3 DESIGN AND OPERATING PRINCIPLE

1
CALENDER DESIGN

The purpose of a calender is to change the surface properties and caliper profile of paper so that they are better suited for the requirements of the printing method and further processing.

The calender is comprised of frame elements and equipment and rolls mounted on the frames.

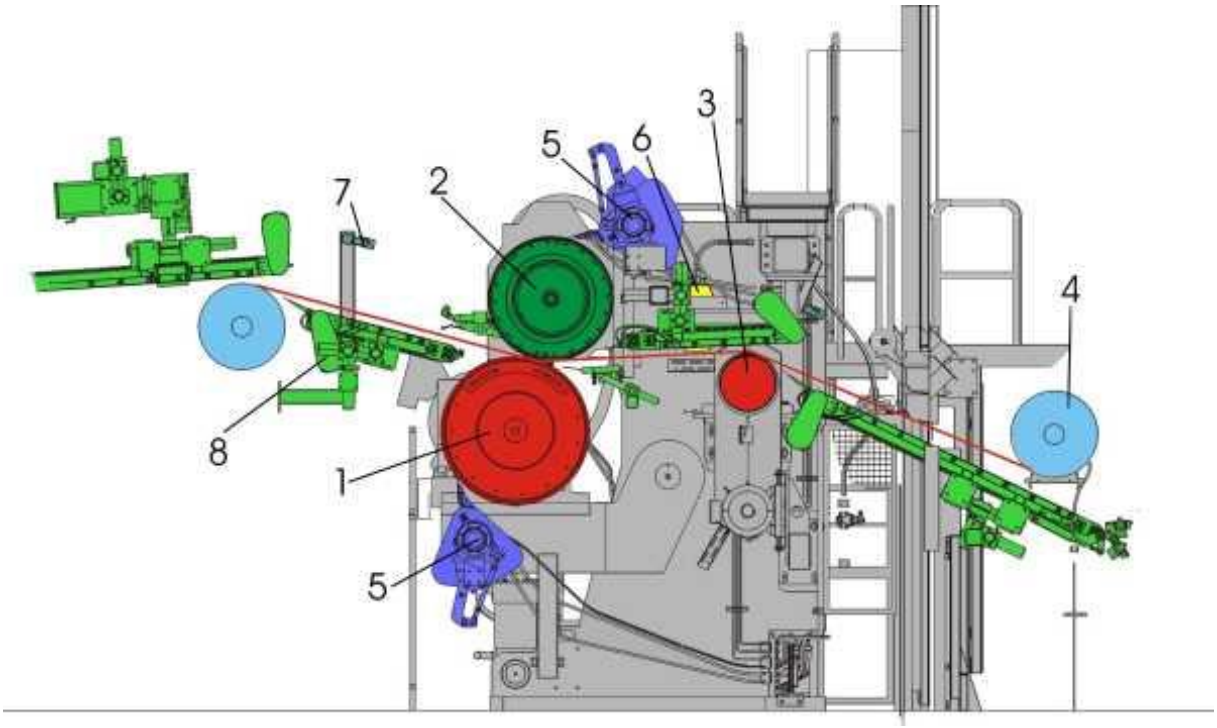

Figure 1. The OptiHard calender

1	*Thermo roll*
2	*Deflection compensated roll*
3	*Spreader roll*
4	*Tension measuring roll*
5	*Doctors*
6	*Web cutting device*
7	*Photocells*
8	*Tail threading equipments*

2
OPERATING PRINCIPLE OF CALENDER

Calender operation is based on various equipment.

- The calender nip is closed and the rolls are pressed against each other externally by hydraulic cylinders. Loading of the nip affects properties of paper.
- The deflection compensated roll controls the caliper and gloss profiles in cross-direction.
- Heat from the thermo roll controls plasticity of the paper surface.
- The spreader rolls carry the web flat and straight into the calender nip.
- The doctor protects the roll surface from impurities and prevents paper from winding around the roll.

The loading and roll hydraulic systems, the circulation lubrication system and the thermo roll heating and cooling system are vital for calender operation.

3
NIP LOADING WITH LOADING CYLINDERS

3.1
Design

The purpose of the loading cylinders is to close and open the nip and to press the bottom roll against the top roll using such a force that the required linear load is achieved.

The loading cylinders are located under the bottom roll on the tending and drive sides.

The loading cylinders are double-acting cylinders. For mounting of the loading cylinder, the upper and lower ends of the cylinder are equipped with grease-lubricated spherical plain bearings. The lower end of the loading cylinder is mounted on the calender frame using a shaft inserted through the lower spherical plain bearing, and the upper end is mounted on the loading arm using a shaft inserted through the upper spherical plain bearing.

