A Study on The Development of Multi Forming Type Progressive Die for STS 304 Sheet Metal

STS 304 Sheet Metal에 대한 멀티 포밍 타입의 Progressive Die의 개발에 관한 연구

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by

M[illegible]n S[illegible]ng

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A Study on The Development of Multi Forming Type Progressive Die for STS 304 Sheet Metal

A Dissertation

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연 구 개 요

Progressive 금형은 2 stage 이상의 복합적인 작업을 수행하는 프레스 공구이며, 이 때 sheet 재료는 다이 블록 위를 통과하며 각각의 STAGE 마다 서로 다른 작업을 순차적으로 수행한다.
본 연구에서는 0.5㎜ 두께의 STS 304 stainless steel 의 sheet 재료를 사용하여 다공정 제품가공의 정밀 금형을 개발함에 있어서 그 결점을 예방하기 위해서는 생산제품의 최적 설계, Strip Process Layout 설계, 제품의 Modeling 과 Simulation, 금형 설계, 금형 제작, 그리고 시험 생산 등의 절차에 따르는 제반 사항을 검토, 분석함으로써 정밀도가 높은 제품생산, 금형 수명 제고, 부품의 호환성 등을 도모할 수 있도록 연구하였다.
특히 I-DEAS software를 동원한 modeling, Fam-Stamp software를 통한 FEM 해석을 주력으로 하여 양호한 금형 개발에 역점을 두고 연구하였다. 따라서 본 연구는 박판의 Progressive 금형 개발에 있어서 산업체의 금형 생산 현장에 중요한 자료로 활용될 것으로 사료된다.

1. INTRODUCTION

Die development is one of the most exact working of all the areas of the general field of press tool developing. The die engineering originates develops of dies employed to stamp and from sheet metal, assemble parts together, and perform a variety of other operations.[1)]

The first step of die design may include components or devices to locate or guide the sheet metal strip. Idle stages of no working are used spread out, closely spaced or to better distribute the forces regarded to perform the work.

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 strip stock moves through the die tunnel 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 ordinary product in industrial production line or society of our general living field as this paper subject.

So, this study needs a whole of press tool data, our field experiences, and theoretical instructions.

According to upper knowledges, this study could be approached to the optimum die design. Furthermore the aim of least defects could be obtained mostly by revision on the try out.

2. Die Design

2.1 Die Development System

Fig.1 shows the flow chart of die development procedure. In this figure most of them are related to this study.

Fig.2 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 to software and hardware, corresponded instructions of wide and deep technology and its theoretical background.

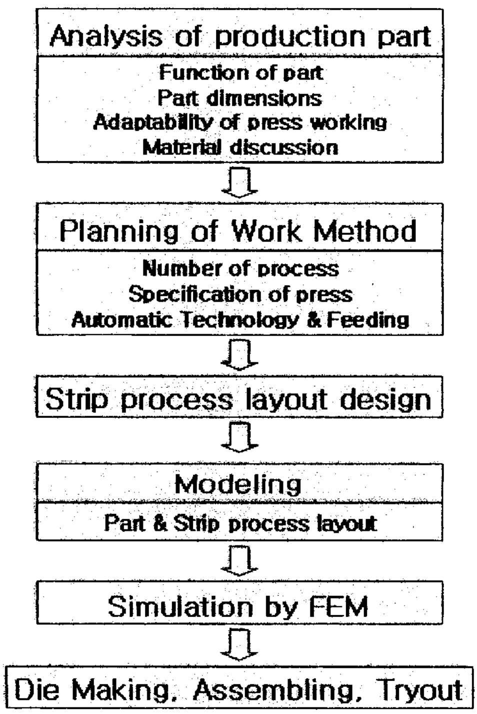


Fig.1 Flow chart of die development procedure

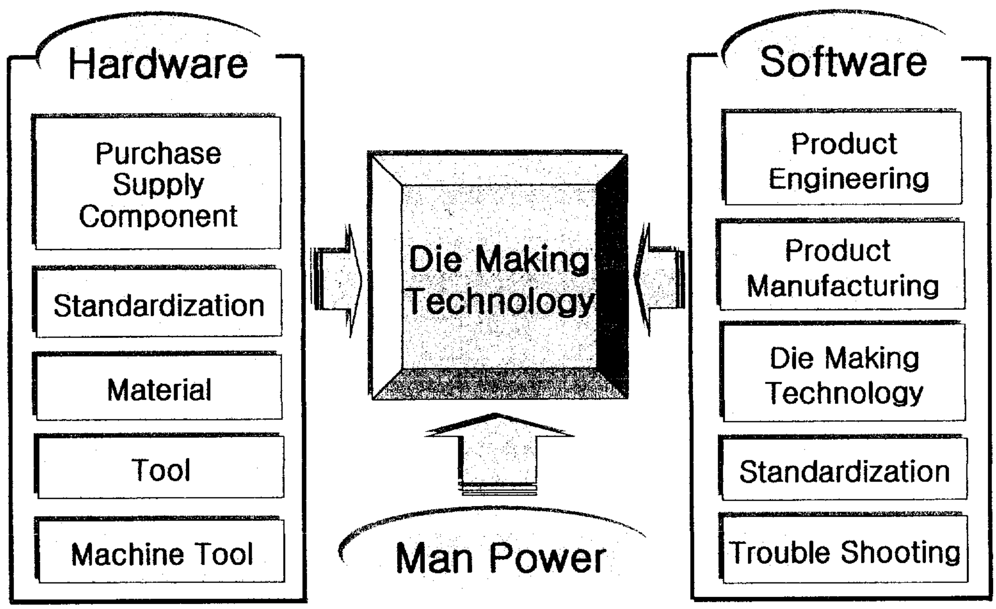
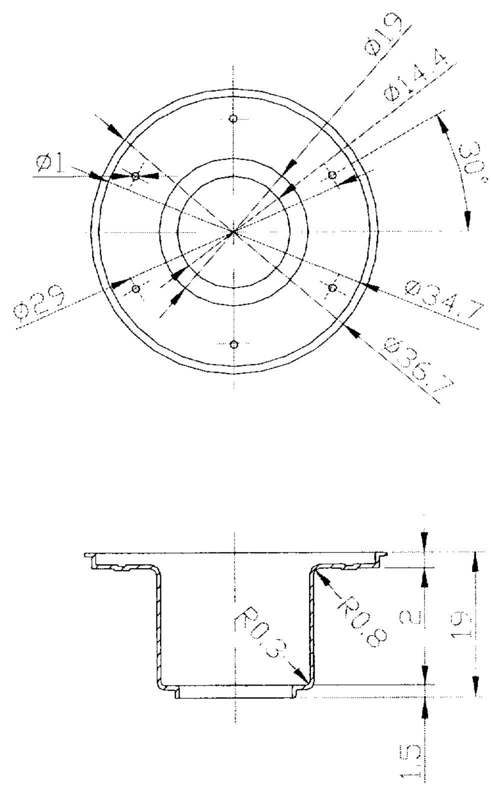


Fig.2 Network of the die developing system

2.2 Analysis of Production Part

Fig.3 shows the production part. This production part could be calculated blank diameter for blanking by following formula. Table 1 shows the chemical compositions of strip material STS 304 stainless steel, also Table 2 shows the mechanical properties.



Where, t = 0.5 mm, STS 304

Blank diameter with trimming allowance D ≒ ϕ 55.5 mm

Fig.3 Production part drawing and its blank diameter

Table 1 Chemical compositions of STS 304 (Wt. %)

C	Mn	Si	P
0.06	1.42	0.44	0.18
S	Cr	Ni	N
0.18	18.38	8.19	0.0573

Table 2 Mechanical properties of STS 304

Yield Strength (Mpa)	Tensile Strength (Mpa)	Elongation (%)	Reduce of area (%)	Hardness (Hv)
343	852.6	66	77	195

3. Back Ground of Data Base

3.1 The Clearance

The clearance means the gap between punch and die block as one side on couple side.
Following Table 3 shows the clearance of one side of various sheet metals from data.
It was selected that the clearance of this study is within 4.0 percent of material thickness.

Table 3 Clearance of sheet metals from data[2)]

Material	Clear. Allow. %	Material	Clear. Allow. %
Aluminum	6.0	Soft steel	3.0
Brass	3.0	Medium steel	3.5
Copper	3.0	Hard steel	4.0

3.2 Calculation of Blank Diameter

Fig.4 shows the out line dimension of production part for blank diameter calculating, also we selected following formula for adaptable calculation by data base.

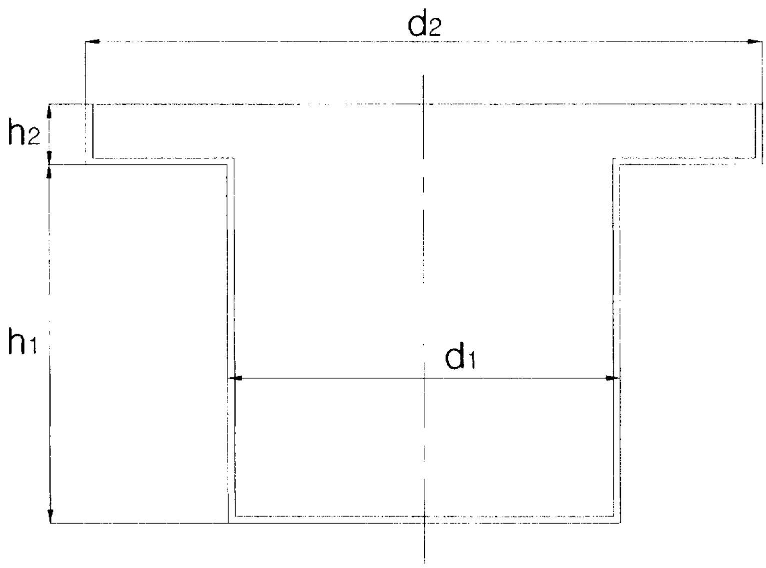


Fig.4 Out line dimension of production part

$$D_0 = \sqrt{d_2^{\,2} + 4(d_1 h_1 + d_2 h_2)} \quad \text{------} \quad (1)$$

D_0 : Blank diameter
d_1 : Large diameter
d_2 : Small diameter
h_1 : Top drawing height
h_2 : Bottom drawing height

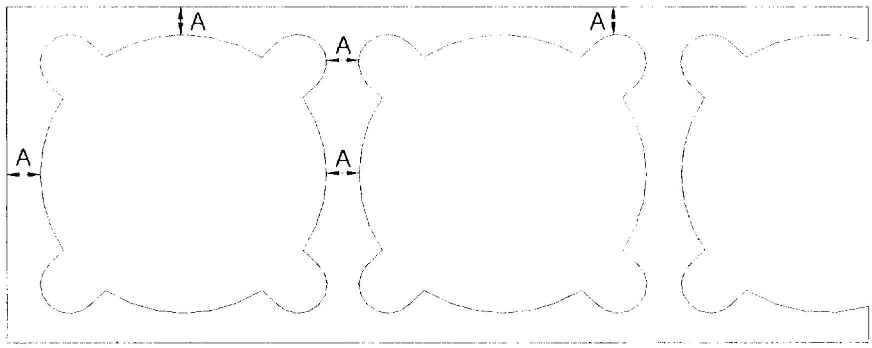
3.3 Scrap Strip Allowances

It is important that correct bridge allowance (web size) be applied between blanks and edge of the strip.
Excessive allowance is waste scrap of material. Insufficient allowance becomes the result in a weak scrap strip subject to possible breakage with consequent slowdown on the press line.
In addition, a weak scrap area around the blank can cause dishing of the part.[1~4)]
Peripheries of blanks may be classified under the distinct outline shapes.

