한국기계가공학회지, 제3권, 제4호, pp.43～49 (2004. 12)
Journal of the Korean Society of Manufacturing Process Engineers, Vol. 3 No. 4, pp.43～49 (2004. 12)

A Study on the Progressive Die Development of Sheet Metal Forming Part

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박판 포밍제품의 프로그레시브 금형개발에 관한 연구

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ABSTRACT

The production parts have required multiple processes such as drawing, piercing, blanking and notching etc. are performed with a high production rates in progressive die. In order to prevent the defects of process result, the optimization of strip process layout design, die design, die making, and tryout etc. are needed. According to these factors of die development process, it has been required that the theory and practice of metal working process and its phenomena, die structure, machining conditions for die making, die materials, heat treatment of die components, processing know-how and so on. In this study, we designed and analyzed die components through the carrying out of upper relevant matters also simulated the strip process layout of multiple stage drawing by DEFORM. Especially the result of tryout and its analysis became to the feature of this study with a system of PDDC(Progressive Die design by computer).

Key Words : Progressive Die, FEM Simulation, Strip Process Layout, Tryout

1. Introduction

The progressive die with multi-stage performs a series of sheet metal working at two or more stages during each press stroke to produce a piece part as the material strip moves through the die tunnel with a front and back gage. Press working for the optimum die design and its making has been become the purpose of industry by strip process layout with multi-stages[1~2].

We used the part of precision production part of Fig. 1 in industrial production line. Therefore, this study needed a whole of press tool data, our field experiences, theoretical instructions, and ultra precision machine tool and its skillful operating and applications. The added process of this work was analyzed by DEFORM according to the FEM simulation parameters of SPCC material.

The result of this FEM analysis was very successful that the output came to the Fig. 2 and Fig. 3.

Hence, this study could be approached to the optimum die design. Furthermore the aim of least

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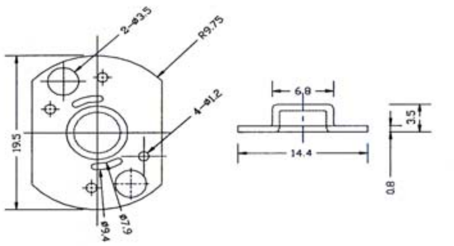
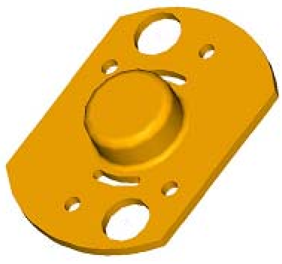
defects could be obtained by revision on the tryout[1~2].



Material : SPCC   Thickness : 0.8mm

(a) Production Part drawing

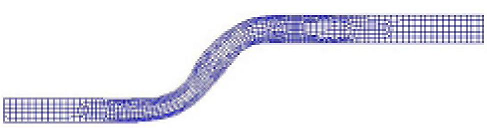


(b) Modelling of production part by I-DEAS

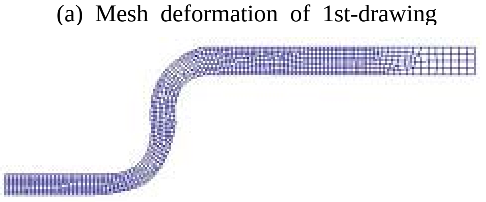
Fig. 1 Production part

Table 1 The parameter for FEM simulation of SPCC

	Unit	Value
Young modulus	GPa	200
Poison ratio		0.3
Tensile Strength	MPa	760
Yield Strength	MPa	380



