The Dynamic Die

Wall Thickness Control of the Parison with Cylindrical Runner and by Tilting the Die

Exact wall thickness distribution is the primary goal in the fabrication of extrusion blow molded hollow articles – regardless of whether the same wall thickness is needed everywhere, or different wall thicknesses are required in certain areas. This means that flexibly changing the wall thickness of the parison has to be possible in both the axial direction and circumference direction during the discharge from the die.

Changing the wall thickness of the parison in the axial direction during discharge is very easy to realize in process technology by using a conical die as well as a conical mandrel, and by shifting the die and mandrel relative to each other in the axial direction during discharge. This is a state-of-the-art mode of operation in the blow molding process. However, producing greater wall thickness differences over the circumference of the parison for more elaborate technical components is hardly possible with conical dies. When the wall thickness of the parison also has to be changed over the circumference during discharge, conical dies require significant process technology effort.

Die Technology with a Conical Flow Channel Geometry

A corresponding approach was developed at the end of the seventies: In order to locally change the flow channel gap at the end of a die, two or four actuators deform the die during parison discharge (well known as PWDS-technology). The PWDS-die has a relatively thin wall for this purpose (**Fig. 1**). However, this partial wall thickness control is not only very technically elaborate and expensive, but also encounters its limits quite quickly with blow molded hollow articles that have a complex geometry, especially when the wall thickness is to be changed over the circumference of the parison according to the molded part. It is for example impossible to achieve the geometry changes of a windshield washer reservoir for a van (**Fig. 2**) over the circumference when the wall thickness of the parison can only be changed with die deformation at a maximum of four positions arranged at a fixed angle of 180° or 90°. Flexibility is further limited since the geometry of a PWDS-die on the one hand can only be deformed where the actuators are form-fitted to the die and, on the other hand, the die can only be deformed according to the natural bending line of the respective die design. This often leads to a disparity between the financial and technical cost on the one hand and the possible economic benefit on the other hand. Therefore, the use of the PWDS-technology is generally not sensible for complicated technical hollow articles with highly differing degrees of stretching in closely neighboring zones.

Furthermore, when using the PWDS-technolgy a dynamic radial wall thickness control is only suitable for a limited range of die diameters. Such PWDS-dies cannot improve the wall thickness distribution of relatively small and very large blow molded articles. The smallest PWDS-system built to date has a die diameter of 50 mm [1]. This makes the process unsuitable for smaller hollow articles with a filling volume up to one liter, constituting the bulk of the rather large packaging market. Dynamically deformable PWDS-dies with diameters of 675 mm and up are not available either, which means this process cannot be used to improve the wall thickness distribution of large tanks. »

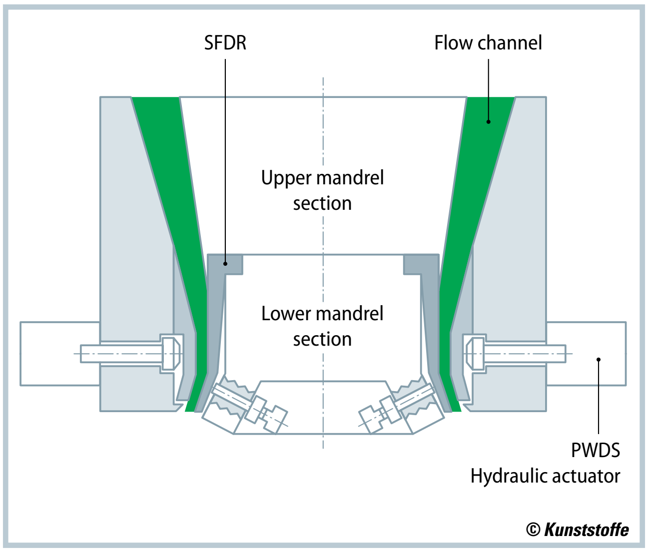

Fig. 1. Partial wall thickness control (PWDS): Actuators guide a static flexible deformable ring (SFDR) to change the die gap (source: [2])

Fig. 2. Fabricated windshield washer reservoir using GWDS wall thickness control technology (left) with optimized wall thickness distribution, it weighs 482 g compared to 560 g in conventional production (right) (© H. Gross)

