiving and the lower machine-roll contacting surfaces of the carrier can be controlled by the appropriate use of temperature, time, and tension. The spirals are flattened so that they are pulled into close contact around the sides of the hinge yarns by increasing either the temperature, the time, or the tension, or any combination of those factors.

The carrier illustrated in FIG. **2** includes spiral coils and hinge yarns that are formed from monofilaments or monofilament-like yarns having circular cross sections. FIGS. **4** and **5** show alternative structures wherein the carrier is formed from spiral coils having non-circular coil yarns **42***a*, **44***a* interconnected by hinge yarns **46***a* (FIG. **4**), or wherein the carrier is formed from non-circular hinge yarns **46***b* that interconnect coil yarns **42***b*, **44***b* (FIG. **5**), in order to provide a desired permeability for the carrier fabric. The non-circular yarns can be defined by major and minor axes, the major axes lying parallel to the carrier surfaces. The yarn dimensions along the minor and major axes can be in the ratio of from about 1:1.1 to about 1:6, and preferably in the ratio of from about 1:1.1 to about 1:2.5. Although described herein principally in terms of its application to a corrugating machine belt, the carrier structure as herein disclosed can also be used in the wet press and dryer sections of papermaking machines, if desired. In that event, the provision of suitable non-circular coil or hinge yarns can be used advantageously to provide a carrier having a desired permeability.

As seen in FIG. **6**, one of the outer surfaces **52** of the carrier **54**, as defined by the flattened coils **42**, **44**, includes a coherent batt **56** of fibrous material that is needled both into and onto carrier **54** by a conventional needling process, which is familiar to those skilled in the art. Batt **56** is preferably formed from a plurality of polymeric fibers **58** giving a finished belt thickness of from about 0.125 inches to about 0.375 inches, and the fibers are randomly arranged to provide a yieldable, porous, non-woven structure with spaces between adjacent fibers. Preferably, the fiber lengths are from about 2 inches to about 3½ inches. Batt **56** can be formed from polymeric fibers made from polyester, polypropylene, nylon 6, nylon 6.6, or the like, either separately or in various combinations, depending upon the properties required in the batt and the conditions to which the belt will ultimately be subjected. For example, for high heat and hydrolysis resistance, coupled with improved wear resistance, a batt formed from a blend of individual fibers of nylon 6.6 and individual fibers of polyester is preferred. In addition to the polymeric materials mentioned hereinabove, other fiber materials can also be used, such as, for example, P.B.I., manufactured by Celanese Fibers Operations, or Kevlar or Nomex, both of which are manufactured by E. I. duPont de Nemours Company, Inc.

Batt **56** is preferably uniformly needled into and onto one surface of carrier **54**. Furthermore, it is preferred that the monofilament or monofilament-like yarns from which the spiral coils are formed have a diameter of less than 0.7 mm, preferably about 0.55 mm, in order to avoid excessive breakage of the needles during the course of the needling operation, and also to permit a tighter and more uniform interconnection between fibrous batt **56** and carrier **54** by virtue of greater engagement of batt fibers **58** with the surface portions of coil yarns **42**, **44**. The hinge yarns are preferably larger in diameter than the coil material in order to obtain the required thickness and stability in the carrier fabric. Preferred hinge yarn diameter can range from about 0.7 to about 0.9 mm.

After the batt has been needled so that a number of the batt fibers extend through the top surface of the carrier and into the interior thereof, some of the individual batt fibers can extend completely through the interior of the carrier to and through the bottom surface thereof. However, the fiber density at the bottom surface of the carrier is considerably smaller than the fiber density at the top surface, and those fibers that do extend outwardly from the bottom surface are relatively small in number and do not define a coherent batt on the bottom surface of the carrier. The needling process causes a number of the batt fibers to pass into the interior of the carrier and to interengage with interior portions of the coils that define the carrier. Thus, the batt does not merely contact the outer surface of the carrier, but a large number of the fibers that form the batt extend into and contact and engage with inner surfaces of the carrier to interconnect the batt to the carrier.

Preferably, the finished belt has a thickness that ranges from about 0.125 inches to about 0.375 inches, and preferably has a weight that ranges from about 6 to about 12 ounces per square foot. Additionally, the permeability of the belt is preferably from about 10 to about 200 cfm. As will be appreciated by those skilled in the art, the choice of batt weight and batt thickness will depend upon the ultimate properties required in the finished belt, which in turn will depend upon the particular end use to which the belt is put.

The wear resistance of the resulting belt having a batt and spiral coil carrier structure can be improved by subjecting the belt to a resin treatment by either lick roll application or by passing it through an acrylic-based resin solution, for example, Rhom and Haas Rhoplex No. TR407. Such resin treatment also prevents undesirable fluffing of the batt, and does not reduce or otherwise adversely affect the surface frictional properties of the belt.

It has been found that the application of a silicone based coating to the resulting belt serves as a release agent to reduce the buildup of contaminants on the belt structure. An example of such a silicone-based material is Sandoperm F.E., manufactured by Sandoz Inc. However, careful control must be maintained over the silicone treatment in order to maintain the desired frictional properties of the surface of the batt while also maintaining the desired contaminant release properties.

