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DESIGN AND DETAILING OF THE FINE BLANKING TOOL FOR A SHEET METAL CAM: A CONCEPTUAL DESIGN PLAN

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ABSTRACT

Fine blanking technology is a metal forming process of a press working technique which makes it possible to produce in one single operation, precise finished components cleanly sheared over the whole material thickness, with close dimensional tolerances and free from fractures and cracks in their functional areas. Secondary operations, such as milling, grinding, broaching or drilling can be eliminated.

. The fine blanking technology of cam is analyzed by the drawing taken, its blank layout was designed, the fine blanking force is calculated , the fine blanking die clearance and rounded edge is determined. The fine blanking compound die structure is designed; the materials and heat treatment specifications of fine blanking die parts are selected. By adopting fine blanking technology, not only improve product quality, but also significantly reduce the mechanical processing time. Thus the product cost would be lowered and the production efficiency increased. Fine blanking technology has wide application prospects.

Keywords- *cam, fine blanking technology, fine blanking compound die*

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1. BASIC CONCEPT DESIGN

Fine blanking technology developed on the basis of ordinary blanking is an advanced technique, it can be obtained that good quality fine blanking components than conventional blanking part of small dimensional tolerances, high geometric accuracy, punching surface smooth, smooth surface and good vertical and interchangeability in a press trip. It is a high quality, high efficiency and high value-added processes. The cam part is shown in figure its material is SS41 steel, thickness 6mm, dimensional accuracy and surface roughness requirements higher. Cam is one of the key components in the automation equipment. Traditional processing method was machining all shape of a cam , or punching in the ordinary blanking and then finish turning round hole and grinding cam profile in a special fixture devices and so on. The disadvantage of these processes was low production efficiency, unstable product quality and poor consistency. To this end, the fine blanking process of cam was studied and the fine blanking compound

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die used in the general press based on conventional blanking process designed. Part after forming is no longer needed to grind outer surface and finish turning round hole, the dimensional accuracy and surface roughness can meet the technical requirements, production efficiency and product quality are greatly improved.

