KS15 SPINNING LINE

Operating instructions

REV No.	DATE	DESCRIPTION	EDITED	CHD.	APPD.
1.0	20.2.2020	Initial version	SRa		
1.1	29.8.2022	Common problems added	SRa		

SAFETY

You should always plan your work before starting and go through all the safety issues involved. A risk analysis may be required, consult your supervisor or technical staff. Read through the material safety datasheets (MSDS) and use appropriate safety equipment and procedures.

Read carefully through the instructions. If something is left unclear, always ask for further instructions. You are responsible for the safety of yourself, the equipment, and others in the vicinity.

Be careful of chemical residues before and after the process. Clean and dry the parts thoroughly after your work!

Label clearly and store your samples appropriately. Minimum information for labels is full name, contact information, date, and chemical contents.

Some of the equipment are used at temperatures that introduce a hazard of burns when handled without proper safety equipment. Some of the equipment are heavy and care must be taken when handling them.

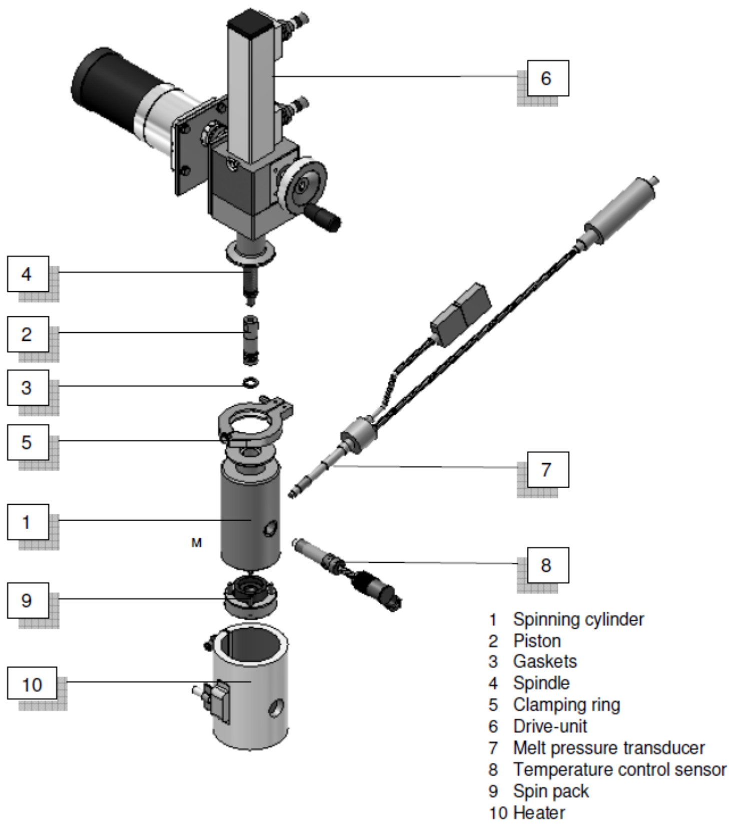
The external temperature sensor, attached on the surface of the spinning cylinder, works as a feedback system for the heating jacket. If the sensor is not attached while the heating jacket is powered, it will disrupt the feedback link and create a major safety hazard. It might lead to extreme overheating, damage to the equipment, combustion gases and fire.

Dry-Jet Wet Spinning

Spinning with KS15

The KS15 spinning unit, used in the line, is a dry-jet wet spinning unit. The spinning line consists of a spinning unit, coagulation bath, godet, control cabinet and computer. Siemens Simatic WinCC software, with a customized user interface, is used to control the spinning line.

Image 1 - Spinning unit KS15 (Image from original manual by Fourne)



KS15 spinning unit employs motor driven piston extrusion, with adjustable extrusion velocity, into a coagulation bath. Main components of the unit are depicted in Image 1.

The piston movement is driven by a synchronous motor. For manual piston control the hand wheel (See Image 2) can be used. When turning the hand wheel, the coupling will unlock the motor. For re-connecting the motor, the coupling must snap into place again. Press the snap-ring in direction of the hand-wheel during slow rotation using the supplied yellow lever (See Image 13).