The spiral coil carrier hereinbefore described can also be the carrier **54** that serves as the base for a corrugator belt **60** that includes a yieldable, porous foam surface **62**, as well as a foam interior **64**. Such a belt is shown in fragmentary cross-section in FIG. **7**. In producing a foam-filled belt in accordance with the invention, a mechanical foam is provided by introducing a liquid resin and compressed air into a mixing head and blending the resin and air by means of a rotor to provide an elastomeric foam of requisite cell size, the resultant foam being spread onto the surface of the spiral coil carrier. The foam passes into the fabric and excess foam is removed by moving a doctor blade across the surface

of the carrier, the spacing of the blade in relation to the surface being such as to provide the desired foam thickness on the outer surface of the carrier.

An apparatus for providing a corrugator belt having a foam outer surface is illustrated schematically in FIG. 8, and involves the support of a spiral coil carrier **70**, which is to be filled with foam, in endless form on spaced carrier rolls (not shown) and the application of a foam mix, as prepared in a foaming unit **72** from ingredients delivered thereto directly or from a resin container **74**, to the upper surface of carrier **70** immediately in advance of a doctor blade **76** by delivery nozzles **78**, each of which can reciprocate transversely between the middle of the carrier to a respective lateral edge thereof.

Delivery of the mix through the nozzles **78** builds up a quantity of foam mix against the doctor blade **76** at the upstream side thereof, and the mix passes into the interior of carrier **70** by the combined effects of gravity and of the doctor blade. Doctor blade **76** is spaced from the upper surface of fabric **70** to provide the desired surface thickness of foam.

Subsequent to the application of the foam mix, the mix is subjected to heat from an infra-red heater **80** beneath which the foamed-cover carrier is passed.

Multiple passes of the carrier beneath the doctor blade may be preferred in some instances to ensure complete filling of the voids within the carrier, as too may the provision of a stripper blade (not shown) at the underside of the carrier for the removal of any excess foam material that passes through the carrier. The foam mix is subjected to heat subsequent to application of the requisite amount of foam mix, whether by a single or by multiple passes of the carrier under the doctor blade.

Although it is preferred to use a mechanical foam, it may be possible in some instances to use a chemical foam, the purpose of the foam being simply to provide a foam interior and a continuous foam surface on the spiral coil carrier at the sheet-contacting side thereof. The foam will provide a requisite level of permeability and frictional properties.

In applying the foam to the spiral coil carrier, the foam can be applied in two layers, the first layer filling the internal structure of the carrier. A second application of the same foam is then applied to the surface of the previously filled spiral base fabric, and it is applied while the first application is still tacky, thereby promoting adhesion between the two foam applications. The second foam application can be applied to a uniform thickness that provides an outer foam surface that ranges in thickness from about 1/32 to $\frac{1}{4}$ inch, preferably from about 1/32 to about $\frac{1}{8}$ inch. The larger the thickness of the foam that extends beyond the upper surface of the carrier, the more likely the foam is to break down, particularly if it is of a very porous open cell structure.

The foam applied to the surface of the carrier provides a soft surface on a very stable base material, and permeability ranging from about 5 to about 150 cfm can be obtained while maintaining the friction of the foam resin surface sufficiently high to carry the corrugated board through the machine.

The weight of the resulting belt in the form of a spiral coil carrier with a foam coating is relatively low, and can preferably range from about 5 to about 8 ounces per square foot because of the lightweight nature of the foam coating. As was the case with the batt-type belt hereinbefore described, a silicone-based release treatment can also be applied to the finished belt in order to reduce build-up of contaminants.

In the case of spiral coil carriers, it has been found that the foam material bonds directly to the monofilaments and provides a continuous layer that extends between and across adjacent coils, the foam thus providing a uniformity of permeability not attainable by the mere insertion of fillers into the individual coils. Furthermore, the desired cell size of the foam layer, advantageously being within the range of between 0.05 mm to 0.50 mm, militates against the accumulation of debris.

Because the density of the foam, and hence the cell size thereof, can be varied at will, not only can cell size be selected having regard to the average size of combined corrugator board contaminants, and particularly glues and fibrous debris, but a cell size can also be selected that is appropriate to the permeability characteristics required of the foam filled and coated carrier.

The continuity of the surface does of itself minimize creation of debris at the belt surface, but any such debris as does exist will lie on such surface and can easily be removed by washing.

Although it is preferred that the foam be applied to the surface of the carrier and be introduced into the interior of the carrier by the combined action of gravity and the doctor blade, it may be preferred, in some instances, to inject foam into the space within the coils, such foam flowing between such spaces to dislodge air present within the carrier.

A typical foam for use in the context of the invention can include an acrylic dispersion, or any other suitable material, which is foamed by the introduction of air into the compounded blend by mechanical action. Additives, for example thickeners and surfactants, can be dispersed in the polymer mix prior to coating, the relative quantities of such additives being selected so as to give a foam mix having properties appropriate to the ready application of the mix to the substrate and to the required characteristics of the foam both in and on the carrier. Further, the air delivery rate and blending action can be adjusted during foam generation so that a foam of the required density is obtained.

An anionic, plasticizer-free aqueous dispersion of a cross-linkable acrylic polymer, for example Rhoplex TR77 (Rohm and Haas Company), has been found suitable for use in the context of the invention, particularly when combined with a stiffer acrylic polymer, for example Rhoplex TR407 (Rohm and Haas Company). ASE-60 (Rohm and Haas Company) can be used to increase the viscosity of the mix on addition of ammonium stearate. Ammonia may be used to modify the pH and resultant viscosity of the mix. Surfactants such as sodium sulphur sucsyamate and ammonium stearate are used to impart stability, to modify the pH and to refine the wet foam.

Open cell foams for application in the context of the invention have a cell size lying within the range of about 0.05 to 0.50 mm. diameter, the range of cell sizes present in a particular foam when set being determined by:

(i) base material and additives used;
(ii) foam density; and
(iii) nature of the substrate.

