Detailed view of the four-flight screw in the new high-performance of the MX Kneader Series being exhibited at the K 2007 for the first time (all figures: Buss)

Buss Kneader for Cable Compounds

Compounding. With the MX Series, Buss will present at the K 2007 a new generation of its Buss Kneaders for compounding of temperature and shear sensitive compounds. Without any increase in size, they offer up to 2.5 times the throughput and require about 15 % less specific energy compared to the present machine.

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The operating principle of the Buss Kneaders from Buss AG, Pratteln, Switzerland, has proven itself and allows plastics to be compounded in an especially gentle manner. A hallmark of this specific processing technique is the combination of longitudinal and radial mixing of the melt that results from the oscillating motion of the screw (see box on page 3).

The high-performance kneaders in the new MX Series (Fig. 1) represent an advanced version of the universally applicable MKS Kneaders. The innovative four-flight screw technology [1, 2] that was already used successfully in the quantec Kneader developed for PVC compounding has been further refined and implemented throughout the new series. As a result of the new concept, which is explained below, the MX Kneaders can be operated at speeds up to 800 rpm. Consequently, the throughput is 2.5 times higher than previously, although the machine size remains the same. At the same time, the MX Kneaders produce enhanced product quality, for instance, when processing halogen-free, flame-retardant polyolefin-based cable compounds, i.e. better mechanical properties, more effective flame retardance and improved processing characteristics. The MX 105 that will be exhibited by Buss at the K 2007 (Booth no. A59 in Hall 16) has a screw diameter of 105 mm and achieves a throughput of 800 to 1,200 kg/h for halogen-free, flame-retardant cable compounds.

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Four-flight Screw and Larger Processing Chamber

A fundamentally new concept for the entire processing section provides the basis for the improved performance and quality. The ratio of outside to inside (root) diameter of the screw has been increased. As a result, the MX Kneaders have a larger processing

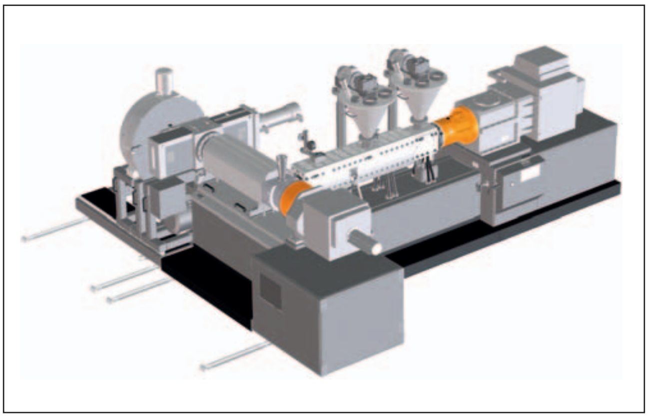

Fig. 1. Major parts of the high-performance MX Kneader Series: motor-gearbox unit, processing section with feed locations, directly flange-mounted single-flight discharge screw with melt filtration and pelletizing

chamber. The transition to four-flight screw technology, however, is the major reason for the performance and quality improvement (title photo) [1]. The ratio of stroke to outside diameter was also increased, permitting a high screw pitch. In addition, there are greater opportunities with regard to design and optimization than with the three-flight screw: Flights with longer flanks improve the conveying characteristics, and the flight geometry can be used to influence the mixing action in specific ways in terms of both distributive and dispersive mixing.

Within the processing section (Fig. 2), four functional steps can be distinguished:

- Feeding of polymers, additives and fillers
- Melting with dissipative introduction of energy
- Addition of further fillers
- Homogenizing and conveying with little introduction of energy

For each of these steps, the interaction of kneading flight geometry and kneading pin was optimized with the aid of mathematical models and confirmed by means of trials. In this way, it was possible to lower the specific energy input overall – it is about 15% less in the MX Kneaders than with the previous design – while simultaneously improving the mixing action.

The new design of the second feed section, which is used for fillers, makes it possible for the air entrained during infeed of material to escape largely via rear venting. The venting/degassing serves to remove volatiles and moisture.

