TILTING DIE, THE CONVINCING NEW SOLUTION TO CENTRE AN ANNULAR DIE

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Abstract

A totally new solution was developed to centre the die in regard to the mandrel of an annular die. The tilting technology overcomes most of the drawbacks of the existing conventional centering solutions. The new tilting technology can be easily retrofitted to existing heads for pipes , for blown films and for the extrusion blow molding process. Tilting dies enable to further reduce remaining eccentric thickness differences in the extruded products. So they help to improve the quality of the products while in the same time the cost of the production is reduced.

Introduction

The simplest dies that are used in Extrusion are annular heads which are used to produce tubes, pipes, blown films and extrusion blow moulded products. Since such heads are in use the general construction has not been modified very much. They consist at their end of a round mandrel and a round die. In the past especially the design of the runner systems have been analysed and intensively optimised. The main goal is always to distribute the melt from the entrance into the head to the exit in such a manor that exactly the same local melt stream emerges out of the head at every location over the circumference of the die. The spiders or the mandrels have been optimised by the time or have been in the meantime exchanged for specific applications by spiral melt distributors.

Since the early days nearly nothing has changed in regard of the method to mount the die to the head and to centre it before the process is started. So it is not surprising that the technical solution seems to be a little bit old fashioned which is still used world wide. Centring screws positioned around the circumference of the head as long as the operator has free access to it. Heads for extrusion blow moulding often use special shifting systems especially when the access to the complete head is not possible. Also these systems have to be manually operated while using adjusting screws. This is not at all a convincing solution to meet the given technical requirements.

List of requirements for the centring operation

The requirements for an ideal solution are easy to formulate. The head has to be designed in a way that the die or the outer ring can only be mounted to the head in a centred position. In this case the head can immediately be heated up and the production can start without any delay after the die has reached the operating temperature. Skilled operating people might reply that it is necessary to move the die slightly out of the centre in order to achieve the best possible thickness distribution. This is the case as mostly the thickness distribution around the circumference is not good when the die is positioned exactly in the centre of the head. Consequently it is nevertheless necessary to adjust the position manually. This is in deed the case. But at least additional machine capacity would have been generated as a special centring operation will be necessary no longer.

In deed to meet the requirements of the practical operation it has to be added that in spite of the compulsory centred mounting it must still be possible to sensitively correct the flow channel gap at the exit of the head in order to achieve the optimum result. This is due to the fact that each machine has some tiny deficiencies which disturb the homogeneous local velocity over the circumference of the head. As the necessary changes are rather small in practical operation the adjusting solution should take this into account. Especially with heads for the production of blown films which possess rather small flow channel gaps at the exit it would be of advantage if the gap could be changed in the range of 0.00004 inches. Additionally it would be ideal if it would be possible to be able to reproduce any gap distribution which has been reached at an early time. Naturally it is also an important requirement that the solution should be realisable with small cost.

Actual solution

While rating the actual solution it must be realised that in the moment the above stated requirements are not at all fulfilled. The use of centring screws or shifting systems within a head does not allow for a close fit between the head and the die. As a consequence the die has either to be centred before the machine is put into operation or this has to be done while the line is running. In the first case this creates machine downtime. Additional scrap is processed in the second case. In both cases naturally qualified operators are necessary.

The technical tools which are actually available for the operators are not at all convincing as well. To seal the shifting area of the head high normal forces are necessary.

That is why the clamping screws are dimensioned rather big. But threads of big screws have by nature great pitches. This is an obstacle for the postulated sensitive adjustment. As it is necessary to first create some tension to break the die free this problem is still enforced. This is the reason why the exact path the die has moved keeps always unknown. This is the reason why with the actual solution it is impossible to reproduce the situation which has existed before the adjustment. Due to that situation operators always stop their efforts to improve the situation before the possible optimum has been reached. Especially for thermal sensitive polymers it is also a problem that in the moment the die is shifted out of the centre dead zones are created in the flow channel.

New solution to optimise the flow channel gap situation of an annular die

Naturally attempts have been made to find a better technical solution. A construction can be found in the patent literature [2,3] where the die is not shifted but where a tilt joint is used. But the tilt joint construction proposed there affords a very precise manufacturing. Therefore it is rather expensive. That is the reason why it is hardly found in the market. The new solution also uses a tilt joint. What has changed is the form and the design of tilt joint. Instead of the mechanical joint which is costly to manufacture an extreme cheap elastic tilt joint is used [4].
Figure 1 shows a tilting joint that has been retrofitted into a conventional pipe head. In principle it is a specially designed elastomeric sealing which seals the dividing plane between the head and the die and which in the same time gives rise to the tilting movement, due to its remaining elasticity.

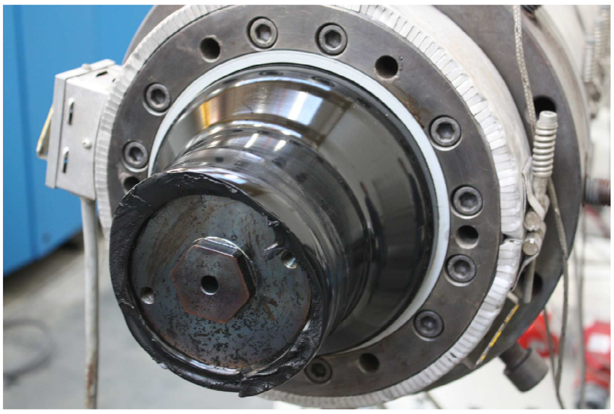

Figure 1. Tilting joint that has been retrofitted into the parting plane between the head and the die

Two stepper drives in linear configuration are mounted to the head in a 90 degree arrangement. The drives can realise adjustments as small as 0.00004 inches with an extreme precision due to the small steps and the additional transmission ration of the worm gear. Now it is possible to reproduce any situation or position which has been existed before an adjustment has been done.