Image 2 - Spindle drive-unit *(Image from original manual by Fourne)*

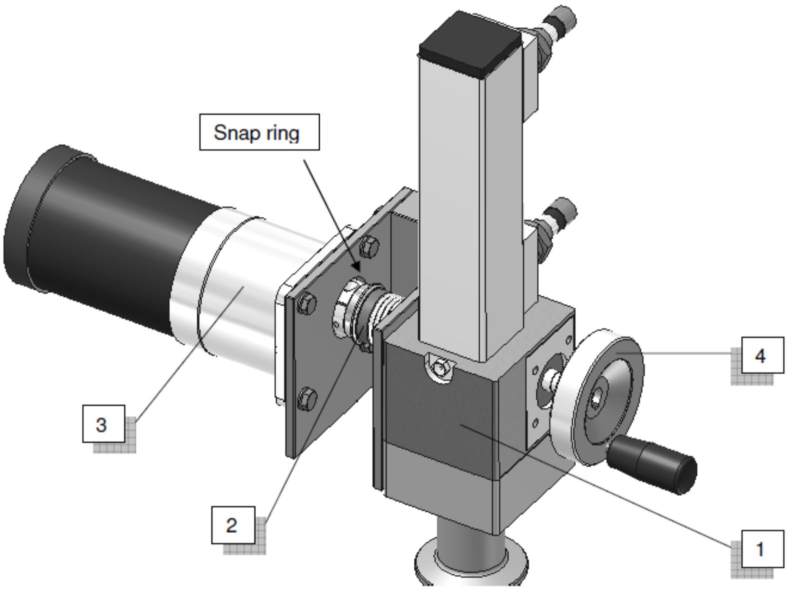


Figure 5: Spindle drive unit

1 Spindle drive
2 Coupling
3 Synchronous Motor
4 Hand wheel

The spin pack and its parts are shown in Image 3. The disposable filters are of different mesh sizes. Spinnerets may have different number of holes and geometries.

Image 3 - Spin pack for KS15 *(Image from original manual by Fourne)*

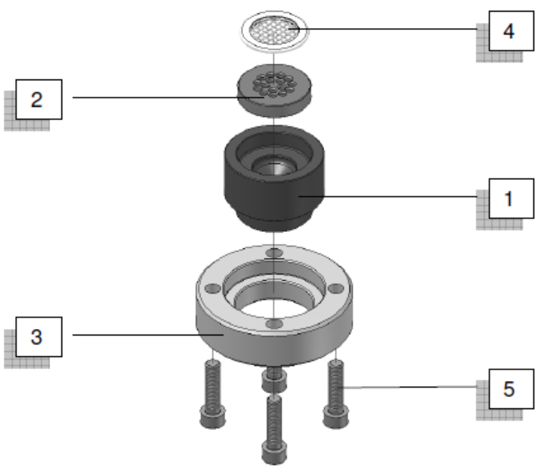
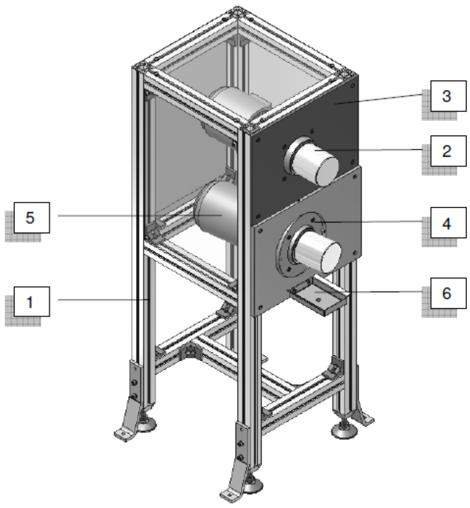


Figure 6: Spin pack

1 Spinneret
2 Support plate
3 Spinneret housing
4 Filter
5 Socket cap screw

The coagulation bath is equipped with electronically adjustable height and water flow. The godet-couples (See Image 4) have a diameter of 100 x 100 mm with an adjustable speed of 1 to 25 m/min. The lower godet can be adjusted to a set angle of 6-7 °.

Image 4 - Godet drive DUO-I *(Image from original manual by Fourne)*



Most often used, detachable parts of the spinning unit and tools should be placed in baskets on the dedicated metal table next to the spinning line. Location of spinnerets and other spare parts can be found from the laboratory map available in the lab.

