NEW DIES FOR EXTRUSION BLOW MOLDING GIVE RISE TO VARY THE RADIAL THICKNESS DISTRIBUTION OF THE PARISON

H. Gross

Gross Kunststoff-Verfahrenstechnik, Rossdorf, Germany – heinz-gross@t-online.de

The optimum parison shows thickness changes over the length and over the circumference to mach the different draw ratios in the final blown part. The thickness variations in direction of the length can be easily achieved by moving the conical mandrel. Now a new technique is available to also dynamically profile the thickness of the parison over the circumference. It can be applied for all die diameters. In many cases the technique can even be easily retrofitted to existing dies to reduce material consumption while in the same time reduce the cycle time and improve the part quality . The details of the technology will be explained and results achieved as well on pilot machines as also on production machines will be presented

Introduction

The geometry of blow-moulded parts are becoming ever more complex. This is mostly the result of technical requirements. However especially for bottles for packaging, it is often designers who determine the part geometry independently of technical concerns. For the parts manufacturer, it is largely immaterial what reason are used to justify the geometry of the part he is required to manufacture. His function is to produce the part with the most optimum thickness distribution using the technical tools available to them.

To generate the desired wall-thickness differences in the parison the nozzle and mandrel can be provided with a profile around the circumference, and the wall thickness in the axial direction can be influenced by the use of a displaceable conical mandrel. However, this leads to undesirable coupling between the axial and the radial wall thickness control, so that a compromise must always be made regarding the optimum wall-thickness distribution in the two directions.

If the part to be produced has a very complex geometry, an optimum wall-thickness distribution can only be achieved by a dynamic change in the thickness of the parison in the axial and in the radial direction. In addition to the conventional programmable wall-thickness control (PWDS) which has been in use for years, part manufacturer now have an interesting alternative for the radial wall-thickness control in the form of flex ring technology. The conventional PWDS-system can only be used properly with a die diameter of 60 mm or greater. In addition the process-engineering potential of this system is restricted as regards the geometry that can be implemented and the wall-thickness differences in the parison that can be achieved with it. It is also a very sophisticated solution that is very expensive. So the long for an improved solution exists which offers a more accurate and better targeted wall-thickness adjustment in the parison.

Technical requirement

The aim in developing the flex ring technology was to provide a solution that is simpler but can be used for all die diameters that normally occur in extrusion blow moulding and that permits a more sensitive control of the wall-thickness distribution of the parison. Beyond this basic requirement:

- a wide freedom in the design of the flow channel geometry should be retained,
- the die should of course be able to withstand the pressure normally occurring in the process
- the integration of the new technology into the die should not require a new parting line
- if possible, the system should not create any area where leakage can occur
- no dead zones should be generated in the flow channel when its geometry is adjusted
- the entire system should be corrosion resistant and therefor applicable for all conceivable dies
- the positioning system must be simple to actuate, and
- a high positioning speed must be possible.

Technical solution

A completely new manufacturing technique was developed to allow inserts (flex ring sleeves) for blow moulding dies to be produced, which are partially designed with multiple walls [1]. These flex ring sleeves can be easily retrofitted to conventional dies or integrated in them.

They are massively thick walled at one end , where they have a conventional flange collar by which they are held in the modified outer ring of the die. The underside of the flange forms the sealing face, which is required in any case in the centring parting line. In this region there are thus no principle modifications required with respect to a conventional die.

The upper end of a flex ring sleeve, which forms the die orifice, is designed with multiple walls to allow limited local variation of the flow channel gap there. This is particularly advantageous since changes of the flow-channel resistance directly at the end of the die are considerably more effective than those that are made in the interior of the die. The flow-channel wall in this region is then assembled from a large number of extremely thin, nested individual walls to enable it to withstand the interior pressure of the melt while at the same time allowing it to be flexible deformable.

The natural flexing line of such a “leaf spring”-like flex ring sleeve is very short. It thus offers the possible of very sensitive, purely linear elastic deformation at any point around the circumference of the die. With the example of a flex ring die having a diameter of only 43 mm, Fig1 shows to what extremes such a multiwalled flex ring can be deformed without plastic deformation taking place. Since the flow resistance in a slit flow changes with the cube of the size of the flow channel gap, very large local wall-thickness changes can be generated in the parison in this manner. Despite this when a flex ring die is used there are also no sudden changes in the flow channel that can lead to dead spots, since the geometry of the flex ring sleeve in the deformed region always alters gradually.

