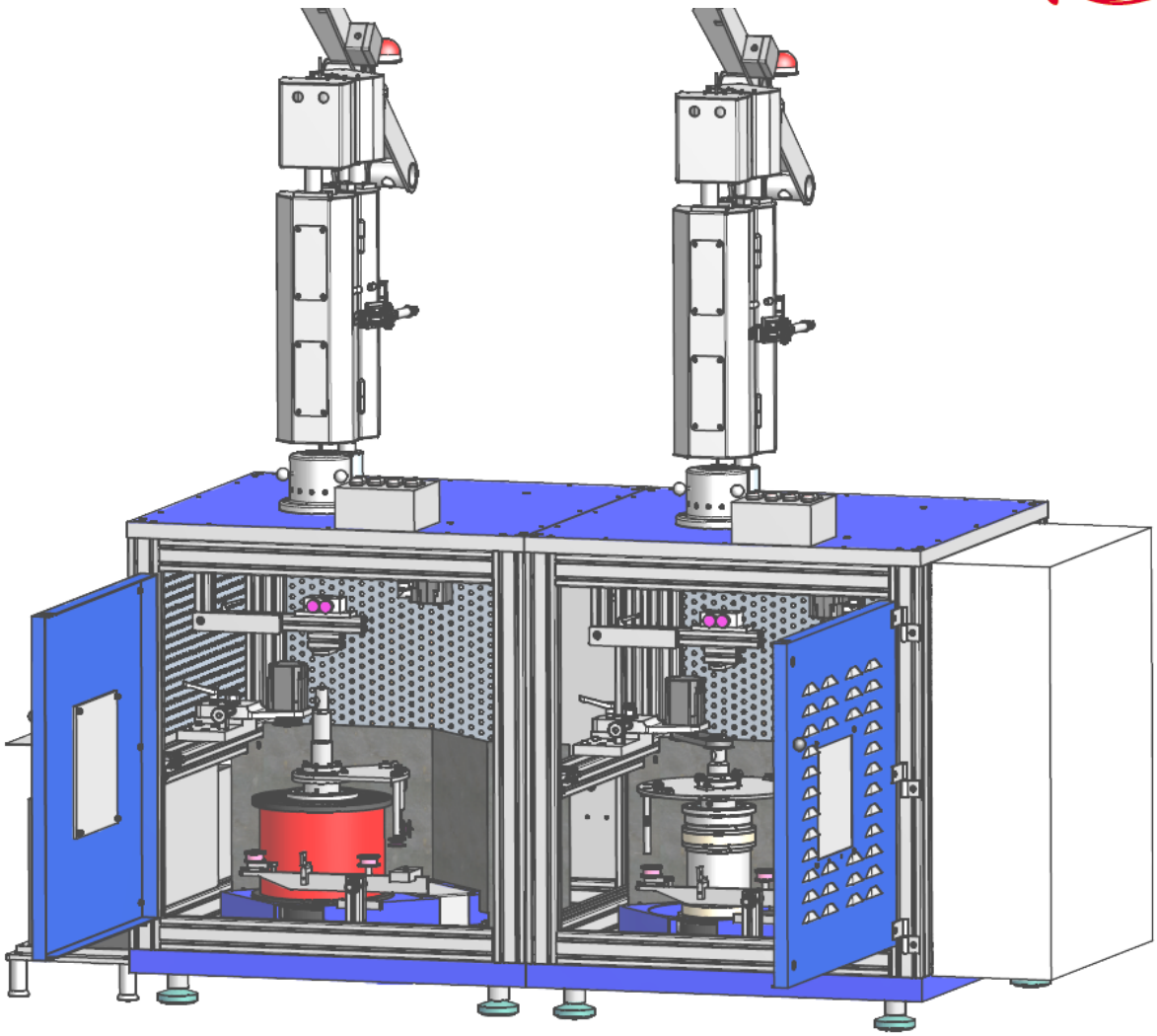
11 / 2015

M&A DIETERLE

MASCHINEN- & APPARATEBAU GMBH



Work specification spiral production

Work specification spiral production

Index

Work specification spiral production

1.0 Layout of the spiral machine

The spiral machine produces spirals for the manufacture of spiral sleeves.
Monofilaments made from various plastic types with various diameters/flat shapes are used as source material
(e.g. PET, PPS, PA, etc.).
Monofilaments will also be referred to in the following as ***thread*** or ***spiral wire***

Complete machine overview

Signal light

Guide arm for spirals

Cooling

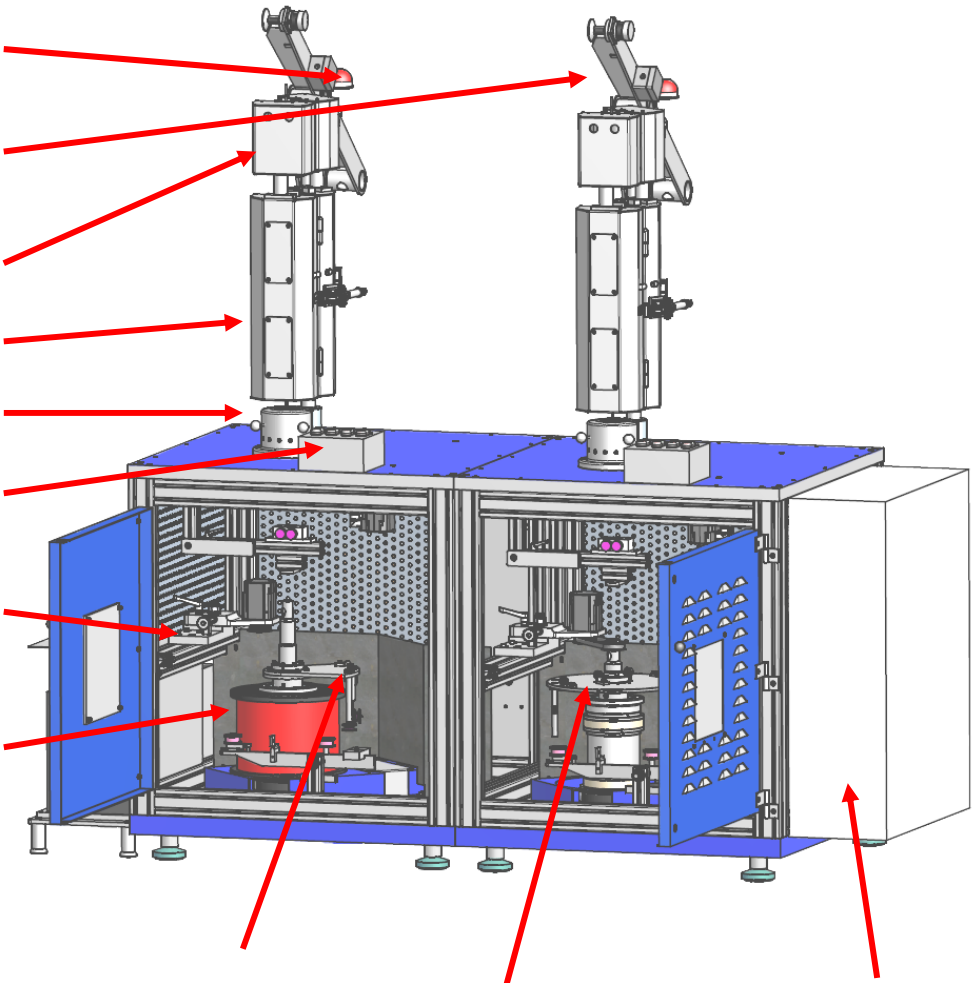
Heater

Winding head

Control buttons

Winding plate locking device

Monofilament coil



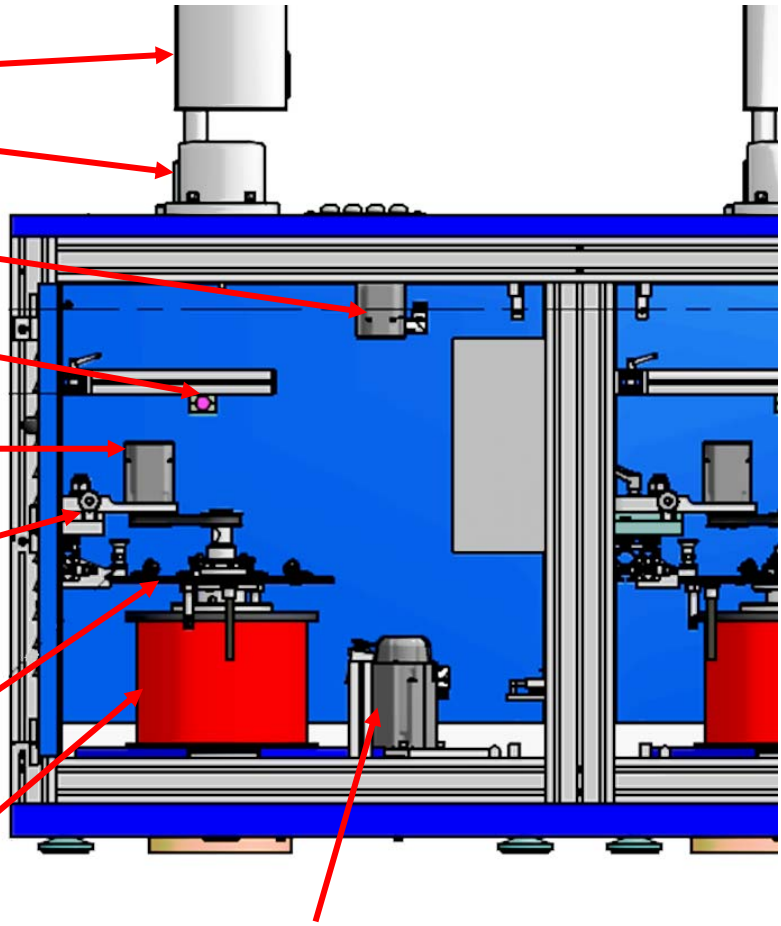
The winding plates are designed as interhcangeable parts:

Winding plate (for ***round*** monofilament)

Winding plate (for ***flat*** monofilament)

Control box

Interior view (left side of machine)