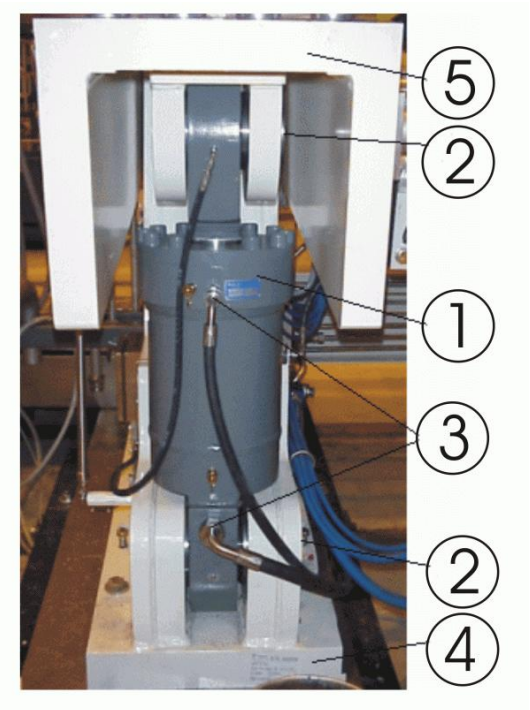

Figure 2. Location of the loading cylinder

1 Loading cylinder
2 Shaft
3 Oil supply
4 Frame
5 Loading arm

3.2 Operation

The loading cylinder performs the work movement, i.e. closes the nip when oil is supplied to the cylinder piston side. When oil is supplied to the rod side of the loading cylinder, the rod retracts and the nip opens.

4 ROLLS

4.1 General

The deflection compensated roll and the thermo roll are the main rolls of the calender, creating a nip. Furthermore, there is a spreader roll before the nip.

4.2 Deflection Compensated Roll, SymZ

4.2.1 Design

The deflection compensated rolls and the facing thermo rolls help produce a specified effect on the caliper and gloss profiles of paper in cross-direction.

The multizoned SymZ roll (Z = Zone) has loading elements over the entire shell length that are grouped into eight control zones. Loading in each zone can be adjusted with the loading elements. The SymZ roll consists of a stationary roll shaft, loading elements and a shell that is rotating around the shaft on spherical roller bearings. The roll shaft is mounted on frame structures via a bearing pedestal, drive gear and spherical plain bearings.

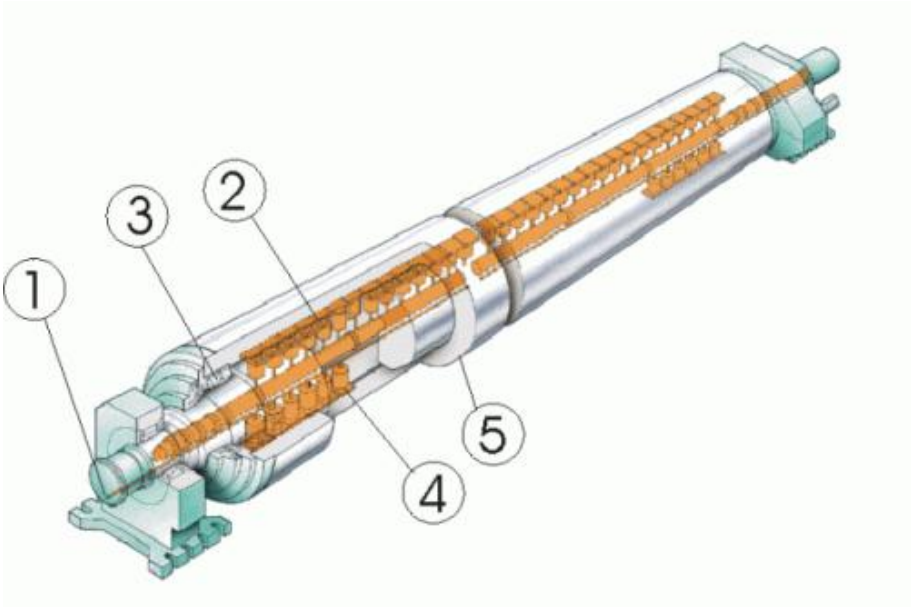

Figure 3. Main components of the deflection compensated roll

1 *Shaft*
2 *Hydraulic loading element*
3 *Spherical roller bearing*
4 *Loading element of counterzone*
5 *Shell*

4.2.2 Operation

Roll Loading

As the shell rotates around the roll shaft, oil at the specific pressure is supplied under the loading element piston. Oil presses the loading element against the shell with a force that is proportional to the pressure. Since the loading elements are divided into zones over the entire shell length, they can be supplied with different hydraulic pressures to allow profiling with the roll. The nip force created in loading is transferred through the shell over to the loading elements and further through the shaft to the frame structures.

4.3
Deflection Compensated Roll Drive

4.3.1
Design

The purpose of the deflection compensated roll drive is to make the deflection compensated roll run at a specified RPM.

The drive power is provided by an electric motor. The electric motor is connected to the universal shaft through a gear coupling. The other end of the universal shaft is connected through a coupling to the deflection compensated roll's gear unit, which is fixed to the deflection compensated roll. The universal shaft and its coupling are surrounded by a stationary guard.