The 32 setting screws of the die shown in Fig. 1 allow the parison to be provided with a much better targeted control of the wall-thickness distribution, which is tailored to the final product than with the maximum four setting positions that are available in the established programmable wall-thickness control system (PWDS).

It is naturally not appropriate to carry out dynamic adjustment at 32 setting positions in a production plant. The tool in Fig. 1 is a pilot tool. It permits to determine the optimum flow-channel contour for a new product rapidly and inexpensively during die design. By purely static adjustment, the appropriate profiling of the flow channel gap around the circumference of the die can be determined for each position along the length of the parison. The geometry can thus be optimised after each shot to obtain the desired result.

Fig. 1 Cross sectional drawing of a flex ring die (right side) and Photo of an outer ring with an integrated flex ring sleeve (left side)

First test results

However such a die which was originally designed for a purely static adjustment can be easily converted into a dynamically controlled production die (Fig. 2). In a partial region the setting screws were removed and are replaced by a linear actuating motor. The linearly moving axis is securely connected to an adjustment jaw to locally deform the flex ring sleeve over a relatively large circumferencial area. The adjustment jaw has distributed across the width, 14 small grub screws (Fig. 3), with whose help the geometry of the jaw can be easily adapted to the requirements of the product.

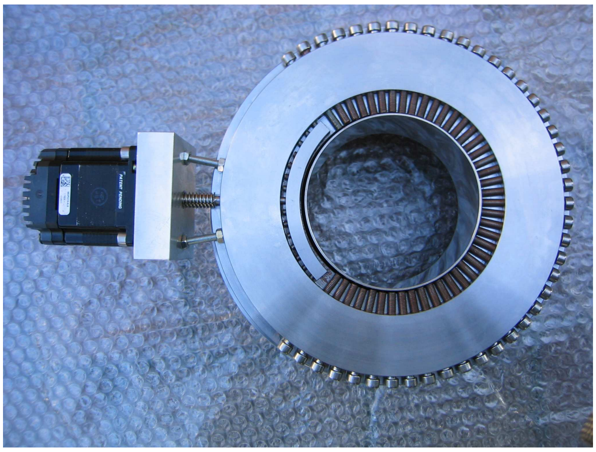

Fig. 2 Originally static test die which was retrofitted with an adjusting drive to perform first dynamic tests

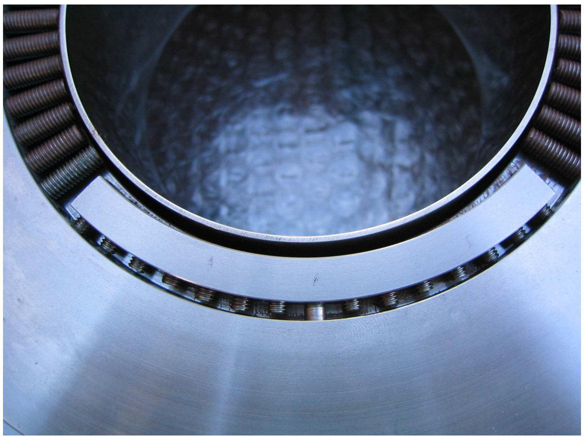

Fig. 3 Adjustment jaw with integrated grub screws for fine setting of the active setting jaw contour

Because of the small mass that has to be accelerated with this system, positioning movements can be executed very rapidly. To demonstrate what is possible with the flex ring technology, in a test run, the flow-channel gap was closed at one point by means of the actuating motor for 0,3 s during the extraction of the parison. A position was chosen at which the container produced by a conventional die always had an undesirable thick wall. The result of the test carried out on an accumulator head die is shown in Fig 4. A purely visual comparison of the generated thin area with the wall thickness at the corresponding opposite position makes clear what severe wall-thickness changes are possible with a flex ring die. The short transition region at the edge of the generated thin area cannot be achieved in this way with any other system.

Fig. 4 Blow moulded bottle with extreme thin area which has been generated for the purposes of demonstration by short term local closure of the flow channel gap on the die by means of the setting jaw

At the Institute of Plastics Processing (IKV) in Aachen/Germany, a flex ring die was intensively studied and tested within a two-year research project. A die with a diameter of only 35 mm having 16 actuating motors was designed (Fig. 5).