(a) Mesh deformation of 1st-drawing



(b) Mesh deformation of 2nd-drawing

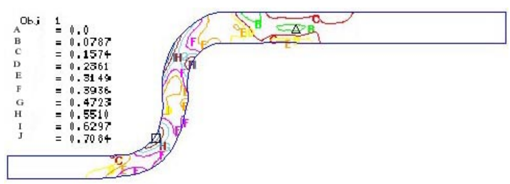
(c) Mesh deformation of 3rd-drawing

(d) Mesh deformation of 4th-drawing

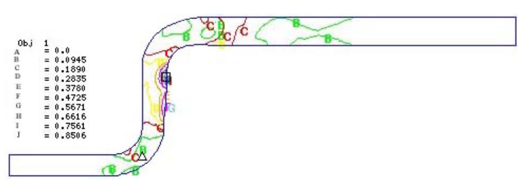
(e) Mesh deformation of 5th-drawing

Fig. 2 Deformation shape on the each drawing process by DEFORM

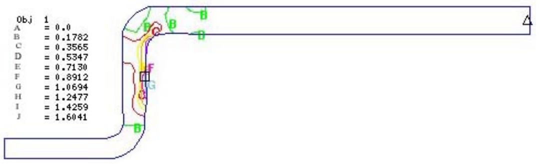
(a) Effective strain of 1st-drawing



(b) Effective strain of 2nd-drawing

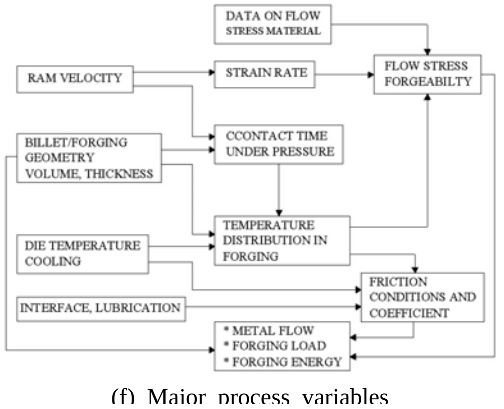


(c) Effective strain of 3rd-drawing

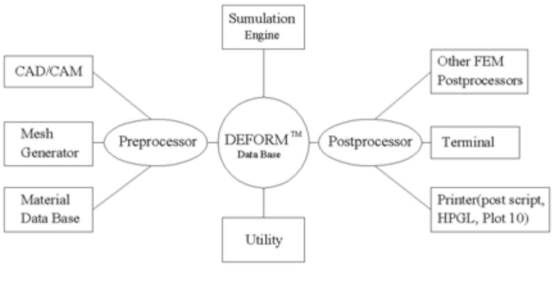


(d) Effective strain of 4th-drawing

(e) Effective strain of 5th-drawing



(f) Major process variables



(g) DEFORM system

Fig. 3 FEM simulation result on the each process drawing by DEFORM(punching speed 0.2㎧) and its major process vaiables and DEFORM system

2. Die Design

2.1 Die developing system

Fig. 4 shows the die development system. In this system, it can be known that the production engineering, die making technology, standardization, trouble shooting, man power, purchase, tool, material, etc. are connected with a software and hardware, corresponded instructions of wide and deep technology and it's theoretical background[1,3].

Fig. 5 shows the one of die components drawing by visual Auto-Lisp under the Auto-CAD and Window environment. The other die components were designed with this method and experiences.

2.2 FEM simulation

The drawing process(using the 150 ton Crank press, stroke 160mm, SPM 35mm) was performed with FEM analysis by DEFORM. The result of five steps drawing simulation by DEFORM is shown in Fig. 2, Fig. 3.