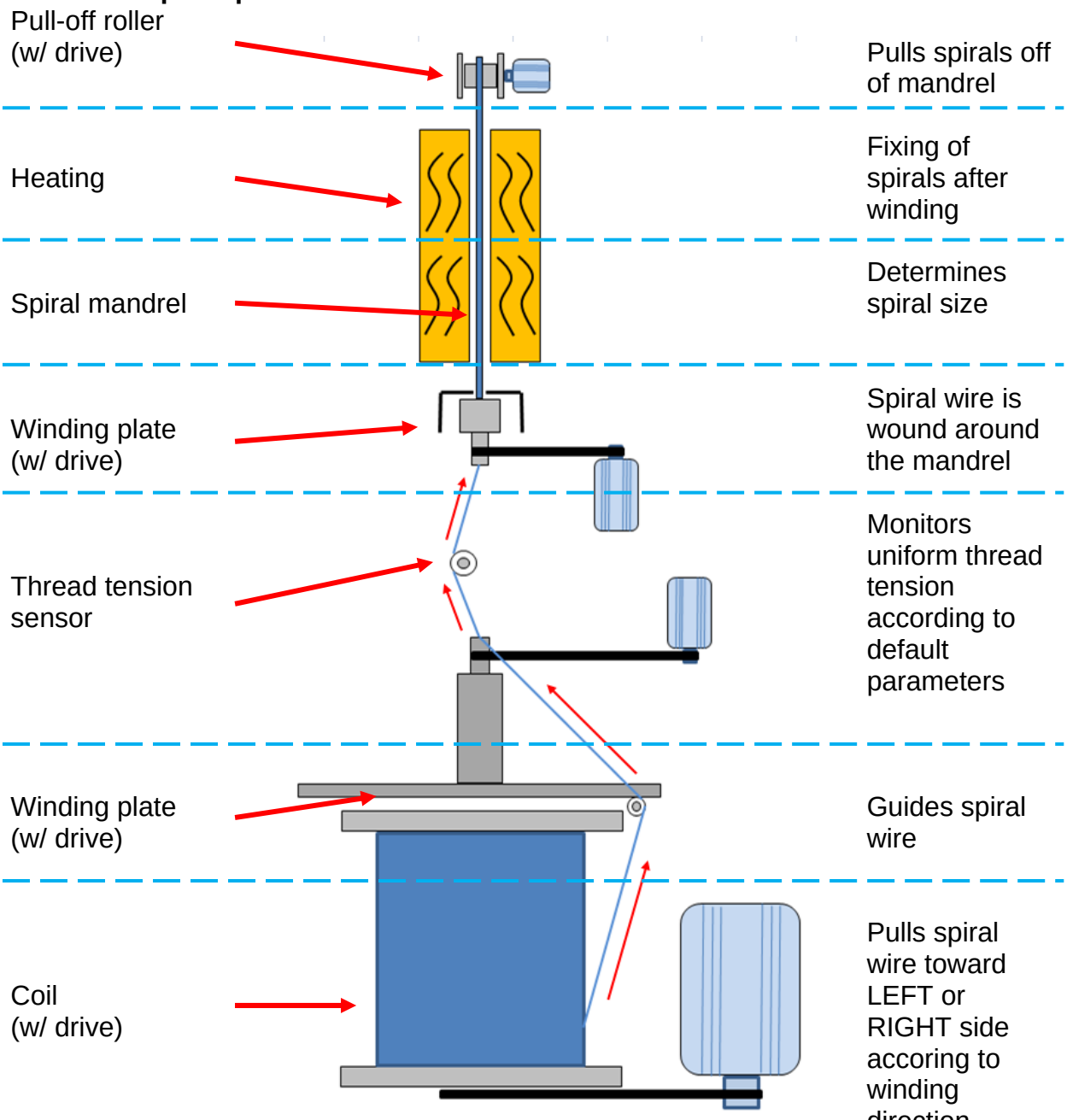


2.0 Functioning of the spiral machine and process flow

2.1 Overview and terms

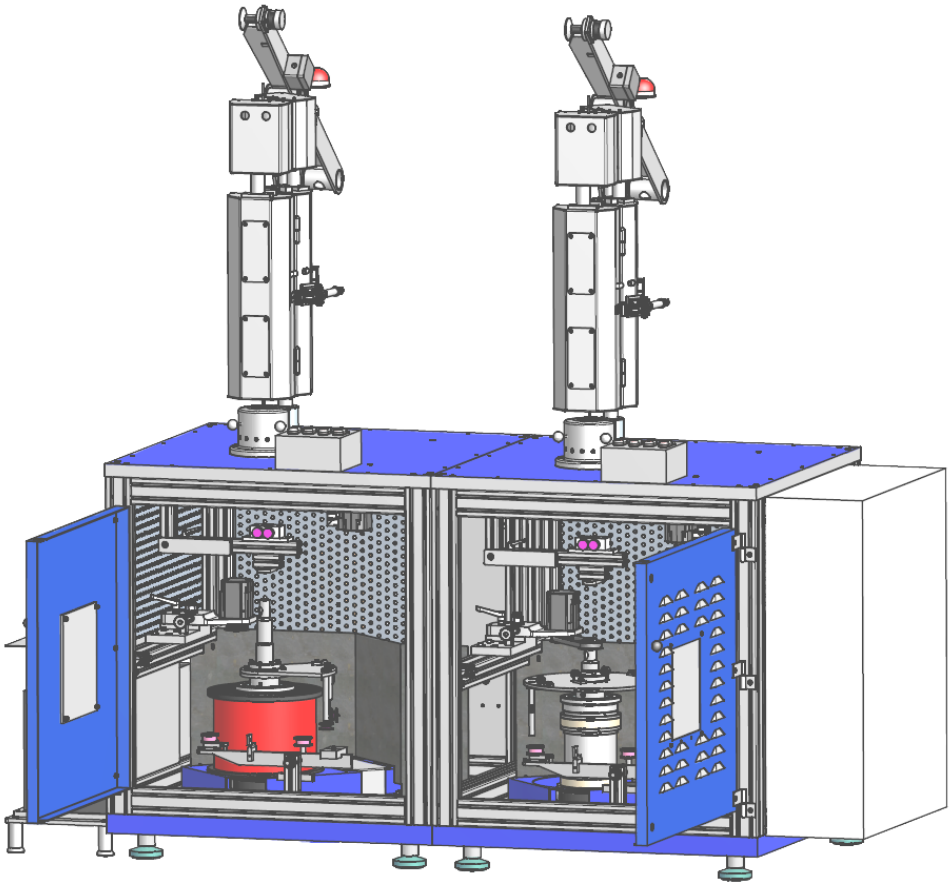
The explanations of the terms below are listed in the order of the monofilament/spiral flow i.e. from bottom to top.

Functional principle



Depiction of left side of machine

The spiral machine essentially consists of two independently operating spindles, allowing for the production of monofilament spirals with round and rectangular cross-sections – spirals that are simultaneously wound to the left and right



High performance spiral machine
with independently operating right and left spindles

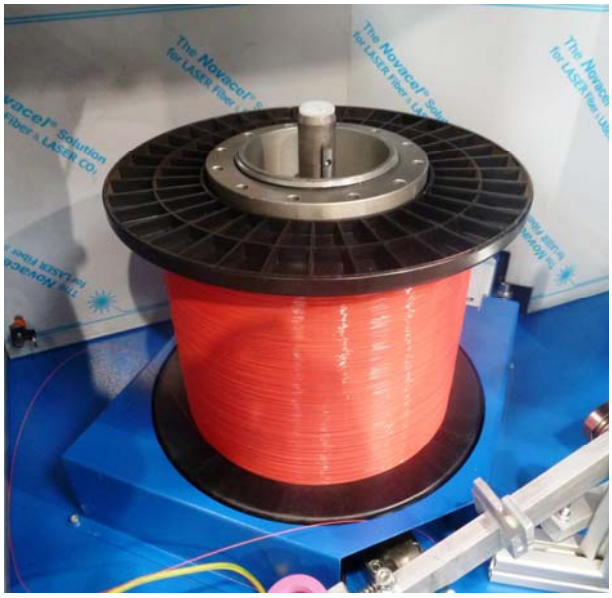
When using <u>round</u> monofilament, right and left hand spirals can be produced on each spindle.

For technical reasons, when using monofilament with a <u>rectangular</u> cross section, only right hand spirals can be produced on the right side and left hand spirals on the left side!

2.1.1 Coil

All monofilaments are processed on a K335 spool. The maximum winding on the coil is between 7kg and 10kg according to the shape and diameter of the wire.

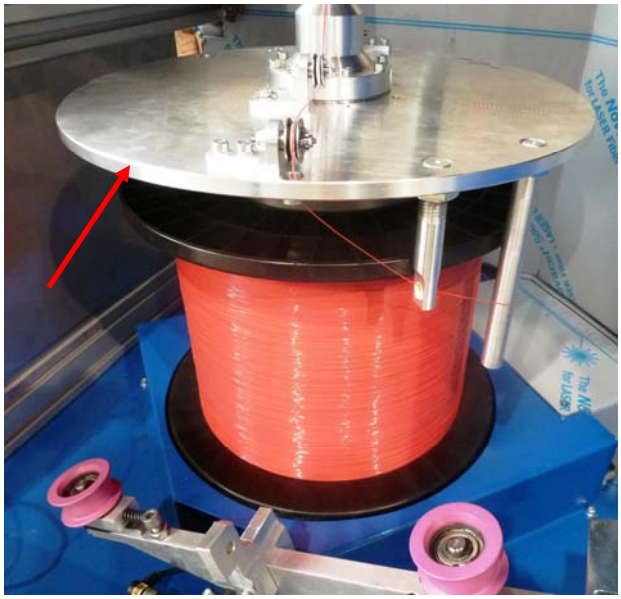
The coil drive depends on the wire tension sensor (>> 2.1.3) and ensures a uniform tension of the spiral wire, regardless of whether the monofilament is still on the coil. In other words, the drive also functions as a brake.



Coil K335 with underlying cover for coil drive

2.1.2 Winding plate

The winding plate guides the spiral wire as it is pulled off of the coil via the various guides and rollers up to the centre of the spindle during the winding process. Depending on the type of spiral wire used (round or flat), ***different*** winding plates are used (see also 2.3.3.). From the centre feedthrough guide, the spiral wire continues up to the winding head (>> 2.1.4).
Round winding plate for flat monofilament. It is driven via a drive belt during the winding process.



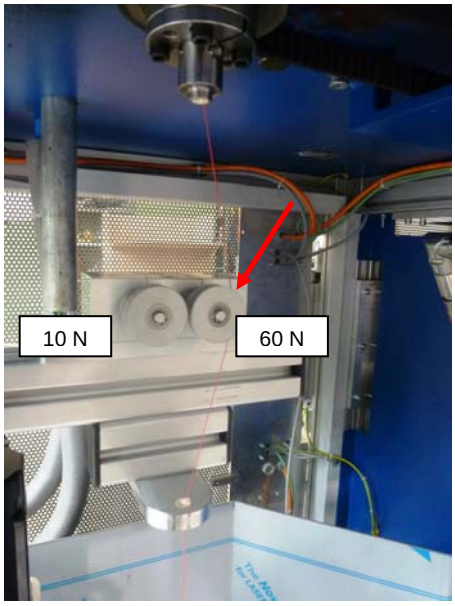
Winding plate (for ***flat*** *monofilament*)

Segment winding plate for round monofilament. It is locked during the winding process; the drive belt is not mounted.

Winding plate (for ***round*** monofilament)

2.1.3 Thread tension sensor

Via the thread tension sensor, the control system constantly adjusts the current thread tension with the parameter values specified in the controls and, if necessary, readjusts accordingly via the coil drive and, with flat wire, also via the winding plate drive.
Depending on the manufactured spiral size, either the left 10N sensor or the right 60N sensor (see image) is used.

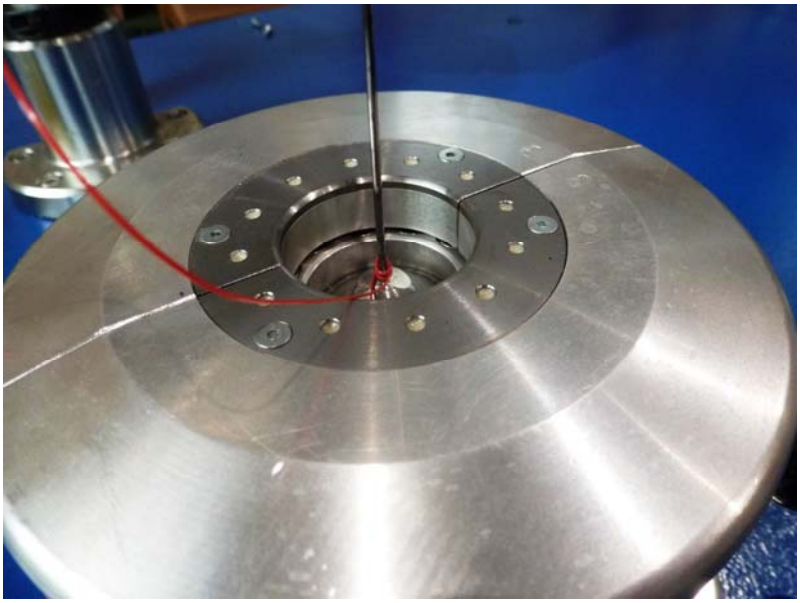


2.1.4 Winding head

The spiral wire enters the winding head from below where it is wound around a spiral mandrel mounted in an intake.

The process speed is set by the drive.

Depending on the spiral wire's shape and diameter, rotational speeds of up to 5,000 r/min are possible.



2.1.5 Spiral mandrel

Depending on the type of spiral wire used (dimensions and material) and the predetermined spiral dimensions, spiral mandrels with various dimensions can be used.
The spiral wire wound around the mandrel through the winding head "heads" up to the mandrel as a spiral with each rotation.
The length of the mandrel passes through the heater to just below the pull-off roller at the top of the machine.
All mandrels included with this machine have uniform intakes, making them easily interchangeable.

2.1.6 Heater

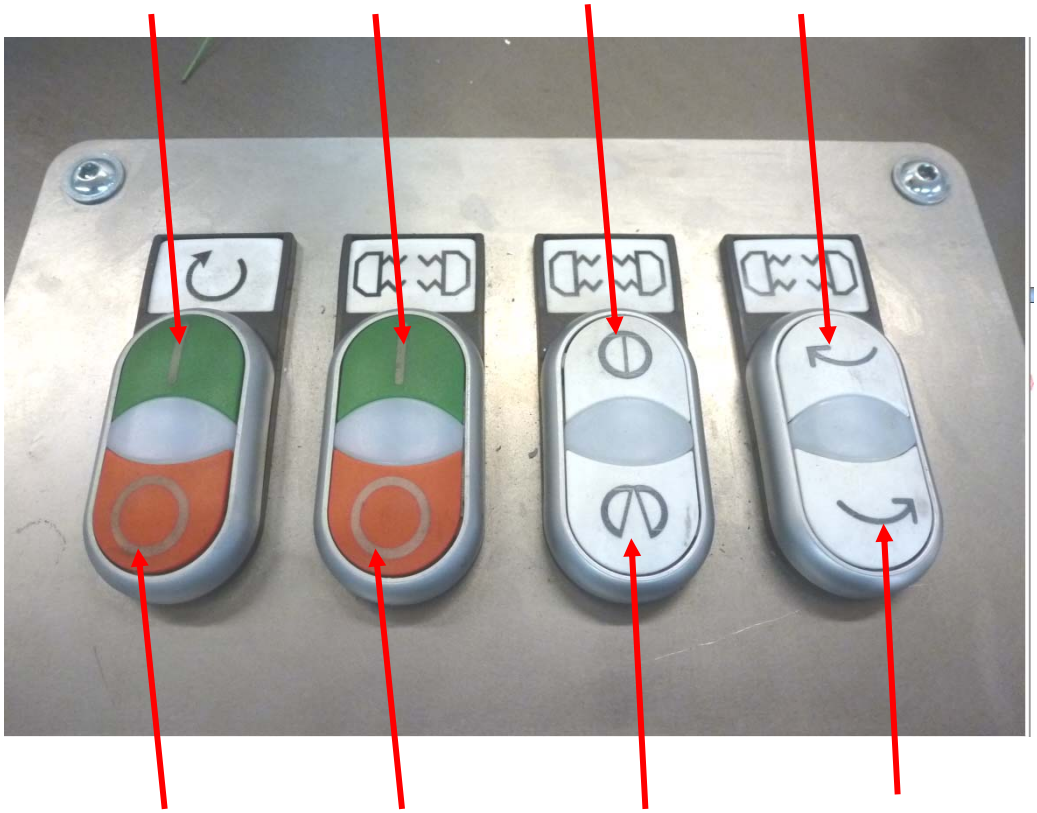
The spiral that traverses the mandrel is fixed in the heater. Heating the spirals prevents them from twisting or uncoiling when leaving the mandrel.
The two-part heater housing contains ceramic infrared heating elements. The controls monitor the temperature in the heater via two thermocouples. If needed, the controls correct the temperature in the heater.
The heater is preheated before the process begins. When the target temperature is reached, the winding process can be started. The target temperature is set in the process parameters.
The idling heater (closed and tilted back) is pneumatically opened (image 01) and pneumatically shifted to the spiral mandrel where it is closed again (image 02). The heater now encloses the spiral mandrel with the spiral feeding in from below during the winding process. The heater's motion sequence is controlled manually with the buttons (> 2.1.7) on top of the machine.