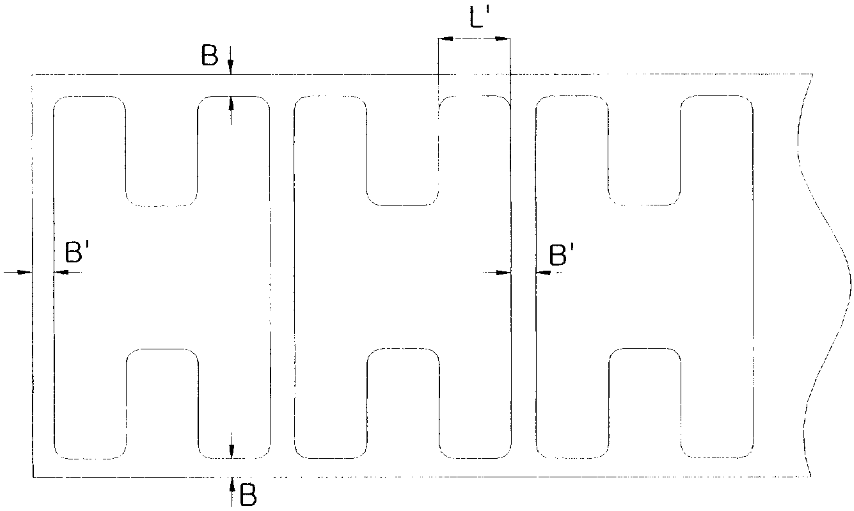
In the illustration,

1) Curved out lines. For these, dimensions A in Fig.5 are given a minimum allowance of 70% of the strip thickness T.

2) Straight edges. Dimensions of B and B′ depend upon the length of the bridge, dimensions L and L′ respectively.
   Where L or L′ is less than 75㎜, B or B′ = 1T, respectively.
   Where L or L′ is 75㎜, B or B′ = 1 1/4T, respectively.
   Where L or L′ over 200㎜, B or B′ = 1 1/2T.



(a) Curved outlines



(b) Straight edges

Fig.5 Classifications of blank peripheries to aid in determining Scrap strip allowances (web size) for one-pass layouts

On the other hand, Fig.6 shows the scrap strip allowance, pitch size, scrap strip width, and the others when the circular lancing type progressive die of drawing is performed.[3)]

$B = D_0 + b_1 + 2n_2 = D_B + 2n_2$ [㎜] ----- (2)

$H = D_0 + n_1$ [㎜] ---------------- (3)

Where

$k_1 = (0.5 \sim 0.7) D_B$ [㎜]

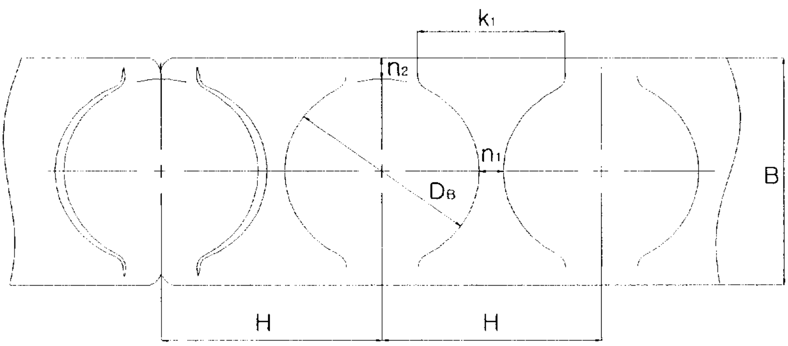


Fig.6 Various dimensions on the scrap strip of circular lancing type drawing

Table 4 Values of n_1, n_2

D_B [㎜]	n_1 [㎜]	n_2 [㎜]
~10	1~1.5	1.5~2
10~30	1.5~2	2~2.5
30~	2~2.5	2.5~3

D_0 : Blank diameter [㎜]

b : Allowance [㎜]

$D_B = D_0 + b$

n_1 : Scrap strip allowance for feeding (Bridge)

n_2 : Scrap strip allowance for periphery (Web)

3.4 Drawing Ratio

The drawing ratio is shown on Table 5 by Romanovski.[4)]

Table 5 Drawing Ratio

Drawing Ratio	t / D × 100						Remarks
	2~1.5	1.5~1.0	1.0~0.6	0.6~0.3	0.3~0.15	0.15~0.08	
m_1	0.48~0.50	0.50~0.52	0.53~0.55	0.55~0.58	0.58~0.60	0.60~0.63	1st Drawing
m_2	0.73~0.75	0.75~0.76	0.76~0.78	0.78~0.79	0.79~0.80	0.80~0.82	2nd 〃
m_3	0.76~0.78	0.78~0.79	0.79~0.80	0.80~0.81	0.81~0.82	0.82~0.84	3rd 〃
m_4	0.78~0.80	0.80~0.81	0.81~0.82	0.82~0.83	0.83~0.85	0.85~0.86	4th 〃
m_5	0.80~0.82	0.82~0.84	0.84~0.85	0.85~0.86	0.86~0.87	0.87~0.88	5th 〃

Where
t : Scrap strip thickness [㎜]
D : Blank diameter [㎜]

When we decided the drawing ratio. It was considered the values of Table 5 and our experiences.

4. Die Design and Its Consideration

4.1 Design of Strip Process Layout

The disposition of each operation on strip feed unfolding is the display with constant repeatedly. Due to upper cause, it must be enough that the decision of feeding distance (advance, pitch) and disposition of each operation on the strip layout must be peformed exactly. The check list when analyzing the preliminary strip process layout is as follows.[5)]

- What stations can be eliminated by combining with another stage.
- Are good die steel conditions maintained?
- Does movement of part between stations require a stretch web?
- Are idle stages provided to permit "breating" of strip, if stretch web is not feasible?
- Provide for pitch notch(s), if possible, to maintain proper progression.
- Avoid sight stop for first hit, if possible.
- If possible, pierce in first stages and pilot in second station to establish pitch control.
- Provide adequate pilots for all subsequent stations.
- Is there room for stock lifters to permit free flow of strip during feed?
- Are close tolerance holes pierced after forming to eliminate development of hole location?
- Use an overlay sheet to run a simulated strip through the die to check each operation and spot any pieces of scrap which might be left on the die.

Tool designer's intention must consider that the best utilization ratio can be found at the top of operating arrangement. This is the optimum method of initial die design.[1~5)]

At this time we must refer the web size on the strip from database and experience too. Fig.7 shows the strip process layout design procedure.

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 as the flow chart in Fig.7.

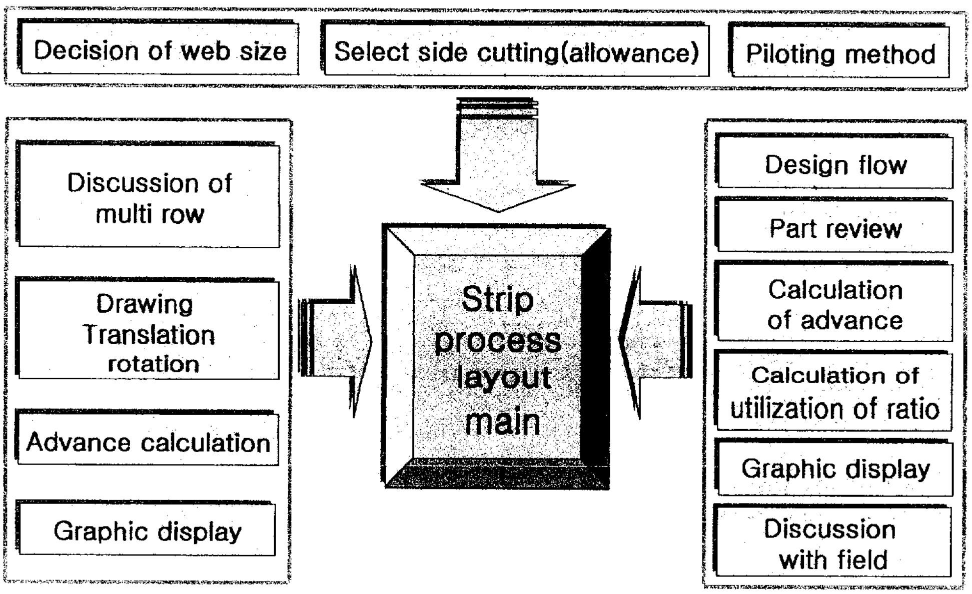
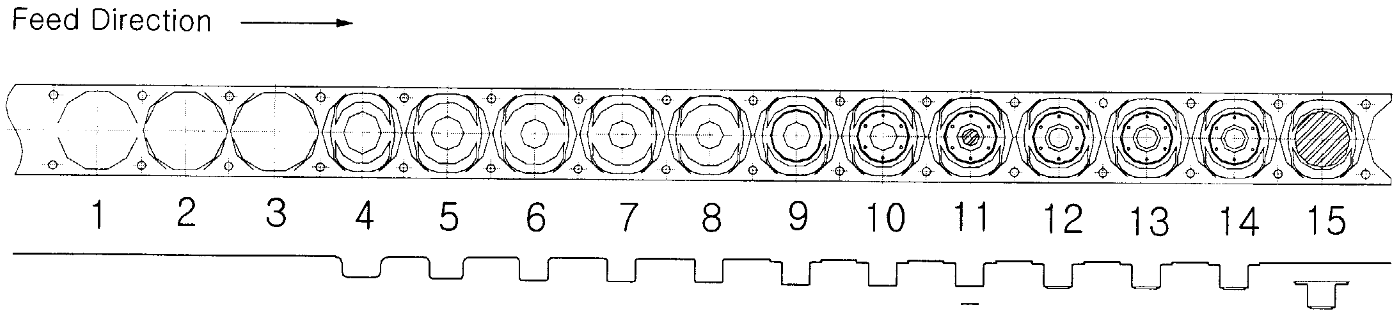


Fig.7 Flow chart of strip process layout design system

The following strip process layout (see Fig.8) was designed from the production part drawing see (Fig.3).
For the strip process layout, it was considered that the proper sizes are strip width, web size, pitch (advance), side cutting selection (allowance), etc.[1~5] the first stage performs piercing circular lancing①, the second performs circular lancing② and piloting, third stage works idle, fourth stage works drawing① and piloting, fifth stage performs piloting (pilots work to make the stability of strip feed and location) and drawing②, sixth is drawing③ stage, and seventh stage works drawing④ and piloting too. The eighth stage works piloting and drawing⑤. Ninth stage works thin drawing and piloting, tenth stage works embossing and piloting, eleventh stage is piercing and piloting stage, twelve stage works burring① and piloting, thirteenth stage also works burring② and piloting, fourteenth stage works sizing and piloting. The last of fifteenth stage works trimming, piloting, ejecting of completed part through the out let of die shoe hole and press table hole with bolster of the press table.
Idle stages have function for die allowable space and die trouble shooting of before or next stage failure. Therefore the strip process layout comes in the result as Fig.8 (drawing of strip process layout).[6~13]



1 : Circular Lancing-1 Piercing for Piloting
2 : Circular Lancing-2
3 : Idle
4 : Drawing-1
5 : Drawing-2
6 : Drawing-3
7 : Drawing-4
8 : Drawing-5
9 : Thin Drawing
10 : Embossing
11 : Piercing
12 : Burring-1
13 : Burring-2
14 : Sizing
15 : Trimming

4~15 stage : Piloting in additional function

Fig.8 Drawing of the strip process layout

Fig.9 shows the result of strip process layout modeling by I-DEAS. In this figure, it can predict to distinct whether the adaptability is sufficient or not.

