A STUDY ON THE ULTRA PRECISION PROGRESSIVE DIE MAKING FOR SHEET METAL FORMING BY COMPUTER SIMULATION

Sung-Bo Sim¹, Chung-Whan Kim², Gwi-Yun Park¹
¹School of Mechanical Engineering Pukyong National University
San100, Yongdang-Dong, Nam-Gu, Busan, Republic of Korea
²Graduate school of Mechanical Engineering Pukyong National University
San100, Yongdang-Dong, Nam-Gu, Busan, Republic of Korea

INTRODUCTION
A great deal of influence of development technology of progressive die for press tooling as a top rapidity operation with a minimizing costs is given to the production part by many kinds of factors, i.e. the complexity of die components of machining and its assembling, pressing machinery capacity, lot size of production part, materials of die components and its heat treatment, etc. The interactions of a whole of many factors to the die development with a optimized method are concerned by tool engineers. The important role of tool engineers is strip process layout design and computer aided FEM simulation with a existing data base and abundant field experiences. The prediction of result on the tryout is critical division on the die development. We used the part of precision production (Fig. 1) in electronic production line. Hence, this study needs a whole of press tool data, our field experiences, relative instructions, and ultra precision machine tools and its skilful operation and applications. The added process of this work was FEM simulation by DEFORM with 3D Unigraphics under the WINDOW environment. The result of this computer aided simulation was successful and very fine as the output coming in Fig. 4, Fig. 5. According to upper work, the optimum die design could be accomplished. Furthermore the goal of least defect could be obtained by the tryout and die revision.

ANALYSIS OF PART DRAWING
Fig. 1 shows the production part drawing in this study through the computer aided die design under the AutoCAD and Window environment. In this drawing the thickness of material is 0.8mm for bending part. The direction of burr is downward regularly, hence we designed strip process layout as the cut-off type progression through the modeling of 3D Unigraphics application. At this time, we could predict the completed actual strip process layout after tryout visually. Table 1 shows the mechanical properties of SPCC material.[1,2]

<table>
<thead>
<tr>
<th>TABLE 1 Mechanical properties of SPCC</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young modules</td>
<td>GPa</td>
<td>200</td>
</tr>
<tr>
<td>Poison ratio</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>Tensile</td>
<td>MPa</td>
<td>760</td>
</tr>
<tr>
<td>Yield Strength</td>
<td>MPa</td>
<td>380</td>
</tr>
</tbody>
</table>

[ Note ]
1. Burr creating direction should be on the "A" surface to the downward.
Material: SPCC, Thickness: 0.8 mm

FIGURE 1 Production part drawing

DESIGN OF STRIP PROCESS LAYOUT
Fig. 2 shows the result of strip process layout in this study. For the increasing of material using ratio, we selected the couple row type method, at the same time the symmetrical disposition and guide line of pin method, pilot locating method were used to accurate process [3,4].
The conditions of DEFORM simulation were opened as same as following Table 2.

**TABLE 2 Condition of DEFORM Simulation**

<table>
<thead>
<tr>
<th>Items</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Press</td>
<td>Mechanical press SPM:60</td>
</tr>
<tr>
<td>Friction coefficient</td>
<td>0.09-0.12 (0.12 fixed)</td>
</tr>
</tbody>
</table>

At this time, the conditions of bending formation were shown as the Table 3.

**TABLE 3 Condition of bending formation**

<table>
<thead>
<tr>
<th>Items</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punch radius</td>
<td>R 0.3mm fixed</td>
</tr>
<tr>
<td>Clearance</td>
<td>0.4-0.08mm</td>
</tr>
<tr>
<td>Die radius</td>
<td>0.8, 1.6, 2.4, 3.2mm</td>
</tr>
<tr>
<td>Height of Coining</td>
<td>0.04, 0.08, 0.12, 0.16, 0.20, 0.24mm</td>
</tr>
</tbody>
</table>

**FEM SIMULATION OF STRIP LAYOUT**

The FEM program used to simulate the strip process layout was DEFORM that is capable of material behaviour, deep and wide deformation and contrast between punch and die shapes. It was possible to determine the stress and strain of bending stage in the strip process.