Heater image 1


Heater image 2

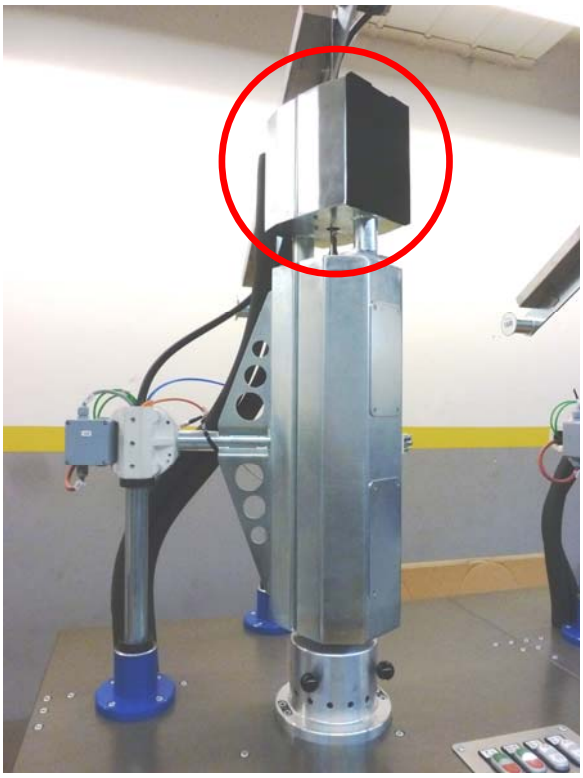
2.1.7 Control panel

There is a control panel located on each side of the machine.
The control panel is used to carry out the machine's basic functions.



2.1.8 Cooling

A cooling device built into an insulated, two-part housing is attached to the top of the two-part heating housing.

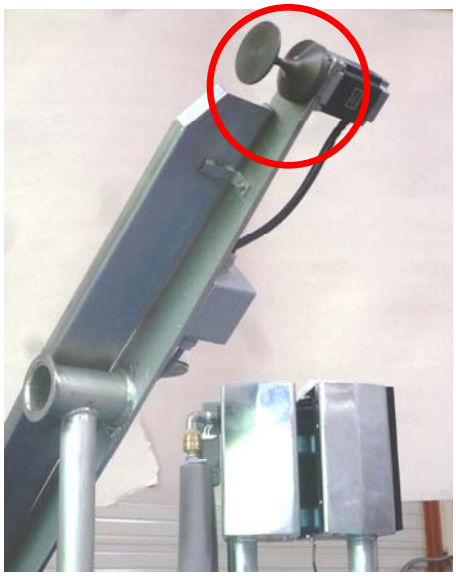


The spirals moving up out of the heater are cooled back down in the cooling in order to compress them and to allow for spirals to be manufactured from thick monofilament.

The two heat exchangers on the spindles are supplied with the cooling medium through the cooling device mounted on the side of the machine.

2.1.9 Pull-off roller

The driven pull-off roller is located above the upper end of the winding mandrel. Depending on process speed and pre-set pull-off value (mm/rev), the roller “pulls” the spiral up from the spiral mandrel, and from there the spiral moves down into the spiral can via a downward sloping guiding track (“slide”).
The spiral can also be wound 1x to 2x around the pull-off roller in order to increase the tensile force.



2.1.10 Spiral can

“Cans” are placed behind the spiral machine to collect the spirals as they exit the machine. The size of the plastic piping cans is selected to fit the amount of spirals coming off of a 7/10kg coil.
The tops of the cans are fitted with slots into which the end of the spirals is hooked.
In order to connect a spiral sleeve, the spirals are processed directly from the cans.

2.2 Description of the controls with push button and switching functions

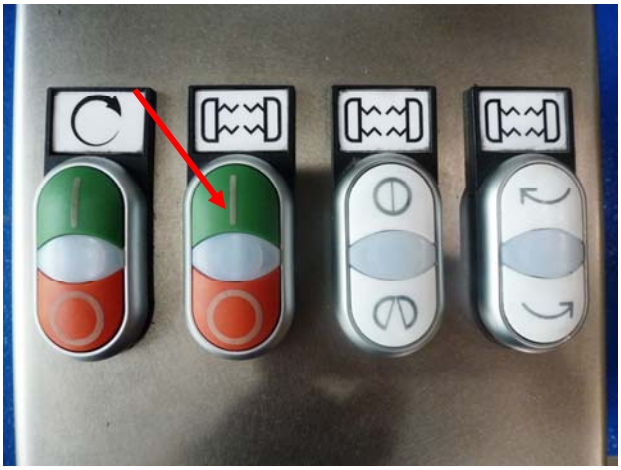
Many spiral machines are monitored via one control centre (server) and programmed via one central touch panel. A few buttons for starting the spindle and operating the heater – separate for each spindle – are located on the machine itself. All remaining functions - in particular the input and monitoring of parameter values – are controlled exclusively via the central touchscreen.
The corresponding station (machine with two spindles) is chosen in the start menu (fig. 2.2.3.1).
All necessary parameters for this machine, depending on the spiral type to be processed, can now be read (separately for each spindle), fixed or changed.

All important machine functions along with the current parameter values are displayed on the clearly laid out control menu screens in the respective menu areas.

2.2.1 Turning on the machine

After the machine is turned on with the main switch located on the side of the control box, the machine's internal operating system will boot up. The heater can now also be turned on with a push button in order to use the setup time on the machine for heating.

Main switch



Heater switch ON / OFF

2.2.2 Selecting the machine

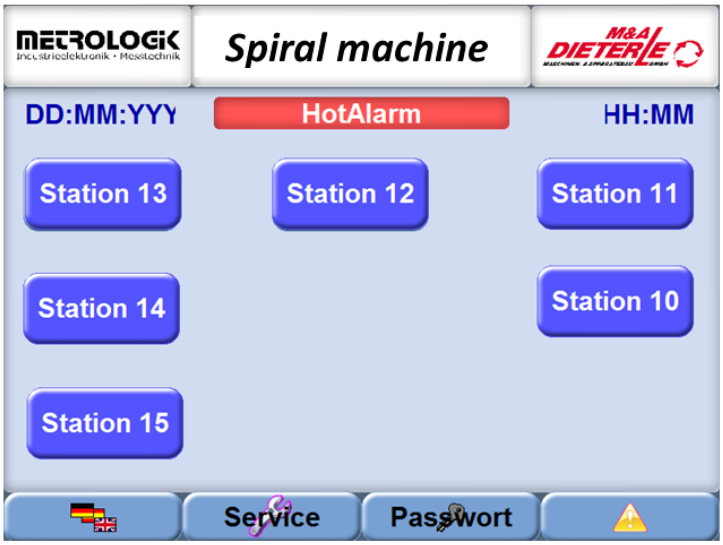
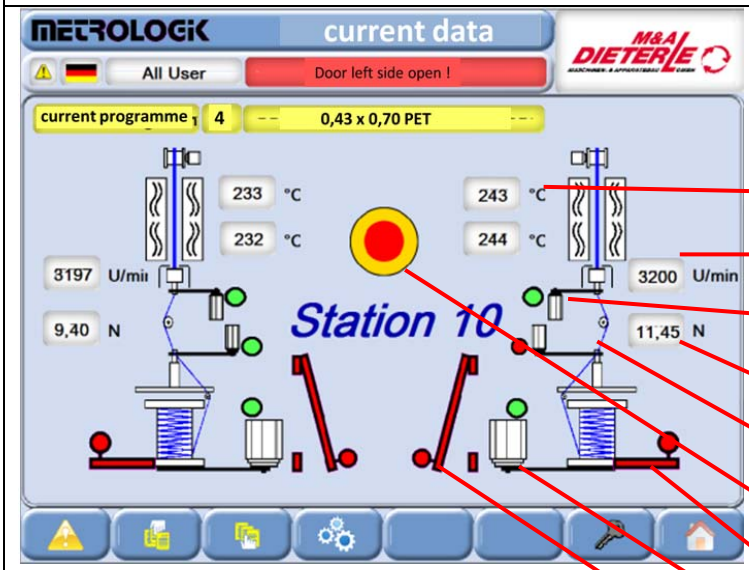
Each machine is displayed with a button on the central touch panel's start menu (fig. 2.2.3.1). Once the desired machine has been selected, that machine's current actual values are displayed for both spindles (fig. 2.2.3.2).

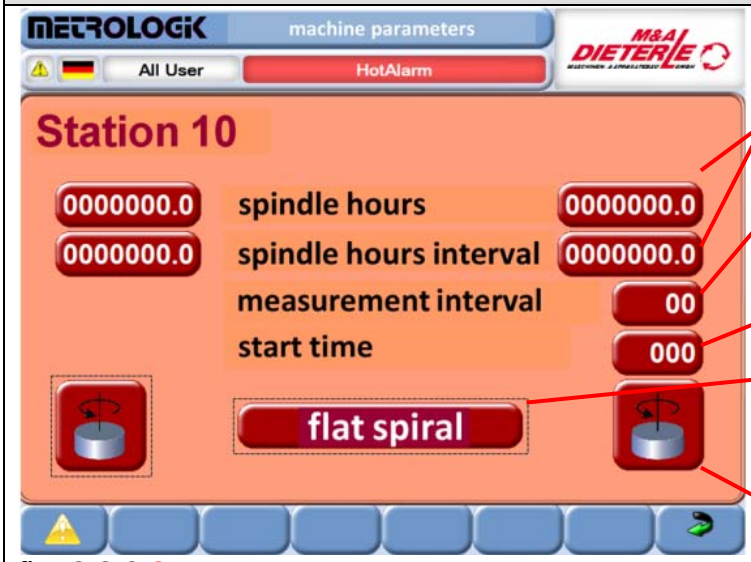
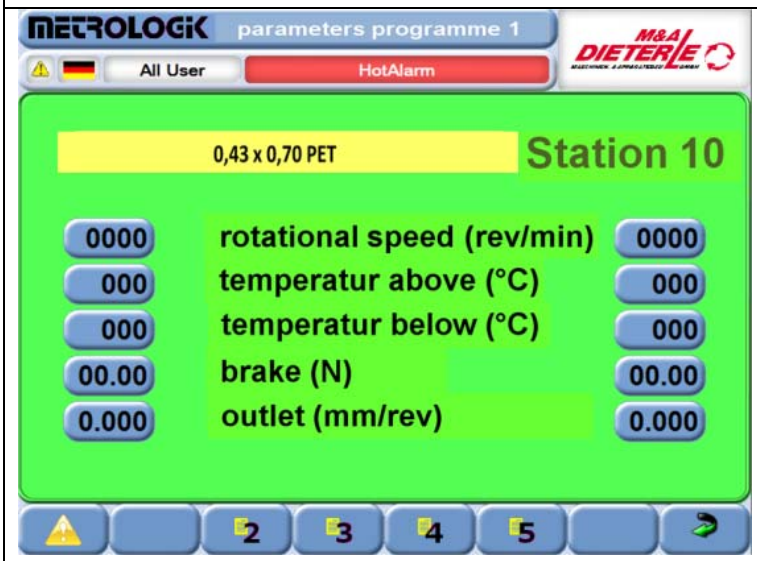
2.2.3 Determining the type of spiral wire and winding direction

From the window with the actual values, the selection window (fig. 2.2.3.3) for the selected machine can be reached via the *Parameter* button (gear icon). The choice between ***Round spiral*** and ***flat spiral*** can be made here. In the next step, the rotation/winding direction for the respective spiral is selected.

2.2.4 Input of production parameters

From the window with the actual values, the parameter window (fig. 2.2.3.4) for the selected machine can be reached via the *Parameter* button (gear icon). Here, the process parameters can either be pre-set or adjusted to requirements during the process.

Menu screen	Procedure
 Fig. 2.2.3.1	Select station / machine
 fig. 2.2.3.2 = Component functioning properly = Component defect	Display of process parameters and operating conditions *actual values* Heater temperature Rotation speed Winding head drive Thread tension sensor Winding table drive Emergency stop activated Coil locked Coil drive Open machine doors

Menu screen	Procedure
 fig. 2.2.3.**3**	The displayed *spindle hours* are for informational purposes The *measurement interval* function is inactive The *start time* is a fixed value Select process mode *flat spiral / round spiral* Select rotation direction (can only be selected for round spirals!)
 fig. 2.2.3.**4**	Input of process parameters target values

2.3 Setting up / adjusting machines and process start (operation sequence)

According to the planned process (*round or flat* spirals), different procedures are required when setting up and programming. The respective sequences are described in the following steps.

Initial situation: *machine is switched off.*
no coil mounted.

