Design and Technology Research of Hot Trimming Die of High Strength Steel for Hot Forming Parts

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Abstract. Hot trimming technology of high-strength steel is to compound trimming process in hot stamping, so that the sheet can be trimmed or punched with high ductility and low hardness, which can improve product quality, shorten cycle time and reduce the production cost. In this research, we researched the influence of trimming temperature, clearance on trimming force, sheared surface quality. The results are as follows: trimming force decrease with the trimming temperature, clearance increase; the higher temperature, smaller clearance assures smoother sheared surface. Based on the above laws, optimal processing parameters are trimming temperature above 700 °C, clearance about 10% of the mould.

Introduction

The rapid development of automobile manufacturing industry, energy-saving emission reduction and reduce energy consumption has become an urgent requirement, light weight is bound to become the development trend of automobile manufacturing industry[1-3]. Hot stamping of high-performance of boron steel, which achieves the reduction of vehicle weight and fuel consumption, while meets the crash safety requirements at the same time[4-5]. This has become a hot technology in automobile manufacturing.

In the heating furnace, the heating billet is heated, then the forming force and resilience are reduced, and the forming performance is improved remarkably. The stamping part is quenched in the closed die, which can get super high strength parts, and its ultimate strength is up to 1.5GPa[6-7].

After hot stamping, hot stamping parts also need to be followed by trimming, such as cutting edge, blanking or punching. However, there are still difficulties for the most automotive manufacturers in cutting hot stamping technology, there are such problems as large cutting fore, sever wear and sometimes unexpected tool failure. And laser cutting technology is generally employed by manufacturer, in spite of its long cycle time, high production cost, and even poor product quality [8]. So research an effective pruning techniques for mass production of low production cost, low energy consumption of hot stamping is very necessary. Hot trimming technology of high-strength steel is made the sheet can be trimmed or punched with high ductility and low hardness, which can improve product quality, shorten cycle time and reduce the production cost.

In this paper, according to the requirements to select appropriate force and displacement sensor, with the standard pressure and displacement calibrated, the change of force and displacement for trimming and punching process were acquired. And according to the characteristics of high strength steel hot forming material, influence of trimming temperature, clearance on cutting force, sheared surface quality were researched by own experimental mold. Through a series of experiments, the process parameters were optimised.

Experimental

In this experiment, the chemical composition of a typical quenchable boron-alloyed steel LG1500, is given in Table 1. The NI 9237 card of half bridge measurement scheme and PM type micro
displacement sensor were used to acquire the change of force and displacement for trimming and punching process. The FLIR infrared thermography was used to shoot the temperature change of hot trimming and punching process. Schematic diagram of temperature field measuring device, as shown in Figure 1. Choose different temperature and the cutter gap (replacement of different thickness of the gasket, replacement of different diameter of die set) for trimming and piercing.

Table 1. Chemical component of hot stamping steel (wt, %).

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>B</th>
<th>Ti</th>
<th>Al</th>
</tr>
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<tbody>
<tr>
<td>0.23</td>
<td>0.17</td>
<td>0.95</td>
<td>0.010</td>
<td>0.002</td>
<td>0.24</td>
<td>0.21</td>
<td>0.0019</td>
<td>0.023</td>
<td>0.030</td>
</tr>
</tbody>
</table>

Figure 1. Schematic diagram of temperature field measuring device.

Results and Discussions

Effect of Temperature. Effect of temperature on maximum cutting force was shown in Figure 2. Effect of temperature on the quality of part section was shown in Figure 3.

Figure 2. The maximum punching force varies with temperature curve.
As shown in Figure 2, with the increase of temperature, flow resistance of materials lower, the required maximum cutting force is reduced, and the required equipment tonnage is smaller.

With the rising of temperature, material plastic is better, fillet larger produced of tensile and bending. The crack formation time is later, then fault zone is smaller. Plastic deformation is better, euphotic zone and burr are more with higher temperature. But due to thermal expansion and contraction, some small and thin burrs in sheet metal contraction are slashing, so the higher the temperature, the less the burr.

Effect of Die Clearance. Effect of die clearance on maximum cutting force was shown in Figure 4. Effect of die clearance on the quality of part section was shown in Figure 5.

With the increasing of clearance between punch and die, maximum cutting force decreases, but change is not obviously. Smaller clearance assures smoother sheared surface. Die clearance should be
smaller in order to get higher quality of cross section, but taking into account difficulties in the mold manufacturing with smaller clearance. Therefore, we should consider synthetically.

Conclusions
The main conclusions are as follows: Trimming force decrease with the trimming temperature, clearance increase. The higher temperature, smaller clearance assures smoother sheared surface. Among these parameters, the influence of die clearance is greater. Based on the above laws, optimal processing parameters with trimming temperature above 700 °C, clearance about 10% for cutting of the mould are determined for LG1500 high strength steel.

References