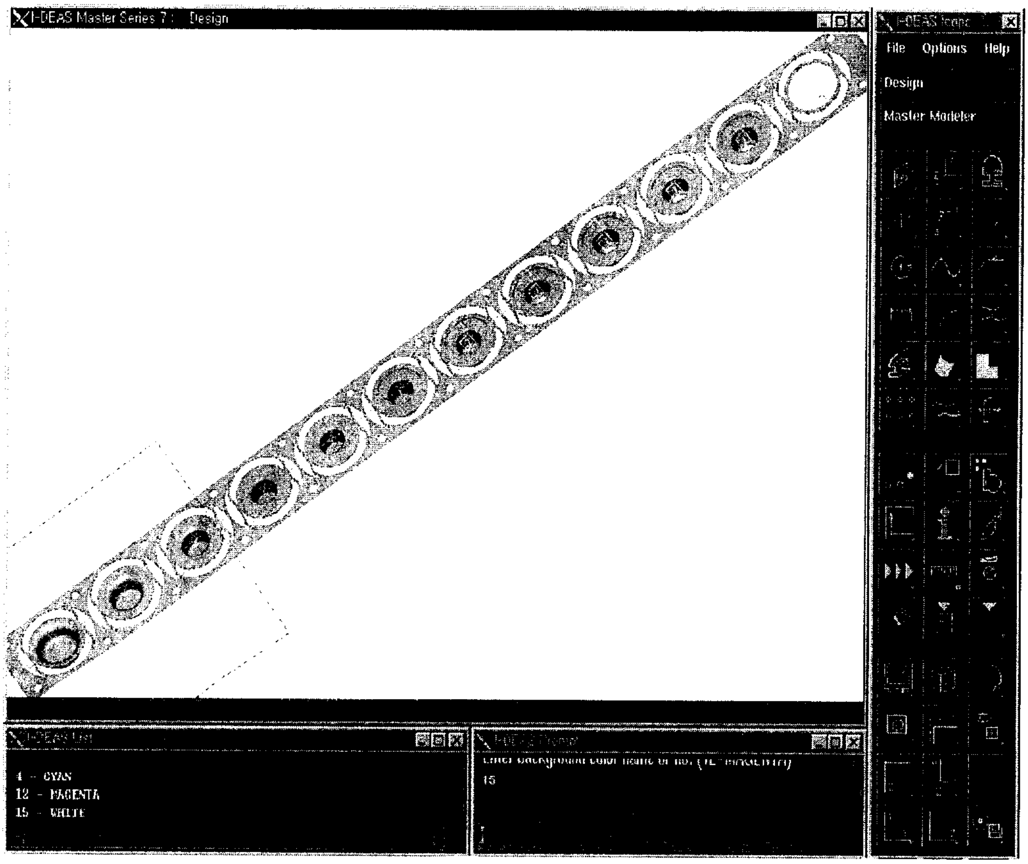


Fig.9 Result of strip process layout Modeling by I-DEAS

4.2 FEM Analysis of First Drawing and Consideration for Prediction

The FEM (Finite Element Method) is the computing program which is used to analyze a thin sheet metal forming.
First of all, 1st drawing part is are modeled to not a solid part but a surface part by the I-DEAS. After modeling, it is transformed by the Fam-Stamp, but the surface is not correctly transformed so that we properly need to modify the surface.
After modeling, we divided a mesh by Auto-Mesh system in Fam Stamp, the mesh size was 3 level, 1st Drawing pressure was 1.9 ton, the holder pressure was 30~40% of drawing pressure, the value was 0.6 ton.
This diagram is result when we used a material STS 304 stainless steel.
Fig.10 shows the displacement of node versus time.
In this figure, the dotted line number① is meaning of the displacement by 3.3sec to the bottom of drawing part.
The dotted line number② shows the displacement of medium height wall in drawing part.
In this figure, the dotted line ①② is showing a smooth trend.
Also the dotted line number③ shows the least displacement of producted part on the blank holding force area as flange of part.
So, we considered that the displacement versus time curve is not found the error of FEM analysis for prediction.
Fig.11 shows the profile of blank and the position of each node.

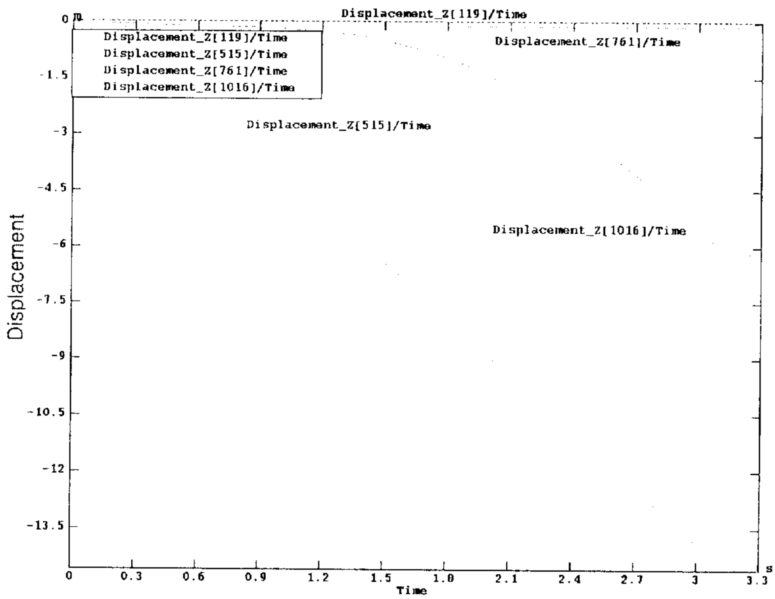


Fig.10 Each Node Displacement vs. Time

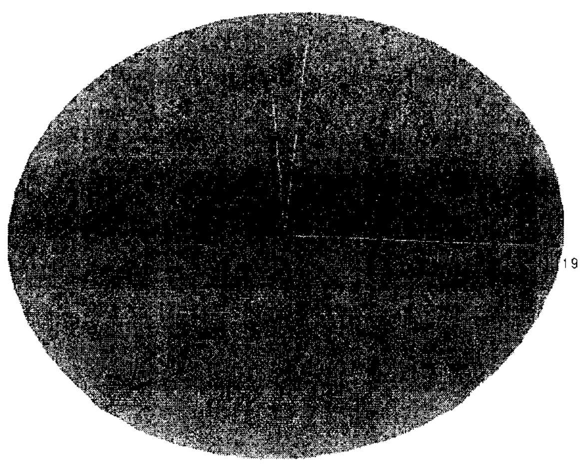


Fig.11 In Each Node Position on the blank

Fig.12 shows the average velocity versus time in the operation of FEM by Fam Stamp.

From point 1 to point 3, the velocity of punching is rapid increase phenomena, so it is meaning that the initial drawing is very easier that after progression to contact lowest point of drawing range.

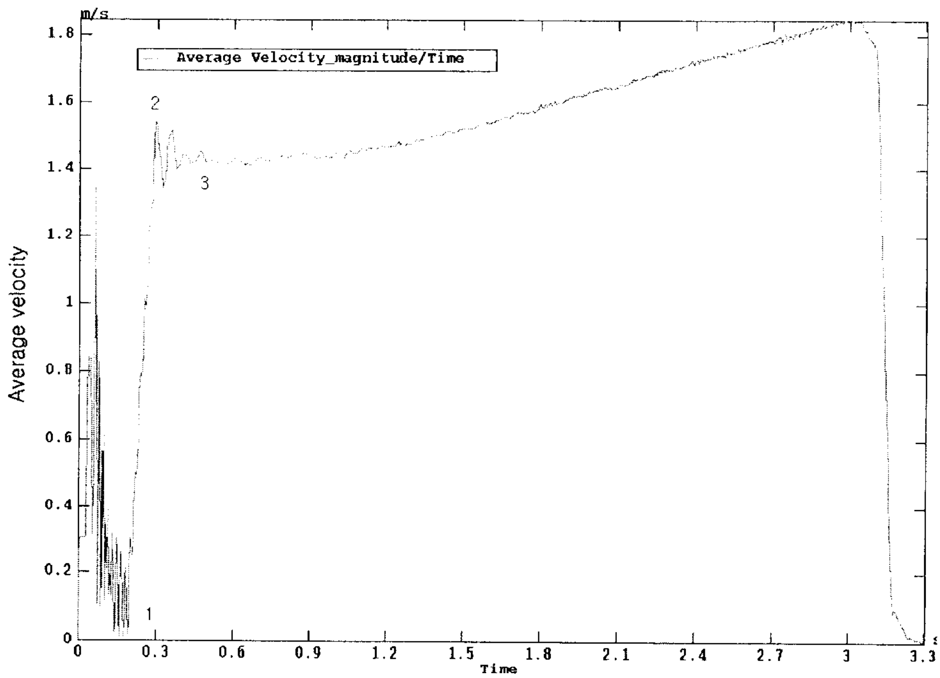
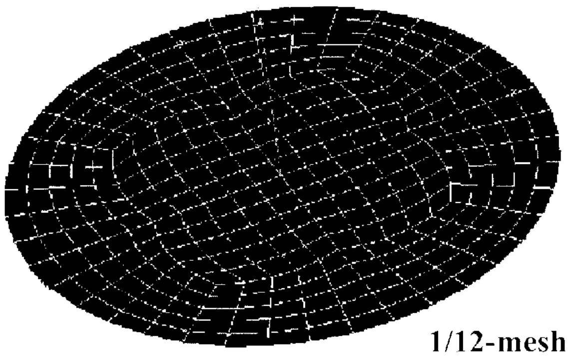


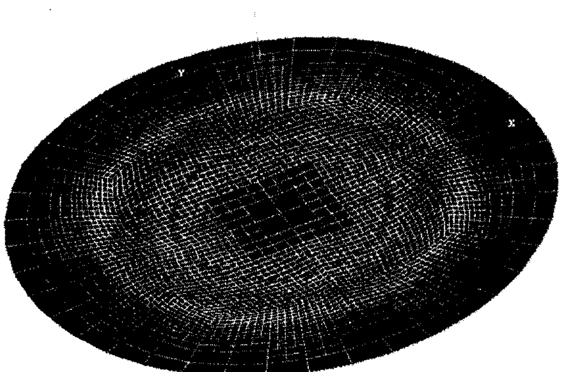
Fig.12 Average Velocity vs. Time

Fig.13 shows the status of blank mesh form (a) to (d) among the twelve kinds 12 steps.
In these figures, the feature of phenomena is normal type of drawing operation prediction at the 1st drawing station.