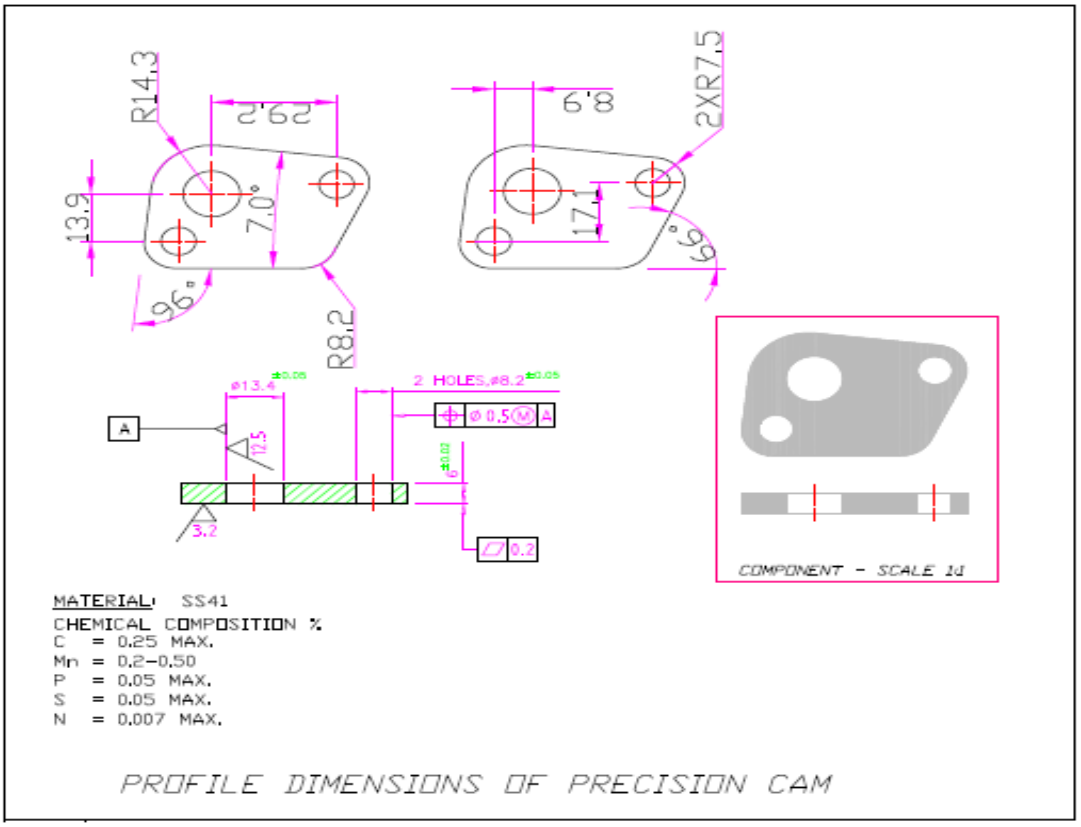

Fig. 1 (a) cam part

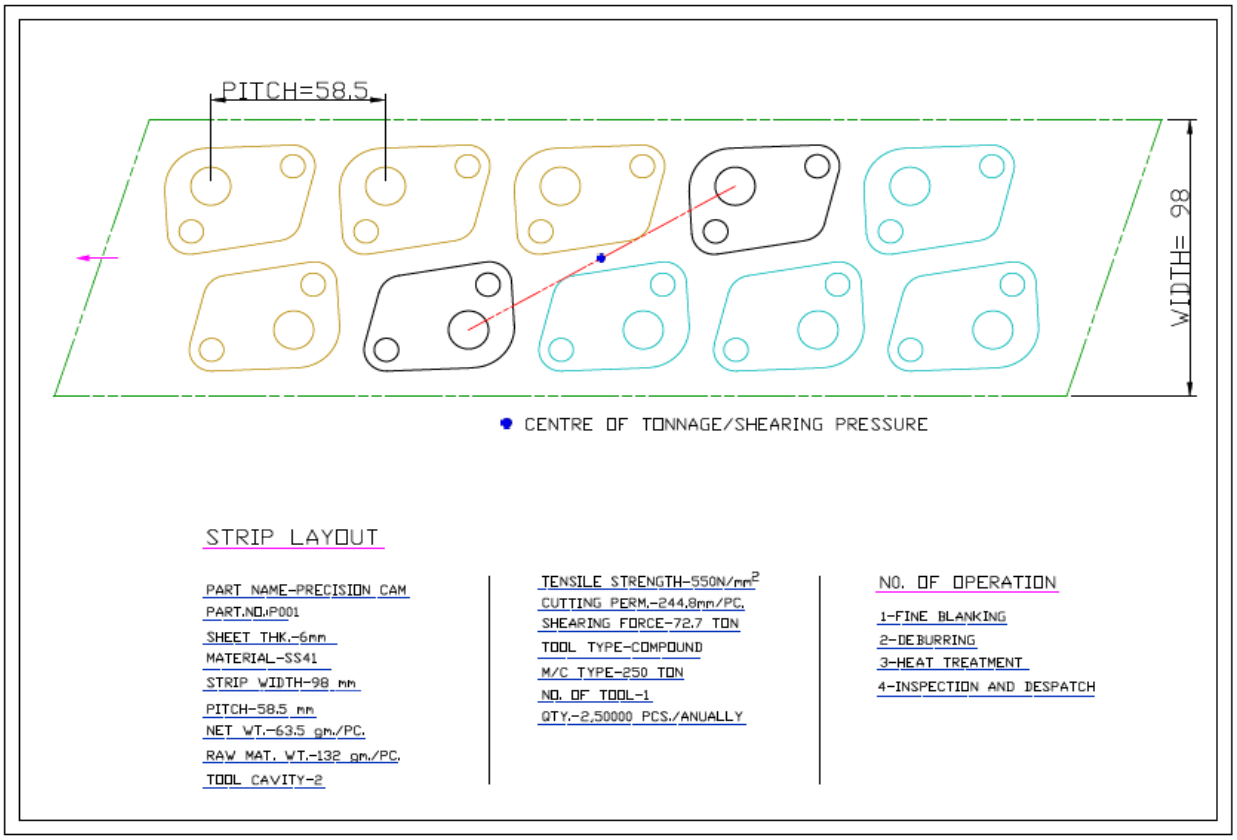

Fig. 1 (b) cam part Layout

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2. Process design of Sheet Metal Cam through Fine Blanking Compound Die

2.1. Layout design

Layout refers to arrangement of the work piece on the sheet, layout is closely related to part quality and economy. Therefore, when layout is made not only to consider the utilization of materials, but also consider the feasibility of achieving fine blanking process.

