All about plasticizing screws
Part 3 of the series

In the issues 1/2020 and 2/2020 of "innovations", the basic principles of plasticizing unit design and screw geometry calculation were discussed. Calculations concerning throughput behavior, pressure buildup capacity and the melting process were demonstrated on an exemplary screw geometry. This third and final part of the series now deals with the possibilities of optimizing a screw geometry.

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Results of the first calculation

In our example presented in the previous issue of *innovations*, 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.

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 8 D 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 should not be allowed to fall below the minimum dwell time recommended by the manufacturer of the material.

Optimizing the geometry

Test 1:
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 diameters unchanged, the compression zone is lengthened accordingly. 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. 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.

Test 2:
Increasing the metering zone depth

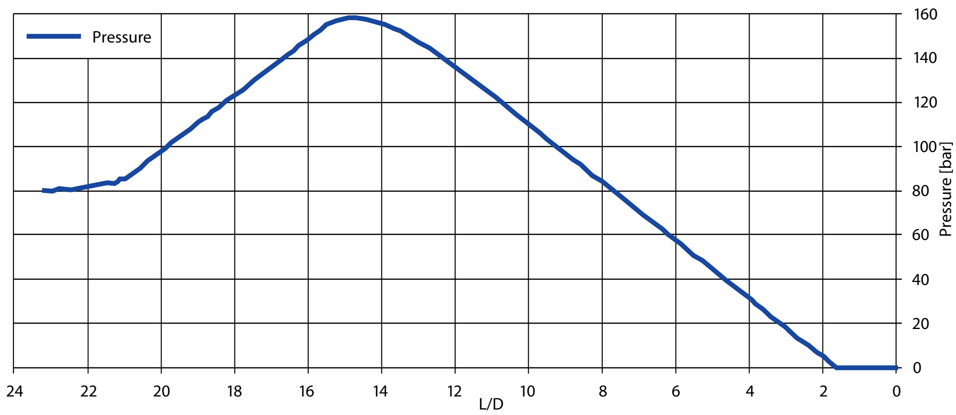
Since the effect achieved by shortening the metering zone is only minor, the flight depth is now examined as a second step. The individual zones are returned to their original lengths (25% / 25% / 50% of the total length). The flight depth ratio of 2 zones remains unchanged, but that of the metering 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. After carrying out this optimization attempt, the pressure curve shows that the original pressure of 158 bar has been reduced to 129 bar. 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.

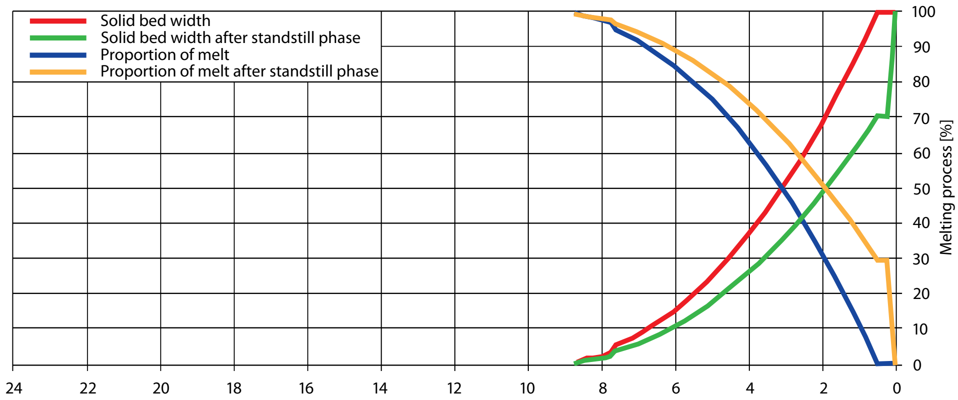
UNIMELT screws from WITTMANN BATTENFELD

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, 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.

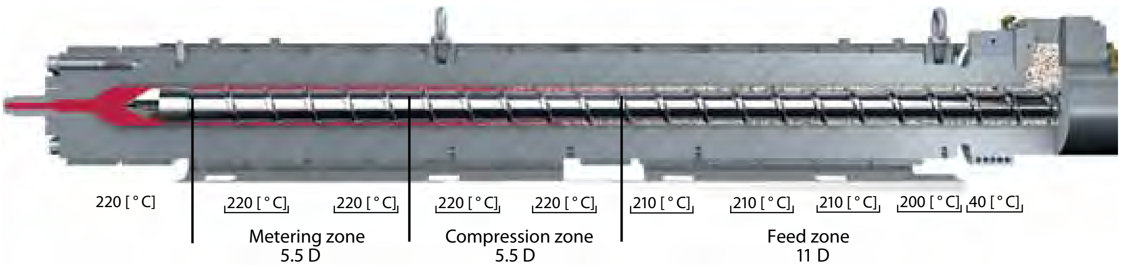
Wherever special challenges in injection molding must be mastered, the WITTMANN BATTENFELD team of engineers stand ready to help their customers in a joint search for the optimal plasticizing solution to fit every individual purpose. ◆



Pressure curve along the screw at 50 mm stroke position prior to optimization.



Melting process for the screw in stroke position 50 mm towards the end of the cycle: results of the original calculation prior to optimization.



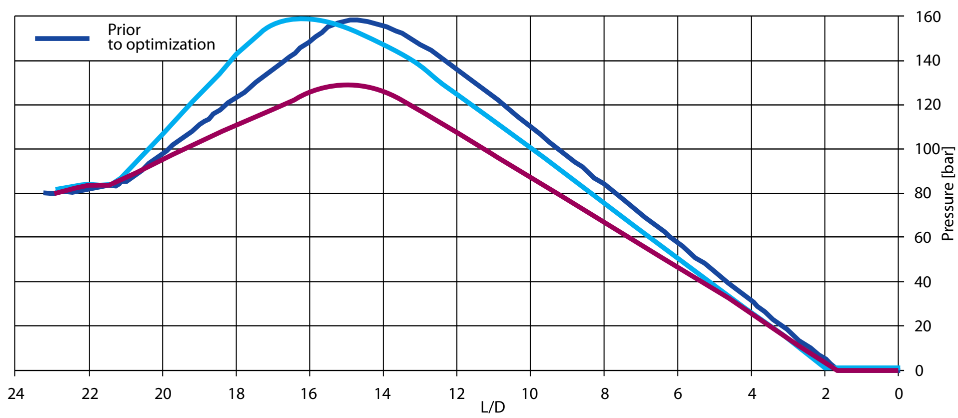
The calculations are based on the barrel zone temperatures.

Zone	Length	Flight depth	Flight depth increase	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
RSP ring check valve	1.96			

Chart for test 1: metering zone shortened, compression zone lengthened.

Zone	Length	Flight depth	Flight depth increase	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
RSP ring check valve	1.96			

Chart for test 2: screw with increased flight depth.



Pressure curves before and after the optimizations. Test 1: pressure curve at stroke position 50 mm. Test 2: increase of flight depth by approx. 28%.

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