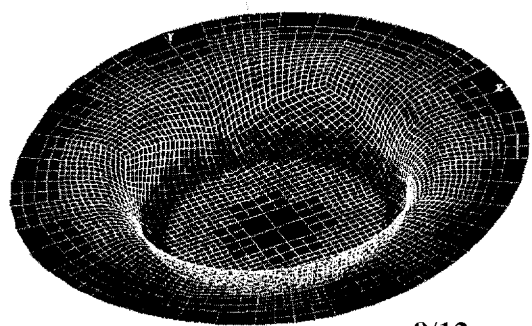
1/12-mesh

(a)



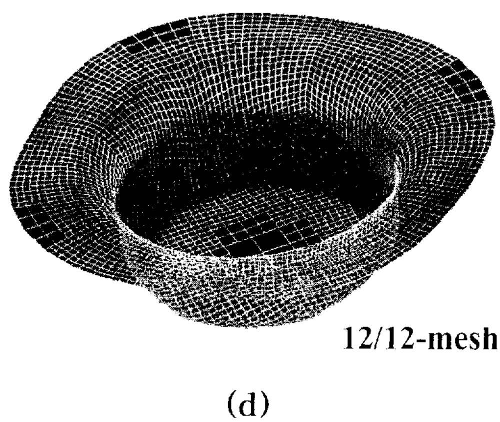
5/12-mesh

(b)



9/12-mesh

(c)



12/12-mesh

(d)

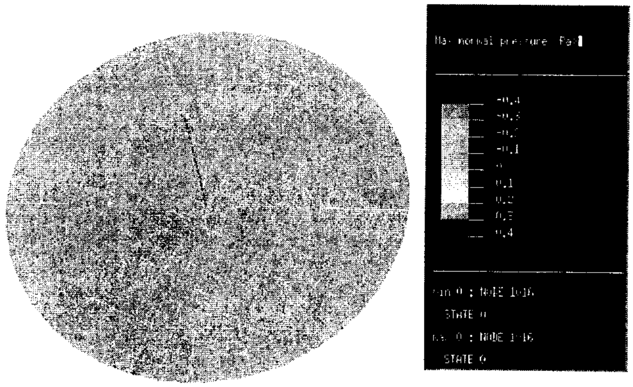
Fig.13 Status of blank Mesh

Fig.14 {from (a) to (d)} is selected twelve kinds of pressure distribution of necessary for 1st drawing.
At this time we used property value of matter of this production part as the following Table 6.

Table 6 Property value of matter

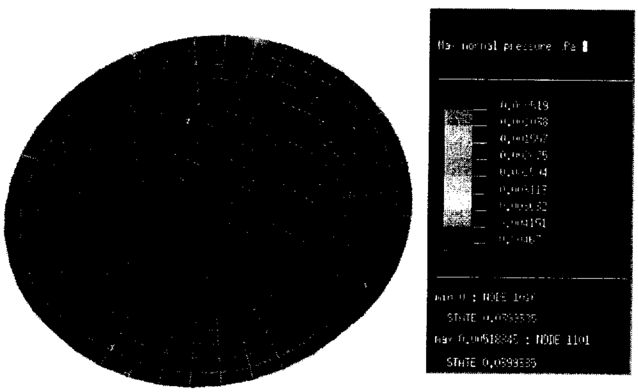
Physical factors	Value
Density	$8e^{-06}$ kg/mm^3
Number of integration point	3 (Default)
Young's modulus	193~200 GPa
Poisson's ratio	0.3 (Default)
Pressure	1.9 ton
Blank holding pressure	0.6 ton

The result of these figure in Fig.14 {from (a) to (d)} was distinct that the 1st drawing is performed fine operation on the tryout for prediction to next drawing process.



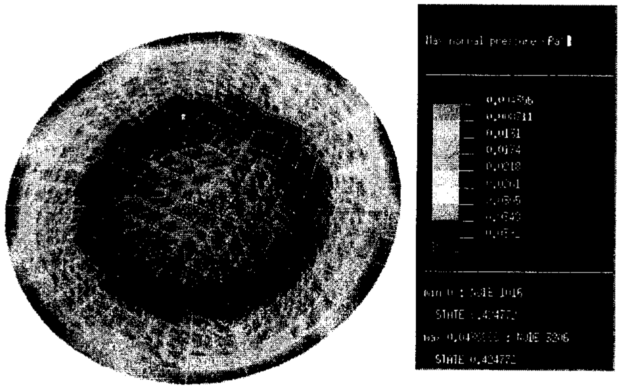
1/12 Pressure

(a)



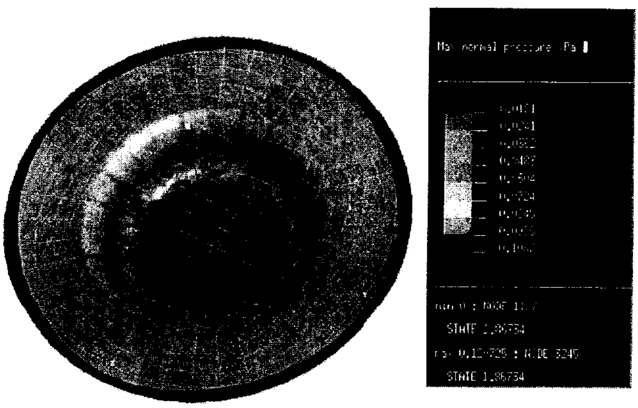
3/12 Pressure

(b)



5/12 Pressure

(c)

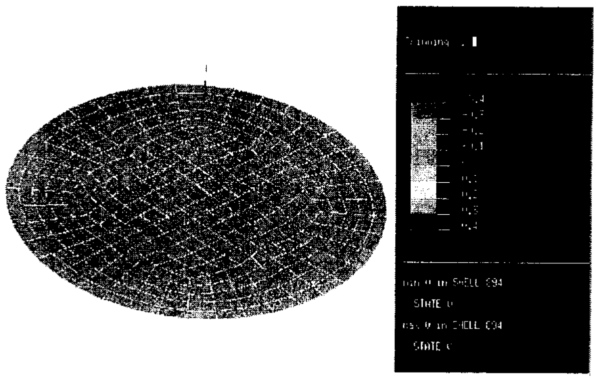


9/12 Pressure

(d)

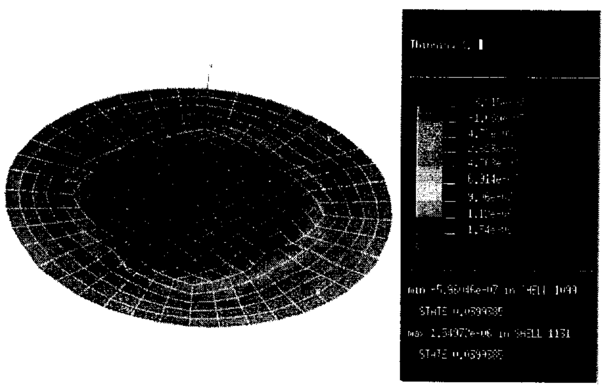
Fig.14 Pressure distribution on the blank of necessary for 1st drawing

Fig.15 {from (a) to (e)} shows the transformation of material thickness of 1st drawing as a step by step to thinning.
In this phenomena, we considered that the material thickness is going to be safe on 1st drawing.
So it is considerate that the 1st drawing is not occurring error to design for next operation.



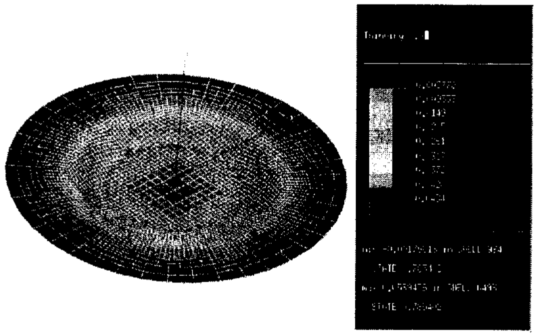
1/12 Thinning

(a)



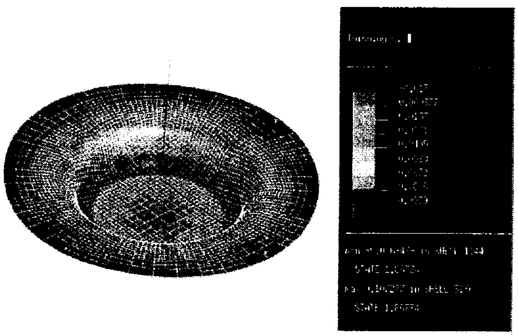
3/12 Thinning

(b)



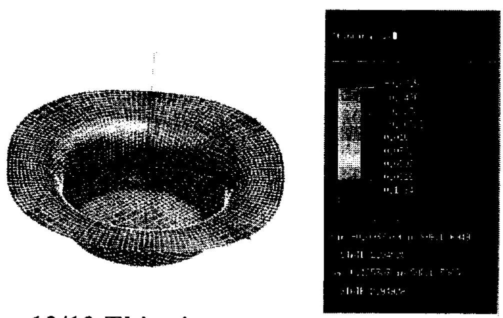
6/12 Thinning

(c)



9/12 Thinning

(d)



12/12 Thinning

(e)

Fig.15 Transformation of material thickness

The FLD Curve is Forming Limit Diagram in Fig.16.
The area over Center Curve means a material's tearing and the area under Center Curve means a material's properly forming.
So we could predict that the next drawing is sufficient drawing allowance in material thickness.

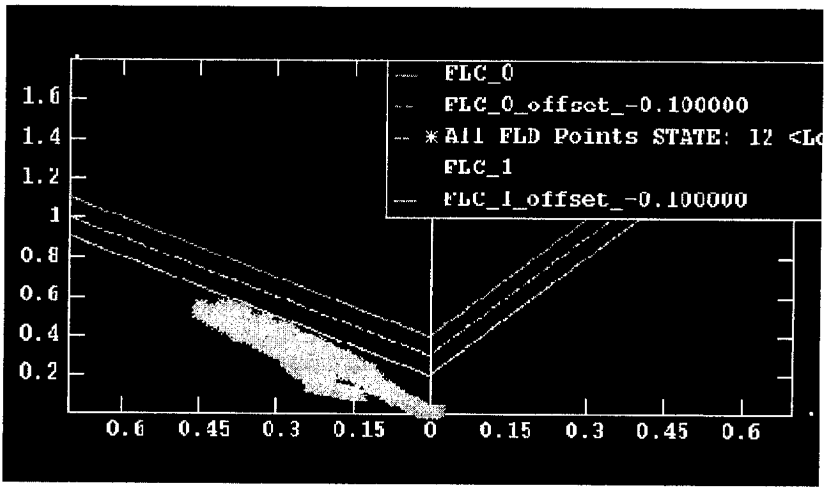


Fig.16 FLD Curve

4.3 Application of Auto-Lisp Under the Auto-CAD and Window environment

Fig.17 shows the one of die components drawing by Auto-Lisp under the Auto-CAD system and Window environment, namely, pilot punch drawing. The other die components were followed as this method and experiences.
Also this result was obtained from the program of Auto-Lisp under the Auto-CAD and window environment. Die components shape and its dimensions.
It was considered very available that the program of Auto-Lisp application to design of the die.[9~13)]

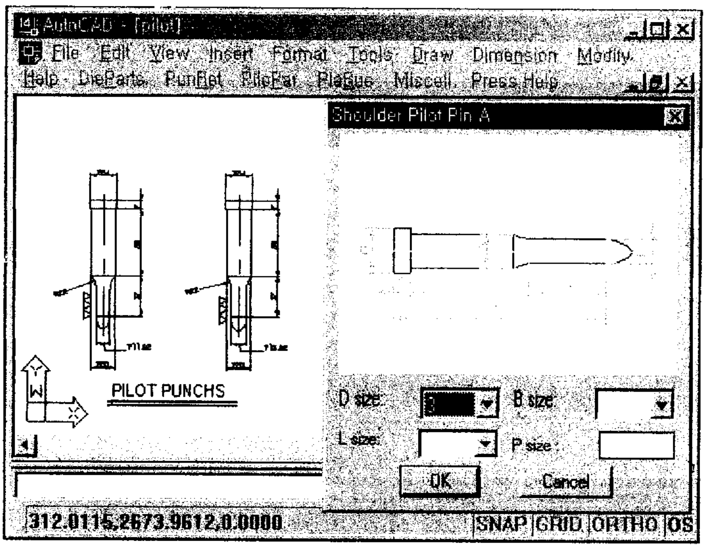


Fig.17 Die component drawing from Auto-CAD and Window environment

4.4 Die Assembling

There are several kinds of die set in the database according to the industrial today's situation.