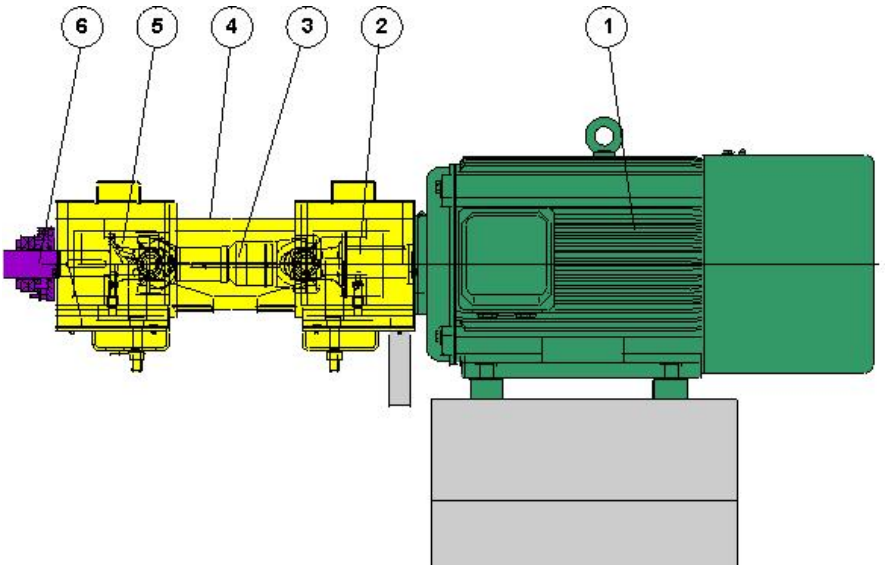

Figure 4. The drive of the deflection compensated roll

1 *Electric motor*
2 *Coupling half*
3 *Universal shaft*
4 *Guard*
5 *Coupling*
6 *Drive shaft of deflection compensated roll*

4.3.2
Operation

The electric motor is run by a supply of electric current. The electric motor drives the input shaft of the gear unit through couplings and a universal shaft. The input shaft drives the deflection compensated roll as much slower as the transmission ratio determines. The guard around the universal shaft and couplings prevents persons from being entangled with the rotating parts.

4.4
Water Heated Thermo Roll, TRIPASS II

4.4.1
Design

Heat from the thermo roll controls plasticity of the paper surface. The thermo roll is heated with hot water.

The main components of the thermo roll are the shell, journals and bearing assemblies. The shell is made of chilled cast iron. The journals made of steel are mounted on the shell with bolts.

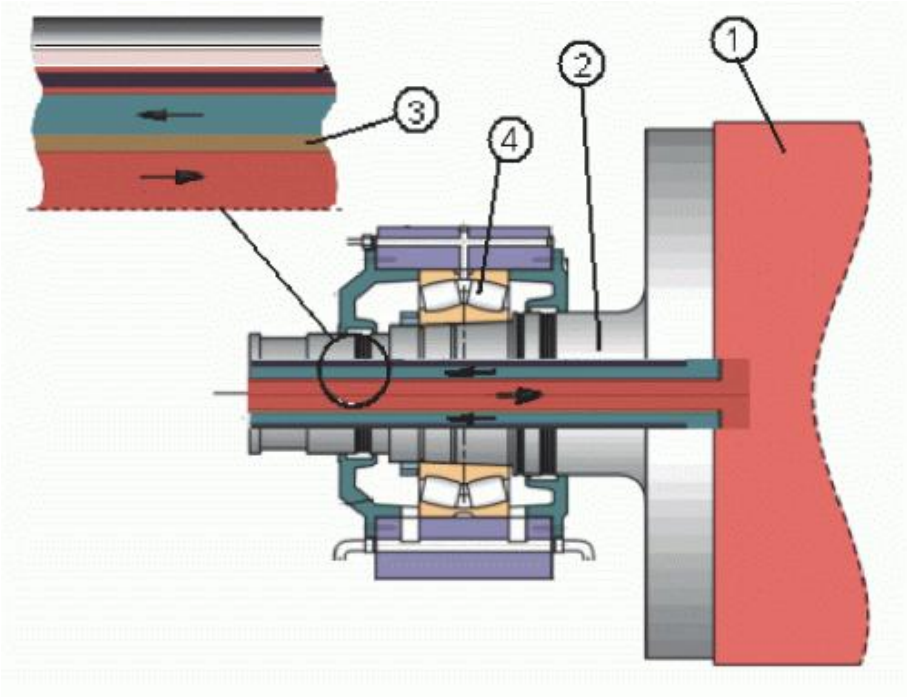

Figure 5. The thermo roll

1 *Shell*
2 *Journal*
3 *Siphon pipe*
4 *Insulating pipe*
5 *Bearings*

Hot water is supplied and removed through the tending side end of the roll. Bores parallel with the shell's surface are drilled over the entire shell length. Water circulates in these bores as shown in the following figure.

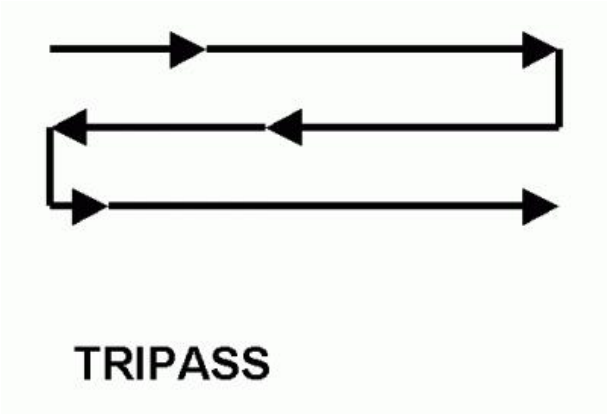

Figure 6. The flow principle in the shell bores

A 2-way water coupling, through which water comes into the roll and exits from the roll, is mounted on the end of the tending side journal.

A drive shaft is connected to the end of the drive side journal of the thermo roll. The other end of the drive shaft is connected to the gear unit, which receives driving power from the electric motor.