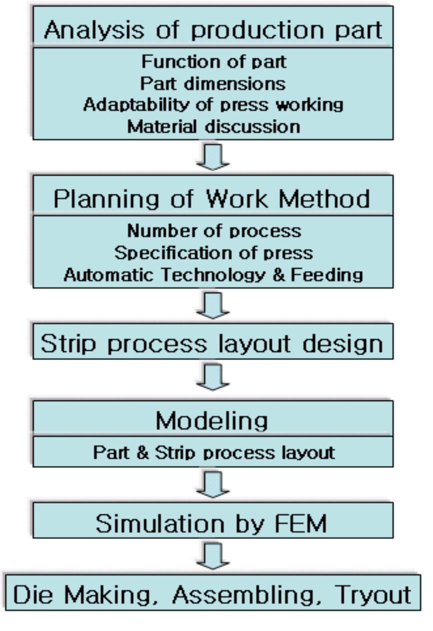


Fig. 4 Flow chart of die development system

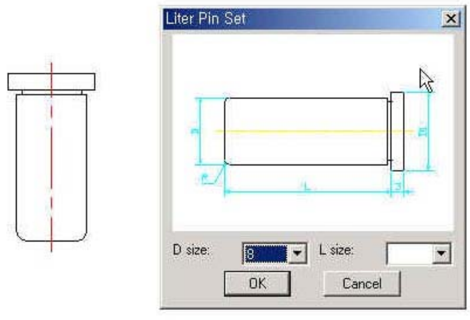


Fig. 5 Die component drawing by visual Auto-Lisp

Table 2 Basic data of 5 steps of drawing

	Punch Diameter	Punch Radius	Die Radius
1st drawing	10.5 mm	1.4 mm	1.0 mm
2nd drawing	7.3 mm	1.0 mm	0.8 mm
3rd drawing	6.4 mm	0.7 mm	0.6 mm
4th drawing	5.5 mm	0.4 mm	0.4 mm
5th drawing	5.2 mm	0.2 mm	0.2 mm

At this time, the base data of each step is described in Table 2. The thickness of material on the five steps was reduced to 0.55mm(at the final fifth drawing) through the more and more every step progression.

Therefore the arrangement of tryout was performed very carefully through the fine machining of punch and die shoulders with a good lubrication.

The last consideration of this simulation was successful drawing process without the critical factors such as a crack phenomena of actual production part.

2.3 Strip process layout

The disposition of part on strip feed unfolding was displayed with constant area repeatedly. Due to upper causes, it must be enough to the decision of part feeding distance (advance, pitch) and disposition of part on the strip layout had to be preformed exactly.

Tool designer's intention must be considered consider that the best utilization ratio can be found the top of part arrangement. This is the optimum method of initial die design[1,5,6].

At this time we must refer the web size on the strip from database and experience too.

Fig. 6 shows the strip process layout design result by IDEAS.

For the design of strip process layout, the first step is how to decide the feeding method which is according to the quantity of production part, material properties, and material thickness, the second step is same with a such as flow chart of Fig. 4.

From the strip process layout designing method, the following strip process layout(see Fig. 6) was designed.

For the strip process layout it was considered that the proper sizes are strip width, web size, advance, side cutting allowance etc.. The first stage performs piercing and lancing, the second stage works idle, third stage performs lancing, fourth stage works idle, fifth stage performs first drawing, sixth stage works idle, seventh stage performs second drawing, eighth stage performs third drawing, the ninth stage performs fourth drawing, the tenth stage performs fifth drawing, the eleventh stage performs piercing, the twelfth stage performs piercing, the thirteenth stage performs trimming for complete production part. In here, the pilot works to take a stability of strip feed and its location as a two side carrier, also the idle stage has function of die allowable space and trouble shooting used for die arrangement.

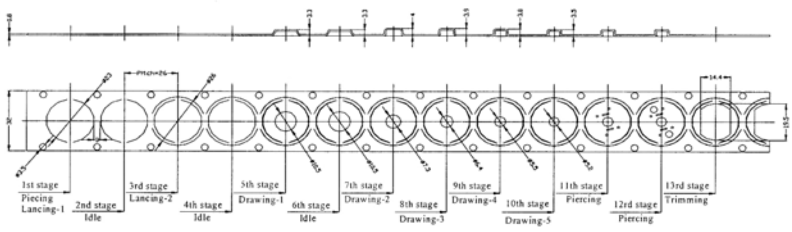
In this die design result, the most important die mechanism factor is inserted component system of die construction in due to long life of die using with tungsten carbide materials and high alloy steels.

3. Die Making and Tryout

3.1 Die making

Punch and die block is main part in die making. In this study, we decided the size of punch and die block depending on data base, theoretical background and our own field experiences. The machining of punch and die block belong to the precision machine tool working, continually raw material cutting, milling, turning, drilling, shaping, profiling, and then heat treating, electronic discharge machining (EDM, Wire-Cut), jig grinding, especially, CNC machining. In this study, we used ordinary machine tools, CNC machine tools and EDM etc.[6,7].