A lower density foam contains an average greater diameter cell size than a higher density foam, and a standard mix of foam material foamed to different densities and applied to the same carrier will give a resultant

belt permeability which varies according to the average cell size in the spaces within the carrier structure.

The following table shows the variation in permeability with variations of average cell size of a spiral coil carrier (having an initial permeability of 950 cfm or 15000 m^3), including a plurality of interdigitated coils of polyester monofilament of 0.55 mm. diameter, the carrier having internal dimensions of 5.04 × 1.09 mm. after heat setting, the coils being joined by hinge wires:

Average Cell Size	Permeability		
(mm)	cfm	m^3	% reduction in permeability
0.078	72	1,150	92
0.20	99	1,580	89
0.25	126	2,020	87
0.32	191	3,060	80

cfm — cubic ft per square foot per min at ½" water guage differential pressure.
m^3 — cubic meters per square meter per hour at 10 mm water guage.

Corrugator belts having the structures described hereinabove provide distinct improvements over existing corrugator belts. In particular, the use of a spiral coil carrier provides exceptional cross-machine rigidity, to keep the edges of the belt from drooping into contact with the heater unit when a narrow width board is being run, thereby avoiding the belt edge sag and rubbing of the edges of the belt along the heater unit that frequently occurs with conventional corrugator belts not formed from a spiral coil carrier. Additionally, the use of the spiral coil carrier permits the formation of an endless belt without any change in belt characteristics at the seam, and thereby avoids the need for heavy, metal seaming hooks that cause seam marking when non-spiral-coil carriers are used for such belts. Furthermore, the spiral coil carrier structure, being inherently stable, provides improved belt dimensional stability, and permits belts to be formed having stretch of less than about 1% at loads in excess of 50 pounds per linear inch. Because the spiral coil carrier undergoes a finishing process that includes subjecting it to temperatures well in excess of the temperature that the belt will see in actual use, the carrier will not shrink in width at temperatures of up to about 350° F., which are the maximum temperatures to which the heater plates in a corrugator machine can be set. Finally, the application of yieldable, porous foam and batt materials as hereinbefore described provide the desired frictional characteristics of the belt to cause it to operate effectively on a corrugating machine.

As earlier noted, the belts hereinabove described can be used in the wet press and dryer sections of papermaking machines. The use of spiral coil carriers in wet press felts offers a base fabric of excellent stability in the way of resistance to stretching and narrowing. The application of a needled batt or foam surface will give the necessary cushioning required in such felts while the open base of the spiral fabric allows for easy drainage of water.

In the dryer section of a papermaking machine, the use of spiral coil carriers provides for soft face, thinner fabrics having a range of permeabilities, thereby allowing moisture to escape more easily through the fabric as vapor from the wet paper sheet in the heat zone. As for wet felts, the spiral coil carriers also offer excellent fabric stability.

Although the present invention has been illustrated and described in the context of specific embodiments, it will be appreciated by those skilled in the art that various changes and modifications can be made without departing from the spirit of the present invention. It is therefore intended to cover in the appended claims all such changes and modifications that fall within the scope of the present invention.

What is claimed is:

1. A corrugator belt for contacting and conveying sheets of material and having an upper surface and a lower surface, said belt comprising:

(a) a plurality of hinge yarns, all of said hinge yarns extending in a common direction;

(b) a plurality of spiral coils disposed in a common plane in a side-by-side relationship, each of said coils extending in said common direction, adjacent coils of said spirals intermeshed and held together in intermeshing relationship by at least one of said hinge yarns to define a carrier having spaced upper and lower surfaces, said spiral coils having an elongated cross section; and

(c) a yieldable, porous material extending into said spiral coils and non-adhesively secured to interior surfaces of said spiral coils, said porous material defining a layer extending uniformly outwardly of and beyond an outer surface of said carrier to provide a soft, sheet-contacting surface on said carrier.

2. A belt in accordance with claim **1**, wherein said sheet-contacting surface includes a yieldable, porous, coherent batt of synthetic fibers needled into and onto one surface of said carrier.

3. A belt in accordance with claim **2**, wherein said spiral coils are formed from a yarn having a substantially circular cross section and having a diameter of less than about 0.7 mm.

4. A belt in accordance with claim **3**, wherein the yarn has a diameter of about 0.55 mm.

5. A belt in accordance with claim **2**, wherein said batt is formed from fibers selected from the group consisting of polyester, polypropylene, nylon 6, and nylon 6.6.

6. A belt in accordance with claim **5**, wherein said batt is formed from a blend of individual fibers of nylon 6.6 and individual fibers of polyester.

7. A belt in accordance with claim **2**, wherein said batt fibers include a resin coating.

8. A belt in accordance with claim **7**, wherein said coating is an acrylic resin.

9. A belt in accordance with claim **2**, wherein said batt fibers include a silicone-based release coating.

10. A belt in accordance with claim **1**, wherein said hinge yarns have a substantially circular cross-section and have a diameter of from about 0.7 mm to about 0.9 mm.

11. A belt in accordance with claim **1**, wherein said hinge yarns have a non-circular cross section and include a major axis and a minor axis, the major axis lying parallel to the belt surface, and wherein said minor and major axes of each hinge yarn are in the ratio of from about 1:1.1 to about 1:6.

12. A belt in accordance with claim **11**, wherein said ratio is in the range of from about 1:1.1 to about 1:2.5.

13. A belt in accordance with claim **1**, wherein said belt has a weight from about 6 to about 12 ounces per square foot.