The boundary of layout map is an important factor influential on fine blanking part section quality, it has the right size. If its value is too large, it can help to improve the section quality of fine blanking part, but the material utilization is low. Too small, it can not play a role. The factors of influence on the size of the boundary value are mechanical properties of materials, material thickness, shape and size of parts, layout form, the way of sheet transporting or stopping and so on. For the cam part, considering the above factors and refering to relational references the Layout design is made. The cam layout is shown in figure 1(b).

2.2. Fine blanking force calculation

Fine Blanking Force is the total pressure needed for shearing the part from the strip. It is the main basis for the selection of fine blanking press and also the necessary data for the fine blanking die design.
The blanking force can be estimated according to the following formula, $P_1=Lt\tau=0.9LtR_m$
Where, L - circumference of fine blanking parts, including the outer perimeter L_1 and the inner L_2
$L=L_1+L_2=151.17+93.63=244.80$ mm per piece
t - sheet thickness of fine blanking part, $t = 6$mm;
R_m-the tensile strength limit, SS41 steel $R_m=550$N/mm^2.
Therefore, $P_1=0.9LtR_m=0.9\times244.80\times6\times550=727.05$KN per piece $=72.7$ Ton per piece

2.3 *Determination of binder force or V-Ring indenter force*

The size of binder force of the gear plate directly affects the quality of cut section. If it is too small, it is prone to tear defects; too large, the friction increases, the punch would cause damaged, which affects the life of fine blanking dies. The binder force P_2 can be calculated according to the following formula
$P_2=4LhR_m$
Where, L- the total length of the work piece outer and inner cutting edge, $L=244.80$ *mm*;
h - V-Ring height = 0.8mm, the main function of V-Ring is to prevent the metal outside the shear zone to flow with the punch in the process of shear, thus generating compressive stress in the shear zone.
R_m-the tensile strength limit, SS41 steel $R_m=550$MPa
Therefore, $P_2=4LhR_m=4\times244.80\times0.8\times550=430.85$ KN per piece = 43.08 Ton per piece.

2.4 Determination of anti-stress or counter force

Fine blanking counter force is the main factor which influence on the part smoothness of cut section. Smaller counter force will affect the dimensional accuracy, flatness and cut section quality and increases the load on the die, thereby reducing the die life. Larger the counter force will not only increases the flatness of the work piece, but also have improves the dimensional accuracy of the parts, blanking angle and cut section quality, but too much counter force can cause the damage of the die. In general it is 20% of the blanking force.
Therefore, $P_3=0.2P_1=0.2\times727=145.4$ *KN*.
Total force of the fine blanking is, $P=P_1+P_2+P_3=727.05+430.85+145.4=1303.3$ *KN* = 130.3 Ton per piece

2.5 *Press selection*

According to the total force of the fine blanking, selection of press machine is determined. The press is selected as per the nearer availability and suitable to the calculated total force of the fine blanking operation. In the case of Cam, the calculated total force of the fine blanking is 130.3 Ton per piece and as per the layout, two pieces of Cam to be made from the sheet metal strip thus the total force for two pieces is 2 x 130.3 = 260.6 Ton. Hence the press machine selected for the fine blanking operation of Cam is of 250 Ton capacity

2.6 *Determination of clearance*

Die clearance in Fine blanking operation is one of the important parameters to ensure parts to achieve the fine blanking shearing action. The significant difference of fine blanking and conventional blanking is that the clearance of fine blanking is very small. Size of the clearance and its uniformity along the peripheral edge are the main factors that affect the quality of fine blanking parts and die life. It is related to the nature of material, material thickness, the shape of work piece and other factors. Blanking clearance is $t\times0.5\%=6\times0.5\%=0.03mm$, punching clearance is $t\times0.625\%=6\times0.625\%=0.0375mm$

