ADVANCES IN PLASTICS TECHNOLOGY

APT ´09

NEW TECHNOLOGY TO ACHIEVE A DYNAMIC RADIAL WALL THICKNESS PROGRAMMING OF THE PARISON DURING EXTRUSION BLOW MOULDING

Nowa technologia dynamicznego programowania grubości ścianek rękawa podczas wytłaczania z rozdmuchem

H. Groβ
Kunststoff-Verfahrenstechnik, Germany

Paper № 20

03 – 05 November 2009, Katowice, Poland

New Technology to Achieve a Dynamic Radial Wall Thickness Programming of the Parison during Extrusion Blow Moulding

Dr.-Eng. Heinz Gross

Abstract

A new technology has been developed to better match the wall thickness distribution of the parison with the local draw ratio at different areas of the blow moulded parts. The technology can be used with head diameters starting from minimum 6 mm to every bigger head sizes. Thus it covers nearly the full range of head diameters which are normally used in extrusion blow moulding. Using this technology improves the part quality while in the same time it saves the production cost by reducing the weight of the produced part. Additionally the capacity of the machine is increased and the tooling cost is reduced.

Introduction

The geometry of blow-moulded parts becomes ever more complex. This is mostly the result of technical requirements. However especially in packaging, the geometry of bottles is often given by designers independently of technical concerns. Designers mostly do not bother about technical questions perhaps how to produce the special bottle. For the blow moulder, it is largely immaterial what reason are used to justify the geometry of the part. He has simply to manufacture it. His task is to produce the part with the most optimum thickness distribution using the technical tools available to him. To achieve this optimum parison should show thickness changes over the length and over the circumference to take into account the specific tool situation and to exactly match the different draw ratios in the blown part to be produced.

To generate the desired wall-thickness differences in the parison the nozzle and mandrel can be provided with a static 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 often a compromise has to be accepted 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 also in the radial direction. In addition to the conventional programmable radial wall-thickness control (PWDS) which has been in use for years [1], part manufacturer now have an interesting alternative. For the first time radial wall thickness programming can be used even for very small die diameters down to 6 mm. The conventional PWDS-system can only be used properly with a die diameter of 70 mm or greater. In addition the process-engineering potential of this system is restricted in regards of the geometry that can be implemented and regarding the wall-thickness differences in the parison that can be achieved with it. It is also a very complicated and therefor a very expensive solution. So for a long time an improved solution was lacking which offered a more accurate and better targeted wall-thickness adjustment of 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 head 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 head should of course be able to withstand the pressure normally occurring in the process
- the integration of the new technology into the head 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 heads
- 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 heads (Fig. 1) to be produced, which are partially designed with multiple walls [2-4]. These Flex Ring sleeves can be easily retrofitted into conventional dies or integrated into them.

Fig. 1 Flex Ring sleeve for the production of industrial bulk containers (IBC), having a diameter of 550 mm and a flexible multi-walled conical wall which has been retrofitted into an existing head

They are solid at one end where they have a conventional flange collar. There they are held in the modified outer ring of the head. The bottom side of the flange forms the sealing face, which is required in any case to be able to centre the head. In this region there are thus no principle modifications required with respect to a conventional head.

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 it can be deformed flexibly.

The natural flexing line of such a “leaf spring”-like Flex Ring sleeve is very short. It thus offers the possibility of a very sensitive, purely linear elastic deformation at any point around the circumference of the die. With the example of a Flex Ring head having a diameter of only 43 mm, Fig. 2 shows to what extremes such a multi-walled Flex Ring can be deformed. This can be done without plastic deformation taking place. Since the flow resistance changes in a slit flow with the cube of the size of the flow channel gap, very large local wall-thickness changes can be generated in the parison. Furthermore when a Flex Ring heads is used there do not exist any 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. 2 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).

Naturally it is not appropriate to carry out dynamic adjustments at 32 setting positions in a production plant. The tool in Fig. 2 is a pilot tool. It permits to determine the optimum flow--channel contour for a new product rapidly and inexpensively during the design of the head. 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.