14. A belt in accordance with claim **1**, wherein said belt has a thickness of from about 0.125 to about 0.375 inches.

15. A belt in accordance with claim 1, wherein said belt has a permeability of from about 10 to about 200 cfm.

16. A belt for contacting and conveying sheets of material and having an upper surface and a lower surface, said belt comprising:

(a) a plurality of hinge yarns, all of said hinge yarns extending in a common direction;

(b) a plurality of spiral coils disposed in a common plane in a side-by-side relationship, each of said coils extending in said common direction, adjacent coils of said spirals intermeshed and held together in intermeshing relationship by at least one of said hinge yarns to define a carrier having spaced upper and lower surfaces, said spiral coils having an elongated cross section; and

(c) a yieldable, porous material secured to interior surfaces of said spiral coils and extending uniformly outwardly of an outer surface thereof to provide a soft, sheet-contacting surface on said carrier, wherein said porous material includes an open cell foam within said carrier and extending outwardly beyond one surface thereof.

17. A belt in accordance with claim 16, wherein said foam includes a first foam layer that substantially fills the interior of said carrier, and a second foam layer applied to the exterior of said carrier and adherently bonded to said first foam layer.

18. A belt in accordance with claim 17, wherein said second foam layer extends outwardly beyond said one surface of said carrier at a thickness of from about 1/32 to about $\frac{1}{4}$ inch.

19. A belt in accordance with claim 17, wherein said second foam layer extends outwardly beyond said one surface of said carrier at a thickness of from about 1/32 to about $\frac{1}{8}$ inch.

20. A belt in accordance with claim 16, wherein said foam is selected from the group consisting of acrylic, acrylate and acrylonitrile dispersions.

21. A belt in accordance with claim 20, wherein said belt has a permeability of from about 5 to about 150 cfm.

22. A belt in accordance with claim 16, wherein said open cell foam has a cell size of from about 0.05 to about 0.50 mm.

23. A belt in accordance with claim 16, wherein said belt has a weight of from about 4 to about 8 ounces per square foot.

24. A belt in accordance with claim 16, wherein said foam includes a silicone-based release coating.

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(71) Applicant *(for all designated States except US)*: ASTEN, INC. [US/US]; 4399 Corporate Road, P.O. Box 118001, Charleston, SC 29423-8001 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: BOWEN, David, Jr. [US/US]; 9349 Old A1A, St. Augustine, FL 32088 (US).

(74) Agents: VOLPE, Anthony, S. et al.; Volpe and Koenig, P.C., 400 One Penn Center, 1617 John F. Kennedy Boulevard, Philadelphia, PA 19103 (US).

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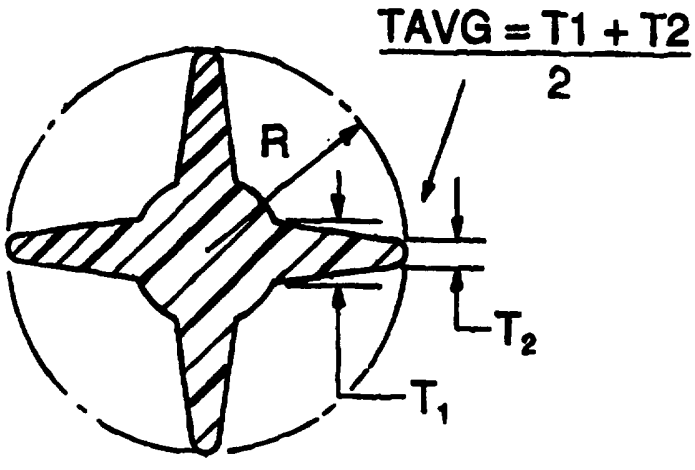
(54) Title: PAPERMAKER'S FABRIC CONTAINING FIBERS WITH FINS HAVING A REDUCED CROSS-SECTIONAL AREA WITHIN THE FIN

(57) Abstract

A woven or spiral papermaker's or industrial fabric characterized in that at least a portion of its fibers have two or more thin fins, some of which fins are designed for ease of flexing or compression by incorporation of a reduced cross section "hinge" area or by a variation in thickness of more than 20 per cent as a function of distance from the fiber center. This will achieve interlocking between crossing fibers at significantly reduced "beat-up" force in weaving or less shrinkage force in spiral fabrics. By remaining extended where there is no fiber to fiber crushing action, the fins fill the fabric interstitial spaces and control fabric porosity. Significant cost and quality benefits are achieved.



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PAPERMAKER'S FABRIC CONTAINING FIBERS WITH FINS HAVING A REDUCED CROSS SECTIONAL AREA WITHIN THE FIN.

BACKGROUND OF THE INVENTION

In the preparation of paper, woven and spiral fabric belts are utilized to support the cellulosic pulp fibers as they are moved through the papermaking process and converted from a thin slurry into finished paper. It has been found that mechanical stability and permeability control of these belts is critical to the production of consistent, high quality paper. As paper machine speeds have increased, fabrics designed for use in the dryer sections of papermaking machines have had their targeted permeability reduced from 500 cubic feet per minute per square foot with a pressure differential of one half inch of water to 100 or less. There has also been a trend toward use of thinner fabric constructions to minimize differential forces on the paper as it passes over and under the belts in certain process steps. For woven fabrics, these two papermaker's fabric requirements are in conflict since the common way to reduce permeability is to increase size of the weft yarn or the number of picks per inch, both of which can result in increased fabric thickness. Increased beat-up forces are required to force wefts into these fabric designs for the desired low permeability products. These high beat-up forces lead to fiber and machine damage. For spiral fabrics, ribbon and X shapes yarns have been developed to insert into the open areas of the fabric design. These designs give satisfactory permeability results, but require very careful size control

and relatively high force levels for insertion into the fabric and prevention of fabric distortion.

