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Die plates for the pelletizing of plastics

Internal heat channels and hard metal cutting face

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Intro

Polymerisation of ethylene and propylene produces polyethylene (PE) respectively polypropylene (PP) as a powder. This powder is processed into a granulate or pellets by means of an extruder provided with a die plate. John Düring and Roel Jochems have written an article on the latest developments in the field of die plates. These are essential for the quality of the pellets.

Pelletizing as a critical step

In the processing of the powder that is polymerised it is first melted and homogenised in an extruder [1]. Next, the viscous plastic smelt is passed through a perforated metal plate or die plate (figure 1). Rotating knives cut the emerging strands (similar to spaghetti) to the desired granulate or pellets with a certain size distribution. In large production lines of PE and PP this is done under water, in order to cool down and transport the granulate. For smaller production lines and other plastics different methods have been developed besides underwater pelletizing, such as strand pelletizing, in which the strands are first carried through a trough with water to cool down prior to being reduced to pellets.
Of all the many pelletizing methods that have been developed over the years [2], this article focuses on the processing of PE and PP in large extruders and compounder units.

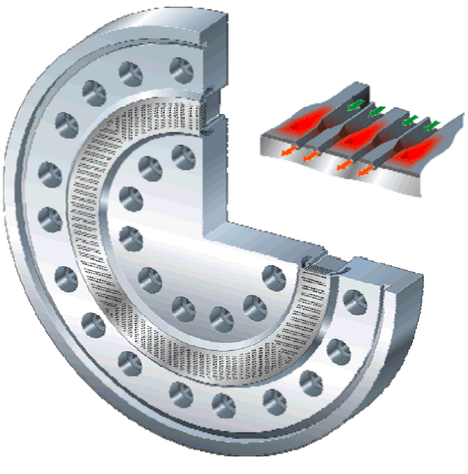

Figure 1: die plate (Kobelco)

Although the investment in a pelleter or pelletizer is relatively small in comparison to the total investment in a complete production line, pelletizing is a very critical process step. In the outlet channels of the die plate the melt changes from the liquid into the solid phase within a couple of centimetres. Often, the core has not even quite set yet because the solidified plastic on the outside acts as a very good thermal insulator. In this state the

strands are cut by rotating knives that press against the surface of the die plate. The knives and the edges of the holes in the die act as a pair of scissors.
From a quality perspective uniform pellets with a narrow size distribution is desirable, but under these circumstances this is not easy task to achieve. This has led to developments to make the pelletizing process less critical, such as improving the heat control and optimisation of the cutting surface of the die plate.

Heat control

In underwater pelletizing the water side of the die plate has a temperature that lies well below the setting temperature of the plastic. Due to the inevitable heat transfer the temperature of the die is relatively low at that point. Consequently, the smelt tends to solidify and clog up in the channels of the die plate. This can't be prevented by simply increasing the temperature because this will cause the plastic to degrade, which is undesirable as well.
The plastic melt is kept at temperature to as close to the exits of the die plate channels as possible, through external heating by means of thermal oil or steam. This heating should be done as uniformly as possible in order to prevent localised changes in viscosity, and thus a pressure drop across the die plate channel. This would cause differences in flow speeds that adversely affect the size distribution of the granulate.

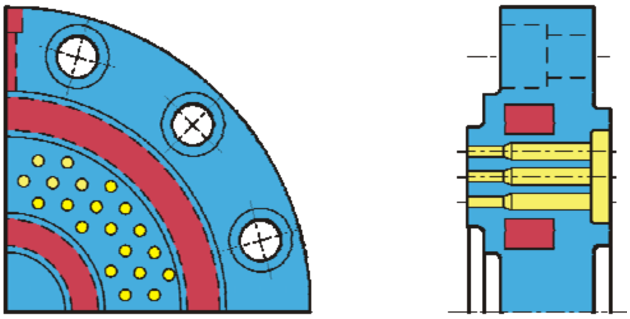

Figure 2: heating jacket (Kobelco)

In the first die plates the ring with extrusion channels was surrounded on the inside and outside by a heating jacket. Due to the distance of the extrusion channels and the heating jacket being unequal, differences in temperature occurred in the smelt (figure 2)

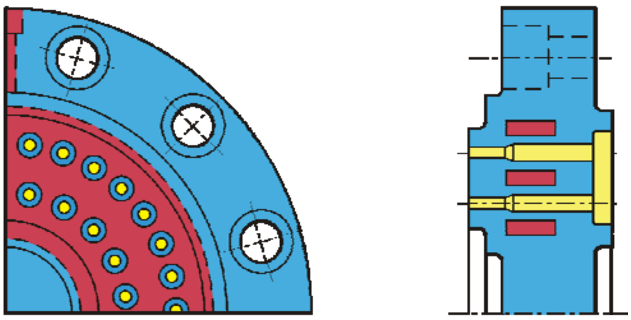

Figure 3: heat exchanger (Kobelco)

Next, die plates were developed in which the melt flows through tubes running through the heating medium, like in a tubular heat exchanger. Although this version produces a much better heat distribution, it is technically complex and expensive to fit thousands of tubes to large die plates (figure 3).

