降低挤塑成本的革命性模具新概念

在挤出的实际过程中通常都会存在许多细微的缺陷。这些缺陷对熔体流在模头中的分布造成了无从预测和计算的影响。在工艺过程中，它们以错综复杂的方式相互影响。结果便是造成产品的厚度波动。尽管大家不希望看到这种波动，但是使用常规设备进行生产却无法避免它。因此，为了进一步改进挤塑产品的质量，人们提出了一种能够灵敏的对这种厚度波动作出反应的解决方案。这种方案可以实现常规模头无法实现的挤出产品厚度稳定性。因此不但降低了生产成本，而且同时也提高了产品的质量。

During practical extrusion there are usually a lot of small imperfections which influence the melt stream distribution in the die in a way which cannot be forecast or calculated. In the process they superpose each other in a complex way. As a consequence the resulting products have always slight variations, regarding their thickness which is not desirable but which is inevitable if using conventional equipment. Therefore to further improve the quality of extruded products a solution has been developed which enables a sensitive reaction to these changes. This leads to a degree of thickness constancy in extruded parts which is impossible with conventional dies. So not only the production cost is reduced but also the quality of the products are improved in the same time.

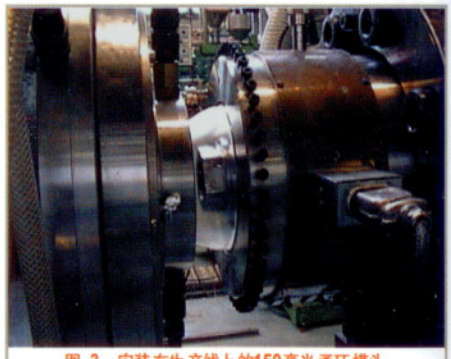


图 3：安装在生产线上的150毫米柔环模头，它的末端圆周上有52个调节螺丝

Figure 3: 150 mm Flex Ring pipe die mounted on the line, having at its end 52 adjusting screws around the circumference

技术方案

现已开发出能够在生产过程中对流道的几何形状进行精确调整的模头。为此，在流道的关键位置整合了具有高度柔性、从而可以线弹性变形的膜片。流道壁由许多单独的膜片组成，这些膜片非常薄，因此具有高度柔性。它们通过相互重叠累加达到足以承受流道内熔体压力厚度。膜片相互之间完全没有缝隙。它们围绕整个圆周接合在一起，变成一个厚壁（图1）。膜片壁的形状可以进行三维变化。

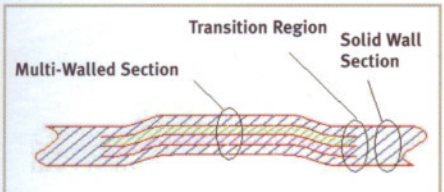


图 1：多膜片壁流道及其无缝过渡区的剖面图

Fig. 1: Cross section of a multi-walled flow channel section with seamless transition regions

由于这种特殊结构，各个膜片之间在力学方面相互支持，单个膜片的厚度最少只有0.2毫米。流道几何形状的改变是逐渐进行的，因此膜片壁的变形不会产生死角。

集成多膜片壁流道段的模头在生产中应用的例子

柔环模头已经在管材生产线中得到应用。图2是一个柔环模头的剖面图，而图 3 是一个柔环模头在生产应用中的例子。通过对柔环套管进行局部的形状改变，生产线操作者能够进一步减少在模头已经被理想地校准以后仍然存在的厚度波动。柔环套管可以用于对任何现有的管式模头进行更新改进。即使太厚的区域位于管材互相对面的位置，也可以通过分别减少相应部位的流道间隙简单地得到解决。一个生产聚酰胺细管的厂商报道说，他的生产线起动时间减少了40%，而30毫米直径管材的厚度波动减少了50%。图4是一个用柔环模头生产吹膜的例子。

在吹塑工艺中，如果要在挤出时改变吹塑型坯圆周的厚度分布，就需要一个大的调整范围。在这种情况下，吹塑型坯横切面的每一点必须按要求的厚度以及该点的拉伸比进行匹配。图5显示了柔环套管在一个小型的测试模口上可以达到的巨大变形程度。

图6显示了一个将柔环套管集成到共挤配料块的解决方案，用来生产一种具有聚氟乙烯发泡芯和密实外层的共挤管材。图7显示了一张柔环套管的照片。采用这种结构可以在生产线运行的同时随时对共挤流道的流道间隙进行佳化调节。

最后，可以通过将多膜片壁流道段集成到共挤配料块中来更进一步减少共挤片材和共挤薄膜的层厚度。图8显示一个三层膜片式配料块，它两个分流区域中的一个被打开，用来共挤生产两面各有一层薄紫外线保护层的PC片材。采用这种解决方案可以在生产线运行的同时随时随地对昂贵的紫外线保护层的分配进行准确的调节。