[INSERT IMAGE OF ALL THE USED TOOLS HERE]

[Ratcheting socket wrench]

[Socket hex bits]

[Combination wrench]

[Yellow tool]

Operating the KS15 spinning unit

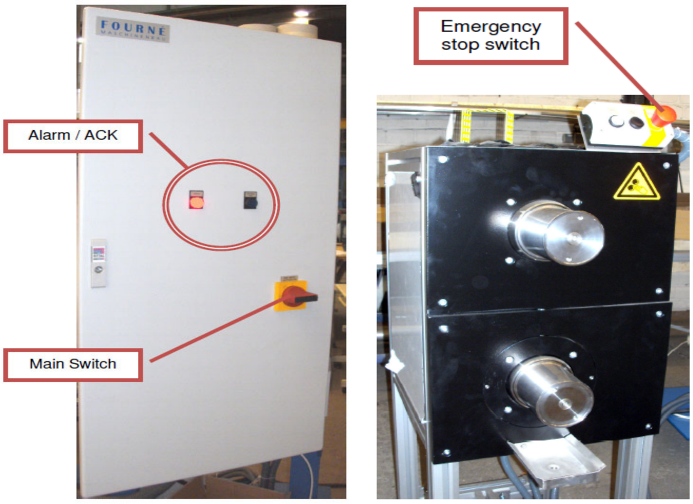
The novel coagulation or spin bath has been developed at Aalto. It has its own panel for electronically controlling the height, switch for the flow pump and adjustable flow valve with meter (See Image 5).

Image 5 - Coagulation bath controls

The godet for stretching and transferring the extruded filament is equipped with an on-off and an emergency switch. When turned on, the godet will start rotating at the set value defined in the controller software. Engaged emergency stop will stop the whole spinning line until disengaged and acknowledged. (See Image 6)

The large control cabinet is equipped with a mains switch, an alarm light, and a physical alarm acknowledgement button. (See Image 6)

Image 6 – Control cabinet and godet controls



Setting up the spinning unit

Make sure all the parts for the spin pack and the cylinder are clean and dry before assembly. To avoid any scratches on the spinneret, do the assembly for example on a paper hand towel.

Insert the spinneret inside the housing, followed by the support plate and finally the filter (See Image 3 and Image 7). The filters have multiple layers – place the coarse side upwards, facing the dope

Image 7 - Assembling the cylinder head

Next you can put the cylinder over the frame and carefully turn the whole setup upside down, the spinneret facing now up. Attach the frame to the cylinder with the bolts. Bolt threads should be lubricated with high-temperature grease. Tighten the bolts to final tightness (10 Nm) using the torque wrench after the cylinder unit has been heated to process temperature.

Now that the cylinder unit is assembled, you can insert the dope inside the assembled cylinder. Move the piston up manually with the hand wheel, as described earlier in the document. Attach the cylinder to the frame using the flange or clamping ring minding the orientation (See Image 1 and Image 8).