For lubricating the thermo roll bearings is connected to the circulation oil lubrication system of the dry end system.

4.4.2 Operation

The thermo roll is driven by the electric motor. The thermo roll's surface temperature can be adjusted by changing the temperature of water circulating in the bores of the shell. Water is supplied to the roll through a rotary joint on the tending side. Bores in the tending side journal distribute the water flow into the shell's inlet ducts. Bores in the drive side journal turn the incoming water flow via the shell's center bore into the return ducts to be returned to the tending side. Water exits from the journal through the rotary joint.

4.5 Thermo Roll Drive

4.5.1 Design

The purpose of the thermo roll drive is to make the thermo roll run at a specified speed.

The drive power is provided by an electric motor. The electric motor is connected to the gear unit through a gear coupling. The gear unit is oil-lubricated. A coupling half connects the output shaft of the gear unit to a universal shaft. The other end of the universal shaft is connected either directly or through a coupling half to the thermo roll head. A stationary guard is located around the universal shaft and gear coupling.

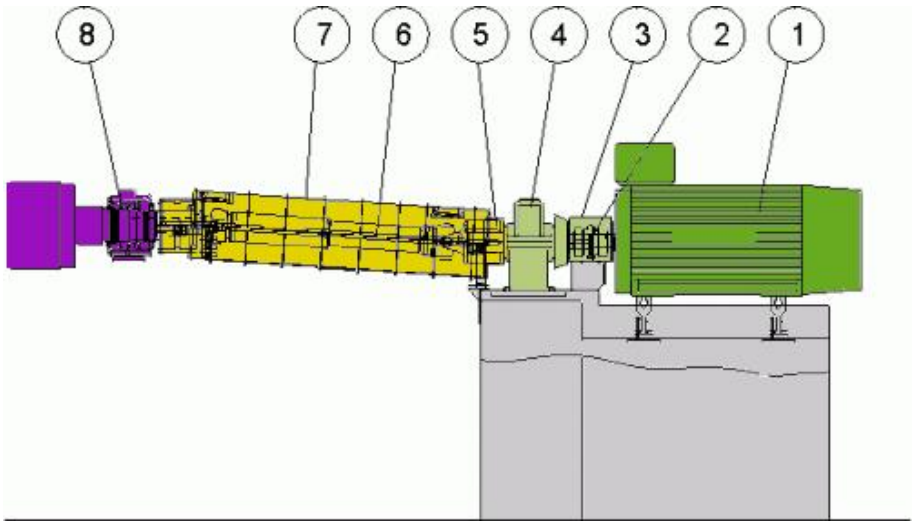

Figure 7. The thermo roll drive

1 *Electric motor*
2 *Gear coupling*
3 *Gear coupling guard*
4 *Gear unit*
5 *Coupling half*
6 *Universal shaft*
7 *Universal shaft guard*
8 *Thermo roll*

4.5.2
Operation

The electric motor is run by a supply of electric current. The electric motor drives the gear unit's input shaft, which drives the output shaft as much slower as the transmission ratio determines. The universal shaft and the thermo roll rotate at the same speed as the gear unit's output shaft. The guards around the universal shaft and coupling prevent persons from being entangled with the rotating parts.

4.6
Rotary Joint of Thermo Roll

4.6.1
Design

A rotary joint leads the heating water circulating in the thermo roll into and out of the roll. The rotary joint acts as a coupling between the rotating roll and stationary hoses.

The rotary joint is also called a water coupling.

The water coupling is mounted on the end of the thermo roll journal on the tending side. The water coupling guard is mounted on the bearing housing cap by means of a bracket. A rotation stopper fastened to the bracket prevents the water coupling from rotating with the roll.

A bearing assembly inside the water coupling allows the rotor and inner part of the water coupling to rotate with the roll. A siphon pipe inside the roll and water coupling distributes the water flow into different ducts of inlet flow and return flow. The water coupling has connections for the hoses of inlet flow and return flow and for the air bleed pipe, and a grease nipple for lubrication of the bearing assembly.