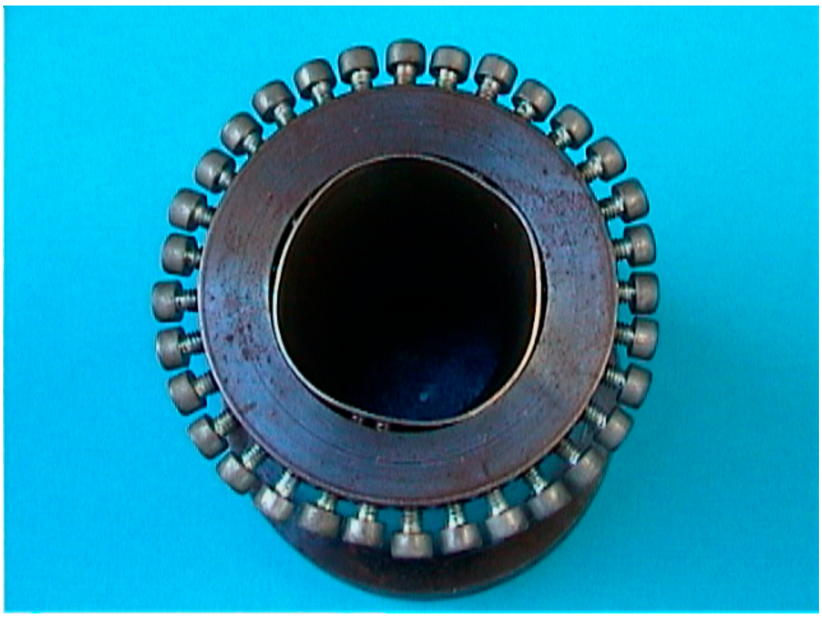

Fig. 2 Flex Ring head having been statically deformed by using adjusting screws

Practical applications and obtained results

Heads in various sizes for different applications have been retrofitted into production machines to enable a dynamic radial wall thickness control. The goal was to improve the thickness distribution of blow moulded parts. For the first time even multi-cavity heads can be retrofitted with a dynamic radial adjustment. Fig. 3 shows a Flex Ring sleeve integrated into one cavity of a twelve cavity head.

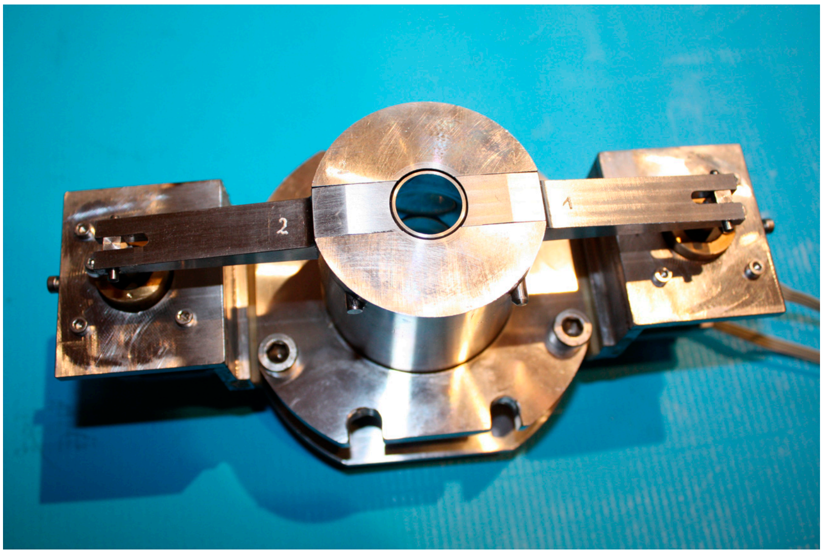

Fig. 3 Flex Ring unit to be retrofitted into a twelve cavity head for the production of an oval bottle having a volume of 200 cm^3

Compared to bottles having produced with a conventional static profiled head the thickness distribution of the bottle could be significantly improved. Thus the weight could be reduced by 10 percent. Additionally the cycle time was reduced which immediately helps to increased machine capacity.

Dynamic radial wall thickness programming is especially advantageous for the production of technical parts which have complex shapes. Fig. 4 shows a Flex Ring kit which has been retrofitted into an existing head to produce the kids toy named BIG Bobby Car. Since the required actuating forces are low due to of the multi-walled design of the Flex Ring sleeve. For the retrofit, stepping motors in a linear configuration were selected. 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. They press directly against the outside of the Flex Ring sleeve through use of positioning jaws.