Image 8 - attached cylinder on the spinning unit

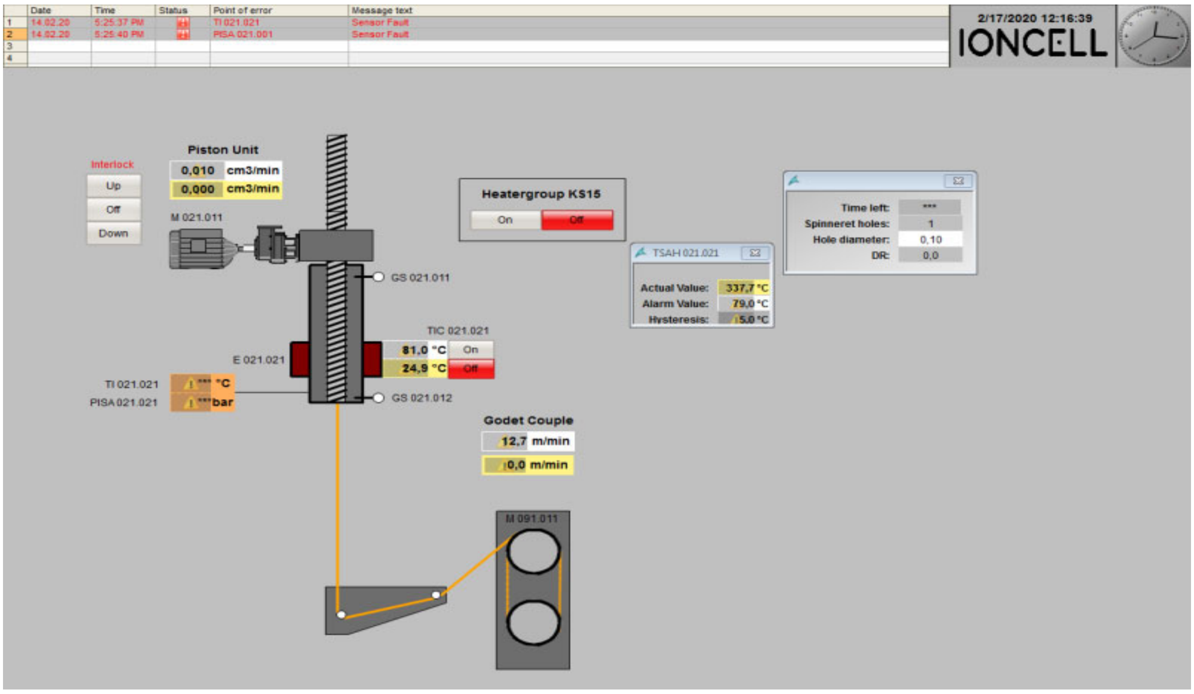
Slide the heating jacket over the cylinder, minding the alignment for the sensor holes, and tighten in place with the two hex bolts. Attach the sensor housing and insert the heat sensor.

Attach the melt pressure transducer (combined pressure and temperature sensor) – use no force! Use Teflon tape on the thread if leaking is an issue. Join the connectors as well. Tighten the transducer using torque of 15 Nm. Your setup should look like in Image 9.

Image 9 - Cylinder unit assembled, and sensors attached

To power on the spinning unit control system, switch on the red main switch on the control cabinet (See Image 6). Press the acknowledgement button (glowing blue) “EM-Stop ACK” on the same cabinet. The “EM-Stop ACK”-button cannot be operated when an emergency stop switch at the plant has been activated. Only after unlocking of the appropriate emergency stop switch and after pushing the “EM-Stop ACK”-button at the control panel, the light in the switch will go off and the process can be continued.

Image 10 – Control software user-interface



On the computer, write desired spinning temperature in the upper box below the heating jacket label (*TIC 021.021*). Click on one of the red blocks representing the heating jacket in the diagram, to open detail window (*TSAH 021.021*). Set alarm value a couple of degrees lower than your target temperature. (See Image 10)

Switch electricity to the heating elements by clicking *Heatergroup KS15* On. **Make sure the temperature sensors are properly attached, before applying heating!** Start actual heating by switching *TIC 021.021* On. (See Image 10)