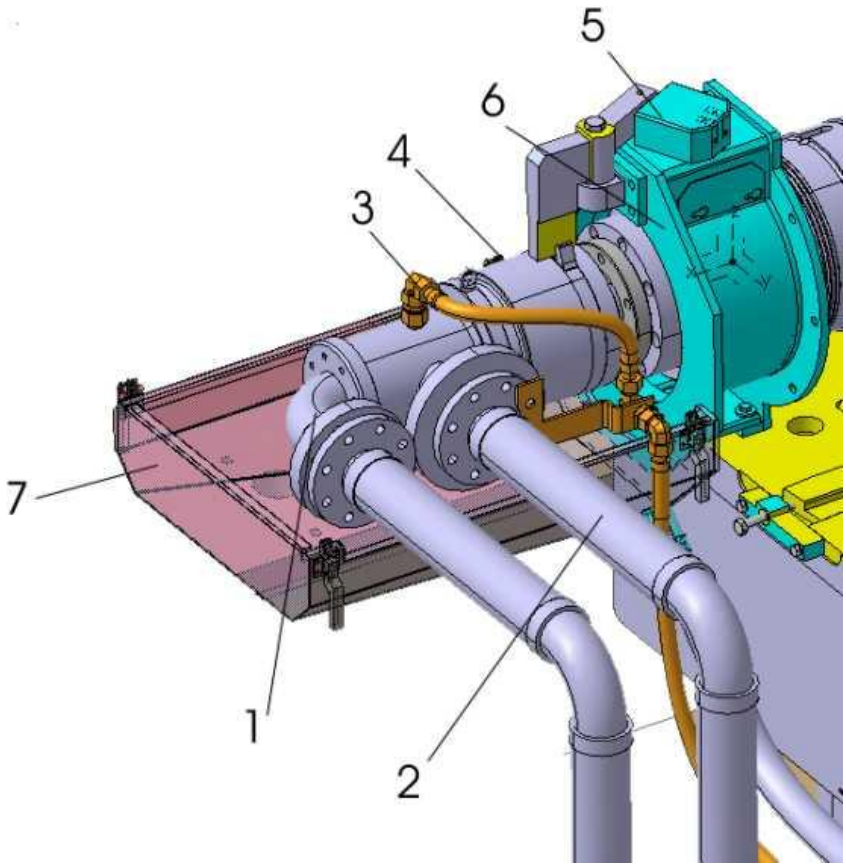

Figure 8. The thermo roll water coupling

1 *Water inlet*
2 *Water return*
3 *Air bleed pipe*
4 *Grease nipple for bearing*
5 *Load cell assembly*
6 *Guard bracket*
7 *Guard*

4.6.2 Operation

Heat carrier water circulating inside the roll is fed through the water coupling.

Operationally, the water coupling is a 2-way coupling. The water going into the roll and the return water are flowing through the same coupling.

Upon filling, the heating system is bled using a manual bleed valve.

The heat carrier water is fed into the roll through the end of the water coupling. Water flows into the roll inside the siphon pipe and is distributed in the journal bores into the ducts of the thermo roll shell. Water returning from the roll flows between the coupling body and siphon pipe. Water exits via the return ducts.

4.7 Spreader Rolls

4.7.1 Design and Operation

Bowed spreader rolls prevent and eliminate web wrinkles in machine direction and even out web tension difference between the edges and center. The bow amount is fixed but its direction can be adjusted. In normal conditions the direction of the bow must not be changed from the neutral position.

When the spreader roll bow is turned towards the web, the middle of the web will be tensed more than the edges. When the bow is turned off the web, the edges become tighter than the middle of the web. If the bow is changed too much from the neutral position, the web may be damaged.

Figure 9.

The spreader roll is made up of steel sections that are mounted on bearings around the bowed shaft. The spreader roll is rotated by a belt drive from the drive side end. Rubber seals between the steel sections transmit the force needed for rotation across the entire roll width.