**SPRING BACK CREATING SIMULATION**

In this Study, as an outer method of the common treatment of spring back of sheet metal bending, punch shoulder shape was considered coining type shape also it was simulated by DEFORM. Fig. 3 shows the bending punch shoulder shape with a coining method.

**FIGURE 2 Strip process layout of couple rows**

**FIGURE 3 Bending punch shoulder shape and size of coining section**

<table>
<thead>
<tr>
<th>b (0.8mm) (100%)</th>
<th>h1 (5%)</th>
<th>h2 (10%)</th>
<th>h3 (15%)</th>
<th>h4 (20%)</th>
<th>h5 (25%)</th>
<th>h6 (30%)</th>
</tr>
</thead>
</table>

(a) Bending deformation rp=.3mm, rd=1.6mm

(b) Bending deformation rp=0.3mm, rd=2.4mm

**FIGURE 4 FEM Simulation of bending Die radius**

Fig. 4 shows the representatives of bending deformation among the conditions of bending formation as showing on the Table3. In this FEM simulation, it could be known that the bending die radius 1.6mm of couple times of material thickness of production part which was satisfied with a reduction of stress and strain under the relieving of transformation of material thickness. It was considered that the bending die radius 2.4mm was become to the lower effect of stress.
and strain, hence, the actual production part by tryout was satisfied as a very important factor.

Fig. 5 shows the representatives of FEM simulation of stress and strain by DEFORM. At this time, bending die radius 2.4mm with a coining height 0.08mm pressing was satisfied with a lower stress and strain appearance but spring back phenomena occurred within 10% of material thickness. The production part could be predicted as a good quality.

![FEM simulation of stress of 0.08 coining](image)
(a) FEM simulation of stress of 0.08 coining

![FEM simulation of strain of 0.08 coining](image)
(b) FEM simulation of strain of 0.08 coining

![FEM simulation of stress of 0.12 coining](image)
(c) FEM simulation of stress of 0.12 coining

![FEM simulation of strain of 0.12 coining](image)
(d) FEM simulation of strain of 0.12 coining

**FIGURE 5 Stress and Strain deformation of 0.08 and 0.12mm coining on the corner at the bending portion**

**DIE MAKING AND TRYOUT**

Fig. 6 shows the assembling drawing of die design result. At this time, we considered the automatic roll feeding of strip for the mass production part above one hundred thousand pieces. Also, the die set was selected special type tool steel die with a outer and inner guide post. For aiding the roll feeding, the guide lifter pin was used [5-7].

![Die assembling drawing](image)
(a) Front view of assembly

![Die assembling drawing](image)
(b) Top view of Upper and Lower Die

**FIGURE 6 Die assembling drawing**

Fig. 7 shows the critical points of die making and assembling for increasing of accuracy.

![Die assembling drawing](image)

**FIGURE 7 Fitting accuracy for die assembling**
Fig. 8 shows the upper and lower die after die making at opening status. The SKD11 high alloy tool steel was selected for punch and die block as a cause of containing of minimized wear among whole of die materials. In this die making, we used many kinds of precision machine tools i.e. EDM, Wire-cut, jig grinding machine, tool, CNC machining center, mirror machine tool and vacuum type heat treatment furnace etc.

(3.3) 2.0. 3.0 times of material thickness of production part, the out view of actual production part was satisfied and the coining site of bending to 0.1_0.15 times of material thickness of production part was brought into existence in allowing tolerance.

3. It was possible that the prediction of result of tryout was successful through the FEM simulation. Also it could be done the optimizing design of strip process layout for the satisfied die making and tryout through the computer simulation

REFERENCES