Tube die in operation
(figures: Gross Kunststoff-Verfahrenstechnik)

Flexible Heads

Tube and Pipe Dies. Fine adjustments of the die gap of round dies allow a wide variety of different wall thicknesses to be extruded without interrupting the production process.

HEINZ GROSS

The dream of every tube and pipe producer of being able to use a simple "rubber head" with which any tube diameter and any wall thickness can be produced without having to stop the extrusion line will almost certainly never be fulfilled. But there are solutions which already come very close to this ideal [1]. The wider the spectrum of the geometries to be produced, however, the more complex and costly the die construction becomes. In many cases it would already be an advantage if the die gap of the head could be easily adjusted – at least within a certain range – with a constant die diameter. This would enable tubes and pipes with different wall thicknesses to be produced. An optimum die gap is particularly advantageous if the molecular orientation between die and calibrating unit is to be kept low in order, for example, to minimize shrinkage. It would naturally also be desirable if this additional process engineering option did not have to be at the expense of a far more complex head construction, and also the ease of operation and maintenance were not impaired.

When we look at the construction of conventional tube and pipe dies, it is difficult to imagine that an adjustment of the flow channel while meeting the wish for a head that can be easily operated and cleaned can be achieved at all. That is almost certainly the reason why such heads have not been available to date. The tilting technology [2,3] that was developed to allow more accurate and specific centering of a head has now created new boundary condition for being able to also very easily adjust the die gap.

Tilting Technology

With the tilting technology, heat-resistant elastomer seals are used to seal the gap between the head and the die **(Fig. 1)**. The die is now tilted instead of being shifted

Fig. 1. Seal of the head illustrated in Figure 5 (sustained temperature resistance of 300 °C) with which the gap between the head and the die is sealed and which permits tilting and shifting of the die

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as to date in order to center the die in relation to the mandrel. This offers a whole range of crucial benefits compared with the conventional metallic seal. Since the die no longer has to be shifted back and forth, a tighter fit can be created between die and head so that the die can only be installed centrically **(Fig. 2)**. The pre-centering of the die that was necessary to date after cleaning a head can thus be eliminated. In order to ensure the reproducible compression of the tilting seal necessary for reliable sealing, it also has a simple bayonet fitting. Eccentric differences in thickness can be reduced by tilting the die. This is currently performed in a transitional phase using axially arranged adjusting screws **(Fig. 3)**. This solution will almost certainly be increasingly replaced in future by a motorized solution.

The advantage of motorized adjustment is that the die can be centered extremely precisely from the machine control panel for the first time. This also opens up the possibility that an optimized position, once found, can be exactly reproduced at any time. After cleaning of the head, the die can be moved during the restart to exactly the same position as used during the last production. During extrusion blow-molding, a motorized adjustment system allows the die to be tilted dynamically even during the discharge of the parison in order, for example, to take account of the different stretch ratios on the inside and outside of the curve when producing curved tubes and pipes **(Fig. 4)**. During tilting of the die, the elastomer seal is simply compressed slightly more on the side on which the die gap is to be reduced. The gap of the flow channel on the opposite side is accordingly increased by the same amount.

But the tilting technology has not only overcome the weaknesses associated with the conventional centering solution, it has also led to a simplification of the construction of annular dies. This also leads to a reduction in the production costs. Once the concern generally prevailing among experts that an elastomer seal could not be integrated into the flow channel of an extrusion die had been overcome, it was a logical next step to exploit the elasticity of the seal to also adjust the die as a whole relative to the head. And if the principle is then breached that a tube die has to have a parallel discharge zone at the end of the flow channel, the way is open for an adjustment of the die gap. A particular advantage is that the head construction is far simpler compared with the generally known solutions used in extrusion blow molding. →

