FLEX RING PIPE DIES OPEN UP NEW PROCESSING POSSIBILITIES

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Conventional pipe dies consist of a solid mandrel and a solid outer ring. With such dies the thickness distribution in pipes can only be influenced by centring the die. Two thick regions situated opposite each other can not be fought. This is possible when you retrofit a multi-walled flex ring sleeve into the outer ring of a pipe die. Similar to the well proved flex lip technique in flat film production the flex ring technology allows for a locally limited adjustment of the flow channel gap. Even the thickness distribution of single layers in coextruded pipes can be fine tuned in regard of their thickness distribution. The new technology which overcomes by far existing limitations to the pipe production process will be explained and results obtained with the new generation of pipe dies will be presented.

Introduction

Greater thickness tolerances in a pipe waste material during the production and reduce the economics of the production process. This is the more of importance as the material contributes at least by more than 50 percent to the total production cost of a pipe. So it should be a steady task in pipe production to work on improving the thickness equality of the pipes. This will not only result in a better pipe quality but in the same time save production cost. But the existing conventional pipe die constructions are not at all suited to achieve very narrow thickness tolerances in the pipes. Pipe dies consist world wide of a solid mandrel and a solid outer ring. So when the line operator starts the line the only thing he can do is to centre these two parts relatively to each other. But even when the line operator has managed this in the ideal way the pipe which will be produced will nevertheless have more or less thickness variations over the circumference.

This is due to the fact that for instance in the course of melting the material in the barrel of the extruder and conveying it to the die many slight insufficiencies superpose each other. The most crucial thing is that the temperature of the melt which enters into the die always differs slightly over the inlet area. These temperature variations result in differences in melt viscosity of the processed material. So having the same flow channel geometry in the pipe die but different melt viscosity at different stream lines this must result also in different local melt streams emerging out of the die. With conventional pipe constructions the line operator has no means to fight non symmetric thickness variations.

To reduce thickness tolerances over the circumference of the pipe the die construction must give rise to a change of the flow geometry in a local limited region while the line is running. This affords a flow channel wall in the die which can be deformed locally limited in a pure elastic way. Cast film processors take advantage of so-called flex lip slit dies where exactly this requirement has been solved by using a flexible lip at the exit of the die. As consequence the tolerances in today’s cast films are much smaller compared to those existing in pipes. So it is obvious to think about constructing also pipe dies with a comparable flexible lip at the exit. As the round geometry is much stiffer than a flat one this is not that easy to manage.

Technical solution

For a mechanical engineer it is clear that you have to design the wall very thin to get it flexible. The problem is only that a thin wall will never withstand the internal pressure of the melt. The solution to this problem is placing as many thin walls on top of each other, comparable to a leaf spring steel construction, as long as a wall thickness is reached which is suited to withstand also the internal pressure of the melt.

In order to reach that goal a totally new process was developed to fabricate metal parts in a form that they are in specific regions partially multi-walled [1, 2]. Such parts can be produced even when they have a complex three dimensional shape, for instance having a wall thickness of only 0.05 mm. Now in the multi-walled region the parts can be deformed in purely linear elastic way. Due to the high flexibility of the multi-walled structure changes of the wall position can be achieved which are restricted to a very small area.

The die designer has the freedom to custom design flex ring sleeves exactly to the need of the special application. He can as well vary the number of the single walls as also their individual thickness in order to take into account the pressure which will exist during the special production. Fig. 1 shows a cross sectional drawing of the parallel exit zone of a flex ring pipe die (right side). The flex ring sleeve is multi-walled at the end and can be deformed by adjusting screws which are positioned around the circumference. On the left side a photo of a conventional outer ring is shown which has been retrofitted with a flex ring sleeve.

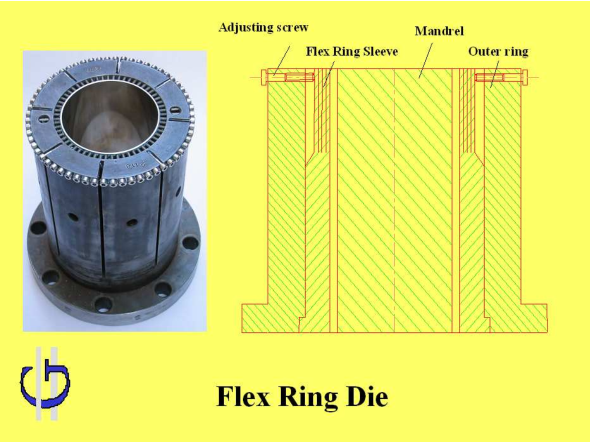

Fig. 1 Cross sectional drawing of a flex ring die (right side) and photo of an outer ring with an integrated flex ring sleeve (left side)

Practical applications and test results

Various pipe dies have been retrofitted with flex ring sleeves for developmental and for production purposes. Fig. 2 shows the thickness distribution which was achieved for a PE pipe having a diameter of 110 mm and a wall thickness of 9 mm. The red distribution was reached after the die has centred in the conventional way. By optimising the gap situation at the exit of the die with the help of the adjusting screws the blue distribution was reached. The absolute tolerance of 0.09 mm is far beyond what can be reached with conventional pipe dies.

