The Application of Sequence Runner System in Avoiding Large-scale Plastic Part Weld Mask

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Abstract. The forming mechanism and solution of weld mask in large-scale plastic part are described. Taking the car front-bumper for example, The CAE comparative experimentation of the several runner system were processed and a series of the data such as weld mask, temperature and pressure were gained. Through the experimentation it was discovered that the sequence runner system can avoid weld mask availability which provide the function of use reference for avoiding weld mask in large-scale plastic part.

Introduction

The cooling layer will be formed between mould surface and plastic melt flow forward when plastic melt flow into mould cavity at a higher speed. The temperature of melt flow forward will decrease and cannot merge fine when more than two plastic melts converge in mould. The weld-line will be formed at the joint of the melt on the surface of plastic part[1].

The weld-line will not only influence the appearance quality of plastic part but also the strength and mechanical property of part[2-5]. According to the relevant data show that the weld-line of part can cause 10%-30% losses of the ABS part’s mechanical property and approximately 30% losses of the PMMA, PS part’s mechanical property. With regard to large-scale automobile plastic part such as bumper, panel, the weld-line have outstanding influence on the appearance quality and strength of the plastic part. Owing to the limit of tradition injection technology, the weld-line cannot be eliminated effectively and limit the plastic large-scale application in automobile industry.

The Elimination Method of Weld-line

The Common Elimination Method of Weld-Line

The influencing factors of weld-line are mould structure and so on. On the part of product structure designing, it is adopted that plastic part wall thickness be kepted uniform and increased in thickness to increase the part strenght. But these method can limit the scope of part design.

On the part of mould structure, melt branch of the large-scale plastic part isn’t avoided. Mould designer not only have to conside the melt can full flow the mould cavity but also eliminate the un-favourable impact of weld-line. In order to increasing the welding quality, it can be adoped, for example, that quantiy of gates be increased and position of gate be designed and so on.

The above method can impove the strength of plastic melt to a certain extend. However these method cannot eliminate weld-line entirely.

The Influence of Tthe Feed System

Now the hot runner technology is put to use on the large-scale automobile mould. Valve hot runner technology is one of the hot runner technology. There is a set of valve transmit mechanism which can control the open and close movement of the valve in the hot runner. The valve hot runner technology can control the time of the gate’s switch by means of controlling the switch-over of the valve-needle. Therefore plastic melt can flow into the cavity according to time sequence and the weld-line can be eliminated.
The Injection System’s Simulation Analysis of the Automobile Bumper Part

The research use HYPERMESH software to repair the part model and mesh the model. The mesh is imported MOLDFLOW in order to simulate plastic flow in the mould.

Selection of the Plastic Material and Injection Machine

The performances requirements of automobile bumper are bettle anticollision, excellent tensile strength and shock strength. PP/EPDM has excellent toughness and strength, so it is the special material of the automobile bumper.

The research use PP/EPDM of Fina Oil & Chemical corporation whose trade name is Finalloy EJ825. Performance of Finalloy EJ825 is shown in Table 1.

According the requirement of mold and injection machine, the research choose HTF1600X2 injection machine of Haitian Group whose performance is shown in Table 2.

Table 1. Properties of the Finalloy EJ825.

<table>
<thead>
<tr>
<th>Mold temperature /℃</th>
<th>Minimum melt temperature /℃</th>
<th>Melt temperature /℃</th>
<th>Maximum melt temperature /℃</th>
<th>Maximum shear rate /1/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>200</td>
<td>240</td>
<td>280</td>
<td>100000</td>
</tr>
</tbody>
</table>

Table 2. Properties of the injection machine.

<table>
<thead>
<tr>
<th>Machine type</th>
<th>Maximum clamp force /ton</th>
<th>Injection rate /g/s</th>
<th>Injection volume /g</th>
<th>Plasticizing capacity /g/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTF1600X2</td>
<td>1600</td>
<td>1100</td>
<td>7114</td>
<td>147.6</td>
</tr>
</tbody>
</table>

The Design of Injection System and the Influence on the Weld-Line

Automobile bumper’s dimension is 1580 mm×296 mm×790 mm (Length×width×height). The part’s thickness is 3.5mm which has no through-hole. The part’s drawing is shown in figure 1. Owing to the parts’ appearance, the part’s injection system adopt 3-flat gates for smooth flowing of pastic melt. The sprue diameter is 16mm. The runner diameter is 16mm. The research used the project of flat side gate whose dimension is 160 mm×8mm×0.8 mm. The gates are shown in Figure 1.

Figure 1. Automobile bumper product drawing.