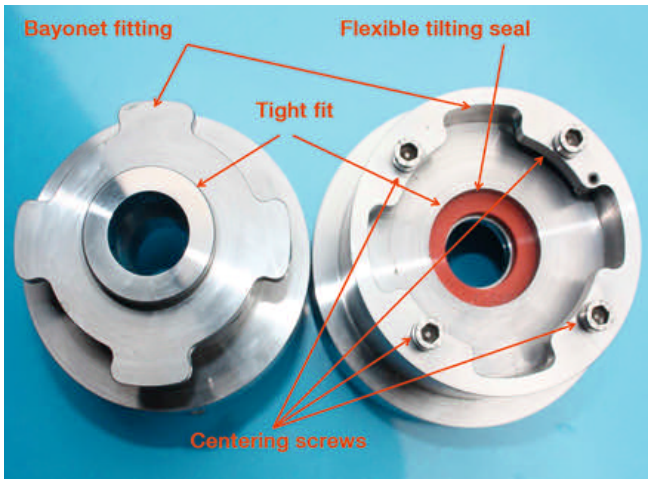

Fig. 2. Open tilting die that can be mounted and removed with a simple twisting action thanks to a special bayonet fitting

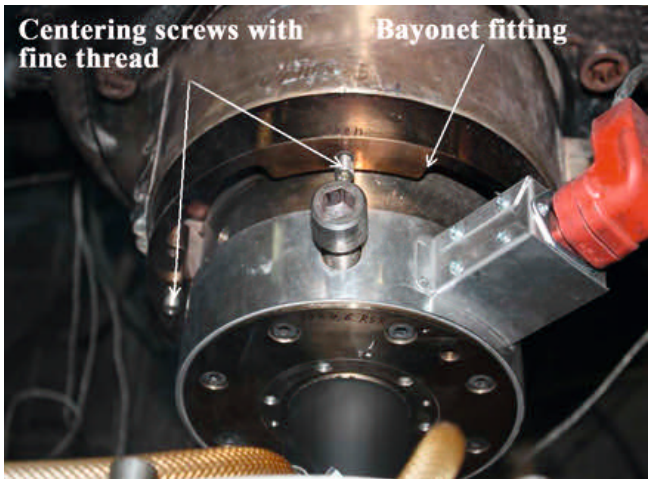

Fig. 3. In operation: Tilting die equipped with fine-thread screws for delicate centering

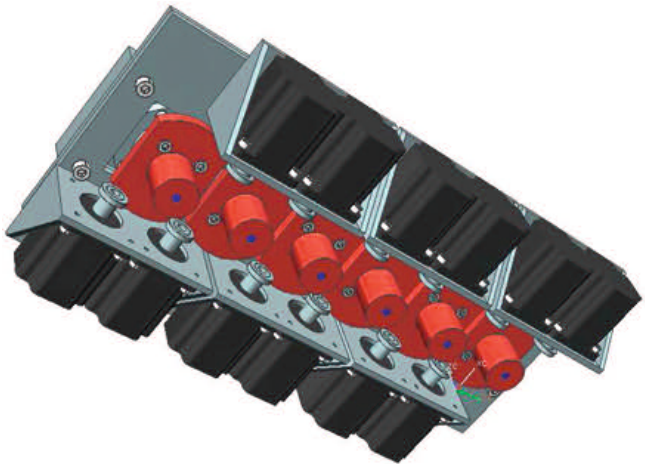

Fig. 4. Six-die head for production of curved tubes in which each individual cavity can be dynamically tilted separately using two maintenance-free stepping motors