DESCRIPTION OF THE PRIOR ART

As the demand for papermaker's and industrial fabrics has moved toward thinner, reduced permeability fabrics, suppliers of such fabrics have shifted from use of round monofilament wefts to use of twisted and cabled yarn constructions which have more capability to conform into the interstitial spaces formed at the crossings of warp and weft yarns. This switch has been moderately successful in regards to production of lower permeability and improved fabric stability. Some negative results of this practice are that the smaller monofilaments used in cabled constructions are more easily damaged by severe environmental exposure and that cabled yarns tend to become contaminated with process "tars" faster than true monofilament wefts. The extra handling and processing stages required to produce these twisted and cabled yarns also makes their cost significantly higher than that of monofilament.

There has also been a shift toward use of more ribbon-like warp yarns. These warps give improved paper contact and decrease the number of interstices, thus resulting in reduced fabric permeability. Reduction in the number of interstices has had a negative impact on fabric stability since interactions at fiber intersections lock the fabric together. Wear due to the thin profile of ribbon warp yarns

has also been a drawback to more widespread use of this concept.

Fabric stability is improved by increasing the interaction between warp and weft yarns. As each weft pick is inserted into the fabric, it is beaten against the warp so that the warp takes on a sinusoidal crimp. The weft remains relatively flat, and the distortion created at the mechanical intersection of the warp and weft contributes significantly to fabric stability. Current methods of improving stability include increasing pick count, use of multifilament warps and/or wefts, use of cabled weft yarns, and application of resinous fabric treatments. Each of the listed methods is acceptable in selected areas, but all carry a cost or performance penalty which prevent them from being generally acceptable.

In patent #5,097,872, Laine et al. teach the use of an X shaped fiber to achieve improved fabric stability, but their application requires almost complete flattening of the fiber on one side by bending forces and the design use described would not contribute to improved permeability control. There is no mention or inferred concept for hinged or variable cross sections in the arms of the X. In contrast, the current patent application requires that some of the finned extensions have a decreased cross sectional area along their length to make them easier to bend and distort during weaving. Forces due to both bending and fiber compression during "beat-up" are present in the weaving process. Where bending or contact

forces are not present, the fins will remain erect to block fabric interstitial spaces.

In patent #4,633,596, Josef teaches the use of warp fibers having a center thinner than the edges and which improves fabric dimensional stability by minor distortion at warp and weft crossings. This is in marked contrast to the use of finned and hinged weft and stuffer fibers which run in the cross machine direction in woven and spiral fabrics. Designs shown would not crush or easily distort during weaving. Josef also makes no claim or mention related to spiral fabrics. The drawings and discussion of Josef's patent tend to lead toward production of fabric designs targeted toward high permeability fabrics.

In patent #5,361,808, Bowen teaches the use of finned weft fibers which deflect at the intersections of the warp and weft, but which fins remain extended to block fabric interstitial space where not mechanically contacted by other fibers. Fin length and use of plasticizers are the mechanisms described to promote flexibility.

In patent #5,364,692, Bowen and Smith teach the use of T, X, or V shaped stuffer yarns to reduce permeability of spiral fabrics No special shape or mechanism to produce "arms" with reduced stiffness to bending forces is disclosed. This application contrasts significantly by specifying that the arms or fins of the shaped fiber contain a reduced cross sectional area designed to promote bending at force levels one half or less of that which would be required if the fin had a uniform cross section.

In patent #4,381,612, Shank describes spiral fabrics containing one or more stuffer filaments, but describes no technology or intent to design the stuffer filaments for ease of distortion.

SUMMARY OF THE INVENTION

The present invention provides thin, stable, controlled permeability papermaking or industrial fabrics, especially dryer fabrics, with the capability of being easily produced on standard industrial looms or spiral fabric lines. Special advantage is achieved in manufacture of fabric designs with permeability targets of less than 175 cubic feet per minute per square foot with a pressure differential of one half inch of water. Fabrics utilizing this invention also have improved dimensional stability over that achieved by the now common use of twisted and plied monofilament wefts in weaving or simple unshaped fins in weaving and spiral fabric production.

Specifically, this invention provides, in a papermaker's fabric, the improvement wherein some or all of the yarns contain filaments designed to flex and distort at reduced fiber to fiber force levels by having two or more finned extensions, some of which extensions are characterized by incorporating a reduced cross section "hinge" area and/or a variable thickness from the center outward. For the purpose of this discussion, a yarn may consist of one or more filaments, but the preferred embodiment of this invention will be a monofilament. A reduction in cross sectional area of 20 per cent or more anywhere along the fin except for the normal

