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A Study on the Multi-row Progressive Die for Thin Sheet Metal Forming by Computer Simulation

Sung-Bo Sim*, Chung-Hwan Kim**

ABSTRACT

The progressive die performs a work of sheet metal processes with a piercing, notching, embossing, bending, drawing, cut-off etc. in many kinds of pressing. Now a days, these processes have been evaluated as a advanced tooling method to increase the productivity and high quality assurance. The first step analyzing of die design is production part review, then the arrangement drawing of product design and strip process layout design should be done as a next steps with a FEM simulation for its problem solution. After upper procedure were peformed, it was started to make the die, then tryout and its revision of the die and product quality, safety, productivity etc. were done continually. For the all of these process, we mobilized the theory and practice of sheet metal forming, die structure, the function and activity of die components, and the others of die machining, die material, heat treatment and know-how so on. In this study the features of representative are production part analyzing through the FEM simulation of bending area with a considering spring back problem by DEFORM.

Key Words : Strip process layout, FEM simulation, Tryout, Fitting accuracy, Springback

1. 서 론

The development of progressive die for press tooling is given the influence to production part by too many factors, ie. the complexity of die components of machining and its assembling, pressing machinery capacity, lot size of production part, the material of die components and its heat treatment, etc. The interaction of a whole of many factors and its do they effect to the 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 then the prediction of result on the tryout is coming soon. We used the part of precision

production (Fig. 2) 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 skillful 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 exactly as the output coming in Fig. 5, Fig. 6. 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.

* School of Mech.Eng.Pukyung National University
** Graduate School of Industry Pukyung National University

2. Design of Stripprocess Layout

2.1 Die development system

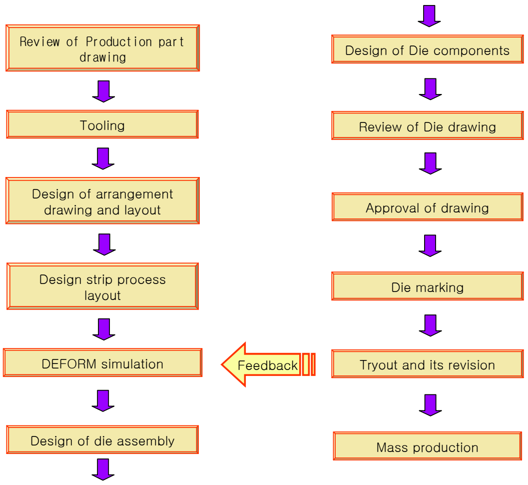


Fig. 1 Flow chat of Die development system

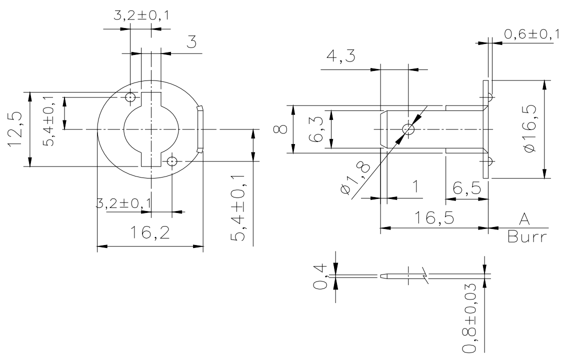
Fig. 1 shows the flow chart of die development system for the press tooling. It is necessary to graft in the many factors with a die making technology, man power, tool, material, expense with a soft and hard ware, harmonizing of wide field experience and theoritical back ground.[1,2] First of all, the review of production part is very important, then it can be planned exacty according to the number of process and press machine specification.

2.2 Analysis of Production part drawing

Fig. 2. 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 0.8㎜ for bending part. The direction of burr is downward regulary, 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.