Sometime in particular field, they make special type steel die set for high precision die assembling function.

In this study, we considered the automatic roll feeding of material strip for mass production above one hundred thousands of quantity of production parts necessary for precision production. Therefore we selected special type steel die set for high precision production part.

In design also the guide post must be installed in the die shoe block size allowance through the accurate guide bushing fit.

The die set of steel has 4 outer guide posts type for a precision working and high pressing force of production part(additional guide posts were 18 inner guide post in die block region). Fig.18, Fig.19, and Fig.20 show the result assembling die drawing.

From Fig.18, Fig.19, and Fig.20 it could be known the split die design system.

The split die system is very essential design and making system in die assembling and its trouble shooting for ultra pression die.[9~13]

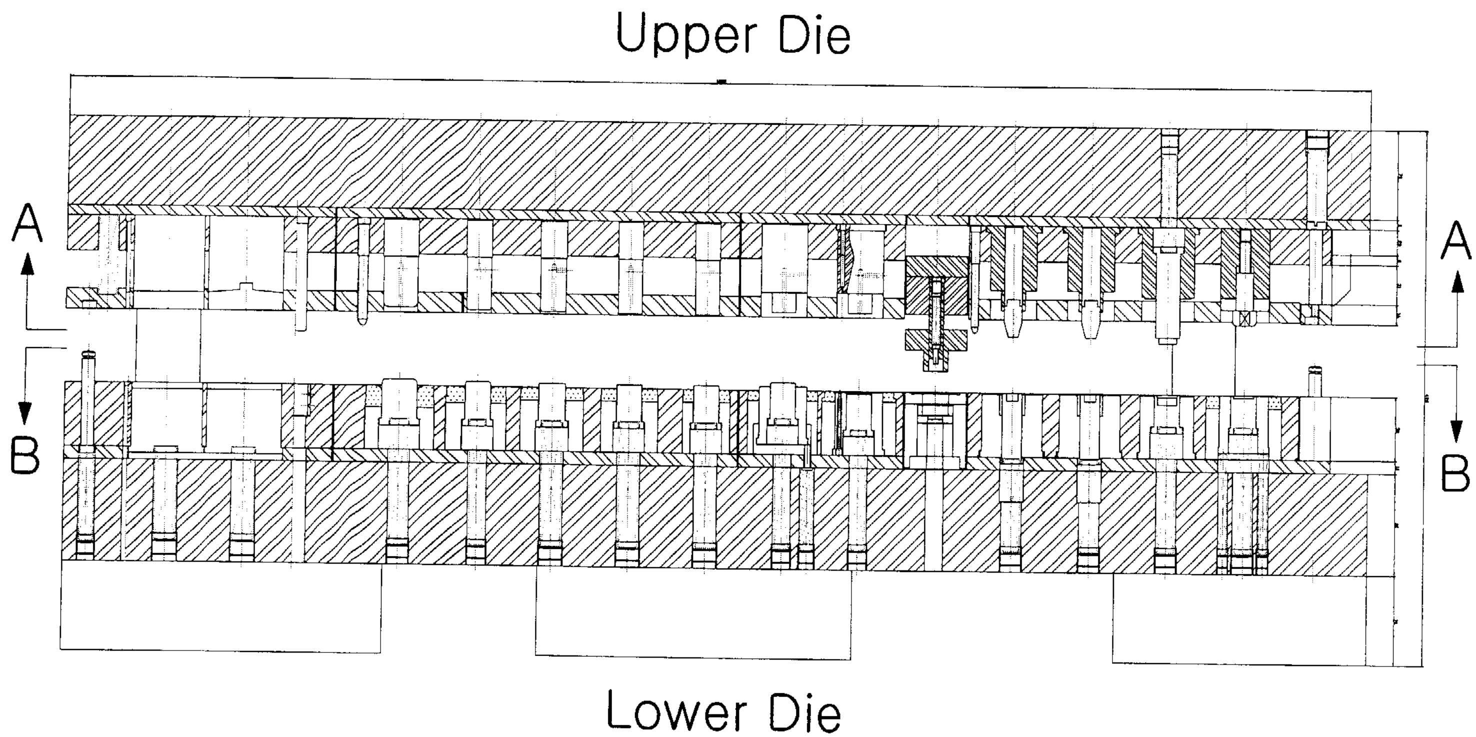


Fig.18 Summary assembling drawing of the die design on front view

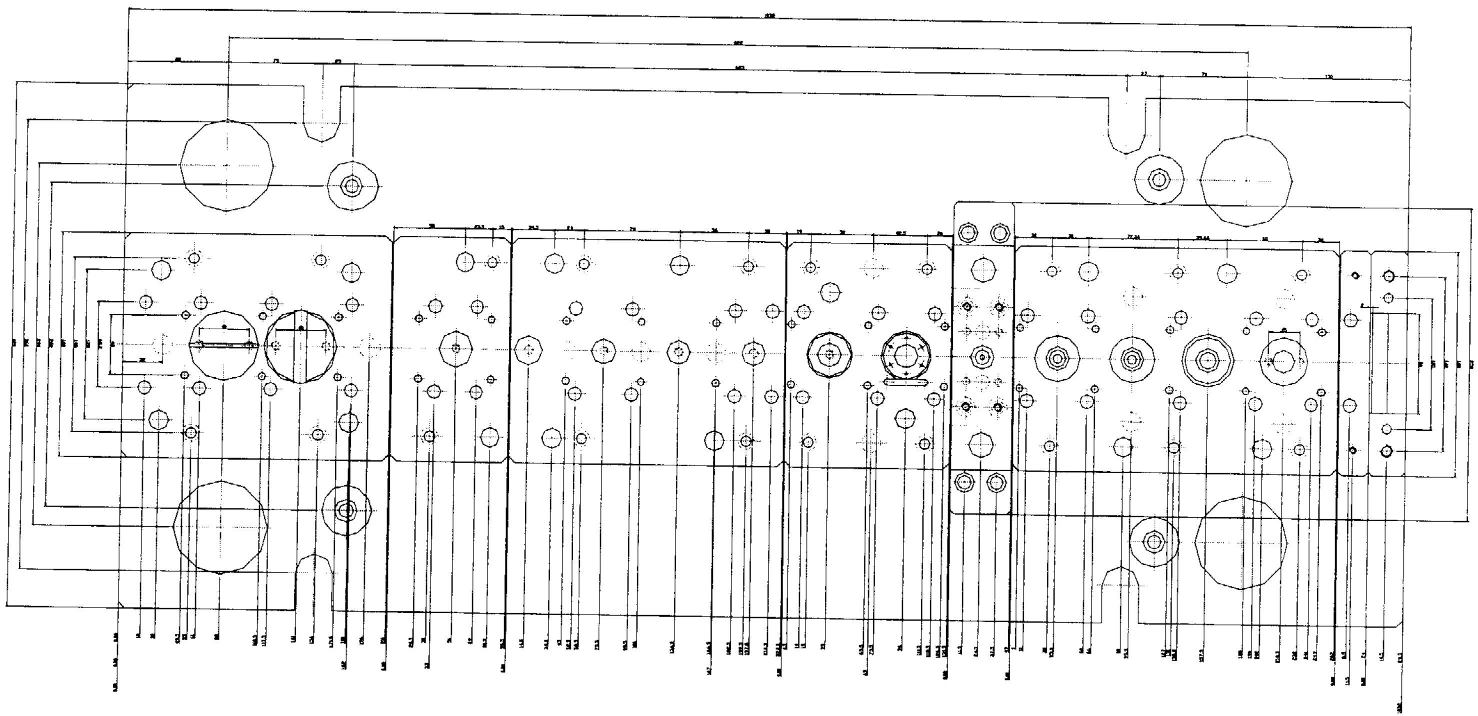


Fig.19 Summary assembling drawing of the die design on top view "A-A" of Fig.18

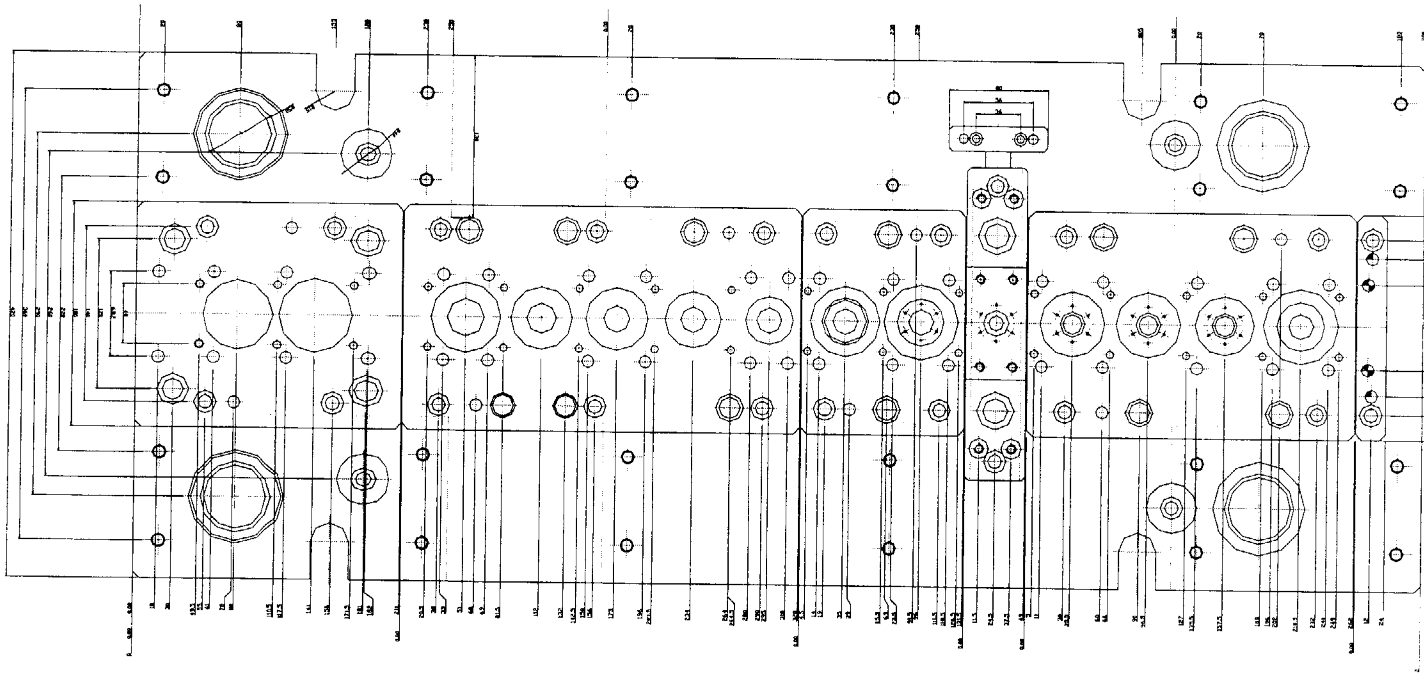


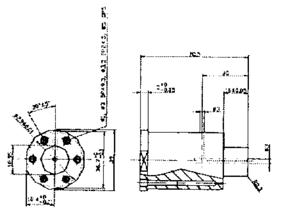
Fig.20 Summary assembling drawing of the die design on top view "B-B" of Fig.18

4.5 Die Components Design

Upper die assembly design was spreaded to die components design Fig.21, but too many components include in this progressive die, so we selected punches and die inserts on split die.[9~13)]

About die inserts treating, Ferrotic steel was used by its maker's suppling by orders, and then die inserts machining was performed by mirror machine tool and hand finishing finally. Especially, die insert's radius shoulders were finished as a mirror surface by too many times hand polishing with a lot of times.