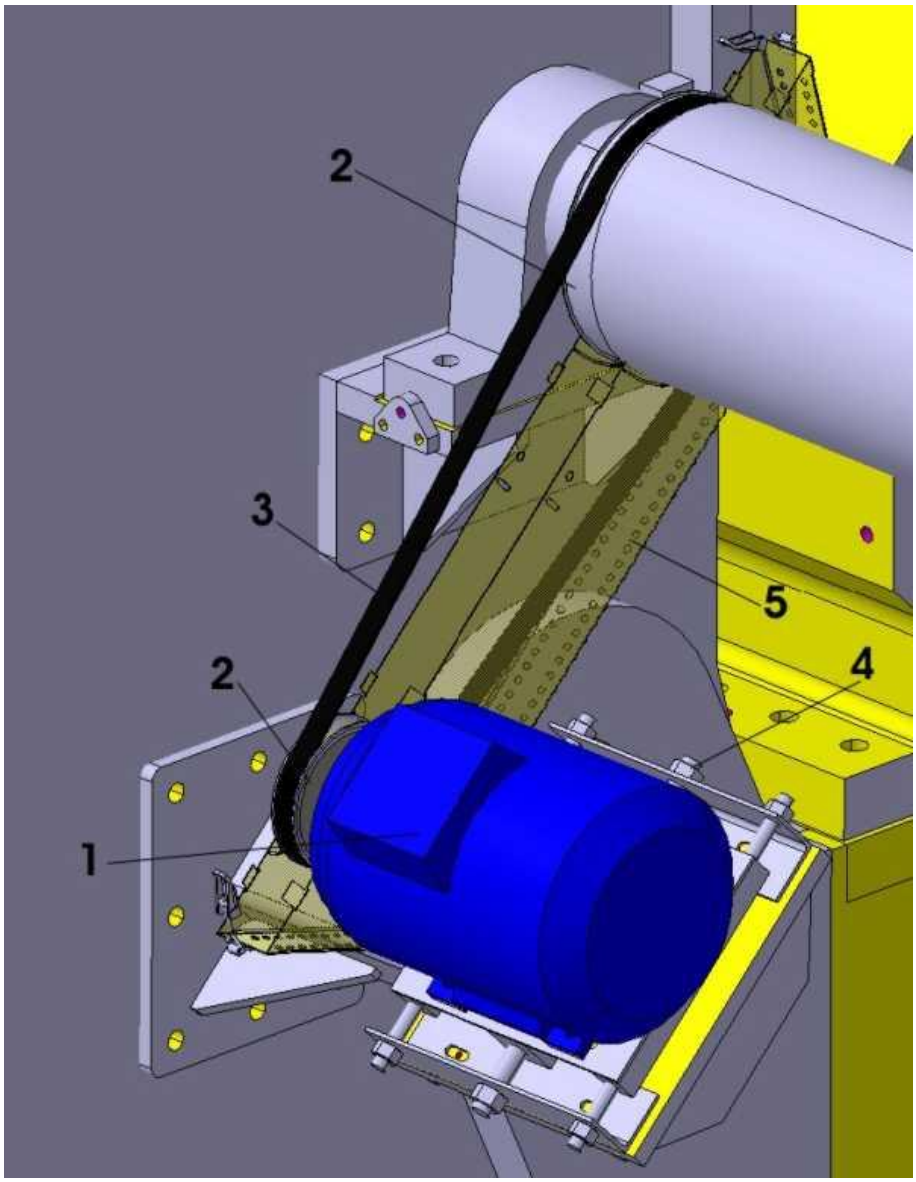

Figure 10. Main parts of spreader roll belt drive

1 *Drive motor*
2 *Belt pulleys*
3 *Cogged belt*
4 *Belt tightener*
5 *Guard*

4.8
Tension Measuring Roll

4.8.1
Design

The purpose of the tension measuring roll is to measure and support the web in the machine line between different pieces of equipment.

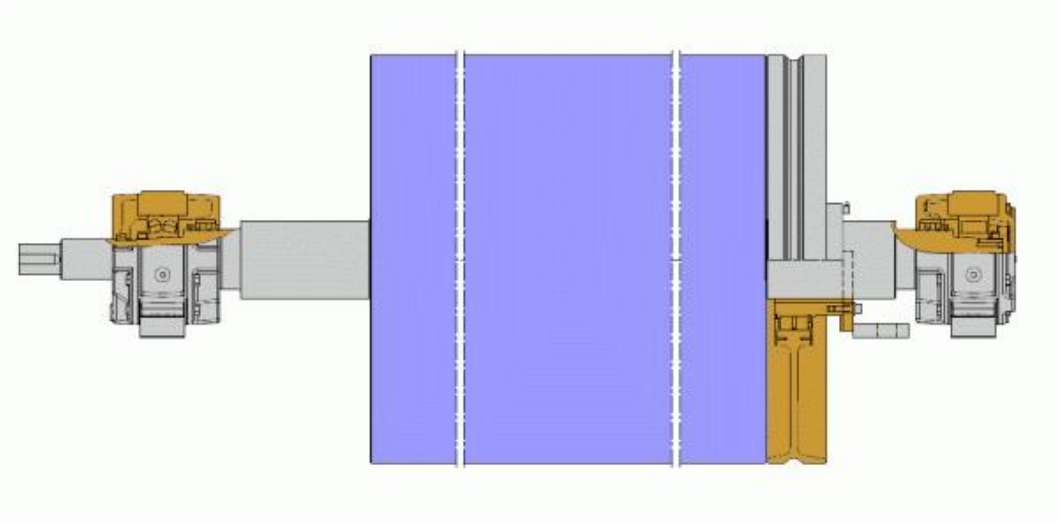

Figure 11. The tension measuring roll

The main components of the tension measuring roll include a single-section shell made of composite material, journals and bearing assemblies. The shell of the tension measuring roll used in the calender is smooth.

The tension measuring roll is covered with V170.

The bearings of the tension measuring roll are connected to circulation oil lubrication.

The tension measuring roll is driven directly, in which case there is a coupling between the roll and the motor. The power transmission elements are enclosed for protection.

4.8.2
Operation

The tension measuring roll is driven by the electric motor.

4.8.3
Load Cells for Tension Measurement

Design

Web tension is determined using load cells.

The load cells are located under the guide roll bearing housings on the tending and drive sides.

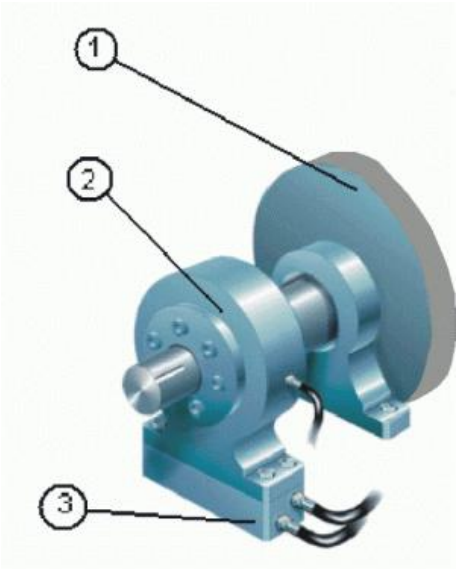

Figure 12. The load cells

1 Roll
2 Bearing housing
3 Load cell

A guide roll, under the bearing housings of which the load cells are installed, is called a tension measuring roll.

Operation

The load cells measure the force on the load cells, caused by the roll and web. Using web angles and the roll mass, the force of tension in direction of the web can be computed.

Correct web tension aims at ensuring troublefree machine operation. Insufficient web tension causes welts on the web, and excessive tension causes web breaks.

5
PROTECTION OF ROLLS

5.1
General

The calender is furnished with the following functions, equipment and properties that protect the rolls:

- Doctor of deflection compensated roll
- Thermo roll doctor
- Web break detection and web cutting device

In addition, it is important to follow the instructions of the roll manufacturers and to observe the rolls visually.

