All about Plasticizing Screws

Part 3 of the Series Deals with the Tests to Optimize the Screw Geometry

In the second part of the series, calculations were carried out on the throughput behaviour, pressure build-up capacity and the melting process on the basis of an exemplary geometry. These results are now to be examined in more detail and subsequently optimized. For this purpose, the effects of adjusting some selected geometry parameters have to be investigated and interpreted.

Through empirical tests and simulation-supported test series, a screw can be designed in a tailor-made manner for the respective application

© Wittmann Battenfeld

The main task of a plasticizing unit is to melt the plastic granulate and homogenize the molding compound. Plasticizing units in which the heated barrel is combined with a three-zone screw are widely used. In the feed zone, the granules are fed from the hopper into the plasticizing unit. In the compression zone, the screw flight narrows so that the molding compound is compressed and melts due to the interaction

Zone	Length [D]	Flight depth [mm]	Flight depth [mm]	No. of threads [–]
Feed zone	11.00	5.00	50.00	1
Compression zone	7.50	5.00 – 2.50	50.00	1
Metering zone	3.50	2.50	50.00	1
Ring check valve	1.96			

Table 1. Geometry optimization, test 1: Metering zone shortened, compression zone lengthened

Source: Wittmann Battenfeld

between the frictional heat generated and the heated cylinder. In the metering zone, the viscous melt is mixed to distribute additives and fillers as well as heat evenly.

Results of the First Calculation

In part 1 and part 2 of the series (***Kunststoffe*** *international* 10/2020 and 1/2021), the basic principles of plasticizing unit design and screw geometry calculation were discussed. Calculations concerning throughput behavior, pressure build-up capacity and the melting process were demonstrated on an exemplary screw geometry. In our example the average metering performance was about 12.49 g/s with a back pressure of 80 bar and a circumferential screw speed of 300 mm/s – a value which can be improved by appropriate geometry optimizations.

As shown in the second part of the series, the screw showed a considerable overcapacity for pressure build-up. With a back pressure of 80 bar, the screw was able to reach a peak pressure of just under 160 bar. But in the interest of gentle plasticizing to protect the material, this peak pressure should be reduced to below 120 bar in practice.

However, the melting process developed very positively, as the material was already completely liquefied after traveling about L/D = 8 in conveying direction. In the course of further optimization, it is now necessary to prevent solid material from traveling too far into the metering zone, since in extreme cases this could lead to excessive wear of the screw, the barrel and the check valve. Ultimately, this is also why the dwell time of the melt »

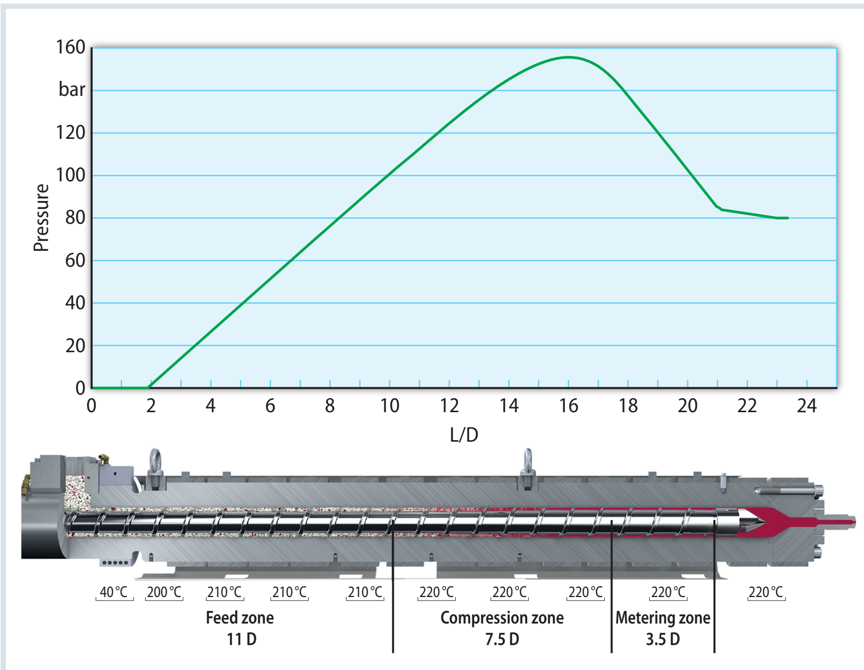

Fig. 1. First test for geometry optimization: Pressure curve along the screw at stroke position 50 mm Source: Wittmann Battenfeld, graphic: © Hanser

The Author

Filipp Pühringer heads the Process Engineering Development Department at Wittmann Battenfeld GmbH in Kottingbrunn, Austria.

Note

The first two parts of this three-part series were devoted to the basics of designing a plasticizing unit and first steps towards optimizing the screw geometry. They have been published in ***Kunststoffe*** *international*, issue 10/2020, pp. 27–29, and 1/2021, pp. 14–16.

Service

Digital Version

- A PDF file of the article can be found at ***www.kunststoffe-international.com/archive***

German Version

- Read the German version of the article in our magazine ***Kunststoffe*** or at ***www.kunststoffe.de*** should not be allowed to fall below the minimum dwell time recommended by the manufacturer of the material.