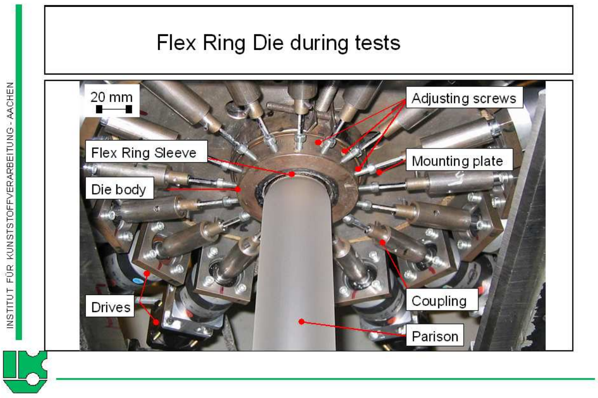

Fig. 5 Flex ring die of the IKV with a diameter of 35 mm which is equipped with 16 actuating motors (source IKV [2])

Additionally, a test bottle was designed with three different zones for research purposes. The geometry changed over the length of the bottle from a rectangular base region via an oval lower bottle zone to a circular geometry (Fig. 6) in the upper region of the bottle [2].

Fig. 6 Special designed bottle with varying cross-sectional geometries manufactured with the test die (photo IKV)

In static tests a very good thickness distribution could be obtained for every zone of the bottle (Fig. 7). In dynamic experiments, the arose a synchronisation problem with the data transfer, which prevented simultaneous actuation of the 16 channels.

It can be stated that this study showed what is possible in principle. In a production application, the conceived symmetrical bottle would also suffice with the conventional four adjustment positions. In such a case, the time problem for data processing would certainly overcome.

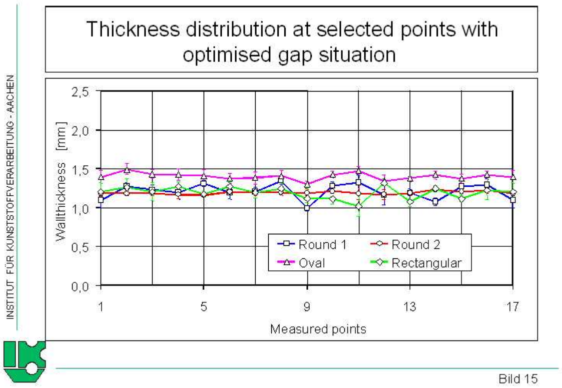

Fig. 7 Wall-thickness distribution in the sectional planes with optimised static sleeve deformation (source IKV [2])

The flex ring technology can also be advantageously for inexpensive optimisation of the mandrel contour. Post machining of the contour is not only very time consuming, but also very tricky. Besides the labour and material requirements it always consumes valuable machine capacity, too. A linear elastically adjustable flex ring mandrel (Fig. 8) considerably simplifies this procedure, since the contour can be purposefully optimised during start-up of the die. The mandrel geometry can be adjusted quasi from shot to shot.

There is thus no risk of removing too much material at a particular region, and in the worst case of having to start from scratch again. With a flex ring mandrel, every change that has not brought about the desired positive result can be very easily reversed in the next step by unscrewing the corresponding screws**.**

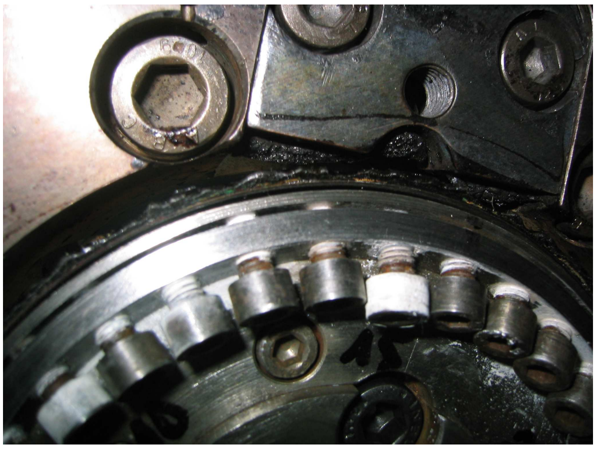

Fig. 8 Cutaway view of a flex ring mandrel that has been retrofitted to a programmable wall-thickness control (PWDS) die for rapid optimisation of the mandrel contour

References

1. Gross, H.: Flexible Die Walls. Kunststoffe plast europe, Volume 93, 8/2003, page 8 -9

2. Grünewald, J. Entwicklung und Erprobung neuer Werkzeugkonzepte zur radialen Wanddickenbeeinflussung beim Extrusionsblasformen. Dissertation at the Technical University of Rhineland Westphalia (RWTH) Aachen 2004