radius at the fin terminus will be considered to meet the reduced cross section specification. Since the force required to obtain deformation is proportional to the cube of fin thickness or width, a reduction of 20 percent in fin thickness results in approximately a fifty percent reduction in "beat up" force required to mold the yarn into the fabric. Advantage of the lower mechanical stress requirement can be taken to increase interlocking of the fibers while simultaneously reducing damage due to warp tensions and "beat up" forces. In production of spiral fabrics, increased flexibility of these shaped or hinged fins significantly reduce the forces required for insertion into the open segments of the design. When the spiral fabric shrinks in heatsetting, the flexible fin designs are interlocked into the fabric with minimum distortion of the fabric surface while simultaneously providing the desired reduced air permeability. For most fabric products, the best design will be a monofilament yarn between 400 and 3000 denier, but use of multifilaments with uniform or mixed cross section designs is possible. Multiple filament yarn designs can be utilized to achieve specific fabric properties including permeability, thickness and stability. The filaments which make up these multifilament yarns will have a denier of more than 100, preferably 200 to 1500, and when combined into multifilaments will usually have low twist levels. These yarns can be utilized in the warp, weft or filling of industrial fabrics. Any appropriate polymer type and additive package used to produce yarns for papermaker's or industrial fabrics may be

used. Significant economic benefits are realized due to reduced denier of these yarns over other yarns previously used for this service.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional perspective view of the preferred embodiment for a filament having fins with a radially reducing cross sectional area.

FIG. 2 is a cross sectional perspective view of the preferred embodiment for a filament having the "hinged" fin concept of the invention.

FIG. 3 shows a fin with stepped area reduction while FIG. 4 shows a combination of fins with and without reduced area cross sections.

FIGS. 5, 6, and 7 show fins with mid hinge, curved area reduction and straight area reduction respectively.

FIGS. 8 and 9 show distortion of the hinged and reducing cross section fins as they are woven into the fabric.

FIG. 10 shows a special "ball" fin design.

FIGS. 11 and 12 show two and eight fin fiber designs to indicate some of the variety which can be produced by this concept.

FIGS. 13, 14 and 15 show spiral fabric designs demonstrating the hinged fin concept.

FIGS. 16 and 17 show arched and crescent filament designs which would be especially useful in spiral fabrics, but which also could be used in woven products.

On FIGS. 1, 2 and 4, the fin thickness at T1 and T2 are those measurements where the reduction in thickness ratio would typically be calculated. If T2 divided by T1 is less than 0.8, the fin will fall within the specification of this invention. It is specifically pointed out that the normal rounding or radius effect at the end of such a fin is not considered to be a "manufactured" reduction except for a design such as that of the "ball" fin. For a special case such as this, the maximum radius will be used as the denominator in the calculation of fin cross sectional area reduction.

DETAILED DESCRIPTION OF THE INVENTION

The finned filaments used in the present invention can be prepared from a variety of thermoplastic materials. Polyethylene terphthalate, polyphenylene sulphide and 1,4-polydicyclohexanol terphthalate are currently widely used but not the only materials which might be chosen. In order to obtain the desired fin flexibility, these new yarn designs often require addition of polymer specific plasticizing agents during the filament extrusion process. Use of standard additive recipes which may include heat and hydrolysis stabilizers, contaminant release agents, and other such processing aids common to production of papermaker's yarns is considered as standard.

Modifications to customary techniques for filament production are required in order to achieve acceptable filament smoothness and uniformity for these new yarn shapes.

This is caused by the overall filament width to fin thickness ratio necessary to obtain flexibility without fracture. This is where the concept of hinged or variable cross section fins excel over prior art. The taper or hinge results in a more flexible fin which reduces the need for excessive plasticizing agents or extra long fins. If the shape factor can be characterized by the ratio of the overall filament diameter divided by the average fin thickness, then filaments with a shape factor of from 3.5 to 20 can be used for these fabrics. The average fin thickness can be calculated by standard mathematical techniques. One such example is given for FIG. 1 where TAVG =(T1 + T2)/2. R divided by TAVG is the shape factor considered for the purpose of this invention. It is desirable to have the lowest possible shape factor in order to reduce surface to volume ratio of the fiber and thereby decrease damage due to diffusion controlled degradation processes. For reasons of practicality, the number of fins will range from two to twelve.

Fabrics are woven from these new variable fin cross section yarns in the same manner as with round, ribbon or twisted and plied fiber constructions currently in common use. In **Figures 8** and 9, warp yarn is shown as 1 and weft yarn as 2. Bending of the weft fins by the warp during weaving is shown. **Figure 8** shows a fabric cross section showing use of all hinged finned weft yarns. The important concept here is that the deformable fins easily conform to fill the available volume between the warp yarns and by so doing, lock the woven structure together and significantly reduce the openness of

the fabric. Wefts containing less than four finned extensions are often found to be sensitive to the slight twist inserted into the weft as it is supplied to the process over the top of supply bobbins. This twist insertion results in small surface and permeability irregularities which can be significant in critical product areas. The X design has been found to very closely match the rectangular or diamond open area common to most weave patterns and is also a very good compromise for economy of material and ease of water removal during spinning. Use of more than four lobes reduces the importance of weft yarn orientation in the fabric, but at a cost of more monofilament extrusion difficulty. The physical size of the filament or fiber design will be determined by the cross sectional shape chosen, the flexibility designed into the fins, the target fabric thickness and size of the chosen companion warp or weft. **Figure 9** shows a fabric design similar to **Figure 8**, but containing a weft yarn with a gradually reducing cross reaction rather than hinged weft yarns. The formation of large numbers of small fin distortions per inch of width during fabric production provides significant lateral stability and rigidity to products containing these flexibly finned fibers. Filaments of this type can be used in the warp, but their advantages are currently more easily achieved in weft or stuffer yarn applications. Warp fibers with fins located to one side of the yarn so that the fins would be turned toward the interior of the woven fabric would be one example of a design which would be suitable for this patent concept.

