Novel constructions for ring-shaped dies broaden processing capabilities in extrusion

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Introduction

Ring-shaped die heads serve for the extrusion of various types of semi-finished products such as pipes, foamed films or sheets, blown films or cables. Annular extrusion heads are employed too in the extrusion of hollow bodies by blow molding. For all processes the die has to be re-centered on the die head each time after cleaning.. Retrofitting an ring-shaped head with an elastic tilt joint (Fig. 1) will pay off extremely fast, if dies need to be cleaned frequently, or if dimensions have to be changed at short intervals. It is also worthwhile considering whether to equip ring-shaped heads with a tilt joint, when processing expensive raw materials, or where narrow thickness tolerances must be adhered to.

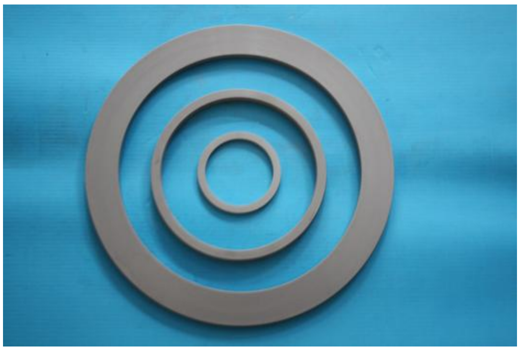

Fig. 1. Three examples of elastic tilt joints inserted into heads of different dimensions and for different processes

Tilting dies in Pipe, Tube and Capillary Production

In order to seal the parting line reliably, the tilting joint must only be compressed by a precisely defined measure. An ideal way of doing this is by using a simple bayonet lock coupling. Figure 2 represents a pipe head with an

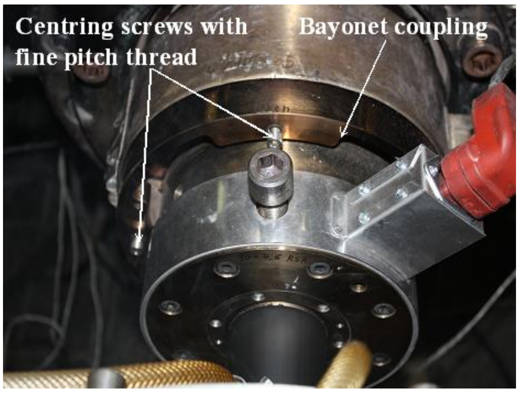

Fig. 2. Tilting die with bayonet lock coupling, with a narrow centering fit between head and die, and with fine-pitched thread screws (M6x0.5) designed for fine optimization of the relative position of die and mandrel.

elastic tilt joint and a bayonet lock coupling, thus featuring no conventional centering screws. The bayonet lock coupling reliably generates the forces required for fixing the die and sealing the dividing plane between the head and the die. This way, the operator can easily flangeor remove the die by a spinning motion. The geometry of the bayonet lock coupling automatically makes sure the elastic tilting joint is compressed just as far as is required to seal the parting line between head and die. This also prevents the gasket from being compressed too hard or too little. Additionally, no greasing of flange screws is required and the danger of screw tearing as a result of thread seizing does not exist anymore. Figure 3 shows the bayonet lock coupling of a small head designed as a tilting die right from the start. This head served to produce capillaries from PLA for medical applications, at a mere 0.2 mm outer diameter. Optimizing the relative position of die and mandrel by means of conventional radial centering screws would certainly be impossible to achieve, considering the wall thickness of the capillary of below 0.1 mm

Fig. 3. Bayonet lock coupling of a capillary die with tilting technique

What is more, it is not necessary any more to pre-center the die in a time-consuming process, after fixing it. Tilting dies have narrow fits between head and die, thus merely allowing for the dies to be fixed to the head center. The great benefit here is the fact that the die exactly sits in the same central position each time the process starts, which used to be different with the conventional techniques. The die used to take on a new position then, each time the process was started, and this was mainly determined by the patience and skill of the respective operator.

For the individual process, optimization of the relative position of die and mandrel can most easily be done by special centering screws, as can be seen in Figure 2. While compressing the elastic joint takes only little power, small screws with little thread pitches can be used for tilting the die. In case extraordinarily fine tuning is required, the operator may employ special screws with fine-pitched threads.