5.2
Doctor of Deflection Compensated Roll

5.2.1
Design

The purpose of the doctor is to clean the roll surface and prevent the paper from getting wrapped around the roll.

The following figure illustrates the simplified structure and main components of a doctor.

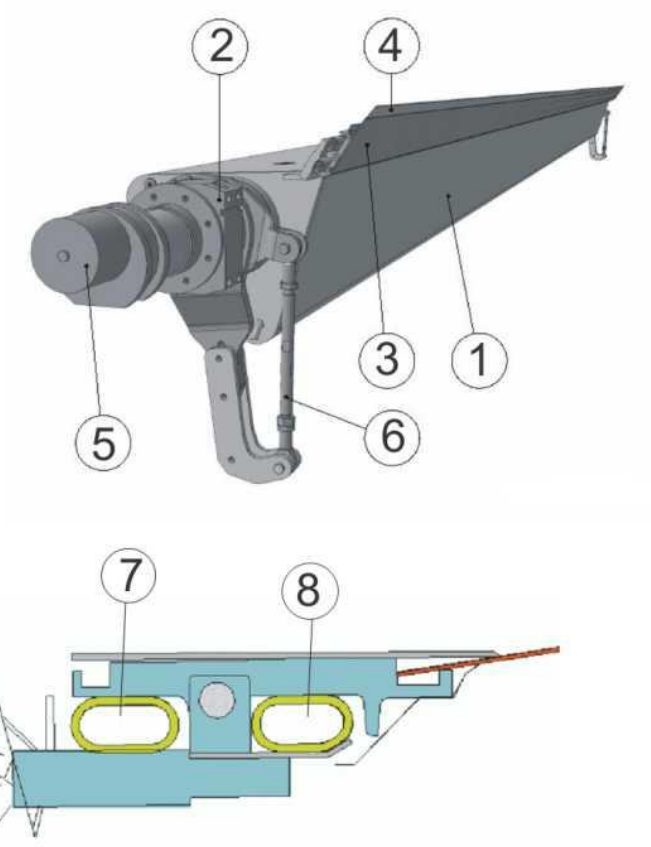

Figure 13. Doctor of the deflection compensated roll

1 Doctor beam
2 Bearing assembly
3 Blade holder
4 Blade
5 Oscillator
6 Turnbuckle
7 Loading hose
8 Unloading hose

The doctor body is comprised of a doctor beam equipped with a DST type blade holder, bearing housings, turnbuckles and an oscillator. The oscillator is pneumatic.

The blade is mounted on the blade holder, which has connections for loading and unloading hoses. A hand control valve is located in the pneumatic panel for the loading hose pressure.

The blade is made of composite material and its type is ValEco.

The blade angles and blade loads can be found in the doctor drawings.

5.2.2 Operation

The doctor is turned into the run position and service position by two turnbuckles.

The doctor blade is pressed against the roll and retracted from the roll pneumatically by loading and unloading hoses. The blade is pressed against the roll when the loading hose is pressurized. The blade retracts from the roll when the loading hose is unpressurized.

The doctor oscillates, i.e. moves back and forth in the longitudinal direction of the roll. Oscillation prevents local blade wear as well as roll damage resulting from wear. Oscillation only works when the doctor is in the run position and the rolls are rotating. The oscillation range is approx. 15 mm.

5.3 Thermo Roll Doctor

5.3.1 Design

The purpose of the doctor is to clean the roll surface and prevent the paper from getting wrapped around the roll.

The following figure illustrates the simplified structure and main components of a doctor.

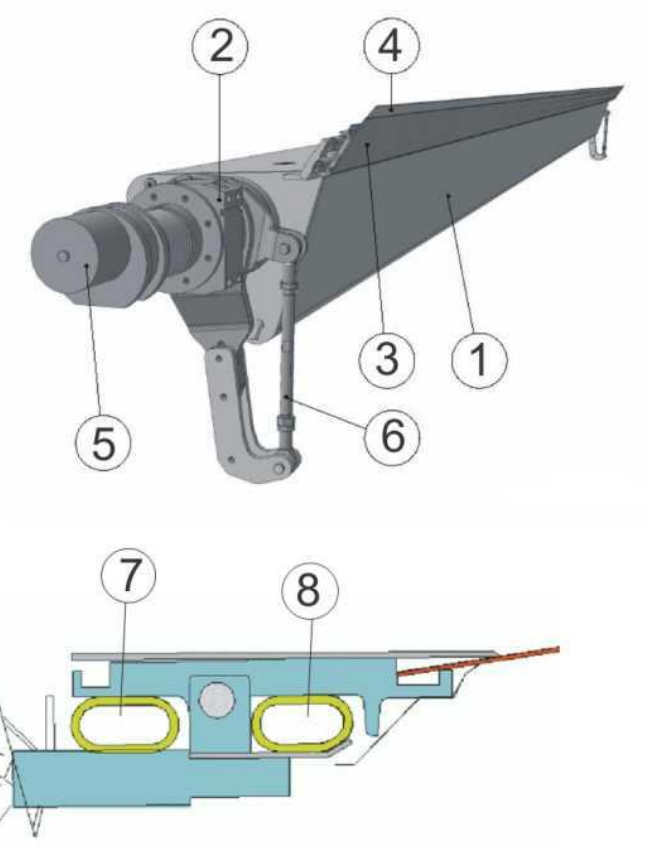

Figure 14. Thermo roll doctor

1 Doctor beam
2 Bearing assembly
3 Blade holder
4 Blade
5 Oscillator
6 Turnbuckle
7 Loading hose
8 Unloading hose

The doctor body is comprised of a doctor beam equipped with a DST type blade holder, bearing housings, turnbuckles and an oscillator. The oscillator is pneumatic.