(118)



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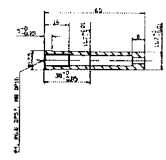

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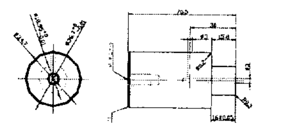

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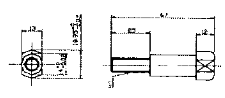

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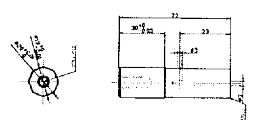

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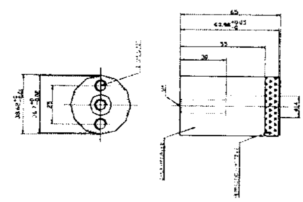

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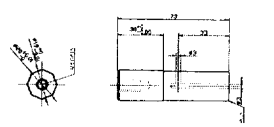

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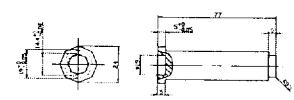

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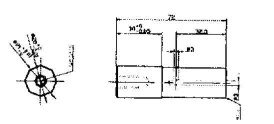

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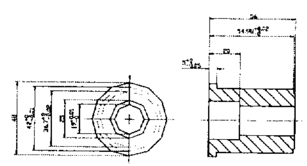

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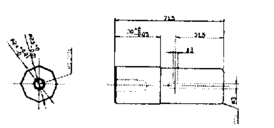

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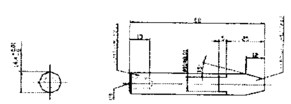

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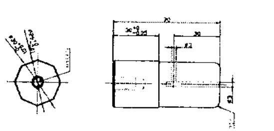

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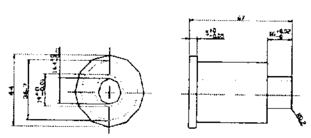

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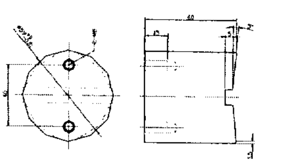

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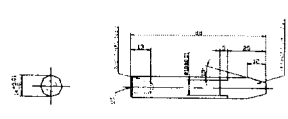

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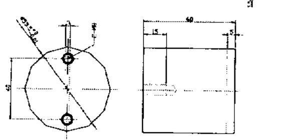

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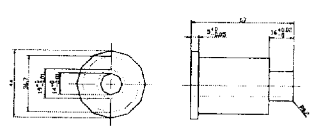


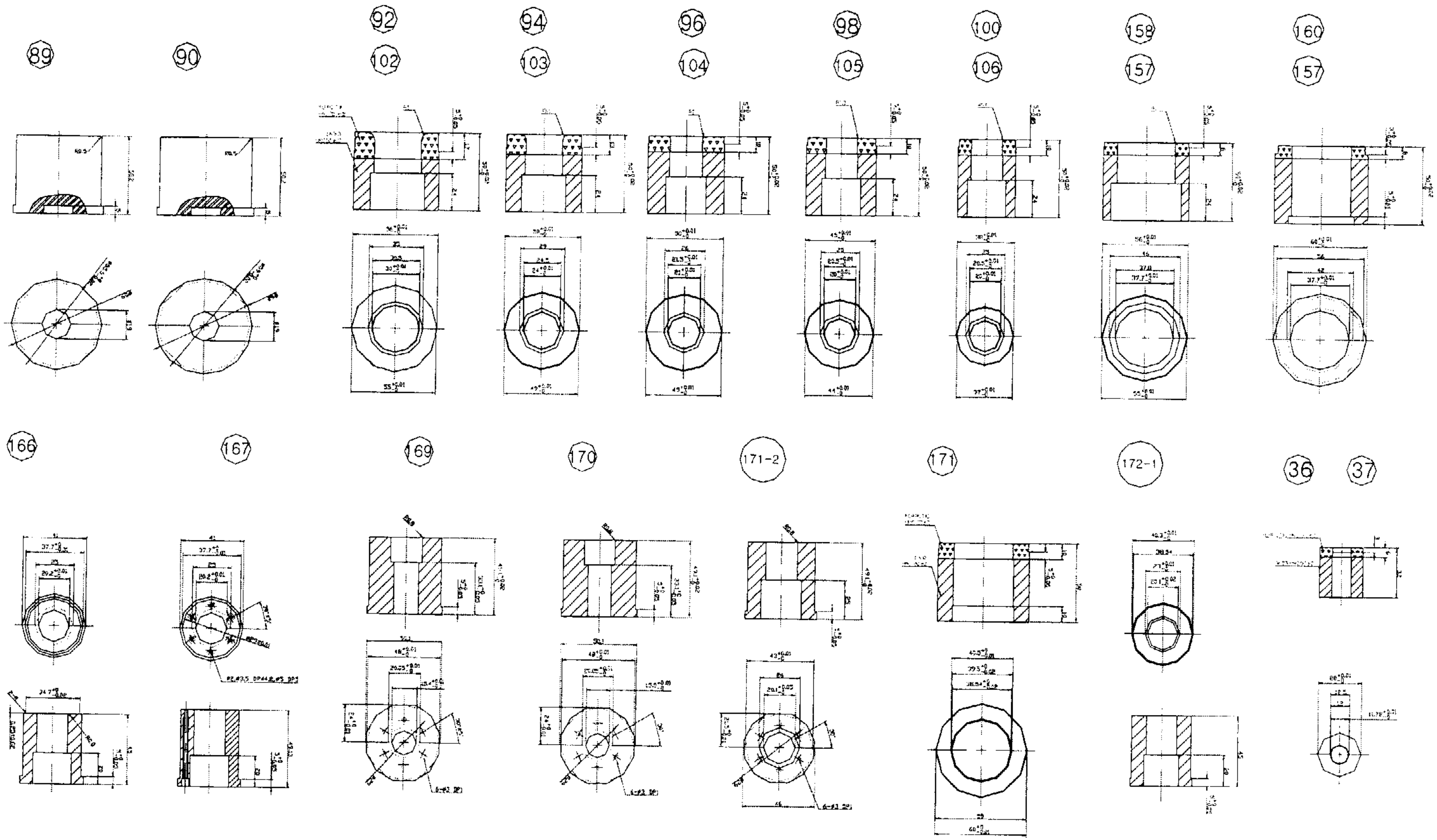


Fig.21 Die component drawing of punch and die insert system

The material lists of die components is shown in table 7. Especially attention of this table, a lot of components have the hardness of Rockwell test as a feature of ultra precision die for long run operation of press working with mass production.

Table 7 Material List of die components

No	Description	Material	Size	MEMO	QTY	No	Description	Material	Size	MEMO	QTY
28	Backing Plate	SK3	49*110*16	HRC58±2	1	105	Drawing Die	Ferrotic		HRC72±2	1
29	Piercing Punch	SKD11	ø12,5*84	HRC62±2	1	106	Drawing Die	Ferrotic		HRC72±2	1
36	D.P. Insert	Ferrotic		HRC72±2	1	111	Upper Backing Plate	SK3	320*180*8	HRC58±2	1
37	D.P. Insert	SKS3		HRC60±2	1	112	Punch	Plate	320*180*28		1
40	Stripper Plate	SKS3	49*180*33	HRC60±2	1	113	Die Plate	SKD11	320*180*50	HRC62±2	1
58	Die Plate	SKD11	131,5*180*50	HRC62±2	1	114	Lower Backing Plate	SK3	320*180*10	HRC58±2	1
59	Lower Backing Plate	SK3	131,5*180*10	HRC58±2	1	115	Drawing Punch	SKD11	ø36,8*70,5	HRC62±2	1
60	Die Plate	SKD11	262*180*50	HRC62±2	1	118	Punch	SKD11	ø39*70,5	HRC62±2	1
60-1	Lower Backing Plate	SK3	286*180*10	HRC58±2	1	121	Upper Backing Plate	SK3	316,5*180*8	HRC58±2	1
60-2	Die Plate	SKD11	25*180*50	HRC62±2	1	125	P.P. Insert	SKD11	ø48*55	HRC62±2	1
63	Upper Backing Plate	SK3	211*180*8	HRC58±2	1	128	Punch	SKS3		HRC70±2	1
64	Punch Plate	SKS3	211*180*28		1	133	Upper Backing Plate	SK3	131,5*180*8	HRC58±2	1
66	Stripper Plate	SKS3	211*180*20	HRC60±2	1	134	Punch Plate	SKS3	131,5*180*28		1
67	Die Plate	SKD11	211*180*50	HRC62±2	1	136	Stripper Plate	SKS3	131,5*180*16	HRC60±2	1
68	Lower Backing Plate	SK3	211*180*10	HRC58±2	1	137	Stripper Plate	SKS3	262*180*16	HRC60±2	1
73	Drawing Punch	SKH9		HRC61	1	138	P.P. Insert	SKS3	ø44*67	HRC60±2	1
75	Drawing Punch	SKH9		HRC61	1	139	Punch	Ferrotic		HRC72±2	1
76	Drawing Punch	SKH9		HRC61	1	140	P.P. Insert	Ferrotic	ø44*67	HRC60±2	1
77	Drawing Punch	SKH9		HRC61	1	141	Punch	SKD11		HRC62±2	1
78	Drawing Punch	SKH9		HRC61	1	142	Punch	SKD11	ø24*77	HRC62±2	1
81	Circular Lancing Punch	SKD11	ø55,5*60	HRC62±2	1	144	Punch	Ferrotic		HRC72±2	1
82	Circular Lancing Punch	SKD11	ø59*60	HRC62±2	1	145	Punch	SKD11	ø18,95*67	HRC62±2	1
84	Stripper Plate	SKS3	222,5*180*16	HRC60±2	1	156	Punch Plate	SKS3	285*180*28		1
84-1	Stripper Plate	SKS3	96,5*180*16	HRC60±2	1	157	D.P. Insert	SKD11	ø61*50	HRC62±2	1
85	Stripper Plate	SKS3	49*250*30	HRC60±2	1	158	Drawing Die	Ferrotic		HRC72±2	1
92	Drawing Die	Ferrotic		HRC72±2	1	158-1	Drawing Die	SKS3		HRC60±2	1
94	Drawing Die	Ferrotic		HRC72±2	1	165	D.P. Insert	Ferrotic		HRC72±2	1
96	Drawing Die	Ferrotic		HRC72±2	1	166	D.P. Insert	SKD11	ø41*45	HRC62±2	1
98	Drawing Die	Ferrotic		HRC72±2	1	167	D.P. Insert	SKD11	ø41*49,13	HRC62±2	1
100	Drawing Die	Ferrotic		HRC72±2	1	169	D.P. Insert	SKD11	ø51*49,1	HRC62±2	1
102	Drawing Die	Ferrotic		HRC72±2	1	170	D.P. Insert	SKD11	ø51*49,1	HRC62±2	1
103	Drawing Die	Ferrotic		HRC72±2	1	171	D.P. Insert	SKD11	ø46*50	HRC62±2	1
104	Drawing Die	Ferrotic		HRC72±2	1	172	D.P. Insert	SKD11		HRC62±	1