Motor-driven Centering of Ring-Shaped Dies

In the long run, however, it is recommended to use inexpensive stepper motors, because once an optimum processing position is found, this position can be stored in the machine control unit, and can always be reproduced exactly at new start-up, for the same pipe geometry. A motor drive for the tilting die can even allow for eccentric differences in thicknesses to be minimized during extrusion by means of a control unit. Figure 4 shows a Flex Ring pipe die head designed for the production of core-foamed PVC pipes.

Fig. 4 Flex Ring die combined with tilting technique which enables to establish a closed-loop control to minimize as well eccentric, as also asymmetric variations in the thickness of extruded pipes

Tilting Die Technique for Extrusion Blow Molding

Integrating elastic tilt joints into blow molding heads will open up entirely new ways of processing. When retrofitting a blow molding head, two low-cost stepper motors, which sit in a 90° angle, can be employed to tilt the die. This way, the die can easily and dynamically be tilted into every needed position, during discharge. Consequently, the die can be centered from the control panel at close to any desired fineness and precision, and the process parameters can even be stored at the end of the production cycle. The tilting technique thus represents the first method ever to enable production at exactly the same relative position of die and mandrel, each time the machine is started up.

Moreover, the relative position of die and mandrel can certainly be changed during discharge of the preform too. This way, the operator can improve, e.g. the wall thickness distribution in crooked curves or in parts with a degree of stretching that varies over the circumference Figure 5. If additionally connecting the tilting technique to the

Fig. 5 Extrusion blow molded pipe with complicated shape

GWDS (**G**ross **w**all thickness **d**istribution **s**ystem) technique, which is just as novel, and is currently in the stage of development and testing, it will be possible to include in any usual blow molding machine a dynamic tilting function, and a well-aimed dynamic axial as well as radial closed-loop control of wall thicknesses of the parison. No special die areas will have to be deformed any more by actuators, in order to conduct axial and radial closed-loop control of the wall thickness. Neither will special software have to be implemented into the control unit. At present, this is done by very expensive and sophisticated PWDS (**p**artial **w**all hickness **d**istribution **s**ystems) or Flex Ring tools.

There are in fact certain limitations to the PWDS system in particular, and to the flexring system too, and that is when the degree of deformation in the part does not change gradually, but rather significantly over a very restricted area. In these cases, the GWDS technique can achieve a more homogeneous wall thickness distribution in the part, than PWDS or Flex Ring systems can do (Figure 6).

Fig. 6 Comparison of the thickness distribution in a small fuel tank. 3D-tecnology (on top) conventional fabrication method (underneath); G= weight; T_b= cooling time

Furthermore the GWDS technique has overcome the former restriction that a radial wall thickness programming system is limited to a certain die diameter range and can not be applied to small multi-cavity heads. Figure 7 shows a retrofitting unit for a 6-cavity head which is equipped with a tilting joint and a GWDS die in order to produce tubes with crooked curves and with changes in the cross-sectional geometry over their length. The die is dynamically tilted in order to achieve a uniform thickness in the curves and the GWDS technology is uses to profile the thickness distribution of the parison to take into account the cross sectional change of the geometry of the tube.

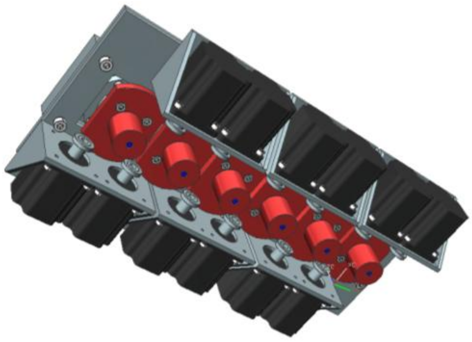

Fig. 7 Retrofitting unit for a head having 6 profiled cylindrical GWDS-dies (diameter 10 mm) and 12 stepper drives to tilt every die individually during the extraction of the parison

References

1 Deutsche Patentschrift (German patent) DE 10 2009 058 361 B3, published: 01.06.2010