The blade is mounted on the blade holder, which has connections for loading and unloading hoses. A hand control valve is located in the pneumatic panel for the loading hose pressure.

The doctor beam is thermally insulated to avoid deformations caused by temperature differences.

The blade is made of composite material and its type is ValEco.

The blade angles and blade loads can be found in the doctor drawings.

5.3.2 Operation

The doctor is turned into the run position and service position by two turnbuckles.

The doctor blade is pressed against the roll and retracted from the roll pneumatically by loading and unloading hoses. The blade is pressed against the roll when the loading hose is pressurized. The blade retracts from the roll when the loading hose is unpressurized.

The doctor oscillates, i.e. moves back and forth in the longitudinal direction of the roll. Oscillation prevents local blade wear as well as roll damage resulting from wear. Oscillation only works when the doctor is in the run position and the rolls are rotating. The oscillation range is approx. 15 mm.

5.4 Web Break Monitoring and Cutting Device

5.4.1 Design and Operation

The web break monitoring system is comprised of optical photocells monitoring the web, tension measuring sensors and web cutter.

When a web break occurs, the web cutter cut off the web automatically ahead of the nip so that paper would not be wound around the rolls.

Web Cutting Device (ForceCut)

The web cutting device is designed for cutting the web in a controlled way in a fault situation.

The web cutting device consists of cross machine frame, a cutting knife, pneumatic boxes, prepiping and valves. All pneumatic boxes have own service hatches.

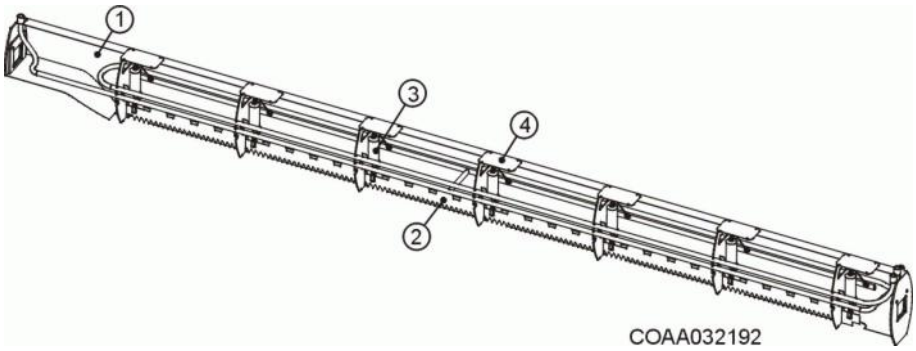

Figure 15. Web Cutting Device (ForceCut)

1 *Frame*
2 *Cutting knife*
3 *Pneumatic boxes*
4 *Service hatch for pneumatic box*

The operation is controlled either manually or automatically by signal from the web break detection system. Web cutting device is activated also when EMERGENCY STOP-button is pushed.

NOTE

Do not cut or modify the beam surface. This would weaken the sheet metal structured beam.

6 EMERGENCY STOP

6.1 Design

The emergency stop buttons are red self-locking mushroom pushbuttons.

Figure 16. The emergency stop pushbutton

6.2 Operation

In a potential emergency, the calender movements are stopped with the emergency stop function. The E-stop must not be used for normal stopping of the machine.

7
HEATING SYSTEM

7.1
Design

The equipment is single-circuit. The equipment consists of a circulation pump, heating and cooling valves, shut-off valves, filters, heat exchangers and condensate recirculation unit. The heating unit is a separate unit from which the heating water is supplied to the thermo roll. The circulation water is heated by steam.

7.2
Operation

The system controls the thermo roll temperature and keeps it constant. Suitable circumstances for each paper grade can be achieved by controlling the temperature of the water flowing to the thermo roll.

Heating is performed by controlling the heating effect to reach the required water temperature. The water is heated in the heat exchanger by steam. Cooling is performed with a three-way valve by controlling part of the circuit's water - depending on the required cooling effect - through the heat exchanger. In the cooler the water is cooled by the cold water circulating in the heat exchanger.

For roll change and shutdown the roll is cooled by means of the heat exchanger. Temperature changes are monitored by the program considering the limitations set by the heated roll.

8
SYMZ AND LOADING HYDRAULIC SYSTEM

8.1
Design

The hydraulic system of a deflection compensated roll generates the volumetric flow that is required by the loading elements in the loading zones, and by the cooling circuit of the roll.

The main components of the hydraulic system of the deflection compensated roll are the hydraulic unit and the valve panels located on DS & TS.

The hydraulic loading system supplies the volumetric flow and pressure for the movements of the hydraulic cylinders.

8.2
Operation

The hydraulic system of the deflection compensated roll controls the loading elements of the roll based on parameters calculated by the control system. The system also controls the required cooling flow of the roll shower pipe circuit.

The hydraulic loading system controls the loading cylinders according to the parameters set by the operator.