The new possibilities which are provided for the pipe producer are well demonstrated by the result that was achieved during the start up of a production line (Fig. 3). Due to some hang up in the die a very thin wall thickness resulted at the location of screw number 12 (red curve). By changing the flow channel geometry with the help of the flex ring sleeve the green distribution could reached without stopping the line and without cleaning the die.

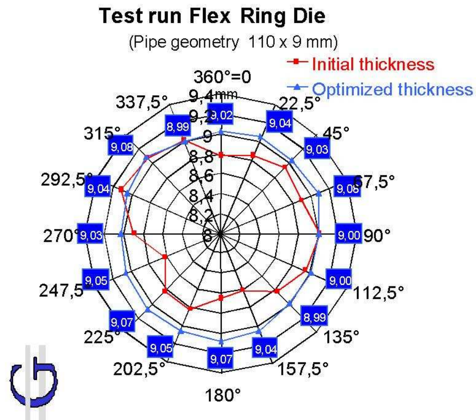

Fig. 2 Test results achieved with a pipe die which was retrofitted with a flex ring sleeve.

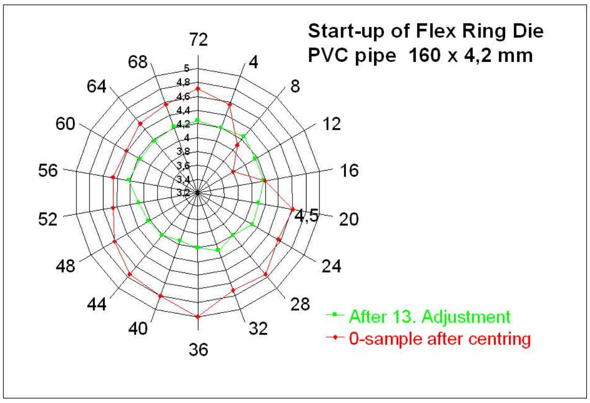

Fig. 3 Correction of a severe initial non-symmetrical thickness distribution due to some hang-up in the die by using a flex ring die

At the moment a research project is running. The goal is to establish a close loop control for the wall thickness of a pipe. It is intended to further reduce the thickness tolerances of pipes and in the same time to ensure an online quality control.

The application of the flex ring technology is not restricted to the flow channel gap at the mouth of the die. Flex ring sleeves can also be integrated into the interior of a die. So in dies designed for coextrusion even the separate flow channel geometry for the coextrusion material can also be adjusted while the line is running. The optimum place to adjust the flow channel geometry is exactly the point where the coextrusion channel joins the main channel. Fig. 4 shows a cross sectional drawing of a feedblock which was designed to cover a main material with a separate outer layer.

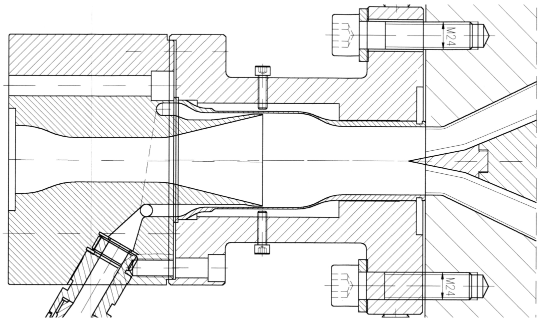

Fig. 4 Flex ring feed block consisting of 15 thin separate walls at the joining area where the radial flow channel gap can be fine tuned with the help of the adjusting screws which are positioned around the circumference of the feed block.

Exactly at the point where the coextrusion channel meets the main channel the wall is multi-walled and thus flexible. So the flow channel gap can be fine tuned over the circumference while the line is running in order to get rid of differences in the thickness of the individual covering layer. While doing this no dead spot or sharp leap in the flow channel geometry is created. The flow channel always alters gradually. So this technique can also be applied for PVC pipes.

For research purposes a brand new Krauss Maffei one channel die was retrofitted with a special flex ring sleeve, which has two regions which can be adjusted separately. It is flexible at the joining point of the two melts in order to fine tune the thickness distribution of the cover layer. Additionally the parallel zone at the exit of the die is also multi walled and thus flexible to adjust the total thickness of the pipe. In Fig. 5 the die is in operation on the line. Characteristic for flex ring dies are rows of adjusting screws positioned over the circumference of the outer die body. The row positioned on the bigger diameter is to adjust the thickness of the outer layer. The total thickness distribution is finally optimised with the screws positioned at the end of the die.