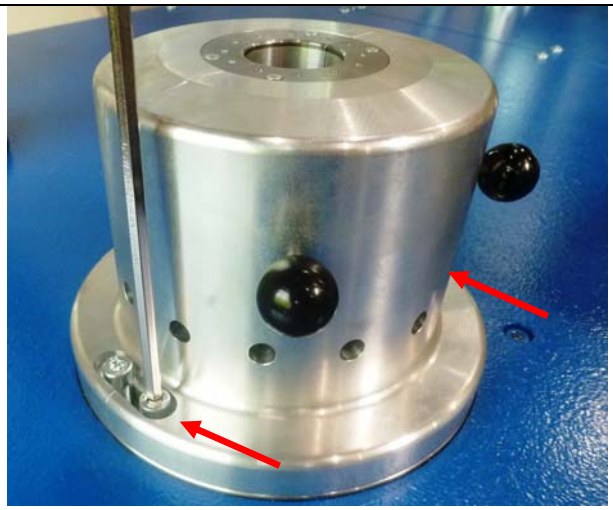
2.3.1 Preparatory work on the machine

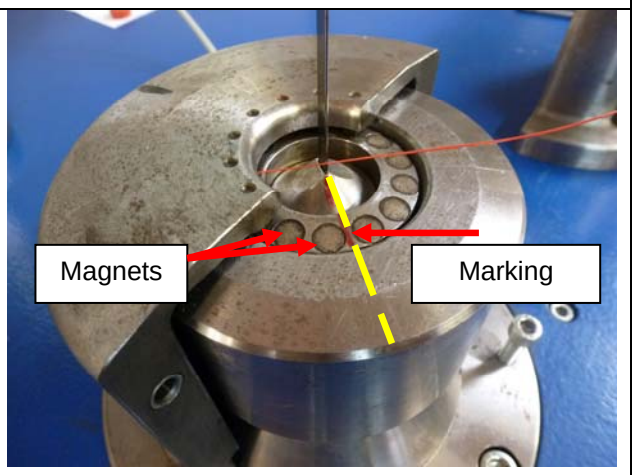
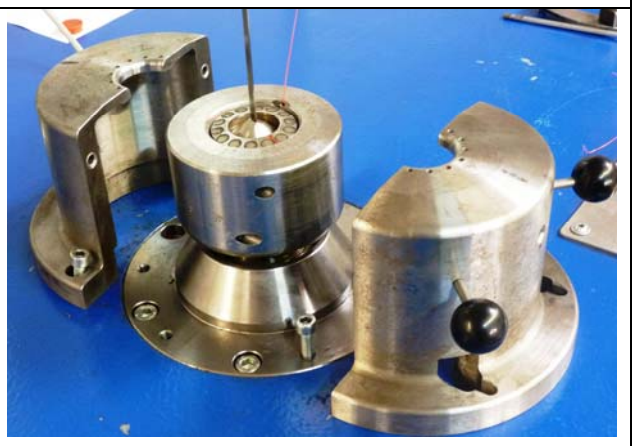
Turn on machine with main switch. The machine controls will now turn on independently.	
Turn on heater	

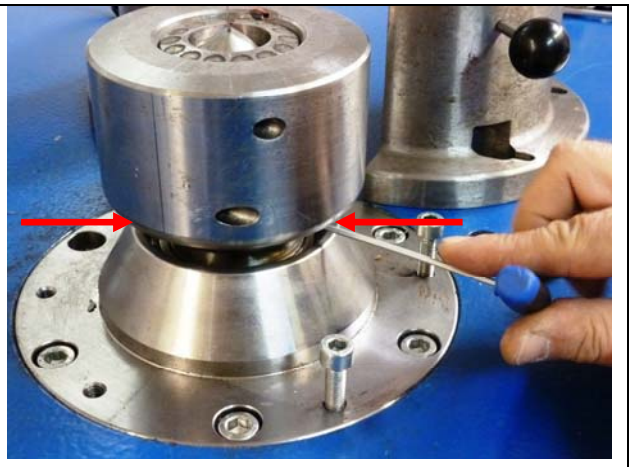
Prepare tools: • Hook spanner (fig.) • Allen key 6mm, long • Control box key • Scissors • Brush • Container with rinsing agent	
Place spiral cans behind the machine. Select size according to the expected spiral quanity (depending on the spiral size and the winding type of the coil).	

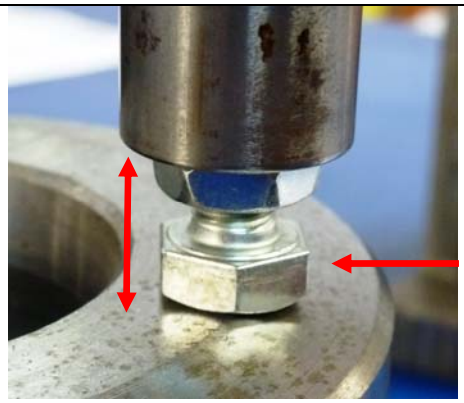
2.3.2 Change spiral mandrel

This procedure is only necessary for changing the spiral size or monofilament.

A long, 2.6mm and 6mm Allen key is required for changing the spiral mandrel. To check the mandrel adjustment, a master gauge for a height of 3.20mm is also used (see fig. right).	
The two screws on the front cover of the winding head are loosened with the 6mm Allen key.	

The housing half can now be removed at the front and set aside.	
The mandrel is then rotated such that two magnets are visible on the left side between the narrow side of the mandrel and the housing. A pen is then used to make a colour marking, as shown to the right.	
The mounting screws on the rear housing half are loosened and housing removed.	

On the hub of the winding head, the two clamping screws located opposite one another for the mandrel intake are removed with a 4mm Allen key.	
The intake with the mandrel can now be pulled out from above.	
After loosening the clamping screw with a 4mm Allen key, the mandrel can be removed from the intake.	

To insert the new mandrel, follow the reverse order of this process. When inserting into the intake, the narrow side of the mandrel must again face the marking. Due to the narrow fit tolerance, the intake slides into the winding head by itself.	
If the intake of the winding head is in stop position, the correct adjustment of the test gauge with the height of 3.20mm is checked. The intake must be easy to turn under the gauge without touching, but also without too much distance. If the winding head is too high up, the spiral wire will touch the magnets during the winding process and tear off. If it is too low, the winding point on the mandrel will not be right and the desired size of the spiral cannot be achieved.	
If it becomes necessary to correct the height, the intake must again be removed from the winding head and the height must be readjusted on the adjusting screw.	

The two covers of the winding head can subsequently be remounted.
It should be noted that the alignment of the marking for the mandrel is the same as the position for disassembly.
If the mandrel is twisted, it will be in the wrong position when closing the heater, which will prevent it from closing correctly.

Correct Mandrel on marking

Incorrect Mandrel twisted

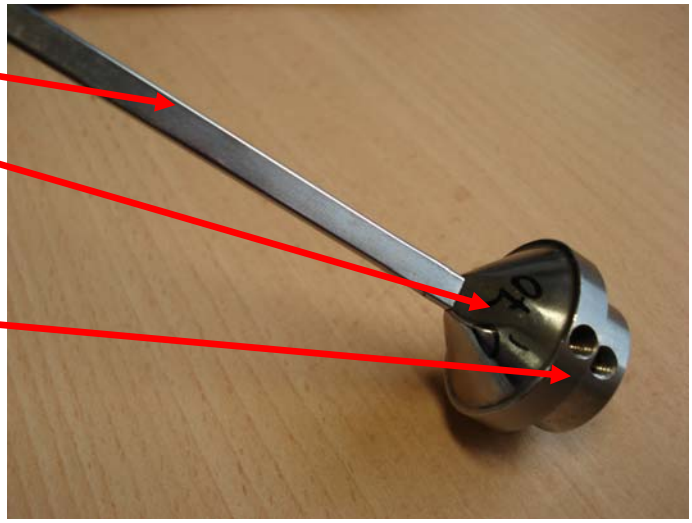
2.3.3 Positioning the spiral mandrel

The spiral mandrel is typically only positioned when a new mandrel is used for the first time or when a different spiral size is required.

The spiral mandrel essentially consists of two parts: the **mandrel** itself

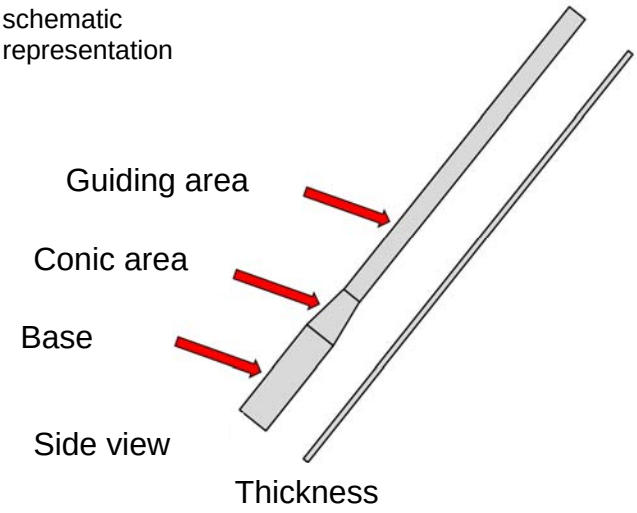
and the **head**.

The height of the mandrel can be adjusted in the head and is fixed with a **setscrew** with hexagonal sockets.

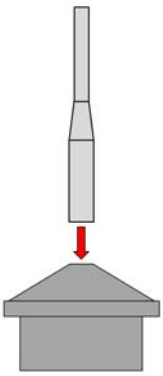


schematic representation

From the side view, the mandrel can be divided into three areas:



The height adjustability allows…

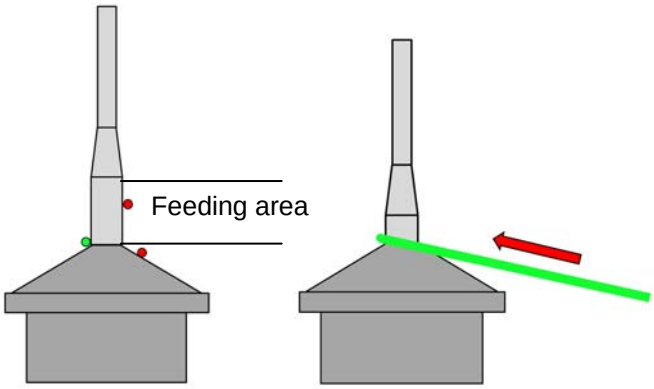


… spiral wire which feeds onto the mandrel during the winding process to hit the mandrel at a particular location: the (ideal) winding point, shown in green on the schematic diagram. If the spiral wire hits too high or too low on the mandrel (shown in red), irregularities in the spirals can result and the thread can break.

The mandrel is positioned differently depending on whether the wire is round or flat.

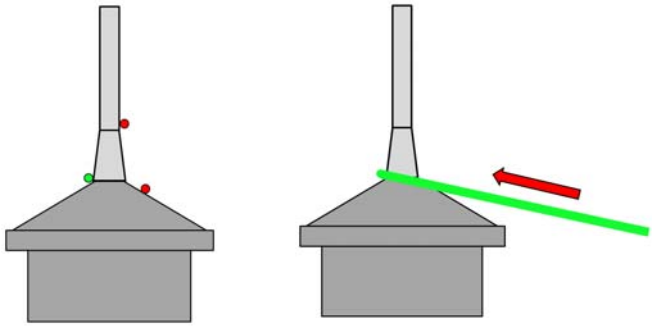
Round

For round wire, the mandrel is positioned in the head such that the mandrel base is visible as a feeding area of approx. 8 - 10mm. The exact size of the feeding area must be checked / determined by a trial run.
The winding point is located here on the lower end of the feeding area, just under the head

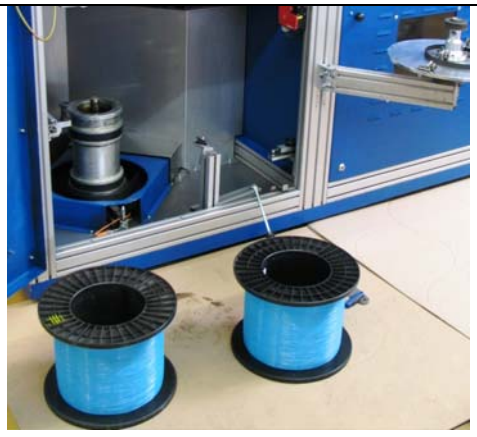


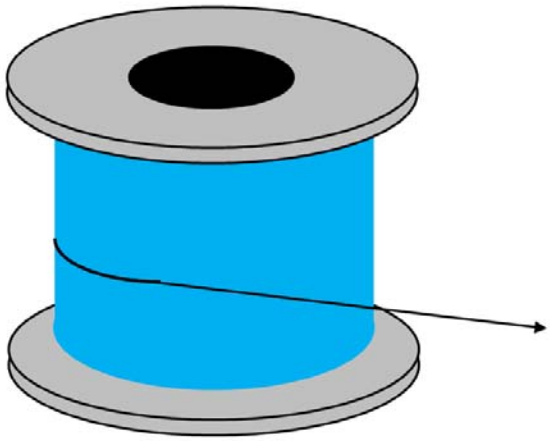
Flat

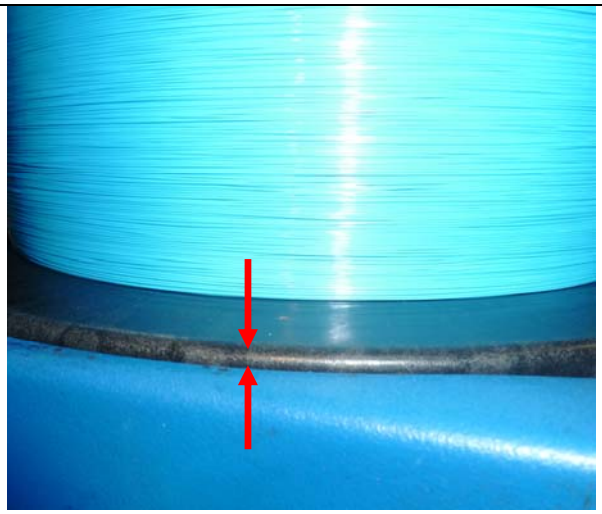
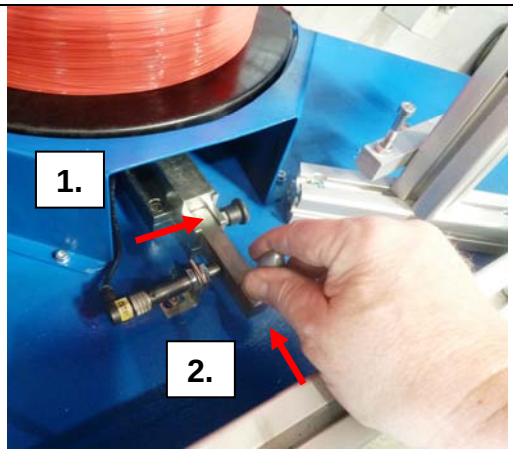
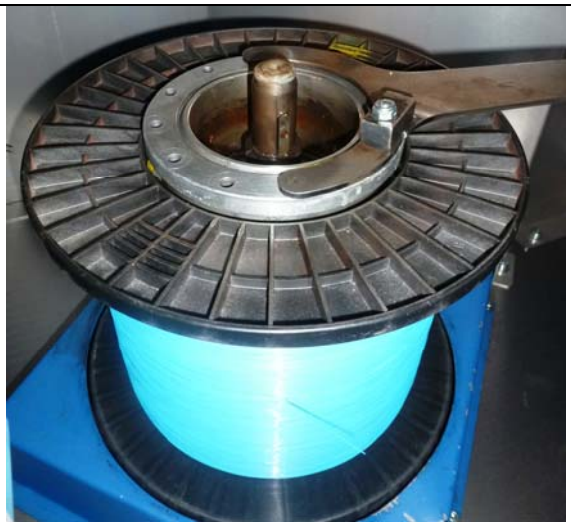
For flat wire, the mandrel is positioned in the head such that the transition from the mandrel base to the conical area sits exactly on the top edge of the head. There is no feeding area here. However, the following also applies to flat shapes: the exact degree of positioning must be checked / determined by a trial run.

