Dynamic Wall Thickness Control. To improve wall thickness distribution, e.g. for pipe production, adjustable yet static Flexring dies are employed. A pilot project has now investigated whether this technology can also be applied to extrusion blow molding.

Outer housing with Flexring sleeve incorporated and actuators attached

Material Savings for Complex Shapes

HEINZ GROSS
PETER KUBISCH
MICHAEL R. RAUM

There are always companies which can prove that, in spite of global competition and the high cost of labor in Germany, it is still possible to produce at competitive prices. A key to being successful in this regard is to not simply rest on an assumed technological lead, but rather to test newly developed production technologies that have not yet been fully validated and, in the event of success, to incorporate these into one's own production process. This is naturally associated with a certain risk, since newly developed production technologies cannot point to years of experience being used on production machinery. With such pilot projects, there are also no guarantees that the expected objectives can actually be achieved. Thus, a willingness to accept a certain amount of risk is required in order to advance technologically.

The BIG-Spielwarenfabrik GmbH & Co. KG, Fürth, Germany, intentionally accepted such risk. In close cooperation with the developer of the Flexring technology, a decision was made to start a pilot project and retrofit an existing blow mold with a Flexring sleeve and dynamic radial wall thickness control. The declared objective was to improve the quality of the blow molded part by optimizing the wall thickness distribution and, if possible, simultaneously lower production costs by reducing the part weight and shortening the cycle time.

Selection of a Suitable Blow Molded Part

After carefully analyzing all parts produced as to their suitability for the pilot project, the mold used to manufacture the BIG Bobby Car (Fig. 1) was selected. The major reason behind this decision was that the Bobby Car is the part produced in the largest quantity. Any material sav-

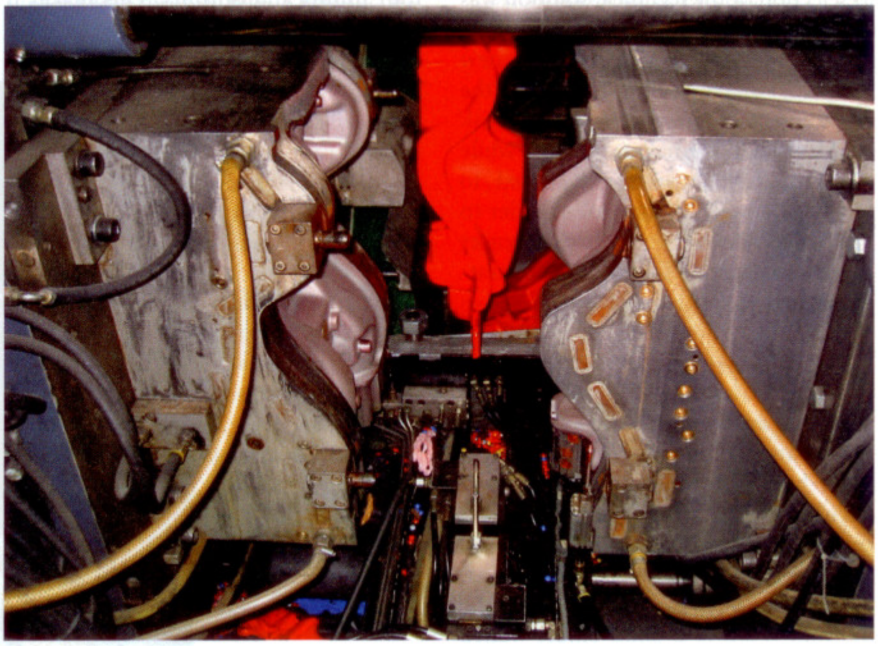

Fig. 1. The Bobby Car being removed from the mold at the end of cooling (photo: BIG)

Translated from Kunststoffe 7/2008, pp. 68–70

ings on a piece part basis would translate into the greatest cost savings. At the same time, the very complex part, which exhibits considerable differences in wall thickness and sudden changes in the degree of local stretching, poses a significant challenge from the technical standpoint. At the bottom in particular, the Bobby Car has a considerable change in the degree of stretching at a flow line. The front end, to which the front axle is screwed, has a relatively large draw ratio. To achieve an acceptable wall thickness in this region, the mandrel in the old mold was highly profiled at this location. The consequence of this, however, was that the adjacent bottom region, where the draw ratio approached zero in some areas, had a much greater wall thickness than necessary.

Fig. 2. One-piece Flexring sleeve with a diameter of 130 mm in which the 15 individual walls of the flexibly deformable conical region mutually support one another

Technical Solution

The specification from BIG with regard to selection of the technical solution was quite clear: absolutely no more technology was to be implemented in the new mold than what was necessary to meet the requirement. In this way, the financial risk could be kept as small as possible while simultaneously avoiding the need to modify the machine control in order to operate the Flexring mold. This latter requirement meant a solution that operated entirely on its own.