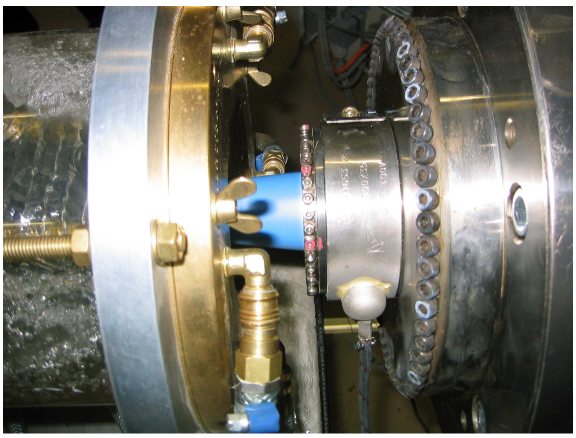

Fig. 5 One channel pipe die which was turned into a two channel die by simply exchanging the outer ring and integrating a flex ring sleeve which has two deformable wall sections.

Based on good results with developmental dies a completely novel three-channel die was conceived for manufacturing PVC foam-core pipes. The die consists of three separate flexibly deformable flow-channel regions. Besides the overall thickness, this also allows the outer and inner layer thickness to be optimised separately (Fig. 6). To regulate the inner layer, the multi-wall flexible flow-channel region was integrated directly into the housing. This reduces the risk of leaks and also increases the ease of maintenance of the die by reducing the number of individual components.

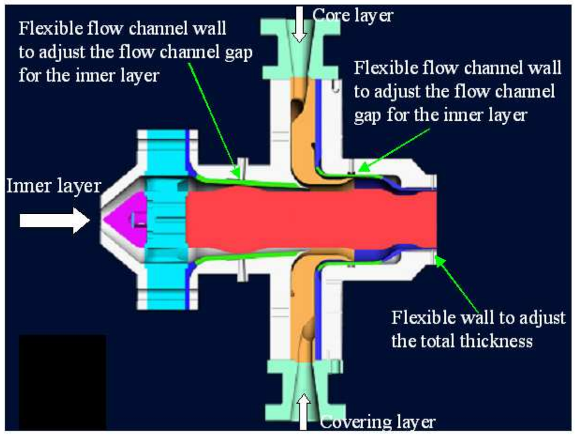

Fig. 6 Cross section of the three layer PVC foam-core pipe die having three independent multi-walled flexible flow channel regions in order to fine tune the thickness distribution of separate layers

The solid covering layers are fed into the die via one single extruder using a branch in the flow channel in front of the die. The geometry of these flow channels have to be exactly dimensioned so that the inner and outer layer can also produced precisely with the required wall thickness. To solve this problem a dead point-free throttle was integrated into one of the two flow channels. This allows the flow resistance to be varied relative to the second flow channel. Fig. 7 shows the throttle, whose wall in the entire central flat region consists of 20 thin, mutually supporting individual walls. The free flow cross-section can be varied by means of a special adjusting device. Fig. 8

Fig. 7 Central flow channel piece of the throttle which has thick-walled solid flanges at both ends and is 20-walled in the whole middle region to give rise to a deformation

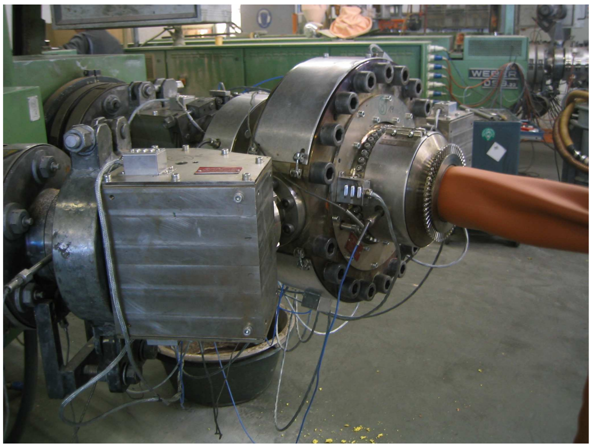

Fig. 8 Three channel die to produce core foamed PVC sewage pipes during the first test

shows a photo of the complete die mounted to the line for the first test run.

Conclusion

A totally new technology to produce complex metal parts which are partial multi-walled at specific areas was developed. By integrating flex ring sleeves into pipe dies the flow channel geometry can be fine tuned to further reduce the thickness tolerances in plastics pipes. This is achieved due to the linear elastic deformation which is realized by the multi-walled flow channel walls. For the first time a pipe die technology is available which enables to establish a close loop control for the total wall thickness of the pipe. It is even possible to establish a close loop control for individual layers of coextruded pipes. But prerequisite for this is that it is possible to measure the individual layer thickness of the single layer online.

References

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