Roller head lines for the production of technical rubber sheets

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Roller head lines have been used for many years for the production of sheets for technical rubber articles. Typical products include sheet goods, tank linings, conveyor belts, V-belts, printing sheets, wear protection panels, preliminary pressing products, shoe soles, pneumatic springs and many more. Standard systems can rarely be used for these production processes; the roller head lines must be specially designed and tailor-made to the relevant customer requirements.

1. Introduction

Roller head lines have been used for many years for the production of sheets for technical rubber articles. Typical products include sheet goods, tank linings, conveyor belts, V-belts, printing sheets, wear protection panels, preliminary pressing products, shoe soles, pneumatic springs and many more (fig. 1).

In contrast to multiple-roller calender lines, in the roller head principle the calender gap is fed with compound from an extruder with a preform head. Due to the preliminary forming of the cross-section in the preform head, rubber sheets up to a thickness range of 20 mm can be produced without bubbles (fig. 1–3).

Modern roller head lines offer a high level of automation and rationalisation possibilities in comparison to conventionally fed calenders. It should be emphasised in particular that roller head lines can be used for almost every type of compound. With the wide range of compounds available, the selection of the individual line components requires both experience and extensive knowledge of the handling of the relevant compound.

2. Extruder technology

The cold-feed extruder, sometimes equipped with a vacuum zone for venting of the compound, has established itself as the preferred system for the production of technical rubber articles. Hot-feed extruders in combination with mills are used for compounds which are difficult to plastify, such as compounds based on natural rubber or those with a high material feedback proportion (fig. 3).

The state-of-the-art technology for roller head lines today is the cold-feed pin-type extruder. Pins in the extrusion barrel serve to distribute the flow and thus ensure good distribution and uniform material temperature.

The performance optimum between homogeneity and output can be adjusted by the screw geometry, the pin configuration or the set temperatures of the screw and the barrel. The selection of the screw geometry is based on the type of material to be processed, and can be adapted to the customer’s requirements (fig. 4).

Cold-feed extruders are also used in medical technology as vacuum extruders in order to remove volatile components from the compound.

When compounds have to be cleaned of impurities or inadequately mixed constituents of the compound prior to forming, this is achieved with the aid of a strainer process, in which the compound is forced through a fine-mesh screen. The straining can take place at various process stages:

1. Directly after the mixing process with an extruder-gear pump combination
2. After storage and before extrusion by means of an independent gear extruder
3. During extrusion and before the preform head.

A cold-feed gear extruder before the extruder enables the greatest process window in terms of output, melt homogeneity and maximum permissible processing temperature. The rubber compound is strained through the volumetric transport in the gear pump under minimum shear load (fig. 5).

3. Preform head (WBK)

The optimum feeding of the roller gap is achieved if the thickness and width of the compound fed can be adjusted to the sheet to be calendered. This requirement is fulfilled by the preform head. The distribution of the compound is carried out by the so-called fishtail contour in the preform head. Easily replaceable extrusion dies are mounted at the end of the preform head. The thickness is adjusted with the aid of the different outlet heights of the extrusion dies. The different flow characteristics of the various compounds can be compensated for by profiling of the extrusion dies. Different product widths are achieved by means of easily replaceable insert parts. The cleaning of the preform head is particularly easy, since both halves of the head are swung open when changing compound. By this means, the compound is released from the flow channel when opening the head halves (fig. 6).

The roller head process is characterised particularly by its ability to achieve very accurate thickness tolerances. The influ-
Fig. 1: Line for the production of wear- and corrosion-protection linings

Extruder: QSM 200/k – 16 D
Extrusion head: WBK 200/2200
Calender: KDI 700x2400
Sheet width: 600 to 2200 mm
Sheet thickness: 0.5 to 15 mm
Speed: max. 25 m/min

Fig. 2: Line for the production of films for pressure expansion vessels, conveyor belts and medical products

Extruder: QSM 120/k – 16 D
Extrusion head: WBK 120/1350
Calender: KDI 600x1800
Sheet width: 250 to 1700 mm
Sheet thickness: 0.3 to 10 mm
Speed: max. 10 m/min

Fig. 3: Line for the production of semi-finished products for seals/gaskets

Extruder: QSM 150/k – 12 D
Extrusion head: WBK 150/1050
Calender: KDI 400x1300
Sheet width: 500 to 950 mm
Sheet thickness: 0.9 to 1.5 mm
Speed: max. 10 m/min