Table 1 Cutting condition for experiments

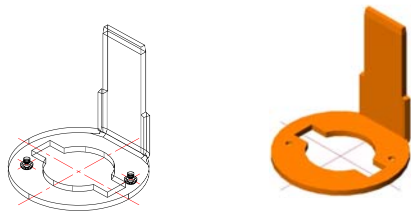
	Unit	Value
Young modules	GPa	200
Poison ratio	-	0.3
Tensile	MPa	760
Yield Strength	MPa	380



[Note]

1. Burr creating direction should be to the "A" surface as the downward.

Material : SPCC, Thickness : 0.8㎜



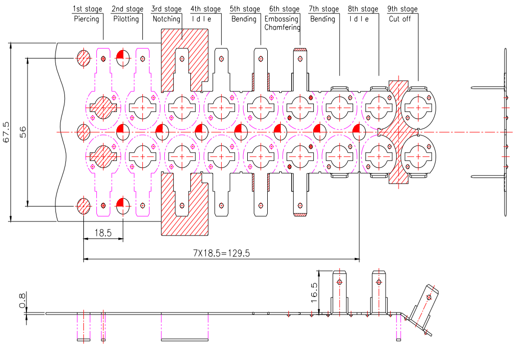
(a) Production part drawing

(b) Modeling of the product by the UNIGRAPHICS

Fig. 2 Production part

2.3 Design of strip process layout

Fig. 3 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 pin method, pilot locating method were used to accurate process.[3,4)]



1st stage	Different shape piercing of central position and piercing to pilot
2rd stage	Indirected piloting process for accurate feeding
3nd stage	Symmetrical notching of bending portion
4th stage	Idle stage with consideration of die strength
5th stage	Left and right wing bending to upper direction
6th stage	Chamfering and embossing of edge portion
7th stage	90 degree bending of edge portion to the upper direction
8th stage	Idle stage as same effectiveness as 4th stage
9th stage	Cut-off stage with a consideration of burr direction for product obtaining

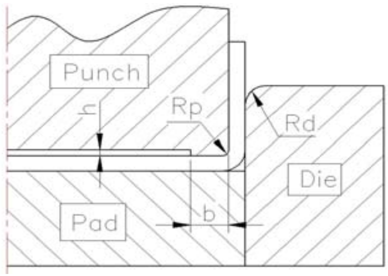
Fig. 3 Strip process layout of couple rows

3. FEM Simulation of Strip Process 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. It is possible to determine the stress and strain of each stage of strip process.

3.1 Consideration of spring back creating simulation

In this Study, as a outer method of the common treatment of spring back of sheet metal bending, punch shoulder shape was considered coining type shape then simulated by DEFORM. Fig. 4 shows the bending punch shoulder shape with a coining method.



b	h					
	h 1	h 2	h 3	h 4	h 5	h 6
0.8㎜ (100%)	0.04㎜ (5%)	0.08㎜ (10%)	0.12㎜ (15%)	0.16㎜ (20%)	0.20㎜ (25%)	0.24㎜ (30%)

Fig. 4 Bending punch shoulder shape and size of coining site

The conditions of DEFORM simulation were same as following Table2

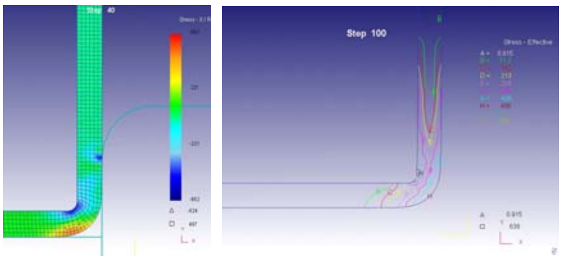
Table 2 Condition of DEFORM Simulation

Items	Contents
Press	Mechanical press SPM : 60
Friction coefficient	0.09~0.12 (0.12 fixed)

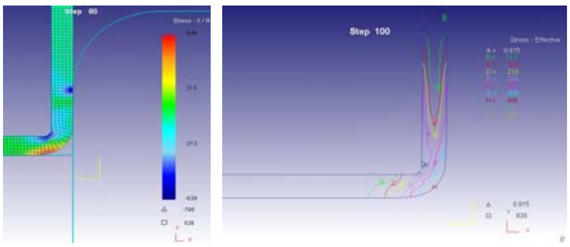
At this time, the conditions of bending formation were shown as the Table3