5. Die Making and Its Consideration

Fig.22 shows the progress of CNC machining center working. Fig.23 shows the press die working system. Fitting tolerances are very careful factors for die making because whole die assembling method must be within fine alignment of punch and die activities for the symmetrical equalized to the left and right side each other.[1~6] In this study, we used ordinary machine tools, CNC machine tools, wire cut EDM, etc. On the accuracy of each fitting component, the first consideration is that the guide bush and guide post(outer or inner) tolerances are H7(hole) h6(shaft) for a side fitting and the die set and guide post tolerances are H7(hole) p5(shaft) for a tight fitting. Punch plate and punch tolerances are H7(hole) m6(shaft) for a tight fitting with minor interference. The second consideration is stripper and the punch tolerances are H7(hole) h6(shaft) too. Die inserting hole and die insert button are H7(hole) and m6 for tight fitting with minor interference.[6,7] Fig.24 shows the wear amount of die materials.

In this figure we can select the adaptive die block material STD11 and die inserts material Ferrotic is available to the punch and die characteristics in this case of ultra precision die. 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 are included 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 and mirror machine tool see at the Fig.25.[9~13]

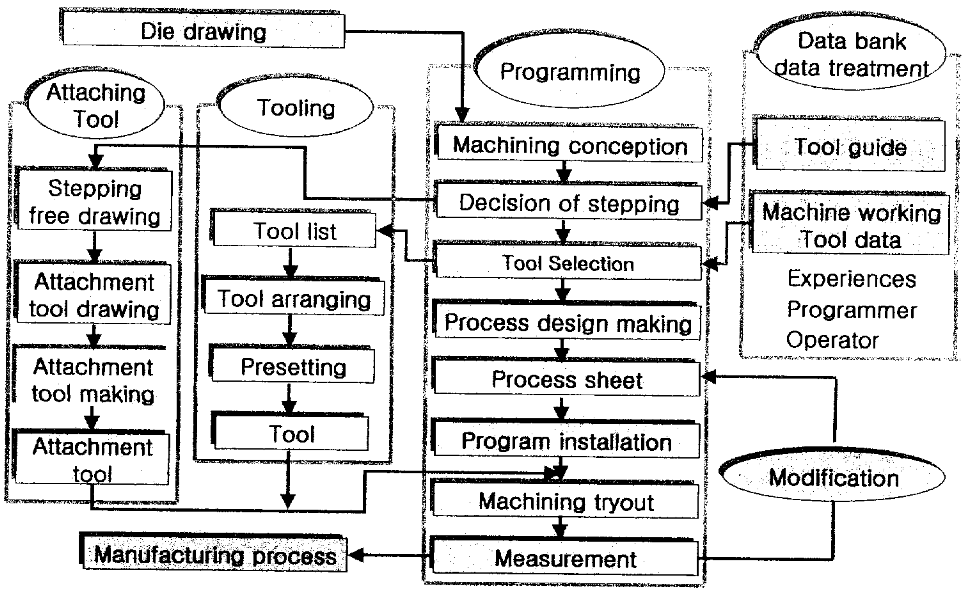


Fig.22 Progress of CNC machining center working

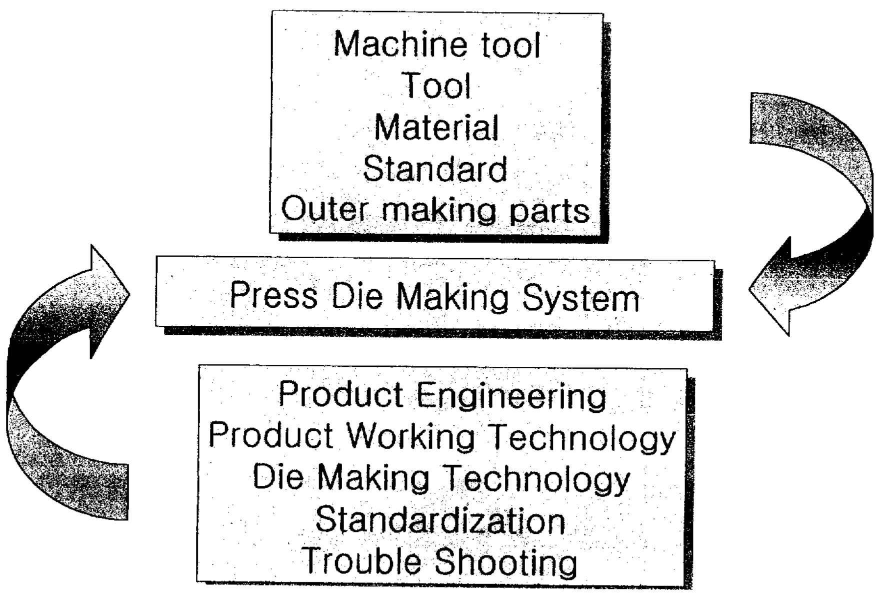
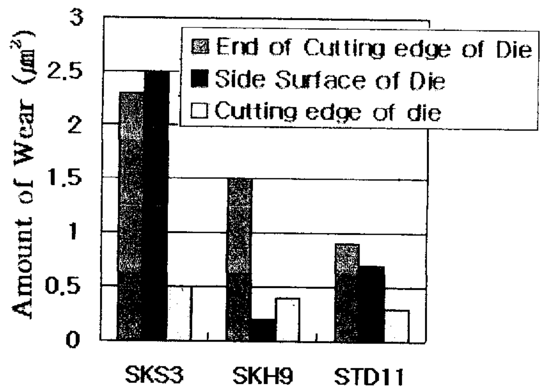
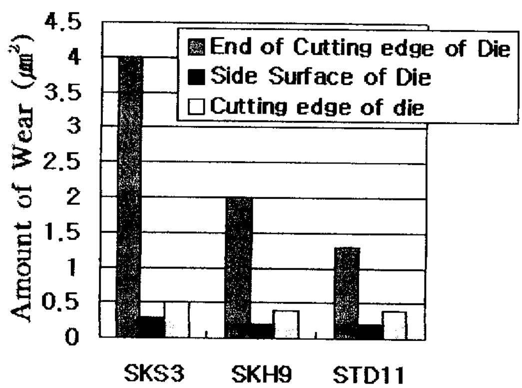


Fig.23 Press die making system



(a) Effect of tool steels by punch wear



(b) Effect of tool steels by die wear

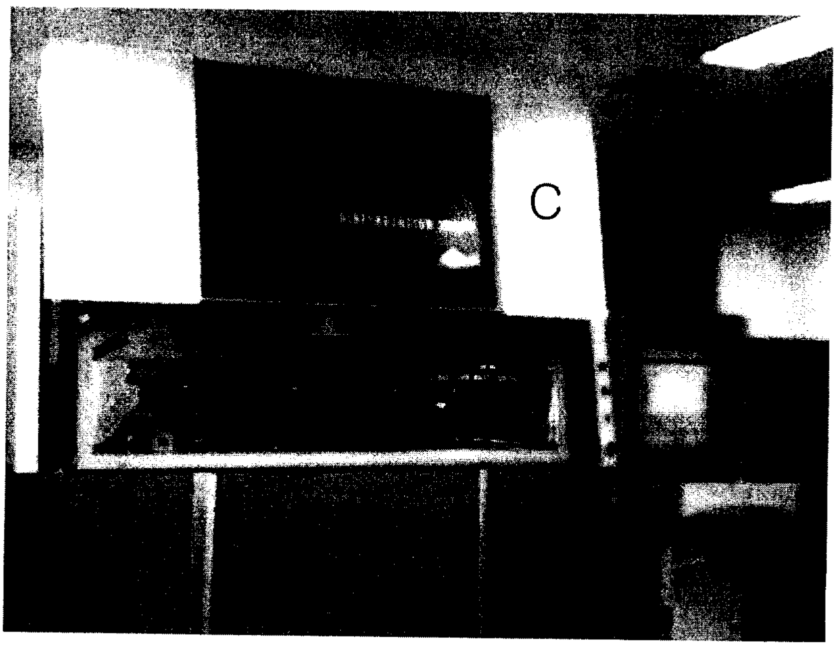
ϕ10 blanking, H_RC61(punch, die)

Bainite steel, 10% clearance-lubrication

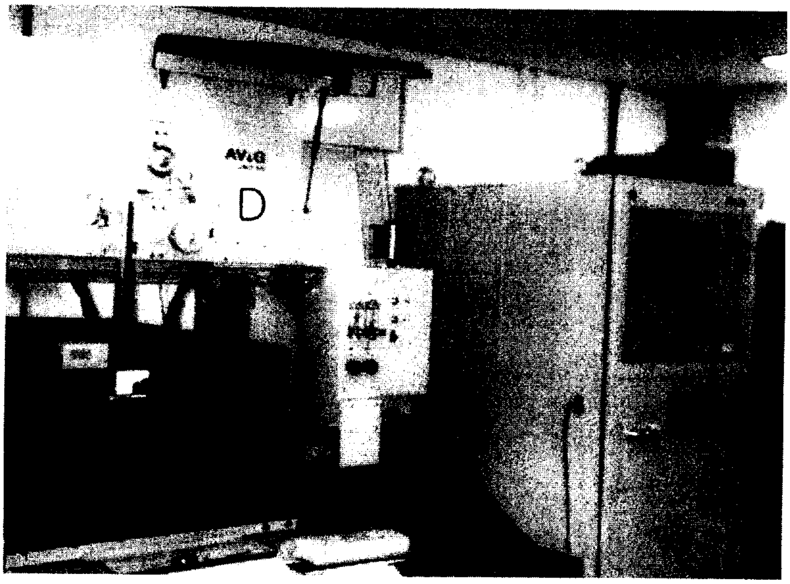
Counting of production part : 10,000

Fig.24 Comparative materials of punch and die [9)]

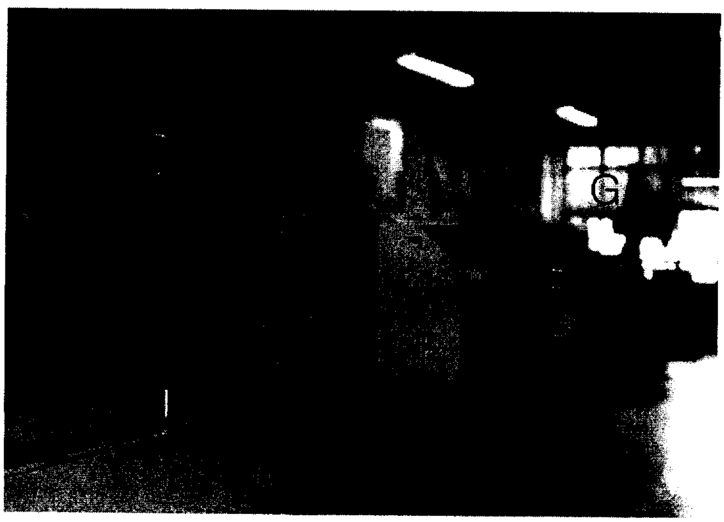
(a) Machining center(A) and cylindrical grinding machine(B)