Design of the Flexring Sleeve

To incorporate the Flexring sleeve, the flow channel configuration in the blow mold had to be modified. The consequence of this was that a new mandrel was required for the conversion. Fig. 2 shows the one-piece Flexring sleeve integrated into the redesigned blow mold. At the bottom, there is a solid single-walled flange, but the upper conical region consists of 15 individual wall segments. The dimensions are such that the overall wall thickness can withstand the internal pressure generated by the melt, while the individual wall segments are thin enough to permit linear elastic deformation.

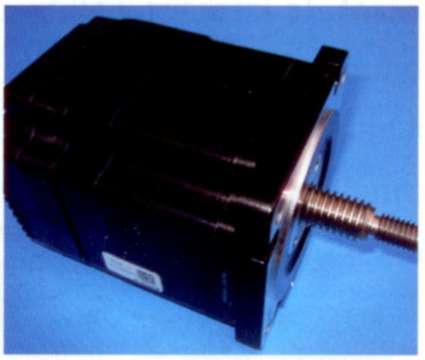

Fig. 3. Stepping motor in a linear configuration with a built-in programmable chip

Selection of Appropriate Actuators

Since the required actuating forces are low because of the multi-walled design of the Flexring sleeve, it was possible to use inexpensive stepping motors (Fig. 3). The benefits here are that they do not need complex positioning controls, they are maintenance-free and they still execute the motions specified by the program with a high degree of precision and repeatability. For the retrofit, stepping motors in a linear configuration were selected. They press directly against the outside of the Flexring sleeve through use of positioning jaws. In addition, the motors feature a programmable chip with four inputs and outputs. This makes it very easy to synchronize the program sequence with the start of the parison discharge.

Positioning the Actuators

The actuators were mounted on a flanged plate that was attached by two bolts to the exterior housing of the Flexring mold (Title photo). To ensure the best possible insulation from the heated head, an insulating plate was sandwiched between the clamping platen and the flange for the actuators. In addition, reflecting insulating plates were placed between the exterior housing of the die and the actuators in order to prevent heating of the actuators as the result of convection and radiated heat (Fig. 4). The objective here was to operate the actuators without the need for additional, separate cooling.

The housing by means of which the Flexring sleeve is attached to the head has eight attachment points for the actuators at an angle of 45°. To achieve a uniform wall thickness in the bottom region, three actuators were mounted at angles of 45°. The fourth actuator was provided to increase the wall thickness for the two seats on the upper side of the seat shell. The actuator shafts act on the Flexring sleeve by means of positioning jaws, the active contour of which can be optimized through the use of setscrews. This permits very accurate matching of the flow channel gap in this region to the complex geometry of the Bobby Car.

Breaking in the Head

Breaking in the head took place under severe time constraints, since the system was really not available for trials due to a large

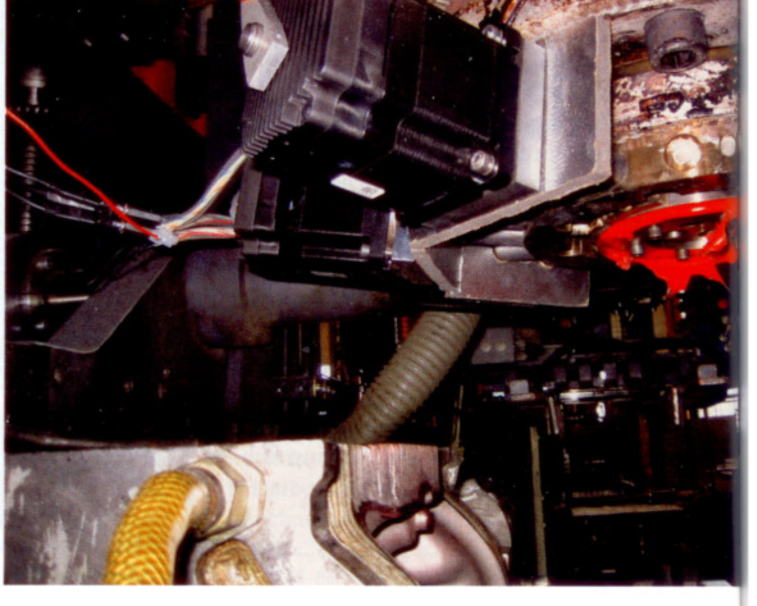

Fig. 4. Flexring die installed on the production equipment during the optimization trials (photo: BIG)

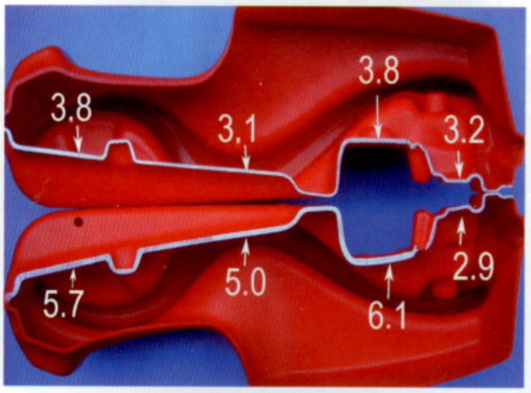

Fig. 5. Comparison of wall thickness distributions (in mm) in the bottom region of the blow molded item produced using the Flexring die (above) and using a conventional die (below)

order backlog. After preliminary trials had been conducted on the system, the actuators for the bottom region were ready for programming, and axial wall thickness profiling could be adjusted to the new situation regarding wall thickness distribution.