The actuators were mounted on a flanged plate that was attached by two bolts to the exterior housing of the Flex Ring mould. To insure the best possible insulation from the heated head, an insulating plate was sandwiched between the clamping platen and the flange of the actuators. In addition reflecting insulating plates (see Fig. 5) were placed between the exterior housing of the head and the actuators in order to prevent unnecessary heating of the actuators as a result of convection and radiated heat. The objective was to operate the actuators without the need for additional, separate cooling.

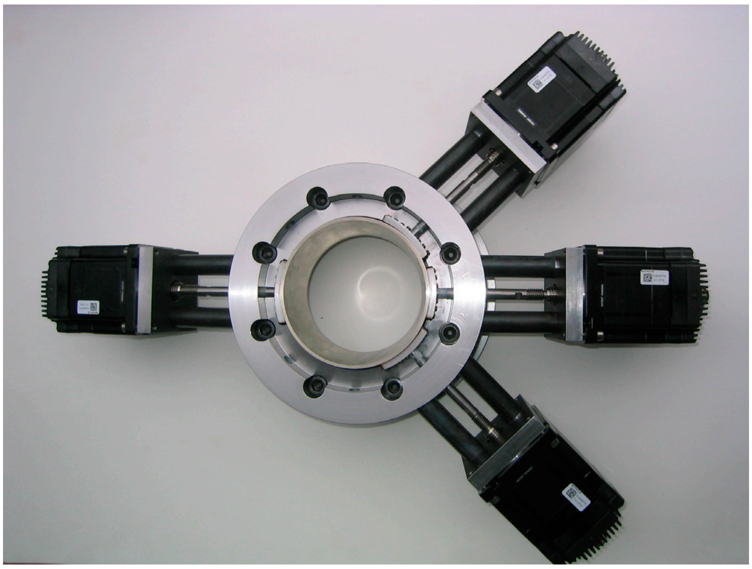

Fig. 4 Complete Flex Ring set-up which was retrofitted into the Bobby Car head

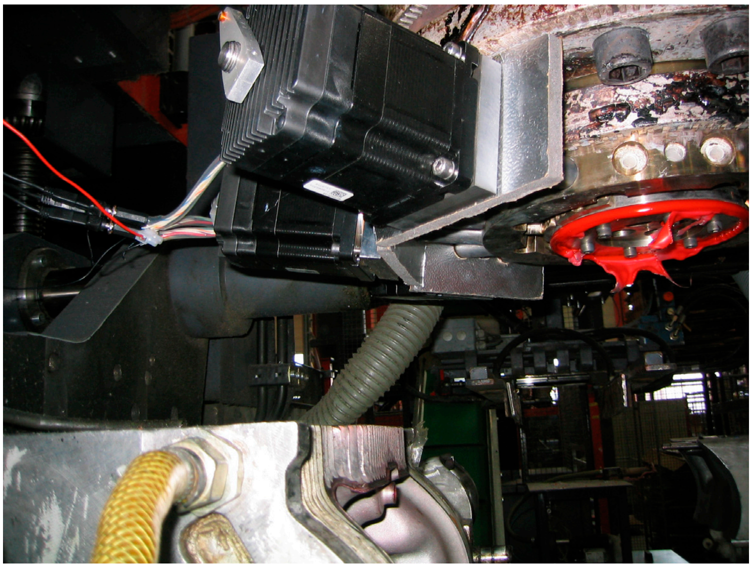

Fig. 5 Flex Ring solution for dynamic radial wall thickness control mounted to the production head

Setting up and optimizing the actuating programs including adjustment of the axial wall thickness control, required one day. Thereafter the improved wall thickness distribution visible in Fig. 6 had been achieved. Again in addition to this improvement, elimination the thick wall in the region of the driveshaft tunnel reduced the weight by 50 g. Since the cooling time for the part depends largely on the wall thickness, it was possible to shorten the cycle time by 6 s.