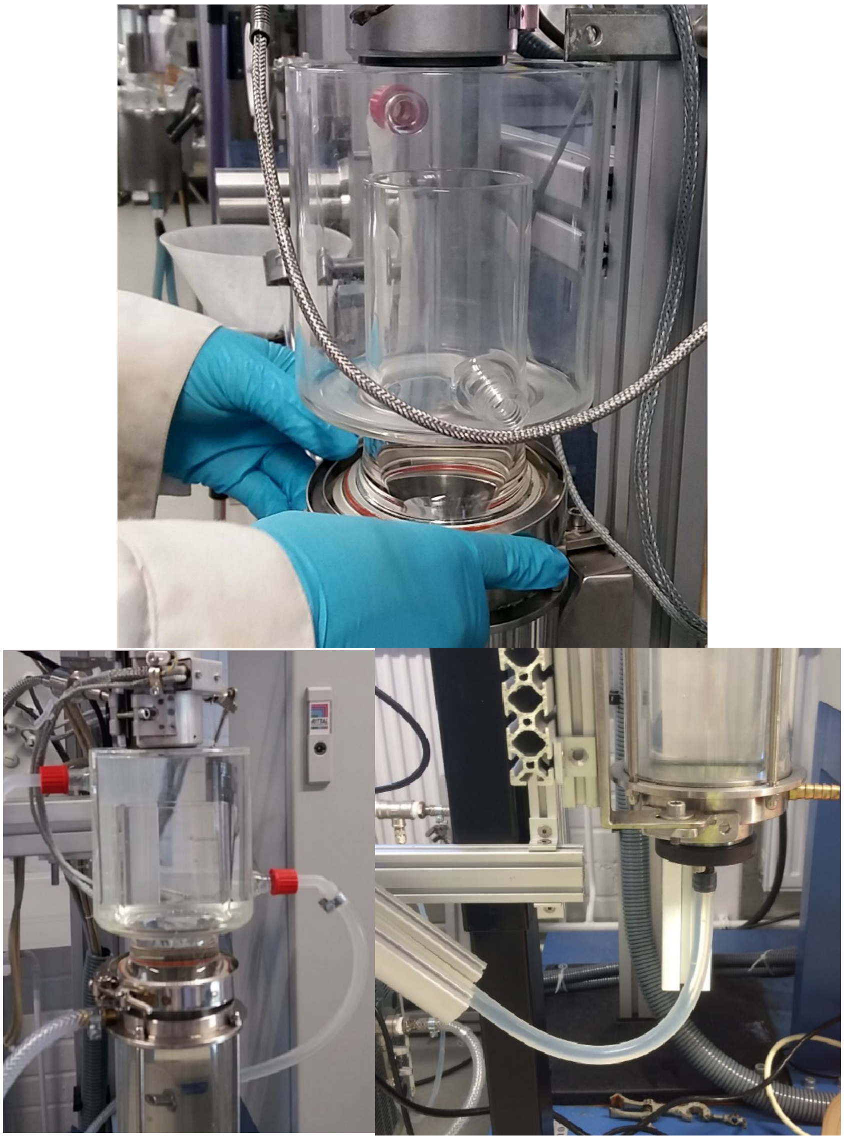
TI and PISA 021.021 show you the actual temperature and pressure respectively inside the cylinder. Often a good spinning temperature is where the zero-shear viscosity of the dope is close to 40 000 Pa·s (Michud: 27000-40000 Pa·s, Ma: 30 000 Pa·s).

In the beginning, you can use a higher temperature to melt the dope. Modify the temperature accordingly before starting actual spinning. When heated to target temperature, retighten the bolts of the spin pack frame using torque of 15 Nm.

Place the glass cylinder over the fixed main cylinder, aligning the tube connectors with running direction of the spinning line. Tighten the flange over the joining parts. The upper connector goes to the overflow vessel tube, the lower connector is attached to the tube coming from the flow meter. Attach the tubing connected to the diagonal out flow bar to the bottom of the coagulation bath. (See Image 11)