The improvements achieved with the modified geometry of the processing section can be illustrated in a diagram showing the melt temperature and throughput versus the screw speed (Fig. 3). In the MX kneader, the melt temperature increases with screw speed much more slowly (rate of about 3.5°C/100 rpm) than in the MKS Kneader (rate in excess of 20°C/100 rpm). Only by gaining control of the temperature rise in the processing section has it become possible to increase the speed in the MX Kneader to as high as 800 rpm and simultaneously maintain a temperature limit of 190°C when compounding halogen-free flame-retardant (HFFR) cable compounds. It is the higher speed that results in the increase in throughput – confirmed by trials - from 170 kg/h in the MKS 70 with 70 mm screw diameter to 525 kg/h in the MX 77 with 77 mm screw diameter. Taking the diameter into account, the throughput increases by a factor of 2.5.

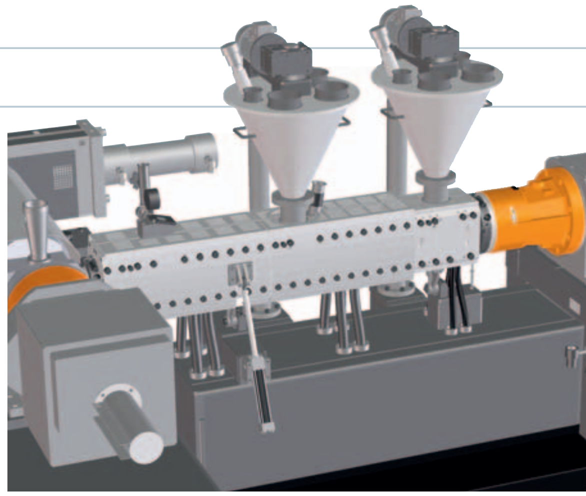

Fig. 2. Flip-open processing section of the MX 105 high-performance Kneader, fitted with two vertical material feed screws and a vacuum connection for degassing

From Drive to Discharge

In addition to the processing section, Buss has also modernized all other assemblies in the MX Kneader and optimized them in terms of manufacturing and operating costs.

A new motor-gearbox unit consisting of four water-cooled asynchronous motors and a planetary gearbox was chosen for the drive of the MX Kneader. The motors drive the planet gears which power the sun gear. The sun gear functions at the same time as a "longitudinal coupling" for the oscillating action that imparts the longitudinal motion to the screw. The new drive unit is more compact than the previous drive with its centrally positioned electric motor. Due to the water cooling, the drive is so quiet that the MX Kneader already complies today with stricter noise limits coming in the future.

Normally, the processing section of an MX Kneader has an L/D ratio of 15:1 (L = length of processing section, D = screw diameter) and is divided into three barrel segments. For especially difficult-to-process compounds or when the compounding quality must satisfy exceptional requirements, the processing section can be lengthened by 7D to an L/D = 22:1.

The first barrel section is used to feed in the polymers, additives and, where necessary, a portion of the fillers. In the subsequent melting region, it is possible to meter in liquid components (e.g. coupling agents). The second barrel section with the previously mentioned rear venting is used to add the remaining fillers to the now-molten material. The resultant cooling of the melt contributes significantly to keeping the stock temperature in the MX machines very low. This is followed by homogenizing the melt without any significant additional energy input, and a second venting/degassing port shortly before the end of the processing section.

The energy required for melting and mixing is provided almost entirely by the screw as shear energy. The temperatures of the barrel halves of the MX Kneader are controlled using water or oil. This heating acts primarily as a dynamic insulation and serves to temperature-condition the inner surfaces of the barrel. This conditioning is necessary to ensure the desired flow characteristics.

A single-flight discharge screw is flange-mounted directly to the MX kneader. It builds up the pressure for melt filtration and pelletizing and is equipped with an additional venting/degassing port. A gear pump can also be attached for pressure build-up as an alternative discharge device for special requirements or applications.