(b) Rapid profile laser machine (C)



(c) Wire electric discharge machine (D)

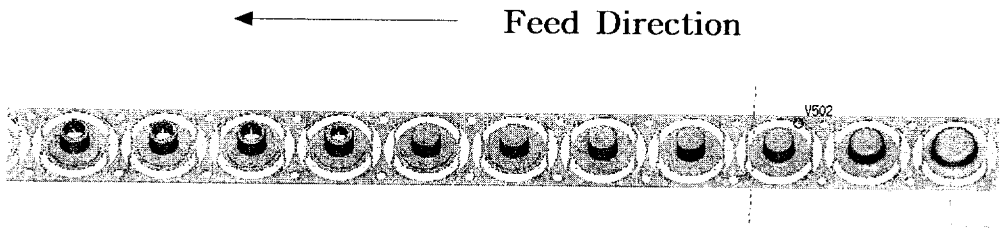


(d) Wire cut(E), turning m/c(F) and power drilling m/c(G)

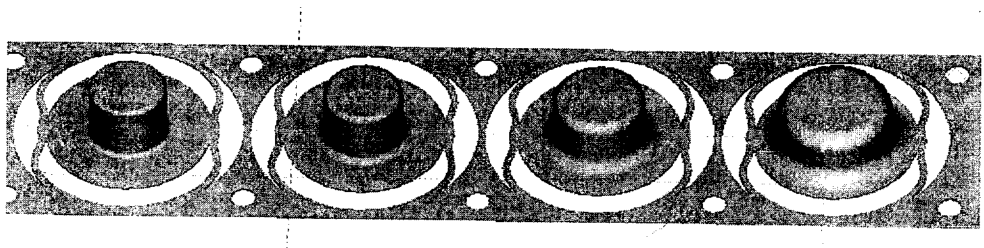
Fig.25 Die making machine tools

6. Result of Tryout and Its Consideration

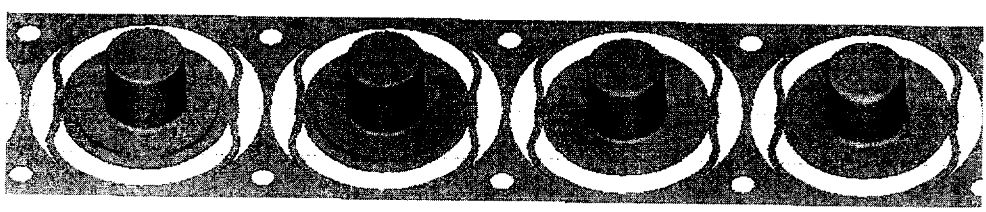
Fig.26 shows the result of strip process layout modeling by I-DEAS, also Fig.27 shows the actual strip process result from tryout working. In this actual process strip, we could confirm the real process for making the production part. Also we checked every size of production part with tolerance control.
We could find the jamming problem while the material strip feeding through the guide tunnel of the front gage and back gage method on the die block surface.
Also, when the material strip passes through the tunnel, the operation roll feeding device must be checked very exactly. The trouble shooting of this problem comes from die setting skill and technology. Furthermore, the production part from tryout was very fine by inspection, too.
At this time, the check of die failures was performed through the production part and actual strip of every stage with punch and die edge by the checking and measuring with fin instrument.
We considered that all of the failures cause are associated those stresses present in the die.
Fig.28 shows the result of production part modeling by I-DEAS also Fig.29 shows the actual producted part by tryout. Through the comparison of Fig.28 and Fig.29, we considered that both figure have minor outstanding on the production part dimensions and its accuracy.[9~13)]



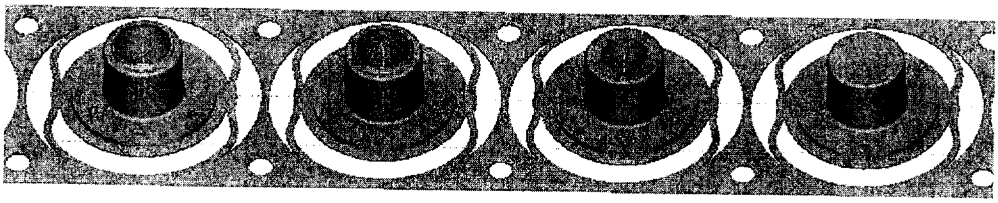
(a) 4~14 stage of strip process layout modeling



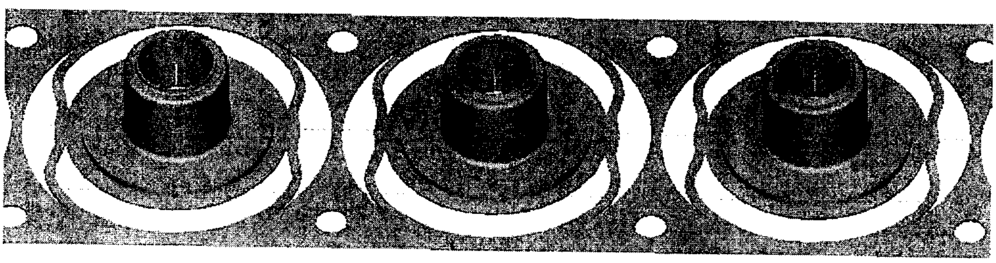
(b) 4~7 stage of strip process layout modeling



(c) 7~10 stage of strip process layout modeling



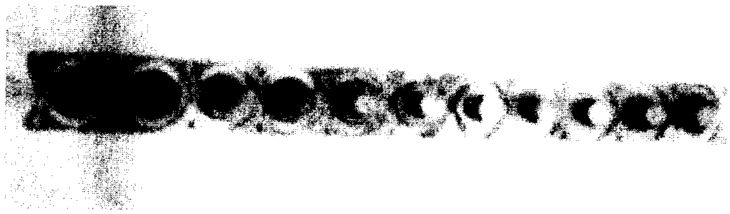
(d) 10~13 stage of strip process layout modeling



(e) 12~14 stage of strip process layout modeling

Fig.26 Result of strip process layout modeling by I-DEAS

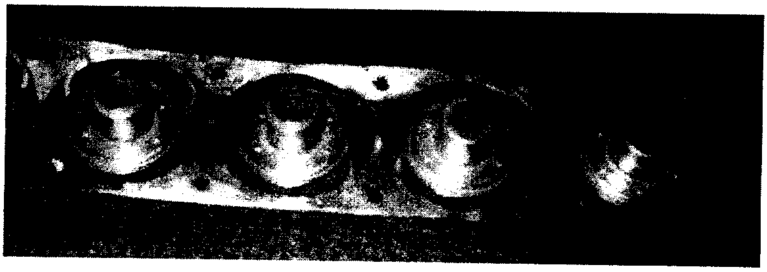
← Feed Direction



(a) 4~14 stage of actual strip process layout

(b) 4~7 stage of actual strip process layout

(c) 7~10 stage of actual strip process layout



(d) 10~13 stage of actual strip process layout

(e) 12~14 stage of actual strip process layout

Fig.27 Result of actual strip process layout by tryout

Fig.29 shows the result of tryout namely real production part. In this result, we considered that the shape and size with tolerance were satisfied.

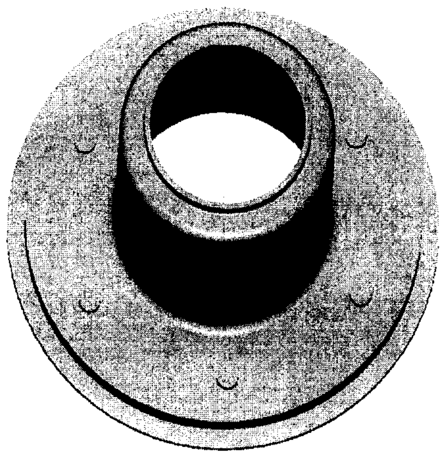


Fig.28 Result of production part modeling by I-DEAS

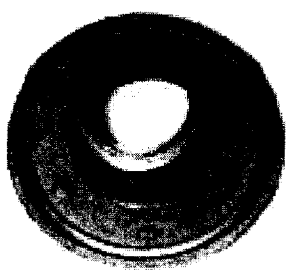


Fig.29 Actual producted part by tryout

7. Conclusion

In order to prevent the defect occurred of die design and making, this study developed the practical and adaptive die assembling and its components.
This study could be carried out by the theoretical back ground, data base and our field experiences.
The result are as follows;

(1) The data base and practical experiences were adaptable for die design comparatively.
(2) The result of high quality production part can be obtained from die design to its making through the modeling and FEM analysis.
(3) Computer aided die design was adaptable for die design because it could have prediction to prevent die making failure.
(4) The split die making system was effective for die assembling function and trouble shooting.
(5) For the continuous die assembling function's increasing, the revision of die components were necessary with die components accuracy on the tryout progress.

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Development of Multi Forming Type Progressive Die for STS 304 Sheet Metal

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Abstract

The progressive die are multiple operations performed by means of a die having above two stages, on the each of stages performs a different operation as the sheet metal passes through the die tunnel.

In the field of design and making tool for press working, the progressive die for sheet metal (STS 304, thickness :0.5㎜) is a specific division. In order to prevent the defects, the optimum design of the production part, strip layout, die design, die making and tryout etc. are necessary They require analysis of many kinds of important factors, i.e. theory and practice of metal press working and its phenomena, die structure, machining condition for die making, die materials, heat treatment of die components, know-how and so on. In this study, we designed and constructed a progressive die of multi-stage and performed try out. Out of these processes the die development could be taken for advance. Especially the result of tryout and its analysis become the characteristics of this paper that nothing might be ever seen before such as this type of research method on all the processes.

감사의 말씀

저의 논문을 처음부터 완성될 때까지 많은 조언과 지원을 아끼지 않으시고 도와주신 심성보 지도 교수님께 먼저 깊은 감사의 말씀을 올립니다.

그리고 바쁘신 중에도 저의 논문에 대해 사려 깊은 조언을 해주신 오세규 교수님과 김병탁 교수님께 또한 감사 드립니다.

또한 저의 논문에 도움을 주신 다이테크 조규성 사장님과 임재영 형님께 감사 드립니다. 그리고 바쁜 학교생활 속에서도 저에게 많은 힘과 도움을 준 이성택, 송영석, 장찬호, 권광진 형, 황시현 조교선생님, 실험실 부원들과 친구인 정태, 동학, 상훈, 진우, 병훈 상민 그리고 주위의 많은 친구들과 사랑하는 귀남이 에게도 이 작은 결실을 함께 나누고 싶습니다.

끊임없는 지도와 조언, 격려를 주신 기계공학부 교수님과 조교 선생님께도 깊은 감사 드리고, 항상 저의 뒤에서 든든한 배경이 되어 주신 저의 부모님과 군대에 있는 자랑스런 동생에게도 감사하며 이 기쁨을 같이 하고 싶습니다.

2002 年 2 月

성 열 민 拜上