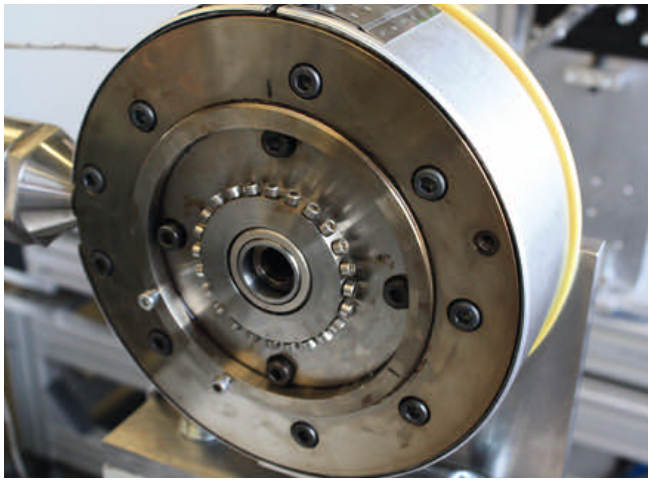

Fig. 5. Simple, compact side-fed tube die with flexible tilting joint, gap adjustment and a Flex Ring sleeve to reduce thickness tolerances

Although it has undisputed process engineering drawbacks [4], it is still quite common in extrusion blow-molding to use heads with a conical mandrel and conical die in order to be able to adjust the die gap. For this either the mandrel or the die is shifted axially over a given distance. A certain leakage has to be accepted, as the moving head section has to be shifted in a bore with a fitting allowance. If the gap of a tube head is to be changed, it is sufficient for only the mandrel to have a conical form while maintaining a cylindrical die. The possible adjustment range of the gap is then dependent on the cone angle of the mandrel end and on the travel distance that can be achieved with the additional compression of the tilting seal.

Axially Adjustable Die

For tubes with the same or at least a similar outside diameter, the bandwidth of desired wall thicknesses is generally fairly small. In practice, travel distances of just a few millimeters are therefore sufficient in order to be able to achieve the required gap variation. If the tilting seal is designed slightly thicker, the seal can be compressed further, starting from the preload necessary to achieve the sealing effect. This can be steplessly achieved using a simple threaded ring. **Figure 5** shows a tube die of this type with integrated tilting joint and die gap adjustment. The die is tilted by means of four axially arranged adjusting screws in the face of the die which act directly on the flanged collar of the die. Between the clamping screws with which the head cover is attached to the head and the centering screws is a threaded ring with which the width of the flow channel can be adjusted. In addition, the head also has a Flex Ring sleeve. Radially arranged adjusting screws allow a limited localized circumferential adjustment of the flow channel gap in order to be able to minimize asymmetric thickness fluctuations. The improved and more precise centering possibility and the localized changing of the flow channel gap using the Flex Ring sleeve thus enable previously unachieved thickness tolerances to be attained in the tube. The **Title figure** shows a tube die in operation.

The newly designed head also sets standards when it comes to ease of maintenance. Despite the gap adjustment feature, the head can be completely cleaned without having to be removed from the extruder flange. After loosening the bolts with which the head cover is fastened to the main housing of the head, the cover can be removed and the whole flow channel of the head is accessible for cleaning. During this time, the main housing remains flanged to the extruder.

The tilting technology still has only limited use at the present time, as the wear resistance of the elastomer blend is not sufficient for compounds with abrasive constituents. This problem could also be overcome, however, if pending trials with an alternative metallic tilting seal prove to be successful. ■

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Automated 100 % Inspection

In-Mold Labeling. Since labeling is no longer a separate process step IML (In-Mold Labeling) helps manufacturers of plastic packaging to save costs and resources. However there are many production machines that generate products in a state that is not amenable to automated quality control, such as loose or stacked goods. To make sure that the dropping of labeling machinery does not lead to sorting machinery having to be used, which would destroy the optimization potential realized by the use of IML technology, Intravis GmbH, Aachen, Germany, has a solution to hand. The IMLWatcher inspects the product during the demolding handling in the machine: the quality of the processing as well as the identity and position of the label.

According to the manufacturer, with a peak performance of up to 20 objects per second the video processing system with its specially developed software can keep up with even the shortest cycle times. Undecorated polymer surfaces from cups and lids as well as all commonly used label types – rolls and sheets – can be assessed for typical IML process faults such as back injection, holes or incorrect positioning of the label. Additional modules allow the objects to be presented to the camera in any rotation, an option that for the first time makes the assessment of round labels possible.

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The IMLWatcher inspects the quality of labeling
(photo: Intravis)

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