The optionally available automatic screen changer has been designed without any decrease in cross-section ensuring that the downstream pel-

Comparison

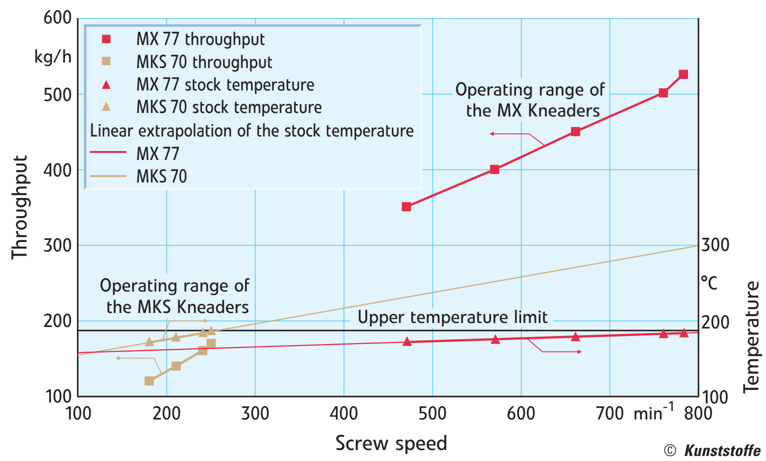

Fig. 3. The plot of stock temperature and throughput versus screw speed shows clearly the improvements in the MX Kneader over the previous MKS Kneader

letizing die is covered uniformly with melt. The pelletizer is designed for hot melt pelletizing, where the pellets drop directly into a fast-flowing water bath that also conveys the pellets away. It has also been possible to reduce the noise from the pelletizer in view of the forthcoming noise limits. The aerodynamically optimized cutting rotor as well as the new design for the pelletizer hood and the conversion from sheet steel to aluminum castings have been major contributors in this respect.

The new MX Series features a modular design for the Buss Kneader and the downstream modules such as discharge screw, screen changer and pelletizing unit. These can be shifted as necessary along two axes on a linear system. This facilitates access to the individual modules for cleaning and maintenance work and makes fast product changes possible. The discharge module can be either a single-flight screw or a melt pump.

The PC control utilizes a Simatic S7 with Cimplicity visualization on a Windows XP Pro platform, has an intuitive operator interface and provides control and monitoring of the entire system, including data acquisition, recipe management etc. The control system can be expanded as necessary to meet customer requirements.

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Field of Application for the MX Kneader

The improvements described above for the Buss Kneaders in the MX Series represent decisive advances with regard to applications and economics. For the same size, they achieve 2.5 times greater output. At the same time, product quality increases: Halogen-free flame-retardant cable compounds possess better mechanical properties even at very high filler levels, exhibit better values for flame retardance and have better processing characteristics.

The most important field of application for MX Kneaders is in the production of high-quality polyolefin-based cable compounds. Use of aluminum hydroxide as a halogen-free flame retardant is especially important in this regard. In the event of a fire, this chemical releases water in an endothermic reaction at temperatures as low as approx. 200 °C. This cools the burning area and restricts the flow of oxygen. For effective flame retardance, filler levels of up to 65 wt. % are common – while the cable insulation must still exhibit good values for strength and elasticity. The anticipated improvements in throughput and product quality have been confirmed in trials.

Semiconducting cable compounds pose a special challenge. They serve to smooth out spikes in field strength in the vicinity of the strands in medium- and high-voltage energy cables and provide external shielding for the cables. To fulfil this function, semiconductive compounds usually contain 30 to 40 wt. % conductive carbon black. During compounding, the MX Kneader must disperse carbon black agglomerates, but not destroy the fine-grained structure of the conductive carbon black in the process of incorporating it into the matrix resin. Here, too, the MX kneader met all expectations in production trials: The surface quality of the cable sheathing achieved with the new compounds is better than previously, with no loss in conductivity. This indicates that the carbon black is dispersed without any damage to its structure.