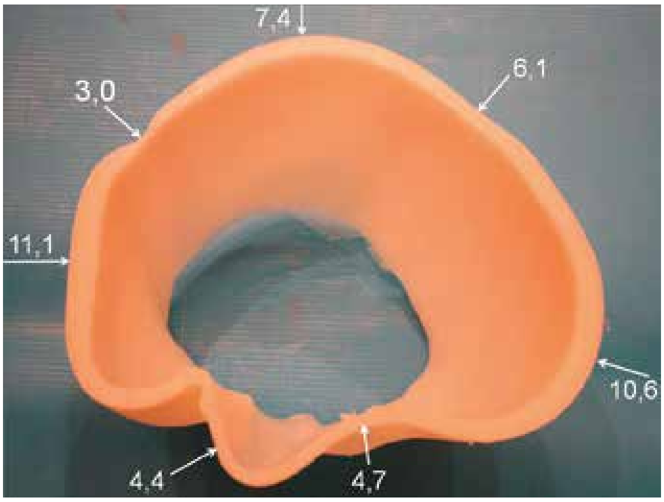

Fig. 3. Unstretched, cooled parison from a GWDS wall thickness control die: Notwithstanding the different wall thicknesses (in mm), the parison came out of the die sufficiently straight to hit the blowing mandrel (© H. Gross)

Die Technology with a Cylindrical Flow Channel Geometry

The GWDS thickness control technology introduced by the author makes it possible to change the wall thickness over the circumference of the parison, both statically and dynamically. It is less technically elaborate and can be used for virtually all applications that occur in blow molding, since there are no limits regarding the size of the die so that the wall thickness of all hollow articles can be optimized. Simply exchanging a die with a conical flow channel design for one with a cylindrical one makes it possible to produce wall thickness changes over the circumference that go far beyond what was previously possible. For example, the wall thickness of the parison for a hollow article needed in automobile construction could be realized even though its geometry was fundamentally unsuitable for the extrusion blow molding process (**Fig. 3**).

The special wall thickness distribution was only needed for a short section of the hollow article, while the rest of the parison exhibited a nearly consistent wall thickness averaging 5 mm. Wall thickness distributions tailored to the respective molded part in this manner cannot be achieved with any other technology.

These process technology benefits can be realized in any existing blow molding line, with no additional costs: Only massive dies and mandrels that are easy and very economical to produce are required. There is no need to retrofit additional actuators nor to integrate special software into system control. The dies are therefore maintenance-free in operation. This makes the GWDS thickness control technology superior to a PWDS wall thickness control solution in regards to the acquisition costs, operating costs, and the process technology possibilities.

Nevertheless, the only difference between a GWDS wall thickness control die

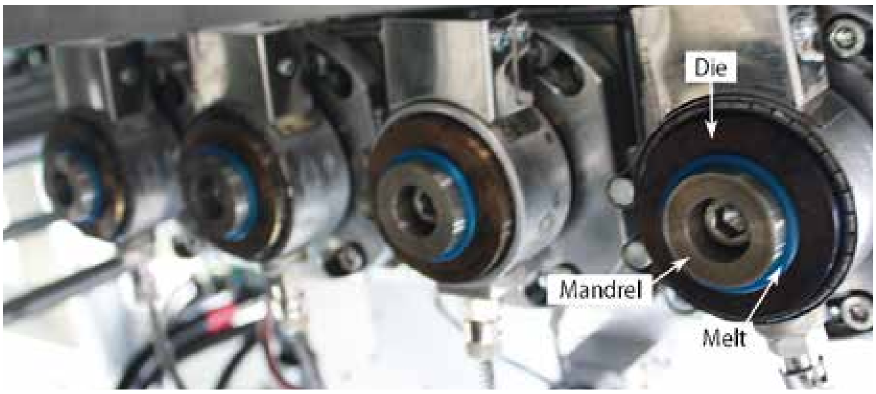

Fig. 4. GWDS wall thickness control dies with a diameter of 40 mm integrated into a fourfold head. The cylindrical mandrels shaped at the end have been extended from the die here since the shaping is not needed for this section of the component (© H. Gross)

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References & Digital Version

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Fig. 5. Straight parison free of waves (left) with a major wall thickness difference (right) discharged from a GWDS wall thickness control die with an extremely shaped mandrel (center) (© H. Gross)

and a simple, conventional blow molding die is merely that both the die and the mandrel at the end of the flow channel are not conical but primarily cylindrical. This allows the mandrel to be extended further from the die without colliding with it or changing the size of the die gap (**Fig. 4**). In the zone projecting from the die, the mandrels can therefore be shaped as desired for certain sections of a hollow article without affecting the melt distribution in the die. Large wall thickness control mandrels are therefore slightly contoured at the end, preventing the thickening of the wall at both ends of the pinch-off weld that is typical for blow molded articles.

Individual zones or also different mandrel disks can be arranged above at the mandrel end, shaped according to the requirements of the blow molded part being fabricated. As long as a mandrel zone with a special shape is outside the die, it does not influence the melt distribution within the die or the wall thickness distribution of the parison discharged from the die. This makes it possible to change the flow channel geometry at the die opening by moving the mandrel. In order to evenly change the overall wall thickness of the parison over the circumference, a slightly conical disk is simply integrated at the mandrel end.