Assembling the bath

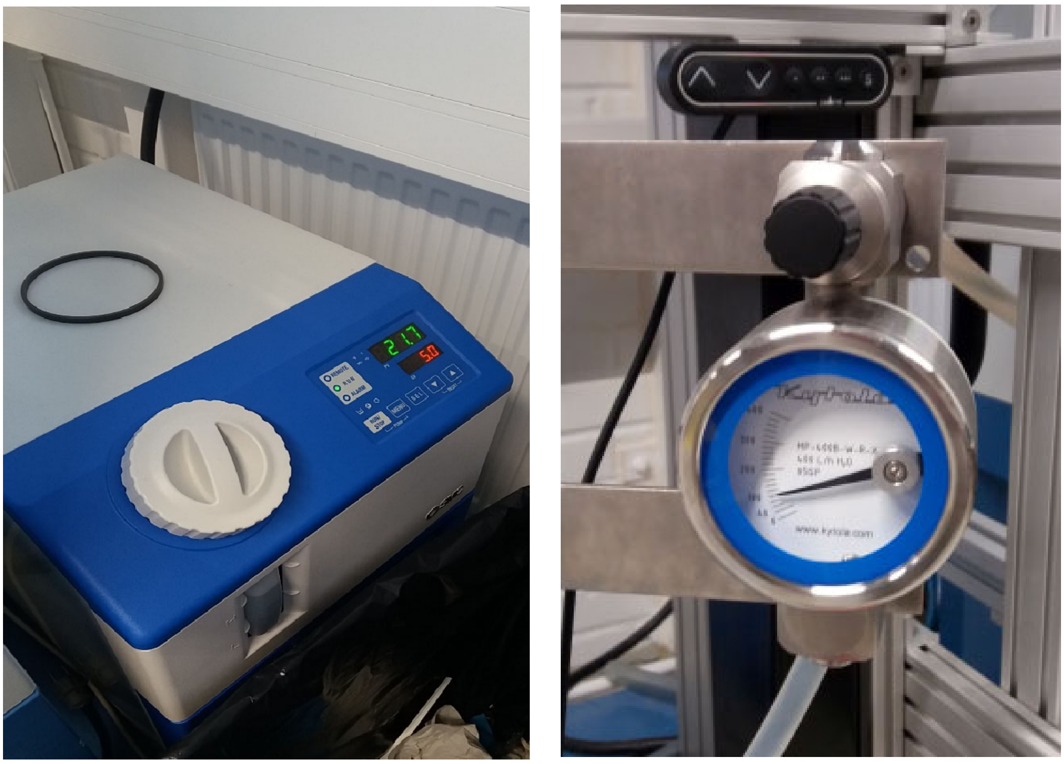
Image 11 - Assembling the spin bath



Preparing for spinning

After assembling the bath and making sure all connections are fixed, the next part is preparing the spinning line. Turn on and start the cooling unit behind the spinning line (See Image 12).

Image 12 - Cooling unit and flow valve



The coagulation bath will be filled with around 4.2 litres of de-ionized water in total. It is a good practise to fill the overflow vessel before starting the water circulation pump. If the vessel runs out of water, it will aerate the water pump and will most probably cause water circulation problems.

Pour the rest of the water in the glass cylinders making the main coagulation bath. Start the water circulation pump with the dedicated switch. Remove all the air from the water circulation before starting spinning, using the valve between the overflow vessel and pump, if need be.

Adjusting the position (height of the end of the) outflow tube will affect the coagulation bath water level and outflow. An equilibrium between the water flow in (flow valve) and out (overflow and outflow) needs to be reached. 100 L/h is a good approximate for the water flow in.

Lift the coagulation bath to get an air gap of approximately 0.5 cm between the spinneret and water level. The air gap might need to be adjusted during the spinning process.

After the actual spinning temperature has been acquired, you auto-zero calibrate the pressure-temperature sensor, by using the attached magnetic tool on the marked spot on the sensor body for less than 10 seconds. This will reset the shown pressure to zero, giving you gauge pressure.

Rotate the handle manually to disengage the coupling and to lower the piston. Rotate until you start feeling pressure raise and finally see a bit of dope coming out of the spinneret. Re-engage the coupling between the piston and the motor using the yellow lever. Push the ring right, towards the handle (see Image 13), while turning the piston slowly, until you hear a click. On the computer, set the desired extrusion throughput speed for the piston unit. Start the piston motor by clicking *Down (See* Image 10*)*.