Figure 13 shows a hinged stuffer yarn inserted into the formerly open area of a spiral fabric design. Size of the yarn is carefully controlled so that it may be easily inserted into the fabric open areas prior to heatsetting. Figures 14 and 15 show preferred embodiments of the concept for spiral fabrics. A crescent shaped stuffer yarn has been inserted into the open area of the fabric design and has been compressed into the upper and lower surfaces during heatsetting where shrinkage of the spirals under tension flattens the fabric, distorts the fins and locks the fabric together. If the fins are easily distorted, the fabric surface will remain smooth and flat. Permeability control may be achieved by inserting these special stuffer yarns into selected open areas or for another example, by alternating between yarns of this invention and other yarn types. For economy of production and material, the use of arched and crescent shaped designs with hinge areas are the preferred embodiment of the invention for spiral products.

In summary, the fibers of the invention will preferably be monofilaments between 400 and 3000 denier, have two to twelve finlike extensions, some of which extensions have variable cross sectional area designed to promote bending at reduced force relative to the force which would have been required if the fin cross section were uniform. In order to make this force reduction significant, design criteria have been chosen to allow for a 50 per cent force decrease by having a cross sectional width reduction of more than 20 per cent. Multifilament fiber designs can be used, with the

finned filaments of such designs having a denier of between 200 and 1500 and some of which filaments contain variable area fins designed to promote bending. The fibers can be used in either the warp, weft or filling of papermaker's or industrial fabrics which can be either woven or spiral designs.

WHAT IS CLAIMED IS:

1. A papermaker's fabric of interconnected monofilament yarns wherein selected yarns have at least two fins which include within their fin profile cross section a reduced cross sectional area of at least 20 percent.

AMENDED CLAIMS

[received by the International Bureau on 25 March 1996 (25.03.96); original claim 1 amended; new claims 2-15 added; (3 pages)]

1. A papermaking fabric of a type having shaped monofilament yarns, characterized by selected yarns having at least two fins which include reduced cross sectional areas of 20% or more so that the bending force required to deform a fin with the reduced cross sectional area is no more than half of the bending force required to deform a fin of uniform cross sectional area.

2. A papermaking fabric according to claim 1, further characterized in that said fins are selectively shaped to further facilitate deformation of said monofilament yarn.

3. A papermaking fabric according to claims 1-2, further characterized in that said fabric is woven.

4. A papermaking fabric according to claims 1-3, further characterized in that said selected yarns are in a cross machine direction.

5. A papermaking fabric according to claims 1-2, further characterized in that said fabric is spiral construction.

6. A papermaking fabric according to claims 1-4, further characterized in that the selected yarns fill the available volume between warp yarns.

7. A papermaking fabric according to claims 1-6, further characterized in that each selected yarn has less than 13 fins.

8. A papermaking fabric according to claims 1-7, further characterized in that the fins are arched.

9. A papermaking fabric according to claims 1-7, further characterized in that the fins are crescent shaped.

10. A papermaking fabric according to claims 1-9, further characterized in that the fins are not symmetric.

11. A papermaking fabric according to claims 1-10, further characterized in that the selected yarns range from about 400 to about 3000 denier.

12. A papermaking fabric according to claims 1-10, further characterized in that the selected yarns have a denier in a range from about 200 to about 1500.

13. A papermaking fabric according to claims 1-12, further characterized in that a shape factor resultant, defined by an equation of R divided by TAVG, wherein R is the

overall filament diameter, and TAVG is the average fin thickness, ranges from about 3.5 to about 20.