Table 3 Condition of Bending formation

Items	Contents
Punch radius	R 0.3㎜ fixed
Clearance	0.04 ~ 0.08㎜
Die radius	0.8㎜, 1.6㎜, 2.4㎜ 3.2㎜
Height of Coining	0.04㎜, 0.08㎜, 0.12㎜, 0.16㎜, 0.20㎜, 0.24㎜



(a) Bending deformation rp=0.3㎜, rd=1.6㎜



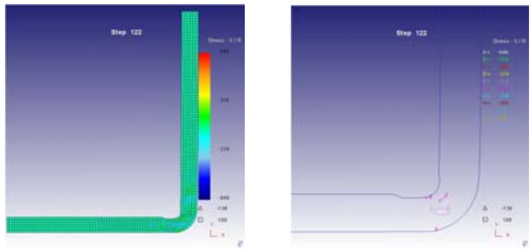
(b) Bending deformation rp=0.3㎜, rd=2.4㎜

Fig. 5 FEM Simulation of bending Die radius

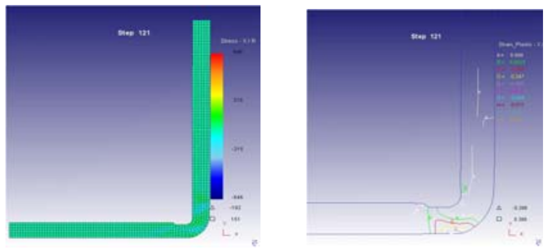
Fig. 5 shows the representatives of bending deformation among the conditions of bending formation as shown on the Table3. In this FEM simulation, it could be known that the bending die radius 1.6㎜ and couple times of material thickness of production part was satisfied with a reduction of stress and strain under the relieving of transformation of material thickness. It was considered that the bending die radius 2.4㎜ was become to the lower effect of stress and strain, hence the actual production part by tryout was satisfied as a very important factor.

3.2 Tables

Fig, 6 shows the reprentantives of FEM simulation of stress and strain by DEFORM. At this time, bending die radius 2.4㎜ with a coining height 0.08㎜ pressing was satisfied with a lower stress and strain appearance but spring back phenomena occured within 10% of material thickness. The production part was predicted as a good quality.



(a) FEM simulation of stress 0.08㎜ depth coining
(b) FEM simulation of strain 0.08㎜ depth coining



(c) FEM simulation of stress 0.12㎜ depth coining
(d) FEM simulation of strain 0.12㎜ depth coining

Fig. 6 Stress and Strain deformation of 0.08 and 0.12㎜ depth coining on the corner at the bending portion

4. Die Making and Tryout

4.1 Die making

Fig. 7 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 outer and inner guide post. For aiding the roll feeding, the guide lifter pin was used.[5~7)]

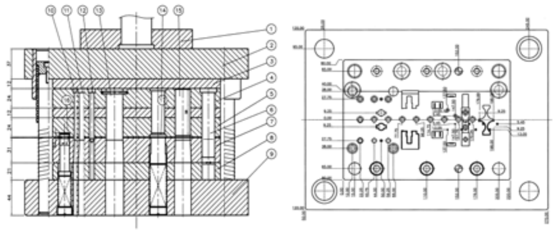
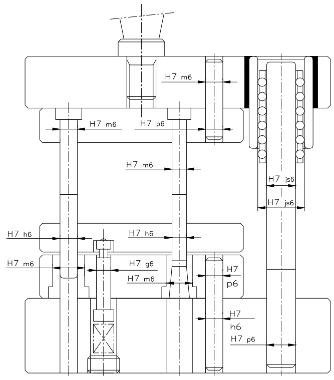


Fig. 7 Die assembling drawing under the symmetrical status

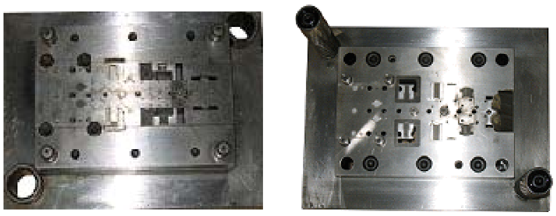
Fig. 8 shows the very critical points of die making and assembling as factors of accuracy.