Principle of Operation: Buss Kneader

In the Buss Kneader, a single-screw kneader, the screw simultaneously executes an axial oscillating motion with every rotation. The screw has kneading flights and kneading teeth or pins are fixed inside the barrel at locations corresponding to the gaps between the kneading flights. The combination of rotation and axial motions of the screw produces extensional flow with highly dispersive mixing action between the kneading flights and kneading teeth. Efficient distributive mixing results from the combination of radial and longitudinal mixing effects. In the MKS Kneader, each screw flight is divided into three kneading segments. The new high-performance Kneaders in the MX Series feature four segments; this expands the design possibilities in the processing section.

Summary and Outlook

One of the principle applications for the new MX Series is for the production of halogen-free, flame-retardant cable compounds. For environmental and safety reasons, these compounds continue to gain in importance. With the new MX Kneaders, they can now be produced at considerably lower costs thanks to the 2.5 improvement in throughput. At the same time, these HFFR compounds exhibit better characteristics in terms of processing and in their application as cable sheathing.

Furthermore, trials at the Buss Test Centre have shown that these same improvements can also be achieved with semiconducting compounds. It can be concluded from these results that the MX Kneaders will also provide similar advances with other cable compounds, for instance, black masterbatches. Further developments will certainly show these advantages can be applied in other shear and temperature sensitive applications. ■

REFERENCES

1 Franz, P.: High-output Compounding. Kunststoffe international 92 (2002) 2, document number PE102261

2 Gotzmann, G.: Innovationspreis für Kneter. Kunststoffe 96 (2006) 5, pp. 24–25

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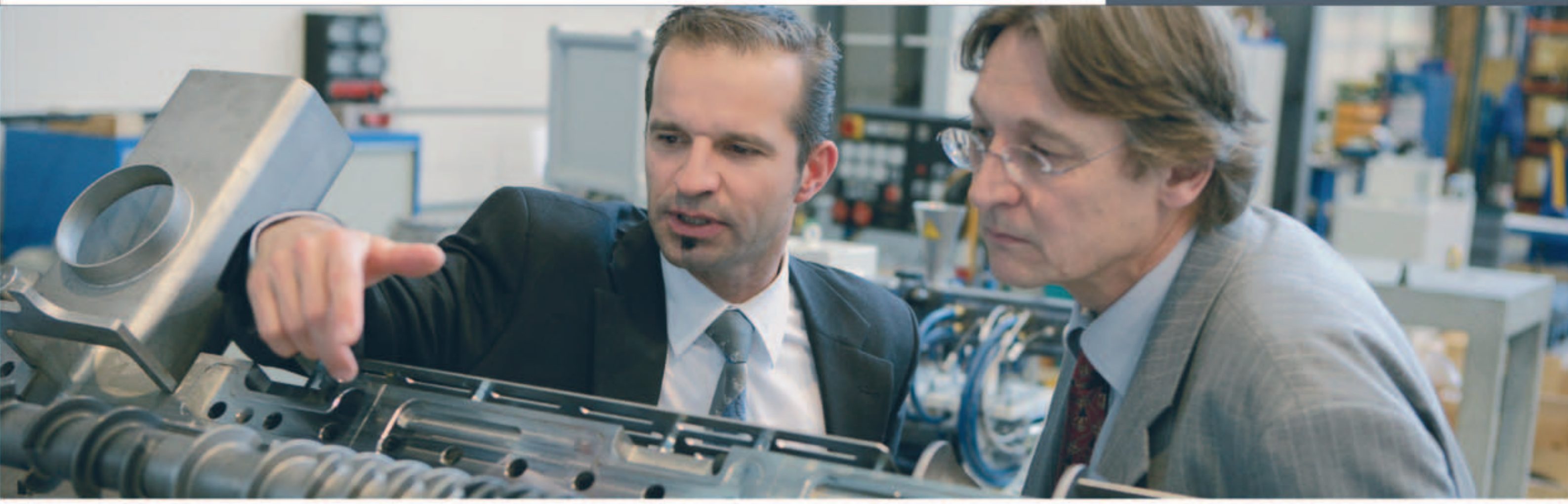

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