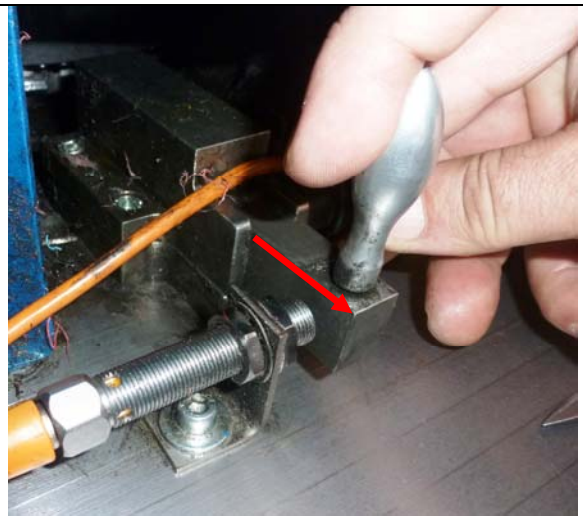


2.3.4 Inserting the coil

Make sure that spindle/ coil intake is clean.	
Place coil in front of machine.	

Stick winding plate onto stacking arm Large winding plate for flat monofilament (pictured) Small winding plate for round monofilament	
Lubricate the coil at the top and bottom with dish liquid of the intake opening so that it more easily slides through the rubber tension rings on the intake spindle.	
Place the coil on the spindle while paying attention to the pull-off direction (depending on the **winding direction** of the spirals to be produced – **left or right**). For **FLAT** monofilament: Left side of machine only left spirals > pull-off direction right side Right side of machine only right spirals > pull-off direction left side **During inserting the coil pay attention on the thread tension sensors!**	

ATTENTION: Lower the coil onto the spindle until it stops! The inside of the lower edge of the coil has to be almost flush with the bottom cover plate. If the coil is not all the way at the bottom, it will come undone during the winding process resulting in the thread tearing!!!	
Secure the spindle and coil below with the stop. In order to move the locking mechanism, the safety mandrel must first be removed from the locking mechanism's right side.	
Securely tighten the clamp disc onto the spindle with the hook spanner.	

Once again unlock coil / spindle at the bottom. The LEDs of the proximity switch are now illuminated.	

2.3.5 Feeding the monofilament into the machine

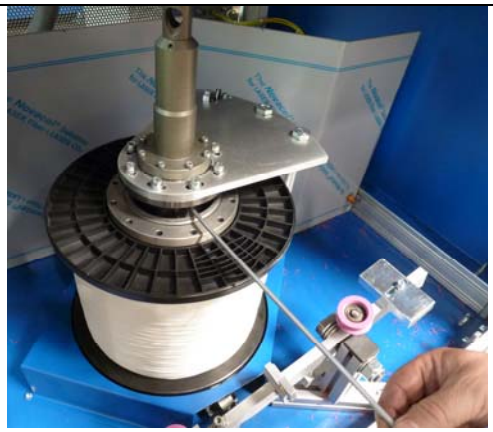
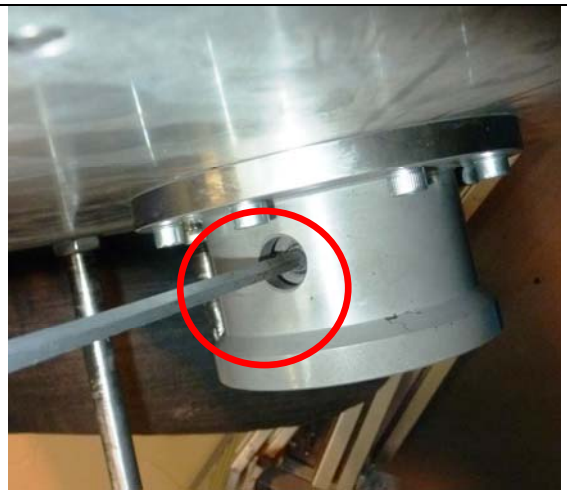
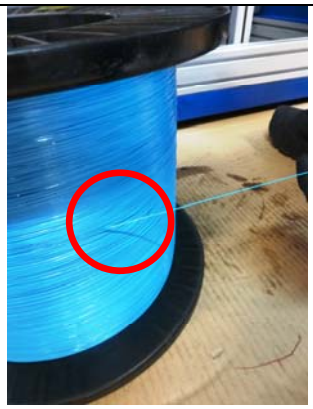
The procedures that follow depend on the type of spiral to be produced:

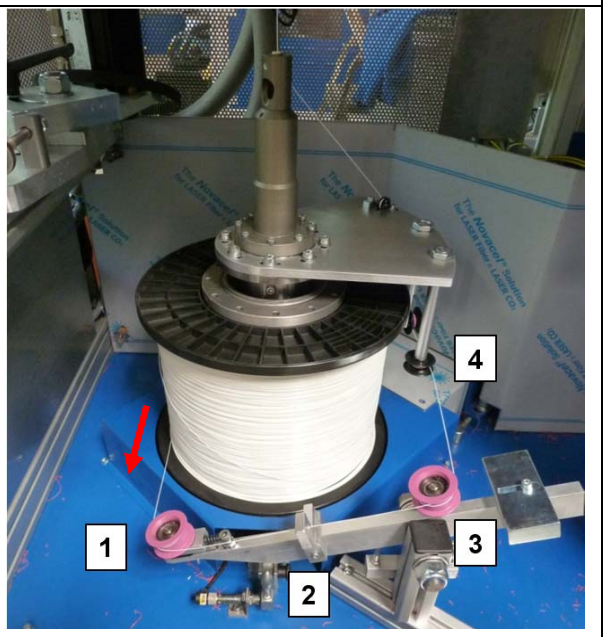
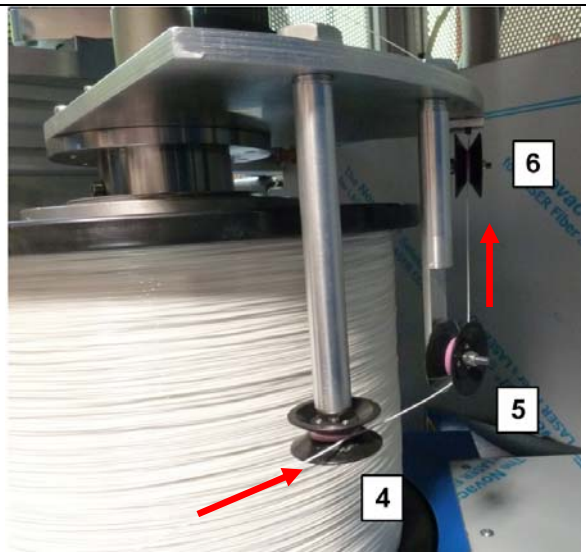
- Spirals made from **ROUND** monofilament: **Alternative A**
  (see page 28)

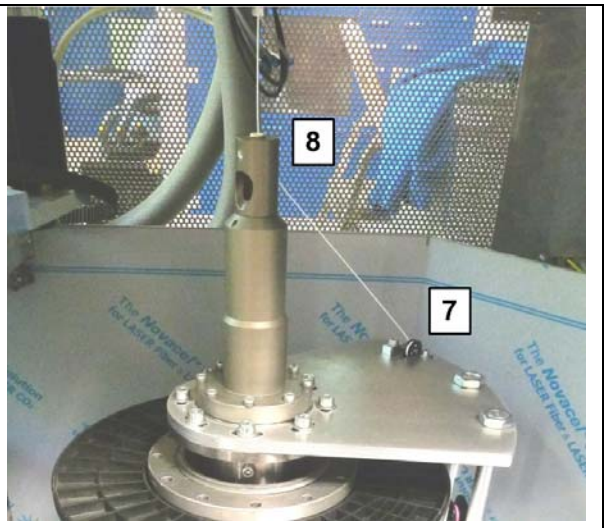
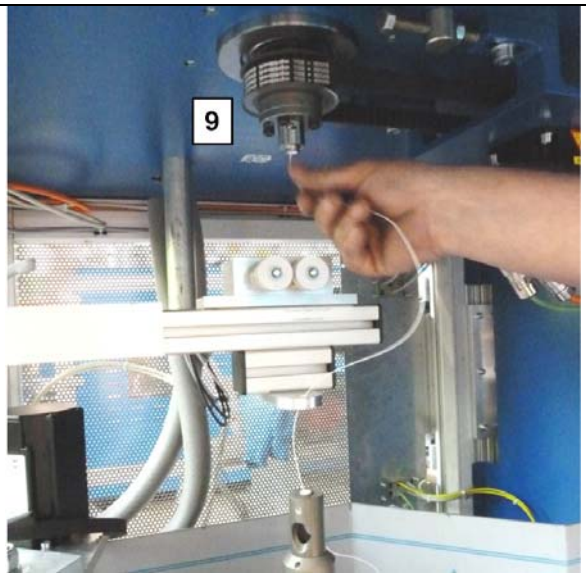
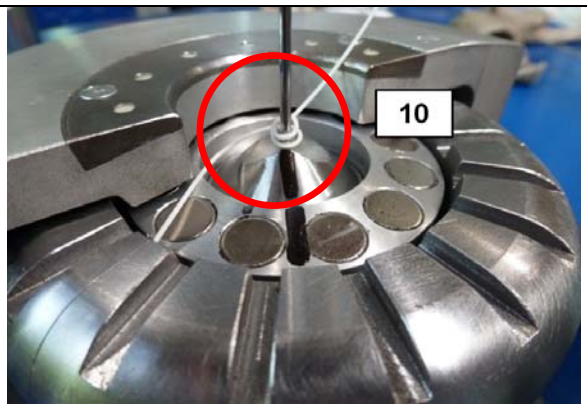
- Spirals made from **FLAT** monofilament: **Alternative B**
  (see page 32)

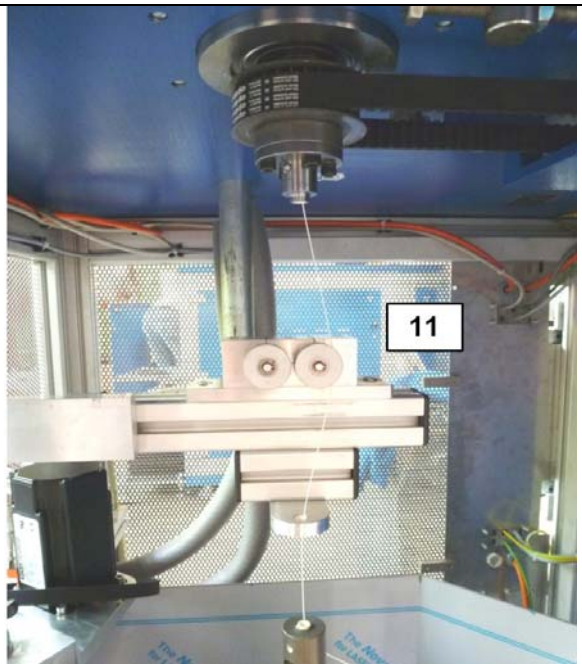
>>> Alternative A for ROUND monofilament

The procedures detailed here apply to both left and right spirals.

Remove the winding plate from the stacking arm and place it on the spindle. Make sure that the intake locks into the fitting key of the spindle! (**no drive belt** is used!)	
Fasten winding plate to threaded pin (allen key 6mm).	
Use scissors to cut the knot of the thread on the coil.	

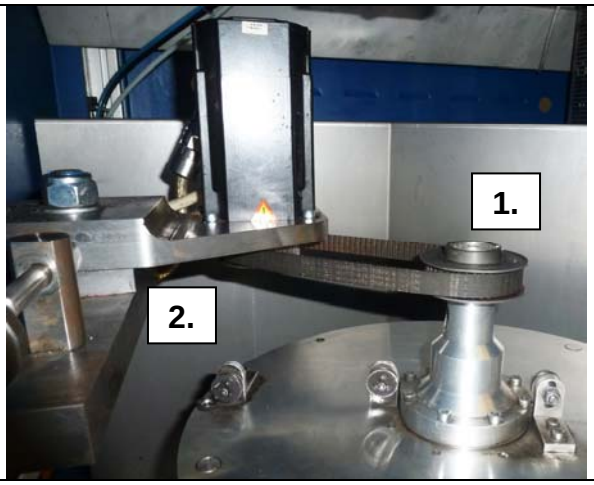
Feed thread into the machine as follows:	
The thread is pulled off of the coil to the left, regardless of whether the spirals are left or right. The thread is wrapped around the left rocker roller (1), fed through the loop (2) and then wrapped around the right rocker roller (3). Then the thread is wrapped around the front horizontal guide roller (4) of the small winding plate and…	
… fed through the second, vertical roller (5) and the rear roller (6) …	

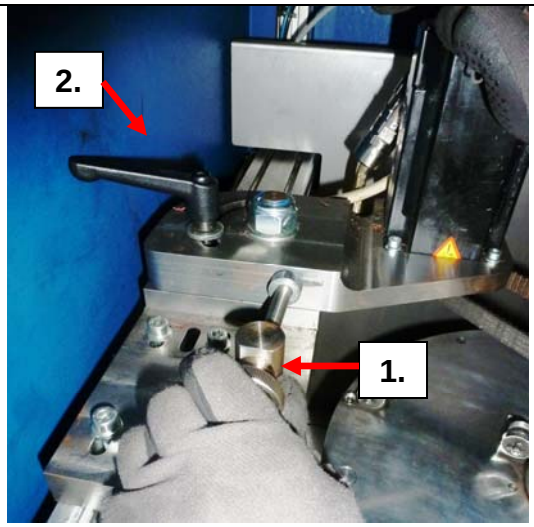
… through the opening on the winding plate. The thread is then fed via the small roller (7), up through the ceramic loop (8) into the hub of the winding plate.	
The thread is then fed up through the hollow axle (9) of the winding plate	
… until it can be pulled out of the winding head (10) and tied. Note the desired winding direction when tying!	