14. A papermaking fabric according to claims 1-13, further characterized in that the selected fins are hinged.

15. A papermaking fabric according to claims 1-14, further characterized in that the selected yarns have "ball" fins.

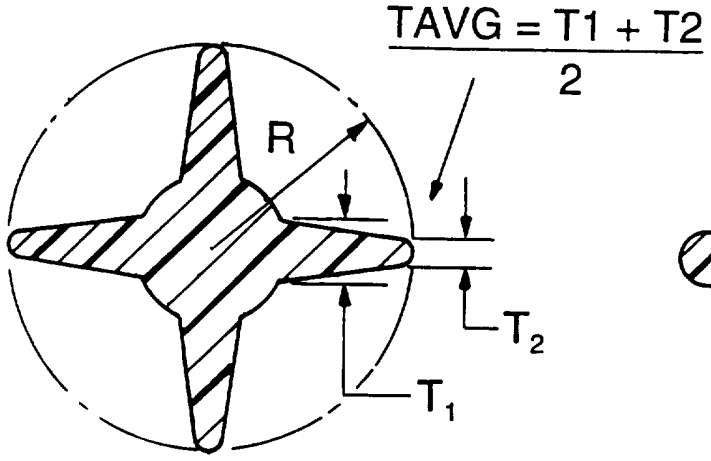

Fig. 1

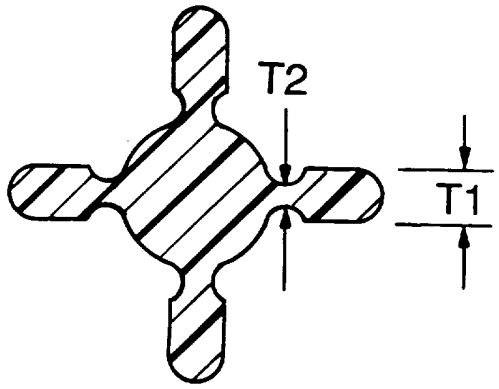

Fig. 2

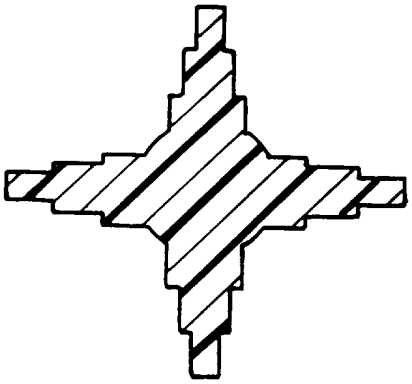

Fig. 3

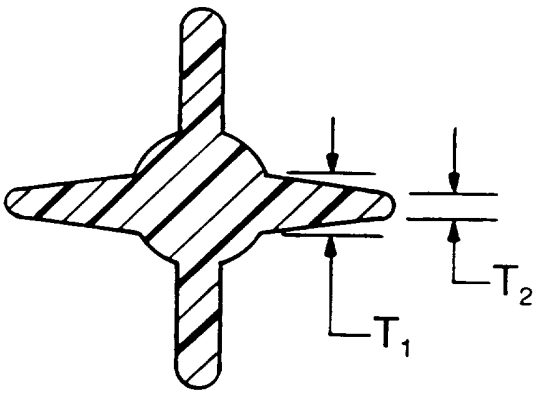

Fig. 4

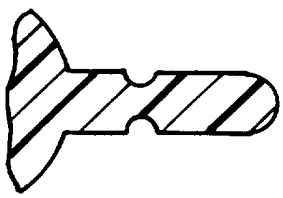

Fig. 5

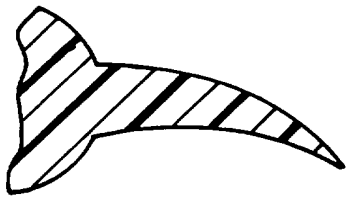

Fig. 6

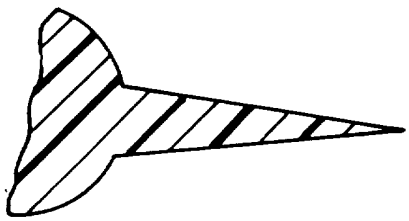

Fig. 7

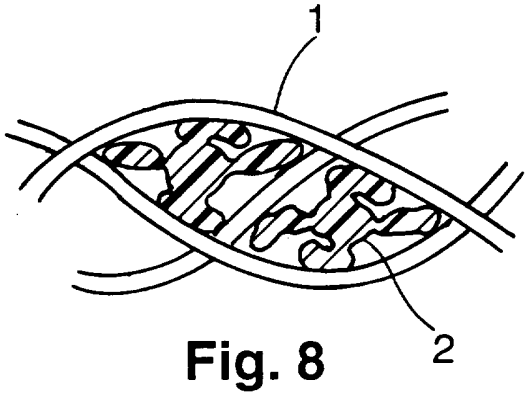

Fig. 8

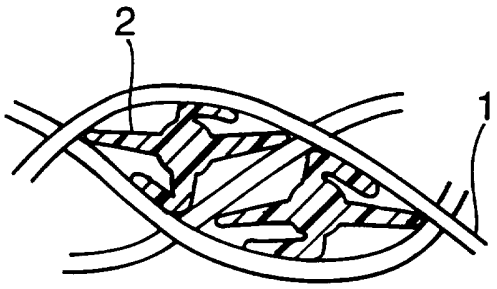

Fig. 9

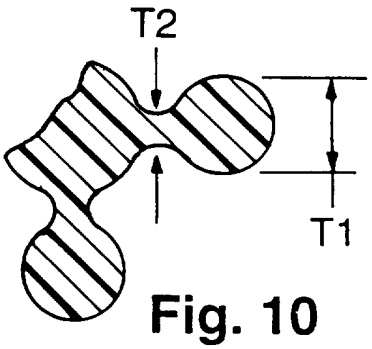

Fig. 10

Fig. 11

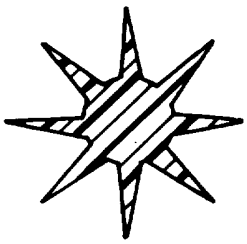

Fig. 12

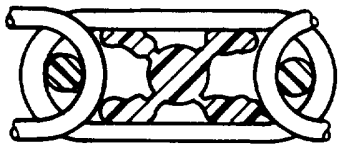

Fig. 13

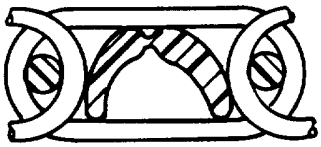

Fig. 14

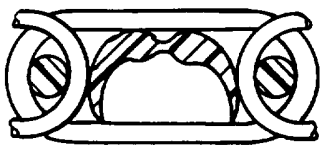

Fig. 15

Fig. 16

Fig. 17

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 95/11506

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D21F1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,A,40 31 608 (TAMFELT OY) 11 April 1991 see the whole document	1
X	GB,A,1 053 282 (THE LINDSAY WIRE WEAVING COMPANY) 30 December 1966 see the whole document	1
X	GB,A,2 216 914 (SCAPA GROUP) 18 October 1989 see the whole document	1
X	EP,A,0 190 732 (SITEG) 13 August 1986 see the whole document	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 December 1995	10.04.1996

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	De Rijck, F

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte[illegible]nal Application No
PC1/US 95/11506

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-4031608	11-04-91	CA-A- 2026750	10-04-91
		SE-A- 9002855	10-04-91
GB-A-1053282		NONE	
GB-A-2216914	18-10-89	NL-A- 8900595	02-10-89
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		JP-A- 61186596	20-08-86