Fig. 4: Line for the production of narrow sheets / Mini roller-head system

Extruder: QSM 90/k – 14 D
Extrusion head: WBK 90/270
Calender: KDI 200x350
Sheet width: 50 to 300 mm
Sheet thickness: 0.3 to 5 mm
Speed: max. 45 m/min

Fig. 5: Gear extruder and vacuum extruder in cascade arrangement

Extruder: QSM 150/k – 16 D
Extrusion head: WBK 150/1400
Calender: KDI 500x1550
Sheet width: 250 to 1270 mm
Sheet thickness: 0.5 to 25.4 mm
Speed: max. 30 m/min

Fig. 6: Line for the production of tank linings, carriageway marking film
ence of the calender gap on the achievable tolerances is particularly great at low sheet thicknesses. In contrast, the influence of the calender gap is reduced at greater thicknesses, and the thickness tolerance of the material sheet is determined largely by the material distribution after the extrusion preform head. The production of elastic NR compounds with a thickness of over 10 mm places particular demands on the roller head system. On the other hand, the roller gap has no great influence, while on the other, reset forces in the transverse direction adversely affect the sheet tolerances. In this case, the design of the flow channels is particularly important. The channels in the preform head must be designed so that the reset forces are minimised, although no impermissible stress is placed on the compound. This requires accurate material distribution over the complete width at the head outlet.

In order to achieve this, flow channels today are designed with the aid of FEM (finite element method) flow calculations. The illustration in figure 7 shows such a calculation result. The particular challenge in this case, and the necessary experience, lies in optimising the flow kinetics of the peripheral area.

For the optimum design of the flow channel therefore, the rheological properties of the compounds must be known in advance.

4. Calender technology

The calibration of the material sheet takes place in the calender gap. The number of calender rollers is determined according to the process task. Two or three-roller calenders can be used (fig. 8).

In order to be able to produce a plane parallel sheet with accurate thickness tolerances, the roller head calender is equipped with one or more of the following devices for compensation of the roller deflection:

- Crowning on one or more calender rollers
- Crossing of one calender roller
- Roller bending of the calender rollers.

Fig. 7: FEM flow simulation of a preform head for different distributor geometries

Fig. 8: Line for production of semi-finished products for V-belt manufacture

Fig. 9: Line for production of semi-finished products for the pharmaceutical industry

Extruder: QSM 200k – 16 D
Extrusion head: WBK 200/1650
Calender: KTI 600x1800
Sheet width: 800 to 1500 mm
Sheet thickness: 0.3 to 3 mm
Speed: max. 30 m/min

Extruder: GS-Vak 90/k-16 D-m/Spw
Extrusion head: WBK 90/1050
Calender: KDI 400x1300
Sheet width: 120 to 1200 mm
Sheet thickness: 0.5 to 25.4 mm
Speed: max. 15 m/min

Fig. 10: Comparison of types of cooling section
(cooling medium temperature = 20 °C, ambient air = 35 °C, extrusion temperature = 100 °C, average winding temperature = 40 °C)
The crowning of the calendar rollers and the crossing device form part of the standard equipment of a roller head calender. The roller bending device of the calendar rollers is used for high-viscosity rubber compounds, which are formed into thin sheets.

Modern roller head calenders are also equipped with a hydraulic roller adjustment device, which enables accurate positioning of the calender rollers. This also enables the monitoring of the maximum gap force, which ensures reliable protection of the rollers against breakage resulting from overloads.

Roller head calenders comply with the latest safety regulations, and in addition to various emergency-off circuits, are also equipped with programme-controlled monitoring of the brake device for the drive of the calender rollers (fig. 9).

5. Downstream following equipment

After the forming of the sheet, it must be cooled down to the winding temperature. The diagram (fig. 10) shows the relationship between sheet thickness, line speed and the type of cooling. Cooling drum assemblies, each with two drums, are frequently used in roller head lines. Cooling drums are very effective in the case of low sheet thicknesses. In the case of higher sheet thicknesses, the cooling characteristics are determined largely by the heat conduction in the rubber compound. In this case, the dwell time in the cooling section must be increased. This can be achieved for example by a multilayer air cooling section. This also enables self-threading, which is not possible with drum cooling.

Within the roller head line, it is particularly important that the material is transported carefully. The transfer points between the individual conveyor belts are designed with the aid of dancers and head rollers so that the material sheet is not subjected to tensile stress and thereby deformed.

Winding can be carried out using contact winders or centre winders. In combination with a cross-cutter, the cross-cutting, the residual winding, the replacement of the winder and the winding take place fully automatically (fig. 11). The centre winders are equipped with an edge control device for the material and the liner. The liner is also unwound under tensile force control.