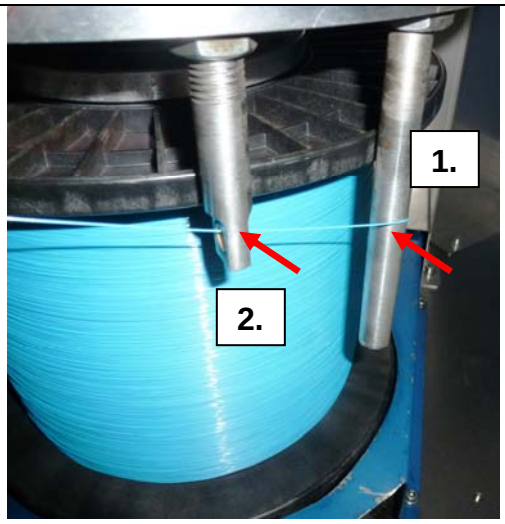
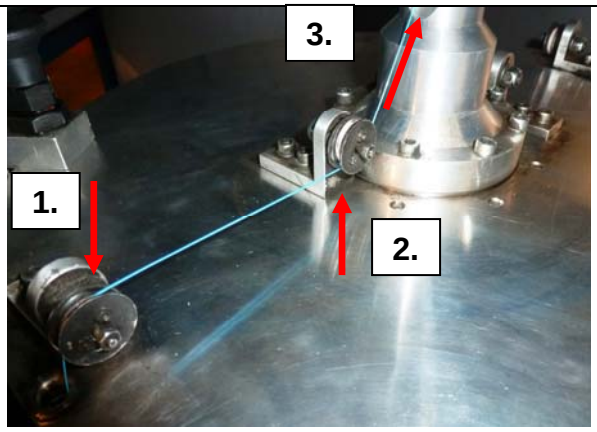
By turning back the coil, the thread is stretched in its guide elements. After the thread has been placed above the tension sensor roller (11), the entire path of the thread is once again checked to make sure that it is sitting properly. **Attention! Overstressing by incorrect course of the thread can destroy the thread tension sensors. Usage as regulated in the operation procedure**	

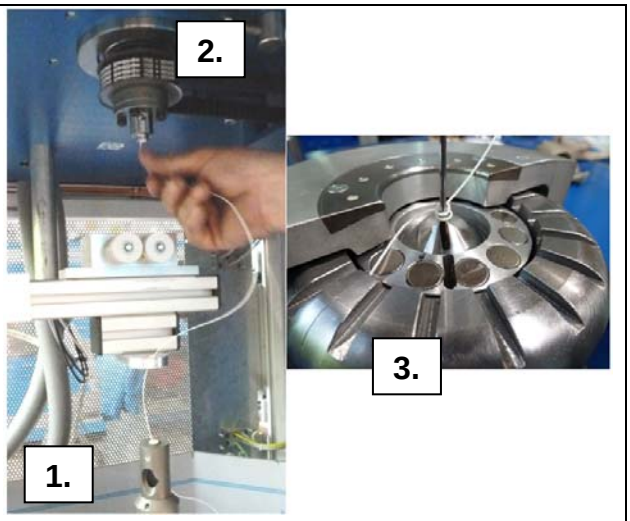
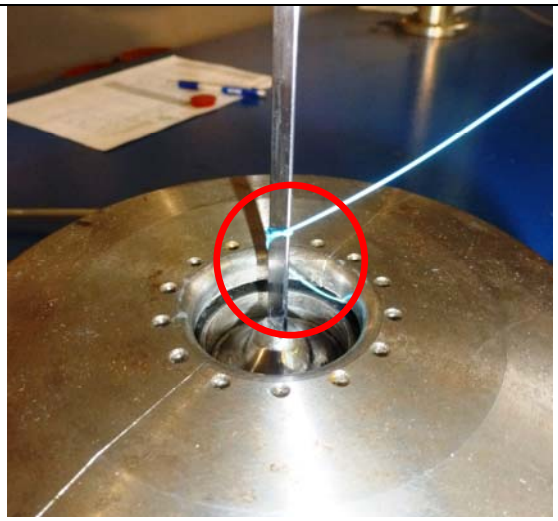
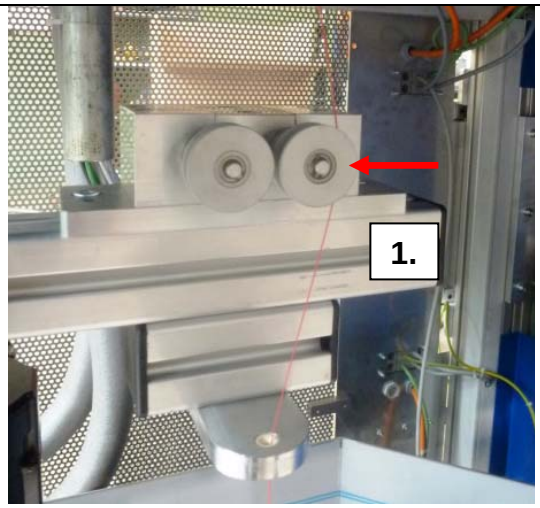
Alternative A (round) again on page 36

>>> **Alternative B** for **FLAT** monofilament

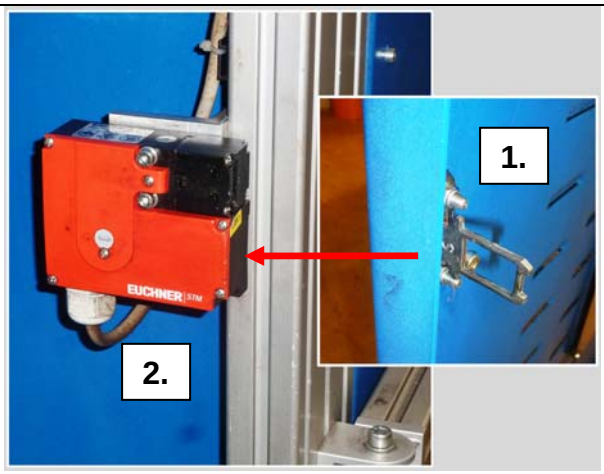
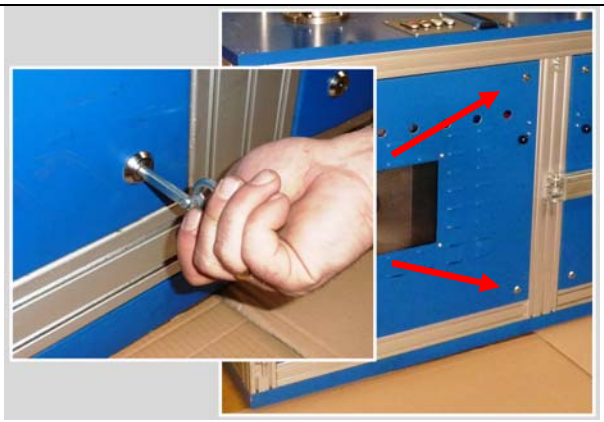
Remove the winding plate from the stacking arm and place it on the spindle. Make sure that the intake locks into the fitting key of the spindle! Place the gear belt over the winding plate's hub.	
Turn the winding plate's drive motor forward.	
Hang the timing belt in the wheels of the winding plate (1) and the motor (2)	

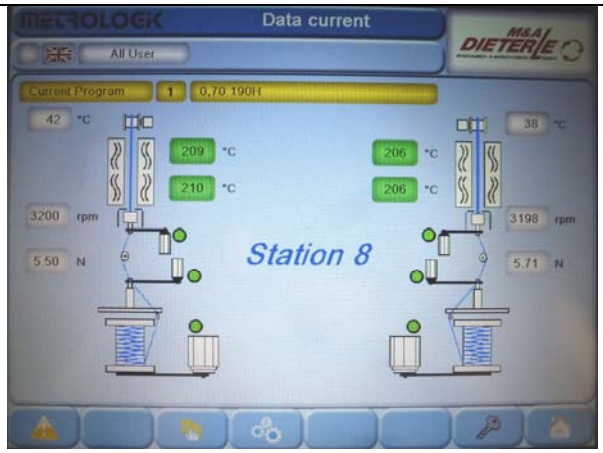
Pretension the belt by pushing the motor back. Then use the tension screw (1) and completely tighten by continuing to turn the belt. Check belt tension manually. Fasten motor with clamp screw (2)	
Use scissors to cut the knot of the thread on the coil.	
Feed thread into the machine as follows:	

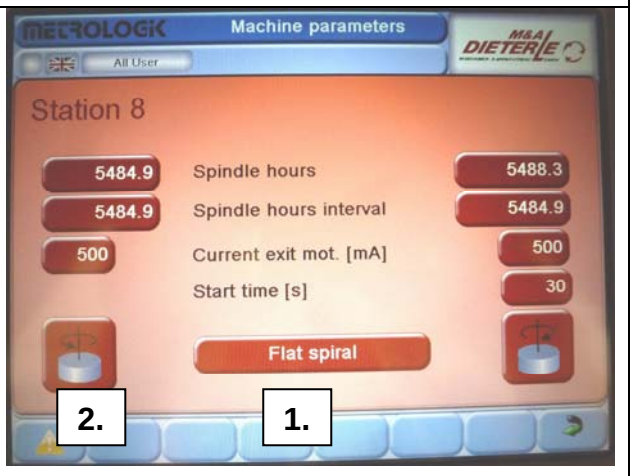
Feed the thread through the guide pins (1) outside and through the thread guide (2) of the winding table. The thread guide shown is for RIGHT hand spirals. RIGHT hand spirals – pull threads off to the LEFT (RIGHT Spindle!). LEFT hand spirals – pull threads off to the RIGHT (LEFT spindle!).	
The thread is then pulled through the guide feedthrough in the winding plate onto the top of the winding plate. For LEFT hand spirals, the opposite procedure applies.	
The thread continues <u>over</u> the outer guide roller (1) and <u>under</u> the inner guide roller (2) to the feedthrough opening (3) in the hub of the winding plate.	

The thread is then pushed up through the hub (1) of the winding plate through the hollow axle until it can be pulled from the top of the winding head (3).	
The thread is now tied onto the spiral mandrel. Continue to pay attention to the **winding direction**!	
By turning back the coil, the thread is stretched in its guide elements. After the thread has been placed above the tension sensor roller *** (1), the entire path of the thread is once again checked to make sure that it is sitting properly. *** Depending from the dimension of the monofilament and the resulting spiral size for small monofilaments the 10N-sensor is used for thicker monofilaments the 60N-sensor has to be used	

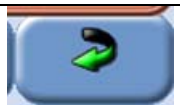
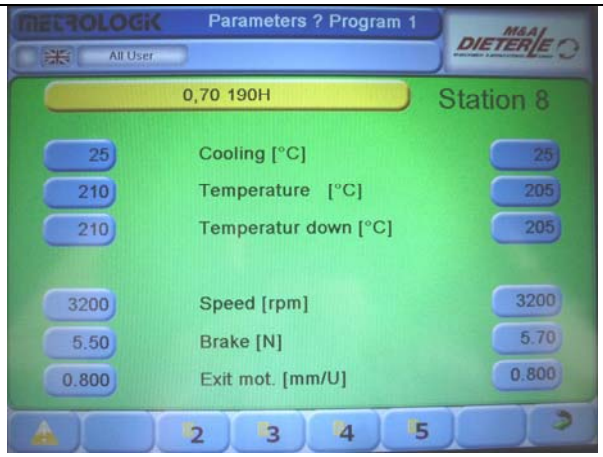
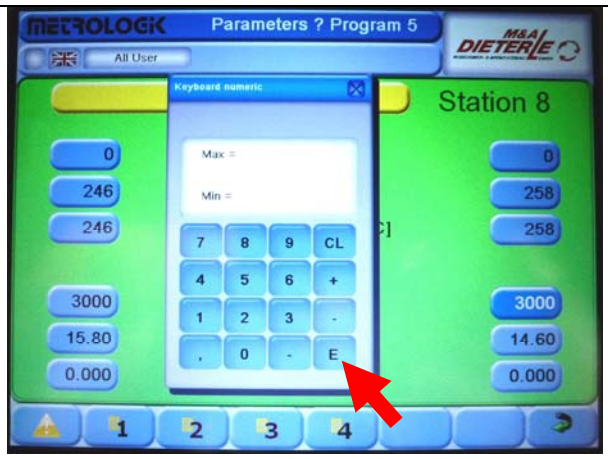
The following operational procedures are identical for **alternatives A and B**:

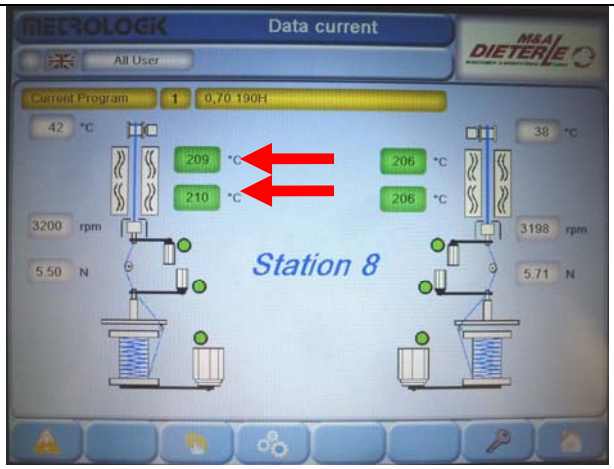
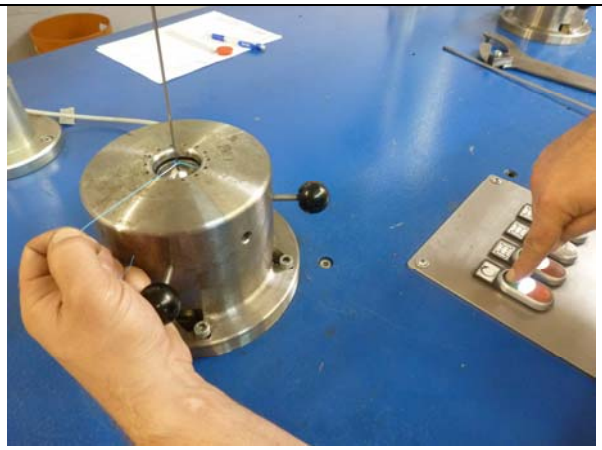
Close machine door. Make sure that the locking plate (1) locks into the safety switch (2),	
… then lock the doors above and below with the control box key. The winding process start is enabled by the safety switch only if the doors are correctly closed and locked!	
The machine is now ready for the winding process. The manufacturing parameters can now be selected according to spiral type and size using the central touchscreen at the controls.	