At the start of parison discharge, the two outer actuators advance and close off the section of the flow channel next to the attachment point for the front axle. As a result, the Flexring sleeve is displaced outward in the critical attachment region between the two actuators, thus increasing the flow channel gap. After this front axle segment of the parison has been extruded, the two actuators retract, and the center actuator advances in order to reduce the flow channel gap for the driveshaft tunnel that follows. Sections through two parts (Fig. 5) show the wall thickness distributions achieved from both a conventional head and a head retrofitted with the Flexring sleeve.

Setting up the Actuating Programs

Actuation of the drives was programmed to provide a time interval that is slightly longer than necessary to achieve the flow channel change. The drives advance a bit early and retract with a slight delay. This creates an operating window that accommodates all of the usually occurring fluctuations in parison discharge rate, e.g. batch-to-batch variations or different color formulations. The benefit of this approach is that an expensive control for wall thickness profiling is not necessary.

Intermediate Results

Setting up and optimizing the actuating programs for the bottom region, including adjustment of the axial wall thickness control, required one day. Thereafter, the more uniform wall thickness distribution visible in Fig. 5 for the bottom region had been achieved. In addition to this improvement, eliminating the thick walls in the area of driveshaft tunnel reduced the weight by 50 g. Since the cooling time for the part depends largely on the wall thickness, it was also possible to shorten the cycle time by 6 s. Since the equipment was needed for production again, the fourth actuator for the seat shell region was not programmed at this time.

Although surely only some of the possible improvements were achieved with this first trial, the decision was made to resume production with the established settings in order to profit from the improved production situation while simultaneously gaining experience with the Flexring mold over a longer period of time.

Summary and Outlook

Static Flexring dies that can be adjusted and optimized have been employed successfully in numerous production systems for many years, primarily in pipe production [1]. Much of the experience gained from work in this area was directly applicable to blow molding tooling, since in principle the parison is nothing other than a short piece of pipe. Dynamic adjustment of a Flexring die such as that required for extrusion blow molding has been tested and technically improved through close cooperation with the Institute for Plastics Processing (IKV) at the RWTH Aachen University, Germany, [2, 3] and simultaneously through trials with direct end users. With the current Bobby Car project, which must still be viewed primarily as a trial, and two other industrial projects that were conducted in parallel on production equipment, the development phase investigating the use of Flexring dies for dynamic radial wall thickness control has almost been completed.

By using Flexring sleeves for local adjustment of the flow channel gap in blow molds, it has been possible to avoid many technical problems that previously would have had to be solved by providing a dynamic radial wall thickness control. The costs to manufacture a Flexring sleeve are surely less than the costs to manufacture the many individual components of a PWDS system [4].

For a molded parts manufacturer, the fact alone that the Flexring sleeve consists of only one piece and can be adjusted by means of maintenance- and leak-free electric actuators provides major benefits. In addition to the low costs and uncomplicated use, the possibilities for technical improvements will be the primary reasons for deciding in favor of a Flexring die in the future. ■

! Info

Introduction of the technology to the market has begun on the basis of a licensing agreement with **Rikutec Richter Kunststofftechnik GmbH & Co. KG**, Altenkirchen, Germany. Rikutec will be selling blow molding heads equipped with Flexring technology to both manufacturers of blow molded parts as well as to manufacturers of blow molding machinery.

REFERENCES

1 Gross, H.: Adjustable Flow-channel Geometries – the Future in Extrusion Die Making? Kunststoffe international 96 (2006) 10, document number: PE103708

2 Grünewald, J.: Entwicklung und Erprobung neuer Werkzeugkonzepte zur radialen Wanddickenbeeinflussung beim Extrusionsblasformen. Dissertation RWTH Aachen, 2004

3 Michaeli, W.; Brümmer, T.; Wenigmann, S.; Fink, B.: Werkzeugtechnik – Schlüssel zur Prozesseffizienz und Produktqualität – Extrusionswerkzeuge. Umdruck des 23. Kunststofftechnischen Kolloquiums des IKV Aachen, 2006

4 German Patent No. 28 23 999 C2: Vorrichtung zum Regeln / oder Einstellen der Wandstärke von aus thermoplastischem Kunststoff gebildeten Hohlkörpern (1978) Feuerherm, H.

THE AUTHORS

DR.-ING. HEINZ GROSS, born in 1950, has been the owner of Gross Kunststoff-Verfahrenstechnik, Rossdorf, Germany, since 1993; heinz-gross@t-online.de

PETER KUBISCH, born in 1963, is Blow Molding Department Manager at BIG-Spielwarenfabrik GmbH & Co. KG, Burghaslach, Germany; peter.kubisch@big.de

DIPL.-ING. MICHAEL R. RAUM, born in 1963, is Chief Technology Officer at BIG-Spielwarenfabrik GmbH & Co. KG, Burghaslach.