The Design of Opening Injection System and the Influence on the Weld-line

As opening hot runner system is used in the mould, plastic melt flow into the mould cavity through 3-gate simultaneously. The technic indexes of injection are shown in Table 3.

Table 3. Process parameters of injection.

<table>
<thead>
<tr>
<th>technic indexe</th>
<th>Melt temperature /℃</th>
<th>Mold temperature /℃</th>
<th>Cooling time /s</th>
<th>V/P switch-over /%</th>
</tr>
</thead>
<tbody>
<tr>
<td>numerical value</td>
<td>240</td>
<td>40</td>
<td>15</td>
<td>97</td>
</tr>
</tbody>
</table>

Packing pressure cuve is shown in Figure 2.
The research first carry out fill analysis of the part and obtain following data: As shown in the Figure 3, the part melt’s fill time is 6.64s. For weld line results from confluence of three different plastic melts, three-branch melts flow into the mold through 3-gate. Owing to plastic melt’s flowing into mold through 3-gates simultaneously, weld-line’s emergence on the part can be predicted. And the part’s weld-line can be observed from the weld-line and fill time composition analysis’s data (as shown in the Figure 4). The weld-line will affect the bumper’s strength throughout all the time.

Figure 2. packing pressure curve drawing.

Figure 3. Injection time plot.

Figure 4. Weld-line and fill time composition plot.

Figure 5. Clamp force: XY plot.
In addition, owing to plastic melt’s flowing into mold through 3-gates simultaneously, injection Machine’s clamp force increase rapidly which reach the maximum pike (2400 tonne) at end of fill (as shown in the Figure 5).

In conclusion, the simultaneously injection technology not only can’t slove the large-scale plastic part’s weld-line problem but also lead to increasing of the injection machine’s clamp force. Although the problem can be relieved through the adjustment of Injection process, but the effect is not obvious. Therefore it is an urgent matter that new injection system is exploited.

**The Designing of Sequence Injection and the Influence on the Weld-line**

Sequence injection possess valve needle hot nozzle and valve motion sequence control system. So the sequence injection can control the time of gate’s closing and opening.

The process of Sequence injection is as follows: when 1st gate open, plastic melt began to fill mold cavity. When melt flow through 2nd gate, the gate open and plastic melt of the 2nd gate flow into mold cavity which push the melt forward. So different melt’s weld problem can be sloved and weld-line can be eliminated or be transfer to unimportant position of the part.

The sequence injection system of the automobile bumper is designed. The valve hot-runner nozzle is set up at 3-gates. The needle in the nozzle can open or close according to time sequence. Middle hot-runner neele will open at first. When plastic melt flow through left gate and right gate, the left gate and right gate open. Therefore the injection system can avoid the confluence of cold melts and eliminate weld-line efficiently. The valve gate’s controlling time are shown in Table 4.

<table>
<thead>
<tr>
<th>Gate</th>
<th>Gate 1</th>
<th>Valve gate 2</th>
<th>Valve gate 2’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open time /s</td>
<td>0~25</td>
<td>3.1~25</td>
<td>3.1~25</td>
</tr>
</tbody>
</table>

The valve gate’s controlling time are imported into Moldflow Mpi. The following results of analysis are obtained.

Injection time is 5.9s (as shown in the Figure 6). Plastic melt flow into mold according to time sequence of gate1-gate2-gate2’. When melt flow through gate 2 and gate 2’, the two side gate open simultaneously to push the middle plastic melts ahead.

The result of Figure 7 analysis are as follows: After sequence injection is put into effect, clamp force rise to 500 tonne at initial stage. Then clamp force nosedive. This time is the open time of gate2 and gate 2’. Soon clamp force pick up gradually owing to melt of gate 2 and gate 2’ flowing into mold. So maximum clamp force reach to 2000 tonne. Thus it can be made out that sequence injection can cut down clamp force of injection machine.
Sequence injection’s another obvious effect can be made out in fig 8. The weld-line can’t be found at the original position of weld-line. It can be verified that sequence injection can eliminate automobile bumper’s weld-line effectively and cut down clamp force of injection machine. The analysis data of sequence injection indicate that sequence injection is an effective method in improving strength of large-scale plastic parts and cutting down clamp force of injection machine effectively.

**Summary**

1. Through CAE technology of injection mold, the injection system of mold can be researched dynamically and the automobile bumper’s weld-line foaming can be comprehended.
2. There are lots of solution of changing weld-line. If structure of the plastic melt-front can be changed, weld-line of the part will be eliminated effectively.
3. Through comparative experimentation of two contrastive injection projects on the automobile bumper, it can be verified that sequence injection can change the plastic melt’s flow process in mold effectively. So one exploration direction of improving plastic part’s quality can be provided.

**References**