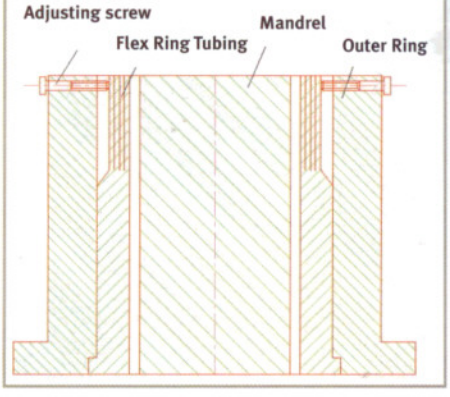
几乎所以的共挤出工艺都可以利用可调节的多膜片壁流道段。采用这样的膜片壁就能够在生产线运行的同时对流道的形状进行精细的调整。在生产过程期间中，如果某些因素发生了轻微的变化，这种调节的可能性就很有价值。例如，一个层的厚度减少了，就会改变共挤出材料的通过率。如果树脂变化了，就会使材料的特性发生偏离。通过将可调节的多膜片壁流道段整合到模头中，生产操作者第一次能够更进一步地减少最终产品的层厚度偏差。而且也不必停止生产线来拆除模头、再加工修改流道的几何形状。流道一旦被再加工修改，就不能再改回来。

未来的发展

从长远的观点来看，为了建立一个厚度控制挤出工艺，流道的调节最好能够自动地完成。

图 2：一个柔环模头的剖面图，只要简单地调节外圈并插入柔环套管就可以更新改进几乎所有的环形模口

Figure 2:
Cross section of a Flex Ring Die which can be retrofitted into nearly any existing annular die by simply modifying the outer ring and inserting the Flex Ring Tubing



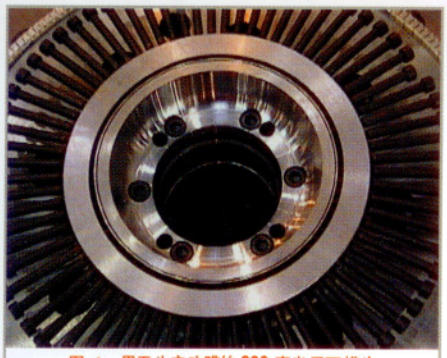


图 4：用于生产吹膜的 200 毫米柔环模头

Figure 4: 200 mm Flex Ring Die for the production of blown film

对某些工艺来说，这是全新的尝试。因此，还必须制定出必要的控制策略来建立一个闭环控制。为此，德国亚琛塑料加工研究所 (IKV-Aachen) [1]已经开始了薄膜以及片材挤出方面的初步工作。对控制系统的需要将会不断增加，因此越来越多的多膜片壁流道将会在生产中得到应用。这种新技术之所以具有巨大的经济价值，是因为它不但降低了生产成本，而且在此同时改进了最终产品的质量。

参考资料

[1] W. Michaeli, R. Peters, T. Schmitz, Mittel zur Prozessbeherrschung, Regelung der Wulstgröße kann Folienqualität verbessern, Kunststoffe 11/2002, pp. 88-90

Technical solution

Dies have been developed which make a sensitive adjustment of the flow channel geometry possible while the line is running. To achieve this wall sections which are extremely flexible and which thus allow for linear elastic deformation have been integrated at critical locations of the flow channel. The wall of these flow channels consist of many single walls which are extremely thin and therefor extremely flexible. These thin walls are piled up on top of each other until a total thickness is reached which can sufficiently withstand the internal melt pressure. There is absolutely no gap in-between these single thin walls. They join around their entire circumference into a thick solid wall (**Fig. 1**). The walls can be shaped three dimensionally. Due to this special construction these single walls which can go down to a thickness of only 0.2 mm support each other with regard to the mechanics. The geometry of the flow channel alters gradually and thus no dead spots are created by the deformation of the wall.

Examples of the integration of multi-walled flow channel sections into practical dies

Production lines for pipes have been equipped with Flex Ring Dies. **Fig. 2** shows a cross sectional drawing of a Flex Ring Die, and **Fig. 3** is an example of a Flex Ring Die in production. By means of a locally limited deformation of the Flex Ring Tubing, the line operator is in the position to further reduce thickness tolerances which remain in the pipe after the die has been centered in an ideal way. Flex Ring Tubings can be retrofitted into any existing pipe die. Even thicker regions of a produced pipe which are positioned opposite of each other can simply be eliminated by reducing the flow channel gap exactly at these locations independently. A producer of small pipes made of Polyaminde reported that he has reduced the start-up time of his line by 40 % and the thickness tolerances in his 30 mm diameter pipe by 50 %. **Fig. 4** shows as another example a Flex Ring Die to produce blown film.

A great adjusting range is required in the blow molding process when you intend to change the thickness distribution around the circumference of the parison while it is extracted. In this application the task is to match the thickness at every point across the area of the parison with the wanted thickness and the draw ratio which exists at that special location. **Fig. 5** shows how enormously the Flex Ring Tubing can be deformed at the orifice of a small test die.

Fig. 6 shows a solution for integrating a Flex Ring Tubing into a feed block to coextrude a pipe with a foamed PVC core and a compact solid outer skin. A photo of the Flex Ring Tubing is shown in **Fig 7**. With this construction the flow channel gap of the coextrusion flow channel can be optimized at every wanted time while the line continues to run.