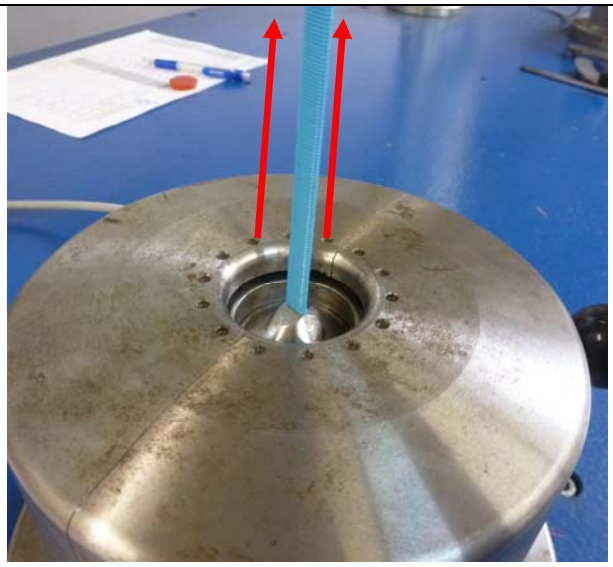
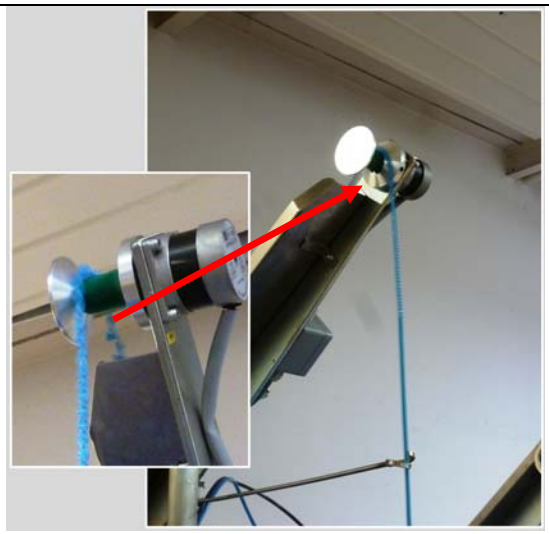
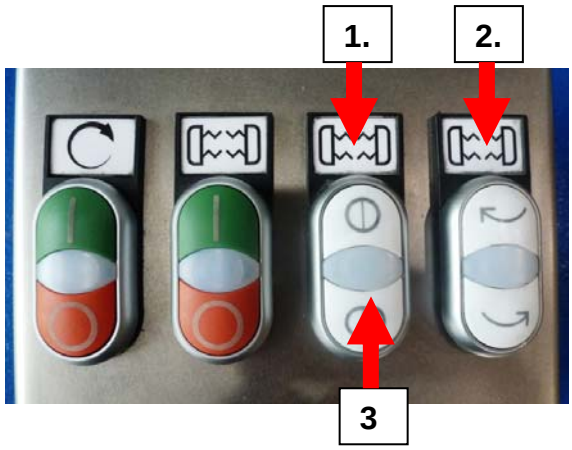
<table>
<tr><td>Selecting the machine / station
(example here is machine 8)</td><td> 
</td></tr>
<tr><td>>>> Display of current actual values for both spindles of the selected machine.</td><td> 
</td></tr>
<tr><td>Press “process” button (gear symbol).</td><td>  </td></tr>
<tr><td>>>> Pre-selection window of the machine.
Spiral type can be chosen here (according to machine preparation) by pressing the middle button (1):
“round spiral” / “flat spiral”
The rotation direction LEFT or RIGHT can be set with the button (2) for the corresponding spindle

(e.g. here: left spindle rotation direction LEFT. Selecting a differing rotation direction is only possible with round material, not with flat material. See also 2.1)</td><td> 

The values shown in the number fields are only for informational purposes; they cannot be changed.</td></tr>
</table>

Use the button “back” to return to the actual values display. From here the input window for the process parameters can be reached with the button “edit.”	 
Default values, depending on spiral type and size, can be entered here: • Cooling temperature (up/down) • Heater temperature (up/down) • Pre-heating temp. (up/down) • Spindle rotation speed • Brake • Exit motor	
Input and changes can be made using a numbers keyboard, which appears by typing in the corresponding display field. Values entered are accepted using the enter button “E” (arrow).	

Once the heater has reached the target value (see window actual value), the spindle can…	
… be started by pressing the green START button on the top of the machine.	
When the spindle starts running, the tied spiral wire must be secured with two fingers during the first rotation to prevent it from winding onto the mandrel.	

<table>
<tr><td>During the start-up phase, the wound spirals – as needed according to spiral type – must be lightly pushed up onto the mandrel by hand to avoid tangling and a resulting tear in the thread. Then the spiral must move upward on the mandrel by itself. If this is not the case then the process parameter is not correct (see also 2.6).</td><td>  </td></tr>
<tr><td>Once the wound spiral reaches the upper end of the mandrel, it is placed on the guiding track via the pull-off roller.</td><td>  </td></tr>
<tr><td>Once the target rotational speed has been reached (see window actual values), the heater can be
• opened (1)
• turned to the spiral mandrel (2) and
• closed. (3)
with the corresponding buttons.</td><td> 
</td></tr>
</table>

2.4 Monitoring of winding process

The dimensions of the spirals must be regularly checked during the first few minutes of the winding process. If needed, the process parameters (as described in 2.5.1) must be corrected. The spirals, which are wound until the desired dimensions are reached, are not suitable for sleeve production.
Once the desired size has been reached, the spirals are guided to the provided cans. At this point, measurements in half-hour intervals are sufficient – one-hour intervals if the machine is warmed up.

The winding process runs automatically. If a disturbance occurs (e.g. a thread tear) or the coil is empty, the machine will shut off automatically, the red light on the spiral guiding arm will illuminate and an acoustic signal can be activated.

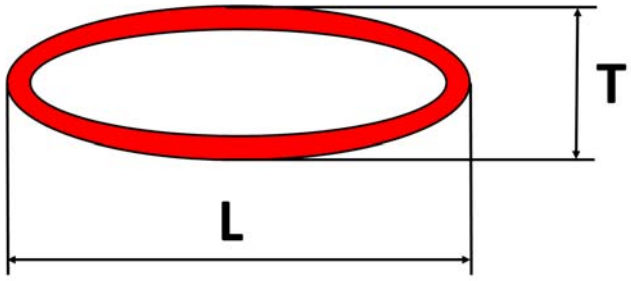
When turning the machine off, the heater is automatically opened and then turned into inactive position.

2.5 Possible irregularities, causes and remedies

Definition of spiral dimensions:

L = length of spiral

T = thickness of spiral



Error	Cause	Remedy
2.5.1		
Spiral size irregularities:		
Size L too large	Thread tension too low	Increase process parameter *brake*. For **PET** in intervals of 0.5 N For **PPS** in intervals of 0.2 - 0.3 N

Size L too small	Thread tension too high	Reduce process parameter *brake*. For **PET** in intervals of 0.5 N For **PPS** in intervals of 0.2 - 0.3 N
Size T too large	Heater temperature too high	Reduce process parameter *temperature above / below* In intervals of 5°C.
Size T too small	Heater temperature too low	Increase process parameter *temperature above / below* In intervals of 5°C.
Error	**Cause**	**Remedy**
2.5.2		
Spiral shape irregularities:		
 irregularites	Mandrel not properly positioned (too high/ too low) Thread tension too low Temperature too high	Readjust mandrel (see 2.3.2) Increase process parameter *brake*. For **PET** in intervals of 0.5 N For **PPS** in intervals of 0.2 – 0.3 N (see also 2.2.3.4) Reduce process parameter *temperature above / below* in intervals of 5°C. (see also 2.2.3.4)

3.0 Calibrating the thread tension sensors

1. Prepare calibration weights

One small and one large calibrating weight with approx. 5,000 g or 500 g and a hook at the top are needed for calibrating the thread tension sensors, as shown in image 1.

The 500g weight is for calibrating the 10N sensors and the 5,000g weight is for the 60N sensors.

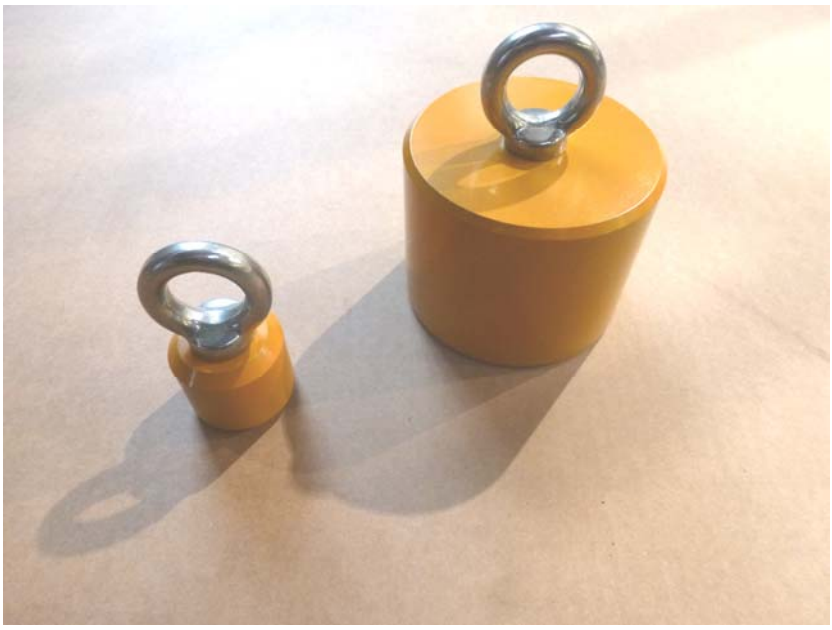


Image 1

Calibration weights

2. Calling up the control window for calibration

The spiral machine's selection window can be found above the SERVICE button located at the bottom of the touchscreen. Select the desired machine by pressing the corresponding button. This will open a window (image 2) in which all further steps are processed as described below.

3. Determine calibration weights in the controls

The exact weight of the small and large calibration weights must first be determined and entered into the data fields shown on image 2:
By pressing the numeric field, a window opens with a numeric keypad for entering the value. Finish entering by pressing the “enter button”.

The values labelled “thread tension 1” refer to the 10N sensor and “thread tension 2” refers to the 60N sensor.

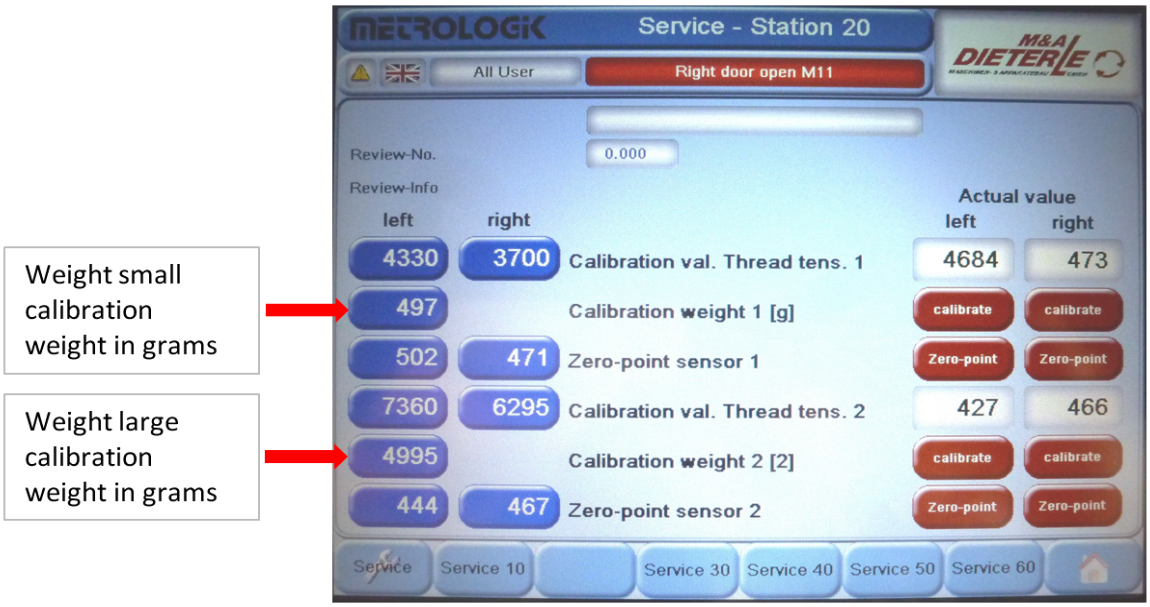


Image 2

Determining calibration weight in the controls

4. Zero point of the thread tension sensors

For unloaded sensors, the zero values (not equal to “0”!) are initially determined in the controls.
Example:
Zero value for the 10N sensor of the left spindle (see image 3).
By pressing the button, the value displayed in the corresponding data field (actual values / left) is transferred to the right side of the display.