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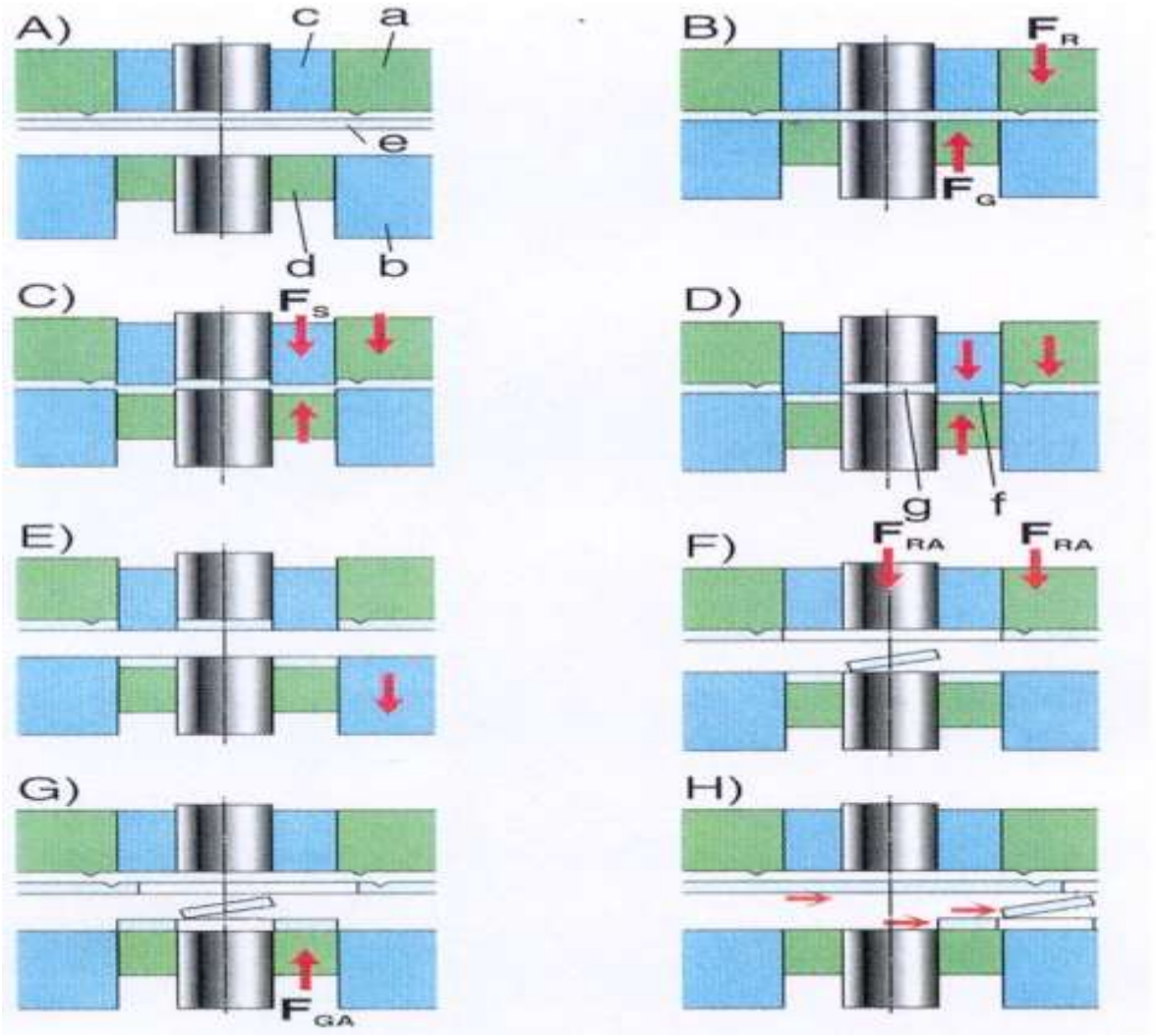
3. Process Sequence of Fine Blanking Operation

A Guide plate
B Die-plate
C Punch
D Ejector
E Work material
F Fine blanked part
G Inner form slugs

FG : Counterforce
FGA: Ejector force
FR : V-Ring force
FRA : Stripping force
Fs : Blanking force



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4. Design of the fine blanking die structure and other work elements

The Fine Blanking die is the main technology device/equipment used in precision stamping production, the quality of fine blanking parts is directly related to the quality of die design. It has a close relationship to the quality and accuracy of fine blanking parts, part productivity and economic efficiency, mold life and operational safety etc. Therefore, the die design must be reasonably and properly. Punch, die and other work parts of fine blanking die are important to ensure the quality of the fine blanking components (ex: The Cam). The shape and dimensional accuracy of die and punch are directly affect the fine blanking die clearance,thus the fine blanked parts. A reasonable choice of die material and heat treatment specifications should be made. In this design, the cam dimension are not too much, its structure is relatively simple, material has good hardenability, wear resistance and high strength and small quenching deformation may be appeared in punch and die.