Finally partial multi-walled flow channel sections can be integrated into feed blocks for the coextrusion of sheets and films with further reduced layer thickness. **Fig. 8** shows a three layer Membrane Feed Block opened at its one parting area which is used to coextrude a thin UV-protecting layer on both sides of a PC sheet. With that solution the distribution of the expensive UV-protecting layer can sensitively adjusted during the production at any wanted time or occasion.

Nearly every coextrusion process can profit from flow channel sections consisting of an adjustable multi-walled area. Such membranes make a fine tuning of the flow channel design possible while the line is running. This is always of interest when something has slightly changed during the process. For example, when the thickness of a layer is reduced, a change of the throughput rate for the coextruded material happens as a result. When the resin is changed it leads to deviated material behavior. For the first time the incorporation of a multi-walled adjustable flow channel section within a die brings the operator into the position to further reduce layer thickness tolerances in the final product. He can do this without being forced to stop the line, to dismantle the die and to rework the flow channel geometry. Once the flow channel is reworked in this way the process cannot be reversed.

图 5：43 毫米柔环套管在一个测试吹塑模口上的巨大变形

Figure 5: Enormous deformation of a 43 mm Flex Ring integrated into a test die for extrusion blow molding

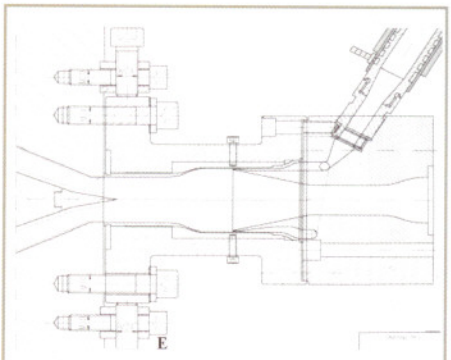


图 6：一个将柔环套管集成到共挤配料块的解决方案，用来生产一种具有聚氯乙烯发泡芯和密实外层的共挤管材。

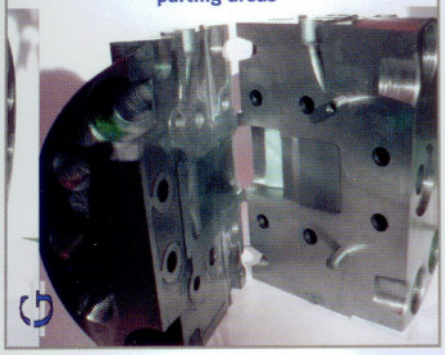
Figure 6: Drawing of a Flex Ring Feed Block for a pipe to cover a foamed PVC core with a solid outer layer

Future aspects

In the long run it is desirable to adjust the flow channel situation automatically, in order to establish a thickness-controlled extrusion process. For some processes this is totally new so that the necessary control strategies will still have to be developed in order to establish a close loop control. For this purpose preliminary work has already been started on the part of the Institute of Plastics Processing (IKV-Aachen) [1] in the field of film and sheet extrusion. The demand for control systems will certainly increase so that multi-walled flow sections will further be integrated into production lines. The great economic value of the new technology is based on the fact that it not only reduces production costs but that in the same time the quality of the final product is improved.

图 7：三层膜片式配料块（A-B-A 结构），它两个分流区域中的一个被打开。

Figure 8: Three layer Membrane Feed Block (A-B-A-structure) opened in one of its two parting areas



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[1] W. Michaeli, R. Peters, T. Schmitz, Mittel zur Prozessbeherrschung, Regelung der Wulstgröße kann Folienqualität verbessern, Kunststoffe 11/2002, pp. 88-90

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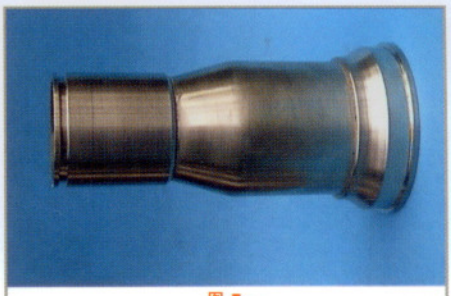

图 7：
配置图 4 配料块的柔环套管，两端接头是固定的，中间为多膜片壁流道段。

Figure 7:
Flex Ring Tubing integrated into feed block of fig. 4 being solid at its both ends and multi-walled in its middle region

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- Line relocations
- Trade and mediation of used machines

■ **Brückner Formtec GmbH**

The company is one of the world's most renowned manufacturers of Film and Sheet Lines for the processing of raw materials, such as A-PET, PETG, PC and PP. The company has successfully installed several lines in P.R. China in recent years .

The product programe has meanwhile expanded by compact extrusion and sheet extrusion lines with new applications for the automotive industry and for the manufacture of technical appliances, such as refridgerators. In particular in the PET film and sheet field, extrusion applying twin screw systems has proven to be most suitable for special applications.

In the course of a technical seminar to be held during the Chinaplas, Brückner Formtec will give a presentation on this revolutionary technology.

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