The values for the other sensors are now recorded sequentially in the same way.

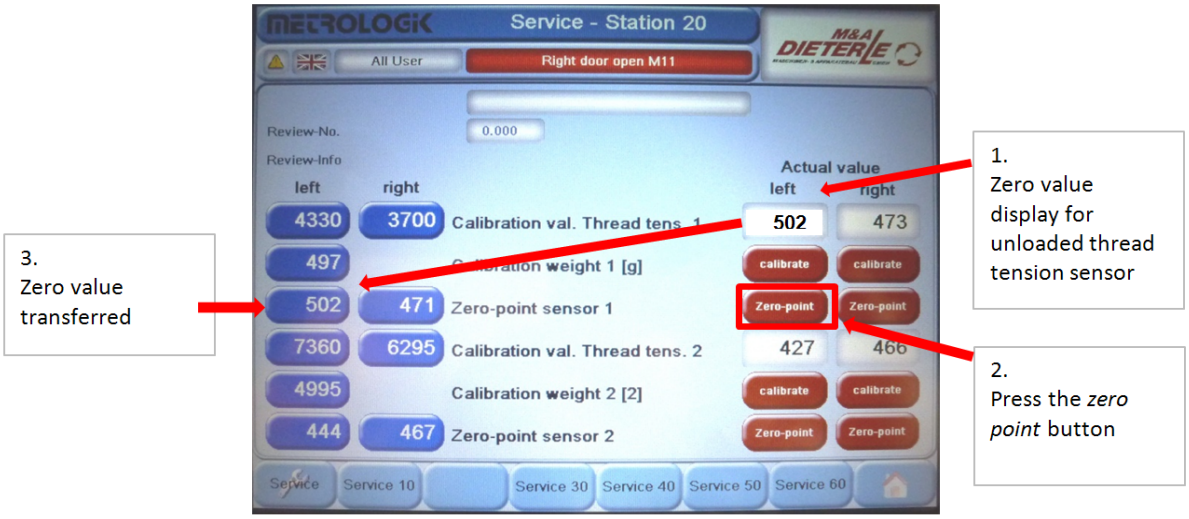


Image 3

Set sensors to “0”

5. Feed in spiral thread

Feed the spiral thread into the machine as described in chapter 2.3.5 and tie it to the spiral mandrel.
Insert the spiral thread between the deflection roller ① and the outer plate roller and guide it above the deflection roller ② mounted under the machine table plate.
Now the spiral wire is cut approx. 0.5m underneath coil and tied into a knot.

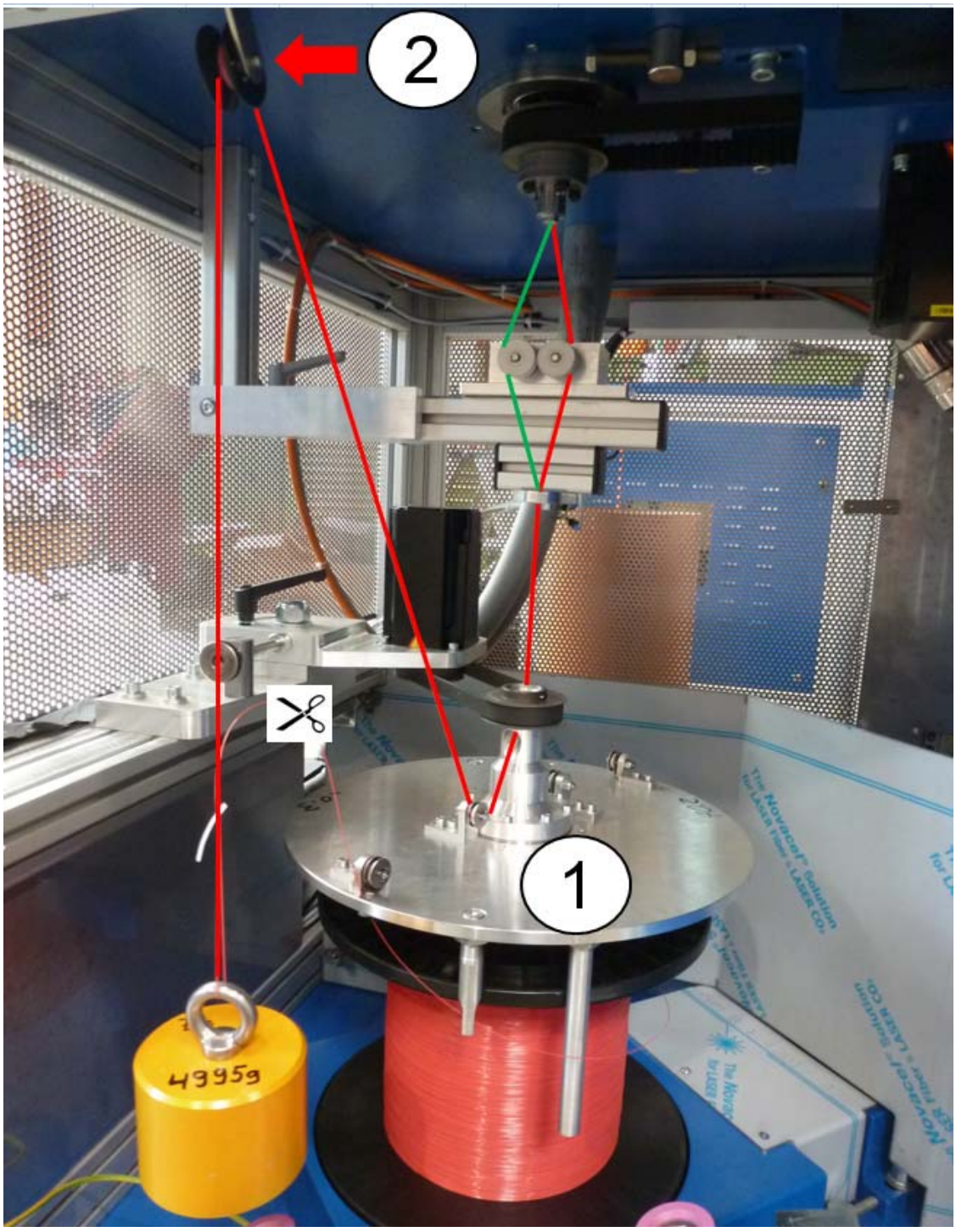


Image 4

Process for calibrating spiral wire
red = 60 N sensor
green = 10 N sensor

6. Test setup

First, the 10N sensor is calibrated with the smaller weight. The weight is also hung in the prepared knot in the spiral wire. Now the spiral wire has to touch the exterior of the roller of the respective sensor, as shown in image 5. The weight must not swing during calibration because; if it does, no single value will be available as a basis.

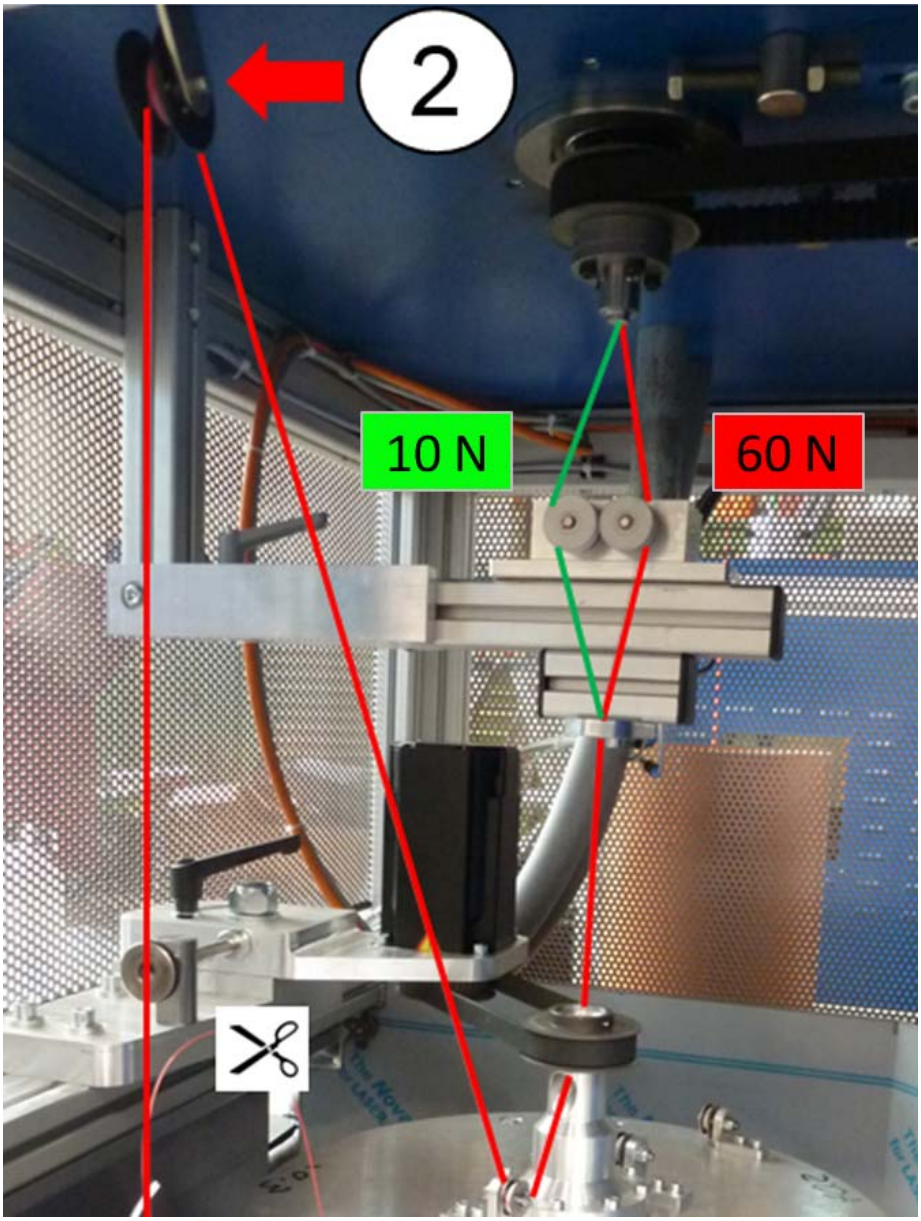


Image 5

Test setup for sensor calibration

7. Calibration

First, the corresponding machine (station) is selected in the controls in the *Service* window (image 6).
In the window “Service - Station xx” on the left, the target values and on the right, the actual values of both sensors are displayed for each spindle.

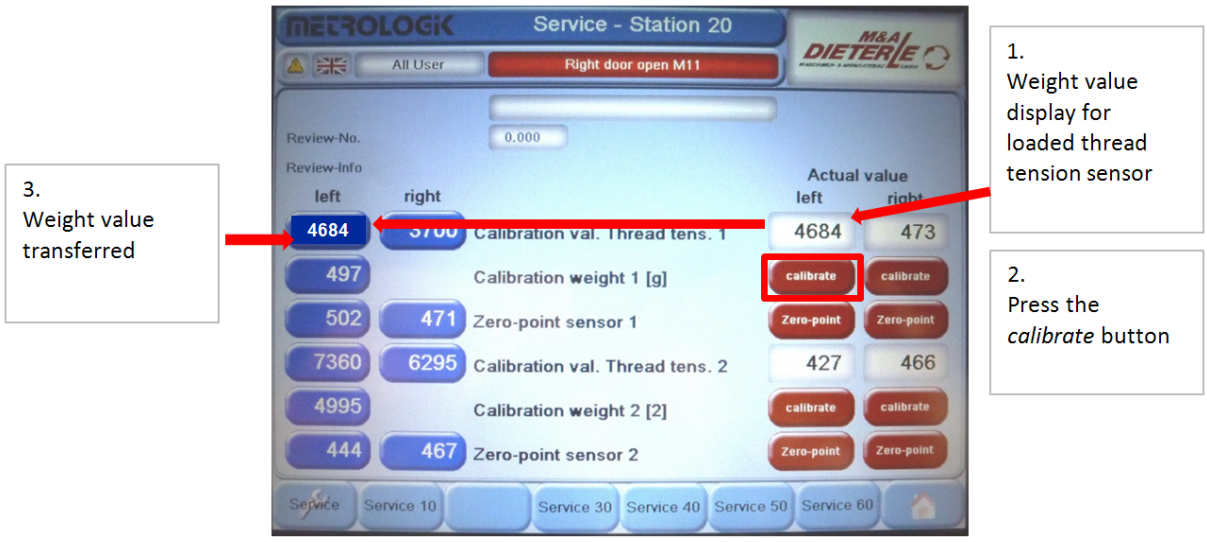


Image 6

Calibration of 10N sensors on the left spindle

In the white data field (actual values) of the 10N sensor currently loaded with the calibration weight, its weight value is now displayed. This value does not correspond with the weight of the calibrating weight in grams! By pressing the *calibrate* button, the value displayed on the right is transferred to the blue data field on the left.

Now the weight can be replaced by the large test weight and the spiral wire can be guided outside over the roller of the 60N sensor. The second sensor is now calibrated in the same manner (thread tension 2).