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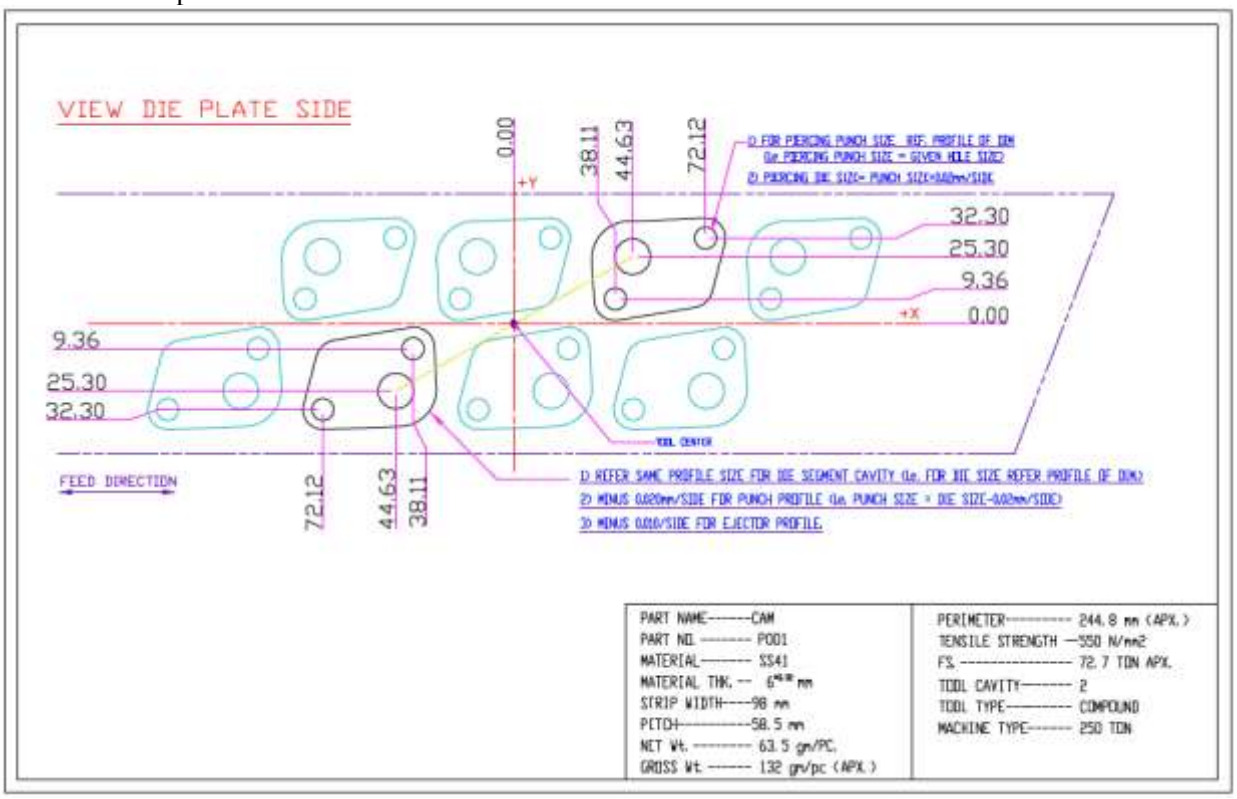
5. Cam Fine Blanking die structure Design (Die half and Punch half in open condition):

5.1 View- Die plate side



Tool centre is calculated from component(Cam) layout plan. It is the most important point treated as origin for die,punch,ejector and other parts of the fine blanking die.Taking this point as reference point other hole position of the entire assembly (die half as well as punch half) is determined so that there is no confusion while making each part undergone with different machining process and finally at the time of real assembly of all parts.It is also called as centre of pressure .