Step 1 of Optimizing the Geometry: Shortening the Metering Zone

As a first step, the length of the metering zone should be reduced. The idea behind this is that the metering zone with its low flight depth and considerable length produces a corresponding blockage effect on the preceding screw zones. This is also shown by the closeness of the peak pressure point to the end of the compression zone prior to the optimization attempt. In this first test, the metering zone is shortened from 5.5 D to 3.5 D. To keep the total screw length of 22 D unchanged, the compression zone is lengthened (from 5.5 D to 7.5 D) accordingly (**Table 1**).

The effect on the peak pressure is negligible. However, the pressure gradient in the metering zone has now become steeper, since the pressure peak has moved closer to the check valve (**Fig. 1**). For the sake of completeness, it should also be mentioned that the change has a similarly minor effect on the melting process and throughput. Liquefication is now completed at L/D = 8.9, and the average metering performance is about 13.02 g/s.

Step 2 of Optimizing the Geometry: Increasing the Metering Zone Depth

Since the effect achieved by shortening the metering zone is only minor, the flight depth is now examined as a second step. The individual zones are returned to their original lengths (feed zone 50 % of the total length, metering and compression zone 25 % each). The flight depth ratio of 2 zones remains unchanged, but that of the metering zone is increased by between 25 and 30 %. In rounded figures, a flight depth of roughly 3.2 mm is calculated for the metering zone (**Table 2**).

After carrying out this optimization attempt, the pressure curve shows that the original pressure of 158 bar has been reduced to 129 bar (**Fig. 2**). It is interesting to see how a 28 % increase in the flight depth reduces the blockage effect much more strongly than a shortening of the metering zone by some 36 %.

Other points worth mentioning here are the average metering performance of 15.23 g/s reached by this move, and the shift of complete liquefication to L/D = 10.4. Moreover, it is basically possible to vary the compression ratio, the zone length ratios, etc., in a similar way in order to optimize their influence on the processing parameters.

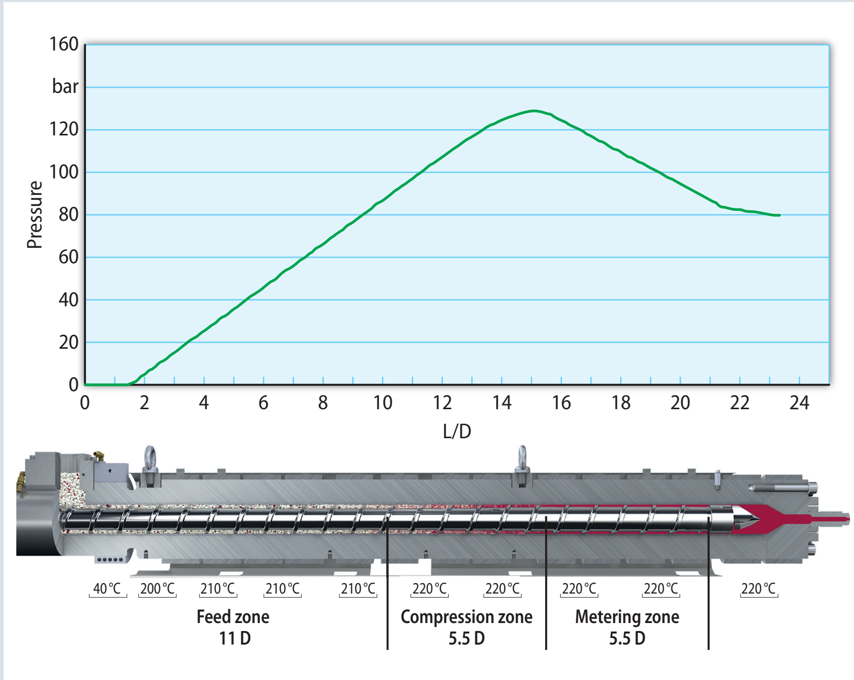

Fig. 2. Second test for geometry optimization: Pressure curve after the increase of flight depth by approx. 28 % Source: Wittmann Battenfeld, graphic: © Hanser

A Multi-Purpose Screw Geometry

Where these tests are carried out for many different materials and harmonized accordingly, a universally applicable screw geometry emerges as a result. At Wittmann Battenfeld GmbH, Kottingbrunn, Austria, multi-purpose screws of this kind are sold under the name of Unimelt. They stand out by their extremely wide range of possible applications in thermoplastics processing. In combination with a suitable anti-wear package, they offer a long-lasting plasticizing system. Wherever special challenges in injection molding must be mastered, the Wittmann Battenfeld team of engineers stand ready to help their customers in a joint search for the optimal plasticizing solution to fit every individual purpose.

Conclusion

Empirical tests and simulation-supported test series allow the design of a screw tailored to the specific application (for example, low pressure build-up or high plasticizing flow). Outside this application, however, such a screw cannot reach its full potential. It is also possible to generate a universal screw by means of comprehensive test variations, which can be used for a wide variety of materials and process parameters. ■

Zone	Length [D]	Flight depth [mm]	Flight depth increase [mm]	No. of threads [–]
Feed zone	11.00	6.40	50.00	1
Compression zone	5.50	6.40 – 3.20	50.00	1
Metering zone	5.50	3.20	50.00	1
Ring check valve	1.96			

Table 2. Geometry optimization, test 2: Screw with increased flight depth Source: Wittmann Battenfeld