A GWDS wall thickness control die also no longer requires a mandrel with an elaborate and expensive static flexible deformable ring (SFDR) since the respective geometry specific to the molded part is integrated directly into the massive GWDS wall thickness control mandrel. This allows much greater gap changes to be produced at the end of the die (see **Fig. 3**) compared to the PWDS technology. When a conventional conical die is highly shaped, this inevitably causes major differences in the discharge speed of the melt over the circumference of the die. The parison is no longer discharged straight from the die as a result. This problem can be overcome with a GWDS die that has a primarily parallel flow channel geometry by coordinating the flow resistance over the length of the runner. The approach is similar to the layout of profile dies, where zones with different runner gaps typically exist at the die end. That is why the also primarily parallel runners are dimensioned so that the melt is discharged at virtually the same speed everywhere even though the discharge gaps of the die vary. Similarly, straight parisons without waves can be discharged from a GWDS die (**Fig. 5, left**) even though the mandrel is extremely »

Fig. 6. Weight and thickness distributions of a windshield washer reservoir produced with a GWDS wall thickness control die (left) and conventionally (right) (© H. Gross)

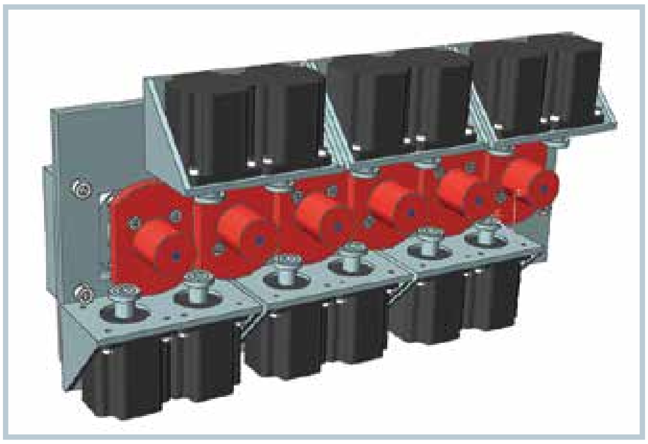

Fig. 7. Multiple GWDS wall thickness control dies with tilting technology: Two stepper motors (black) can individually tilt each die (red) in every required direction relative to the mandrels (blue) in the interior of the die (© H. Gross)

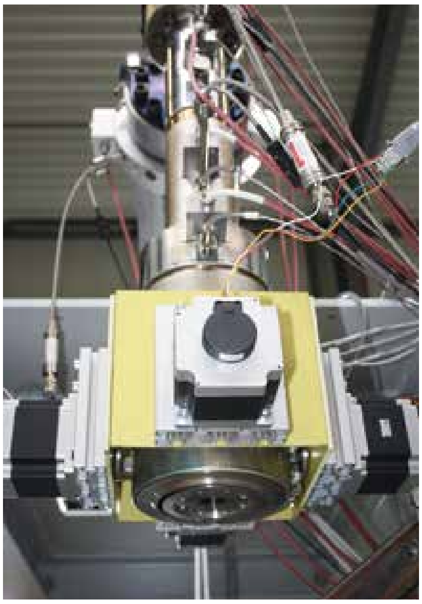

Fig. 8. Compact autonomous GWDS die head with integrated tilting joint: Both the translational stroke movement and the tilting movement of the die were realized using identical stepper motors (© H. Gross)

shaped (**Fig. 5, center**) and therefore produces a relatively great wall thickness difference (**Fig. 5, right**) over the circumference, reducing the weight of the windshield washer reservoir produced in this manner by more than 20 % (**Fig. 6**).

Trifunctional Component for Dynamically Tilting the Die

When a patented [3] trifunctional component is integrated in addition, sealing the die towards the head, then the die can also be tilted and moved relative to the mandrel in order to change the runner gap. Since much smaller forces are required to tilt the die on the one hand and the forces are also easy to amplify using a lever arm, small and low-cost actuators are sufficient – for example very fast and economical stepper motors. Such tilting dies with an integrated trifunctional component are also maintenance free in operation. **Figure 7** shows a sixfold head with GWDS dies. Each die can be tilted individually with two stepper motors for dynamic centering or bringing out of center. An eccentric and a ball bearing pressing on the flange collar of the die are installed for this purpose on the respective motor shafts.

Fully autonomous die heads can in principle be realized with a trifunctional component by flange mounting four stepper motors on the head (**Fig. 8**). When all stepper motors operate at the same speed, the resulting die movement is translational. Individual drives are respectively operated to tilt the die. Such a head is quick and easy to remove from one machine and flange-mount again on another machine. Then only the lines of the stepper motors required for operation have to be connected to system control. ■