6. Line control and regulation

An essential component of a modern roller head line is the line control with fully automatic process regulation. The optimum design of the user interfaces, both on the PLC screen and on the PC screen, provides ergonomic system operation for the operator. The display language can also be switched to the relevant national language. Due to the selected hardware of the system controls, very high system availability is ensured.

During the project planning and commissioning of the system, the controls are adapted and optimised to the relevant customer requirements, in order to be able to operate the system with short product change times and optimum start-up technology. The graphic process visualisation and the disposition and recipe management represent further essential elements for efficient production. For the evaluation of past production, the production planner and process engineer are provided with online and historical trend displays of the different process parameters, production reporting and evaluation, and statistical process control. These process data are available not only on the system itself, but can also be made available to other computers of the customer by networking via Intranet or Internet, enabling either centralised or decentralised data storage.

With the aid of remote maintenance, Troester engineers can monitor every system worldwide, provide assistance and if
necessary carry out programme modifications. This ensures quick reaction times follow system stoppages and rapid resumption of production.

Maintenance personnel are provided with an online maintenance management system, which draws attention at the relevant time to what maintenance work must be carried out. The system also provides information on which auxiliary materials are needed for this purpose, and displays instructions for the performance of the work (fig. 12).

7. Summary

Standard systems can rarely be used for the production of technical rubber goods; this must be carried out instead with roller head lines specially designed and tailor-made to the relevant customer requirements. All the requirements can be fulfilled thanks to the wide range of extruder designs and sizes available, with screw diameters of up to 250 mm, and the corresponding calender equipment with roller diameters from 80–700 mm.

8. Literature


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**LSR India Roadshow**

Momentive, Engel and Elmet will together present a cross-country roadshow to rubber and plastics producers in the Indian market. Taking place from 25–27 February 2008 in the automotive hubs Pune, Delhi and Chennai, this series of events will allow manufacturers to discuss the latest advances in LSR technology directly with experts in the areas of raw materials (Momentive), moulds, coldrunner-blocks, pumps and turnkey systems (Elmet), and LSR injection moulding machines and systems (Engel).

The roadshow will give access to expertise across the entire LSR value chain and the latest LSR solutions.

Jointly led by representatives of the three organising companies the discussions will focus on a broad range of LSR topics, including self-bonding technology, self-bleeding products, liquid fluorosilicone elastomers, applications, machines and machine technology, local support, and LSR pumping and mixing units. Each programme will be followed by a cocktail reception and individual discussions.

**Schedule:**

- **Pune**
  - 25 February 2008
- **Delhi**
  - 26 February 2008
- **Chennai**
  - 27 February 2008

**Speakers:**

- **Oliver Franssen** (Global Marketing Manager Automotive, Momentive)
- **Paul Fattinger** (Global R & D Manager, Elmet)
- **Leo Praher** (Global Sales Manager LSR/LIM Machines, Engel)

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**Advantages of LSR manufacturing include:**

- Fast cycle time through platinum catalysed addition curing system
- Flash-less and trim-free parts directly from the machine, no de-flashing or manual trimming
- Process can run fully automated 24 hours/day
- Wasteless manufacturing: through cold-runner technology no waste material
- Long flow length, low injection pressure, moulding of highly complex parts possible
- Available materials for consumer goods, automotive, industrial goods, electrical connectors etc.
- Supplied materials are ready-to-use and are easy to pigment within the process

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**About Momentive**

Momentive Performance Materials was created from the sale of GE Advanced Materials and its former joint ventures, GE Bayer Silicones and GE Toshiba Silicones to Apollo Management, L.P. in December 2006. The company is the world’s second-largest producer of silicones and silicone derivatives and a global leader in the development and manufacture of products derived from quartz and advanced ceramics.

**About Engel**

As an individual brand, Engel is the biggest manufacturer of injection moulding machines in the world. The Engel group currently offers all technology modules for plastics processing from a single source: injection moulding machines for thermoplastics and elastomers, tools and automatic systems. The group has 8 production facilities in Europe, North America and Asia (China, Korea), own branches in 17 countries, and representations in more than 70 countries. The company is based in Schwertberg, Austria.

**About Elmet**

Elmet is a specialist in the field of elastomer moulding technology by means of designing, manufacturing and automation of LSR, 2K, HTV and rubber injection moulds; standardised valve gate cold decks, LSR dosing systems, LIM peripheral devices and complete turn-key production systems. The company is located in Oftering, Austria.