A close fit can be used while using a tilt solution as the die has no longer to be shifted relatively to the head. The big advantage is that the die is by itself centred immediately after it is mounted to the head. A further advantage is that every existing annular head can be easily retrofitted with a tilt joint. Even an automatic adjustment is possible [5]. To achieve this simply two stepper drives have to be attached to the head. Fig. 2 shows a retrofitting kit for a blow moulding head during tilting test in the lab.

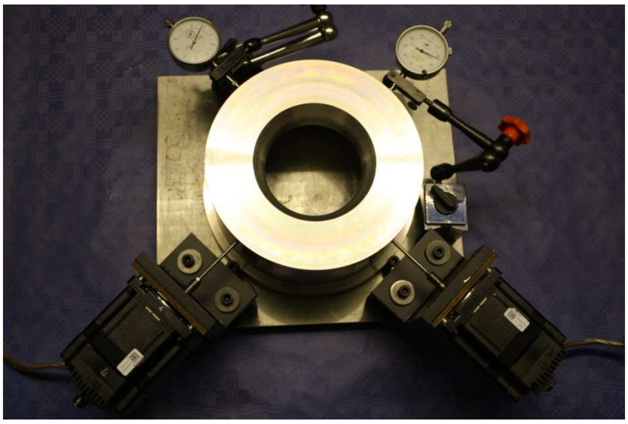

Figure 2. Tilting die retrofitting kit (entrance diameter 7,8 inch) equipped with two stepper drives mounted on a flat ground plate in order to test the achievable tilting angle.

Advantages of the use of a tilting die for different processes

During pipe extrusion it is no longer necessary to pre-centre the die after it has been dismantled for cleaning and attached to the line again. The optimisation of the thickness distribution around the circumference of the pipe can be done much more accurate. Elongated tools to adjust the big conventional adjusting screws will be superfluous. The danger of injuries which exists with those manual adjustments is also eliminated. The future in pipe extrusion will be a closed loop control to reduce as well eccentric as also asymmetric thickness tolerances in the pipes [6].

Using an elastic tilt joint no great forces are necessary. That is why normally four clamping screws are sufficient to fix the die to the head. They mainly have to carry the weight of the die apart from those dies where the flow channel diameter reduces from the entrance to the exit of the die. In this case naturally the forces generated by the pressure in the die have to be taken into account additionally. Fewer clamping screws promote a quicker assembling and disassembling of the die. In consequence not only cost for the line and the operators but also resin cost can be saved. This is due to the fact that a better adjustment of the die immediately leads to a reduction of the thickness tolerances. So additionally in the same time also the quality of the extruded products is improved.

The advantages described for the extrusion of pipes are more or less valid for the production of blown films. Additionally the last hindrance is eliminated which prevents an automatic start-up of blown film lines after the bubble has been built up. In the future the blown film head can be operated with a close-loop control which reduces not only the thickness differences over the circumference of the bubble but also the eccentric thickness distribution within the bubble. As a result the quality of the produced films are totally independent from the special skill of the line operator who is available.

During pipe and blown film extrusion the head can be centred while the line is running. The same can be done while producing small hollow parts using the extrusion blow moulding process. This is unfortunately no longer possible when the parts and consequently the machines become bigger. In this case the process has to be stopped. The guard door has to be opened and the operator has to climb into the line between the opened tool to be able to adjust the die at all. The chief of production will not only profit from an improved security at his machine but also from an increased line capacity. This is due to the fact that the process has no longer to be stopped and afterwards a certain time is necessary until the machine has reached the steady state production situation again. During this time the machine produces scrap and precious production time gets lost. While using a head with a tilt joint which is actuated by stepper drives (see Figure 3) this problem is eliminated totally.

Figure 3. Head mounted to a blow moulding machine equipped with a tilting joint which is actuated by stepper drives.

The biggest progress is achieved when using a tilt die for the production of blow moulded tubes which possess a bent. The tilt die first solves the wear problem which exist in the shifting area when using conventional x-y dies. Second the tilt die is much cheaper in production compared to the actual solution. This is due to the fact that no high forces have to be overcome in the shifting area because small forces are necessary to tilt the die. Those forces can be realised with stepper drives which work with high precision, which are totally maintenance free and which never the less are rather cost efficient. Expensive servo valves and heavy hydraulic pistons with their hydraulic hoses become superfluous. No hydraulic unit is necessary in the case that electrically operated blow moulding machines are used, which are coming up more and more.

Future prospects

Probably every existing annular head can be retrofitted with an elastic tilt joint. The relevant cost vary naturally according to the size and the construction of the special head. For head diameters equal or smaller than 12 inches less than a five figured dollar amount will not be sufficient. The economic advantage will naturally vary with the special application. The biggest profit can be achieved without doubt when a tilt head is used to produce tubes which have a bent. Such tubes are used widely in the automotive industry. In this case the tilt joint can be used to centre the die statically and then to tilt the die dynamically to profile the parison according to the needs of the tube which has to be produced. In regard of economics it is also of importance that it can be expected that tilt dies will need few maintenance and will not show wear problems. It depends from several individual internal factors of the relevant producer after what time the return on investment is reached. In the end a precise calculation of the economic value is consequently only possible when an existing conventional die is retrofitted with a tilt joint and when the achieved savings are determined in detail and then compared to the former situation.

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