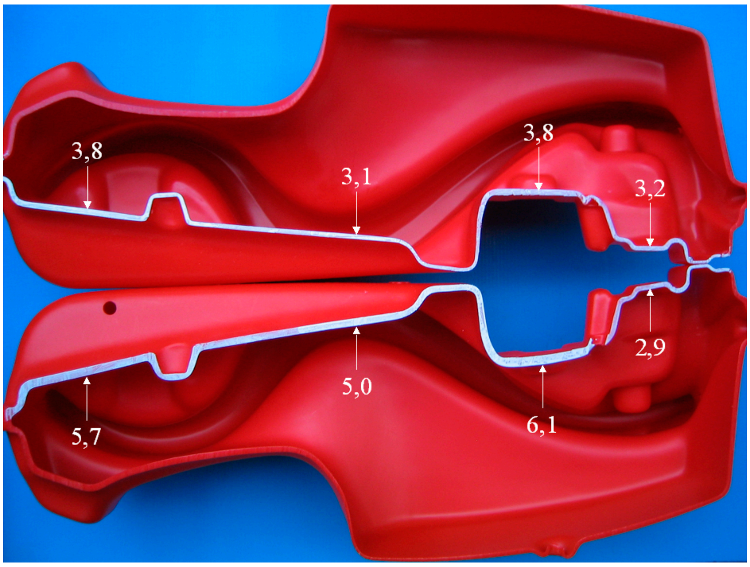

Fig. 6 Comparison of wall thickness distribution (in mm) in the bottom region of the blow moulded Bobby Car produced using a Flex Ring head (above) and a conventional head (below)

Industrial bulk containers are the last example for the use of dynamically controlled wall thickness for the parison (Fig. 7). Again an existing conventional head was equipped with a especially designed Flex Ring construction (Fig. 8) where the Flex Ring sleeve shown in Fig. 1 is incorporated. Fig. 9 shows the complete head during a purging operation just in front of production. In this case conventional hydraulic pistons are used to dynamically deform the Flex Ring sleeve as rather large adjusting jaw are used to deform the sleeve. Compared to the former production method using a static profiled flow channel a weight reduction of 10 % could be achieved while the IBC still fulfills all necessary requirements of the application.

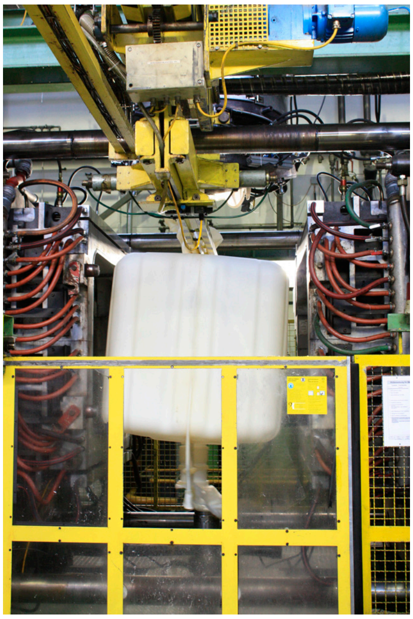

Fig. 7 IBC taken out of the machine at the end of the production cycle

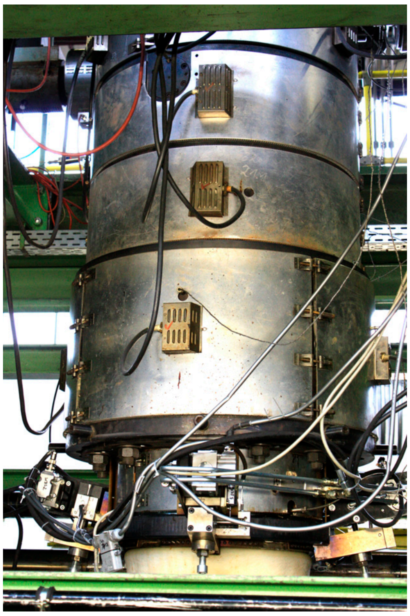

Fig. 9 Complete head with integrated dynamic radial wall thickness control

Fig. 8 Flex Ring assembly retrofitted into the head shown in Fig.7, having four adjusting pistons which act on special adjusting jaws

Outlook

The restriction of the use of a dynamic radial wall thickness programming to bigger head diameters does no longer exist. So now the advantageous use of a parison having also a tailored thickness distribution also over its circumference will become more and more common also for the production of small blow moulded parts. Improved thickness distribution can now be achieved for small bottles used in packaging. For example it will be possible to manufacture small oval bottles having a decisively improved wall thickness distribution while during production of such small bottles in the same time material is saved. Concerning blown articles which are produced by using bigger diameters the use of the costly PWDS system will more and more be substituted. Flex Ring heads are not only less expensive but they also offer much better processing possibilities to the user. Furthermore the construction of Flex Ring heads is less complex so that cleaning and maintenance of Flex Ring heads are much easier.

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