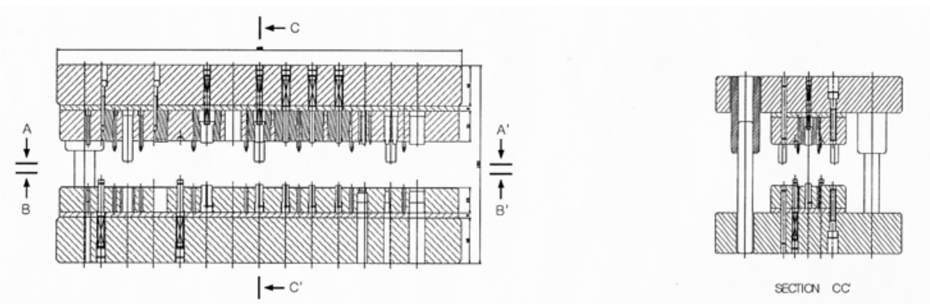
On the accuracy of the each fitting components, namely, with combination of the following tolerance, the first is guide bush and guide post(outer or inner) tolerance H7(hole) h6(shaft) and the die set and guide



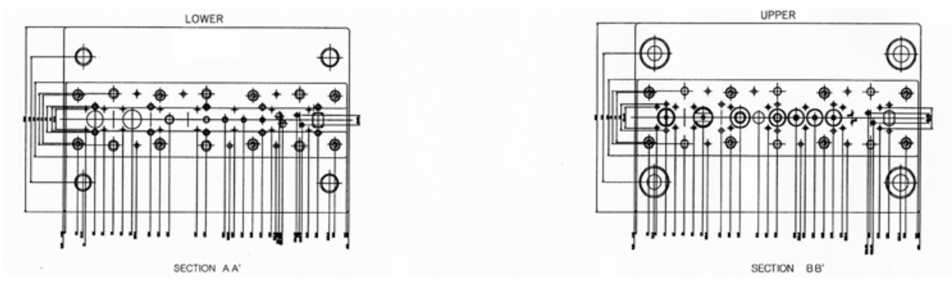
(a) Drawing of Strip Process Layout

(b) 1∼13 stage of strip process layout modeling by IDEAS

Fig. 6 Drawing of Strip Process Layout



(b) Assembly drawing of the die design on side view (a) Assembly drawing of the die design on front view



(c) Assembly drawing of the die design on Top view "A−A" (d) Assembly drawing of the die design on Top view "B-B"

Fig. 7 Die assembling drawing

post tolerance are H7(hole) p5(shaft) for a tight fitting.

Punch plate and punch tolerance are H7(hole) m6(shaft) for a tight fitting with minor interference.

The second is stripper and punch tolerance as the H7(hole) h6(shaft) too. Die inserting hole and die insert button are H7(hole) m6(shaft) for a minor tight fitting too.

These fitting tolerances are very careful factors for die making because the whole of die setting method must be within fine central punch and die activities for the symmetrical equalized clearance to the left and right side each other.

3.2 Tryout

Fig. 8 shows the actual strip process result and its produced part from tryout working by the crank press. In this actual process strip, we could confirm the real process for making the production part. Also we checked every dimension of production part with a tolerance control.

We could find the jamming problem such as the material strip through the guide tunnel on the die block surface. Also, when the material strip pass through the tunnel, the auto-feeding attachment operation must be checked every time exactly. The trouble shooting of this problem comes from die setting skill and technology. Furthermore the production part from try out was very fine by inspection too[8].

(a) Actual production part

(b) Actual strip by tryout

Fig. 8 Actual part and strip by tryout

At this time, the check of die failures was performed through the production part and strip of every stage with punch and die edge by the survey and fine instruments.

We considered that all of the failures cause are united with stresses present situation in the die those are generated during either its manufacturing, its using life or others[9~10].

4. Conclusion

This study performed optimization method by visual Auto-Lisp under the Auto-CAD and WINDOW environment and FEM simulation as a PDDC on the five steps theoretical calculating and skilled experiences with the others of database including the other of wide instructions. The results are as follows.

(1) The FEM simulation increased drawability of production part for this progressive die development of five step drawing.

(2) The results of fine quality of production part were accomplished without fail by tryout and its revision after die components making and assembling.

(3) The auto-feeding treatment with a relevant attachment was comparative effect for this production part material strip progression.

Acknowledgement

This work was supported by Pukyong National University Research Fund in 2002.

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