Expression		Tolerance	Expression		Tolerance
H7	∅5	+0.012 0	k6	∅5	+0.008 +0.001
	∅15	+0.018 0		∅15	+0.012 +0.001
f6	∅5	-0.010 -0.018	m6	∅5	+0.012 +0.004
	∅15	-0.016 -0.027		∅15	+0.018 +0.007
g6	∅5	-0.004 -0.012	n6	∅5	+0.0016 +0.008
	∅15	-0.006 -0.017		∅15	+0.023 +0.012
h6	∅5	0 -0.006	p6	∅5	+0.020 +0.012
	∅15	0 -0.011		∅15	+0.029 +0.018
js6	∅5	± 0.004			
	∅15	± 0.0055			

Fig. 8 Fitting accuray for die assembling

Fig. 9 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 kind of precision machine tools Ie. EDM, Wire-cut, jig grinding machine, CNC machining center, mirror machine, and vocuum type heat treatment equipment etc.



(a) Upper Die Assembly (b) Lower Die Assembly

Fig. 9 Upper and lower die assembly at opening status

4.2 Tryout

Fig. 10 shows the actual production past after tryout completed. At this time it was confirmed that the result of tryout and its revision were preformed very exactly.

(a) Actual strip by tryout

(b) Actual Production part (c) Actual test part

Fig. 10 Actual Production pant and strip by tryout

5. Conclusion

For the increasing of material using ratio, prod productivity, smoothing of strip feeding on the die block surface, and balancing of bending power. We designed two lines blank deposition type strip process layout. Also it was applicated to reduce the spring back phenomena by coining type die shoulder. Then, we performed DEFORM simulation with a strip process layout design, die making, tryout and its revision through the analysis of actual production part. Upper methods producted outcome to coincide between Simulation and tryout.

The result of this study was obtained as follows.

1. Under the condition of clearance of bending site 5~10% aided to material thickness of production part and die radius 2.0～3.0 time to 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 time to material thickness of production part was in existence in allowing tolerance.

2. It was possible that the prediction of result of tryout was successful or not through the FEM simulation.

Hence, we could optimize to design of strip process layout for the satisfied die making and tryout.

ACKNOWLEDGEMENT

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6. References

1. Sim, Sung-Bo, Park, Sun-Kyu, Development of the Practical and Adaptive Die for Sheet Metals(1), Proceedings of KCORE Conference, 1999, May, pp.141-148.
2. Sim, Sung-Bo, Song, Young-Seok, Development for Practical and Adaptive Progressive Die for Design and Making of Marine Part Sheet Metals(1), Inter. Jour. of Oceam Eng. and Tech, KCORE, Vol. 2, No. 2, 1999, 1925.
3. Sim, Sung-Bo, Jang, Chan-Ho, Sung, Yul-Min, Development of the Pilotless Type Progressive Die for Thin Sheet Metal, the Proceeding of KCORE Conference, 2001, pp.289-294.
4. Sim, Sung-Bo, Jang, Chan-Ho, Lee, Sung-Taeg, A study on the Development of Two side carrier Type Progressive Die for Multi-Stage Drawing Process. The Proceeding of the 2002 Autumm Conference of Korea Society Machine Tool Engeineers, 2002, pp.341-346.
5. Jung Il Choi, Chang Bong Kim, Chul Kim, Byung Min Kim, Jae Chan Choi, Development of Integrated Computer-Aided Process Planning System for Press Working Products, Journal of the Korean Society of Precision Engineering Vol. 16, No. 8, 1999, August, pp.59-70.
6. Karl, a.Keys, Innovation in Die Design, SME, 1982,. pp.71-99.
7. B. Fogg, G. A. Jamieson, The Influencing Factors in Optimization Press Tool Die layouts and A solution using Computer Aids, Annual of the CIRP Vol. 24, 1975, pp.429-434