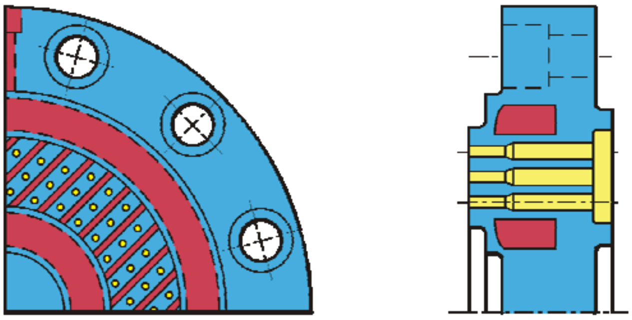

Figure 4. heat channel (Kobelco)

The latest state of the art are die plates with heating channels running in between the die plate channels. The circular channels of the heating jacket act as distribution and collection channels. Introducing these internal channels complicates the production process but provides die plates with an excellent heat control due to the adapted design of the heat channels and great mechanical reliability (figure 4 and 5). This solution is particularly suitable for large die plates.

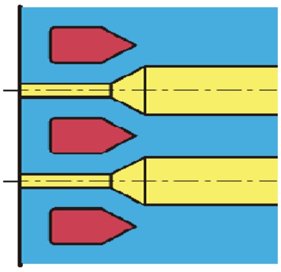

Figure 5: detail heating channel (Kobelco)

Hard metal cutting surface.

Initially, because the rotating knives are pressed against the extrusion surface during cutting, a hard metal surface was applied to prevent premature wear. However, the life span of such die plates proved to be insufficient, so soon after hard metal inserts were used.

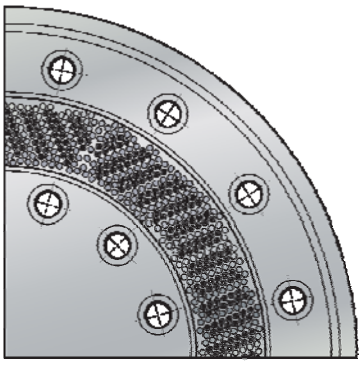

Figure 6: nibs (Mercatel)

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At first, hard metal nibs were fitted in cut-outs in the steel surface of the die plate (figure 6) In this version rapid wear of the steel part, caused by cavitation , is the cause of rapid wear of the cutters. Manually soldering the nibs in place is time consuming and the quality of the bond is hard to control. Loss of the nibs consequently is more the rule rather than the exception.

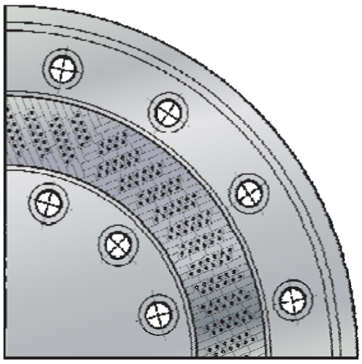

Figure 7: tiles (Mercatel)

The use of close-fitting hard metal tiles is an alternative (figure 7). These tiles, like the nibs are soldiered manually, and here too, breaking away occurs, albeit less than with nibs.

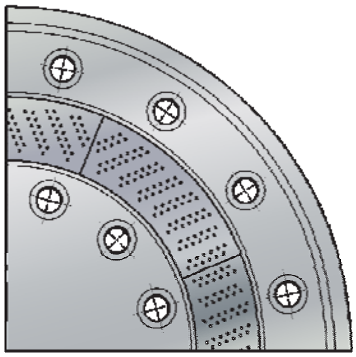

Figure 8: segments (Mercatel)

The solution for the breaking away of tiles or nibs is the use of hard metal discs or segments (figure 8). The annular wear surface is made up of a small number of large hard metal segments containing extrusion holes, that form one continuous surface. The segments and die plate can only be joined in an automated and controlled process, with a very reliable joint as a result.
At first the very hard and durable tungsten carbide (WC) was used for the hard metal nibs and tiles and titanium carbide (TiC) for the hard metal segments because these were easier to solder. The fact that TiC provides a better heat insulation is an added benefit.
The latest development is the use of tungsten carbide hard metal segments, which is more durable than TiC.

Summary

The aim is a uniform granulate with a narrow size distribution, as few granulation problems as possible and as long as possible a life span of the die plate and the cutter knives as possible. To this end the latest generation of die plates uses a combination of internal heating channels and hard metal segments as a wear surface. Depending on the granulation job at hand a choice can be made from titanium carbide or tungsten carbide. Obviously the choice of cutter knives has to be made accordingly.

References

[1] Polymer extrusion, C. Rauwendal, Hanser Publishers, Munich – Vienna – New york, 1986
[2] Granulieren von thermoplastische Kunststoffe, VDI-Verlag GmbH, Düsseldorf 1974