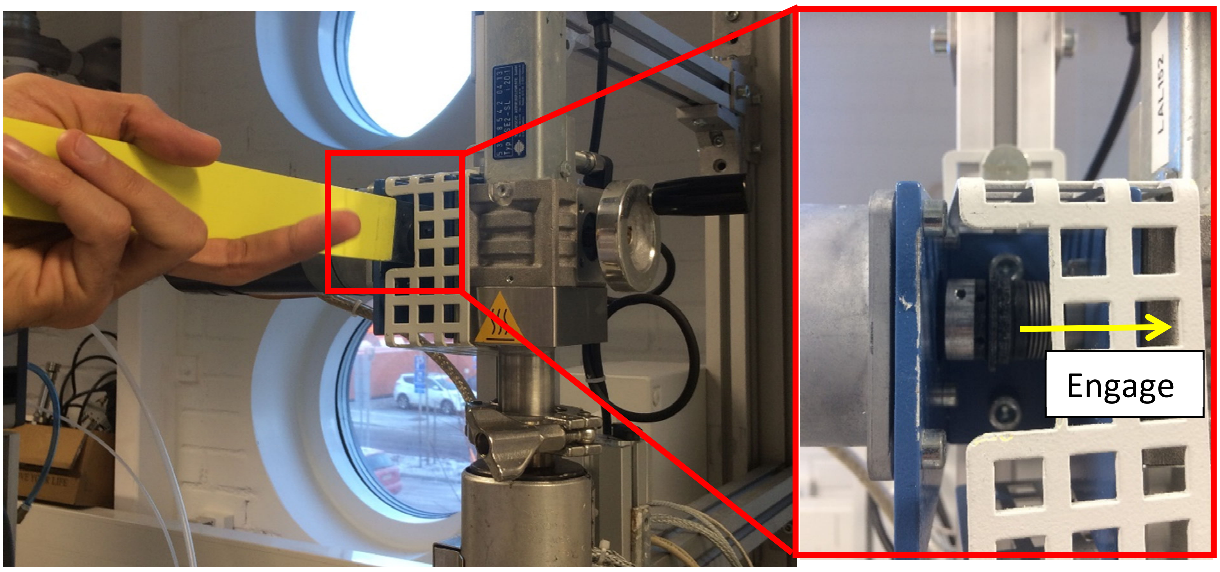


Image 13 – Engagement of the motor and piston

Adjust the godet speed in the software starting from low speeds, at draw ratios of 1-2. When the filament starts collecting on the overflow vessel mesh, guide it carefully over the guide roller and on the godets. Turn on the godet with the switch on top of it. Water and/or painter's tape can be used to ease the attaching of the filament on the godet surface.

Adjust the godet speed gradually to achieve higher draw ratios. Re-check that the temperature and air gap are as wanted. Let the system run for 2-3 minutes to make sure it is stable and filament quality is consistent, before collecting.

Finishing and cleaning

Lower the coagulation bath. Turn off the water circulation pump, godet, and cooling unit. Turn off the piston drive motor, heating jacket and heating unit from the software. Switch off the control cabinet mains switch.

Collect samples, remove waste filaments from the godet and guide roller. Wipe godet and guide roller clean with moist paper and if need be, using ethanol. Cover clean and dry godet rollers with the protective caps.

Empty the metallic back-flow cylinder into a bucket by opening the white valve attached to the tube below it. Remove waste filaments from the top sieve. Empty the fixed coagulation bath cylinder into a bucket by carefully detaching the tubing from beneath it. Rinse the cylinder and reattach the tubing. Detach the upper coagulation bath cylinder and rinse it. Reassemble.

Detach the sensors using the 16 mm wrench, sensor housings and heating jacket from the spinning cylinder. Untighten the spinning head bolts while the cylinder is still attached to the frame.

Detach and disassemble the spinning cylinder. Clean with water all the spinning cylinder parts that have been in contact with the dope. Clean also the piston with its screw and the pressure-temperature-sensor head.

Dry all the rusting parts like the spinning cylinder bolt holes, spin pack frame and bolts. Dry the PT-sensor, replace the protective caps (3 in total) and store carefully in the cardboard box on the table next to the spinning unit.

Replace all the parts and tools back in their dedicated places! Most of them belong on the table next to the spinning unit. Still drying parts can be left on the same table on a paper towel. **Recheck there are no unprotected blades or needles, tools or parts left laying behind.**

Update the consumables list. Export the spinning log.

Report all anomalies, malfunctions, or problems!

Common problems

The bath height adjustment does not work upwards

Move the bath to its lowest point. This will reset the two lifting elements to a common zero-point.

There is no / low flow of water

Check there is enough water in the system.

Check the adjustable rotameter is not closed.

Check if there is air in the pump / line starting from the overflow tank. Ensure the overflow tank has enough water. Try removing the air from the line by constricting the elastic hoses or by adjusting the rotameter.

The software gives an error about license (WinCC Runtime License)

This can be ignored (move the window just out of view), and/or the computer rebooted.

I cannot turn the extrusion piston motor on from the software

If the system is in “interlock” status, piston motor cannot be turned on. Check that the heating is on, piston pressure is lower than 80 bars and that the piston is not too low or high.

The piston does not move even though the motor is on

Turn off the motor. Ensure the coupling between the piston motor and piston has been engaged and try again.