The view die plate side drawing (i.e. Top view of die half in open and lying on horizontal surface) is much important drawing for the designing of each parts of the entire assembly.It helps and avoid confusion to start the fine blanking die design i.e. assembly of die half and punch half. It also helps as a reference while making the die segments, blanking punch, ejector,piercing punches etc.

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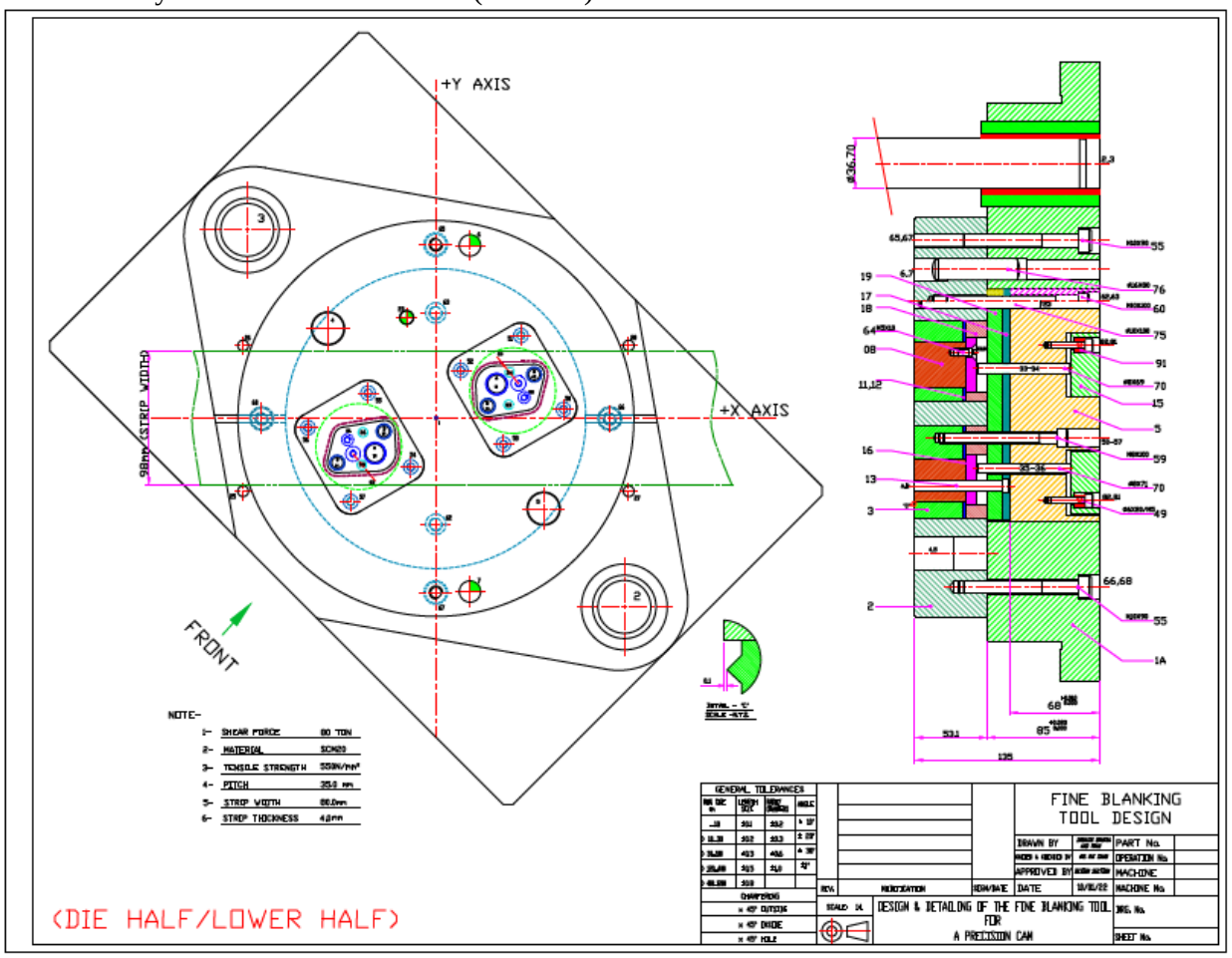
5.2 Assembly Structure of Lower Half (Die Half)



5.3 Assembly Structure of Upper Half (Punch Half)

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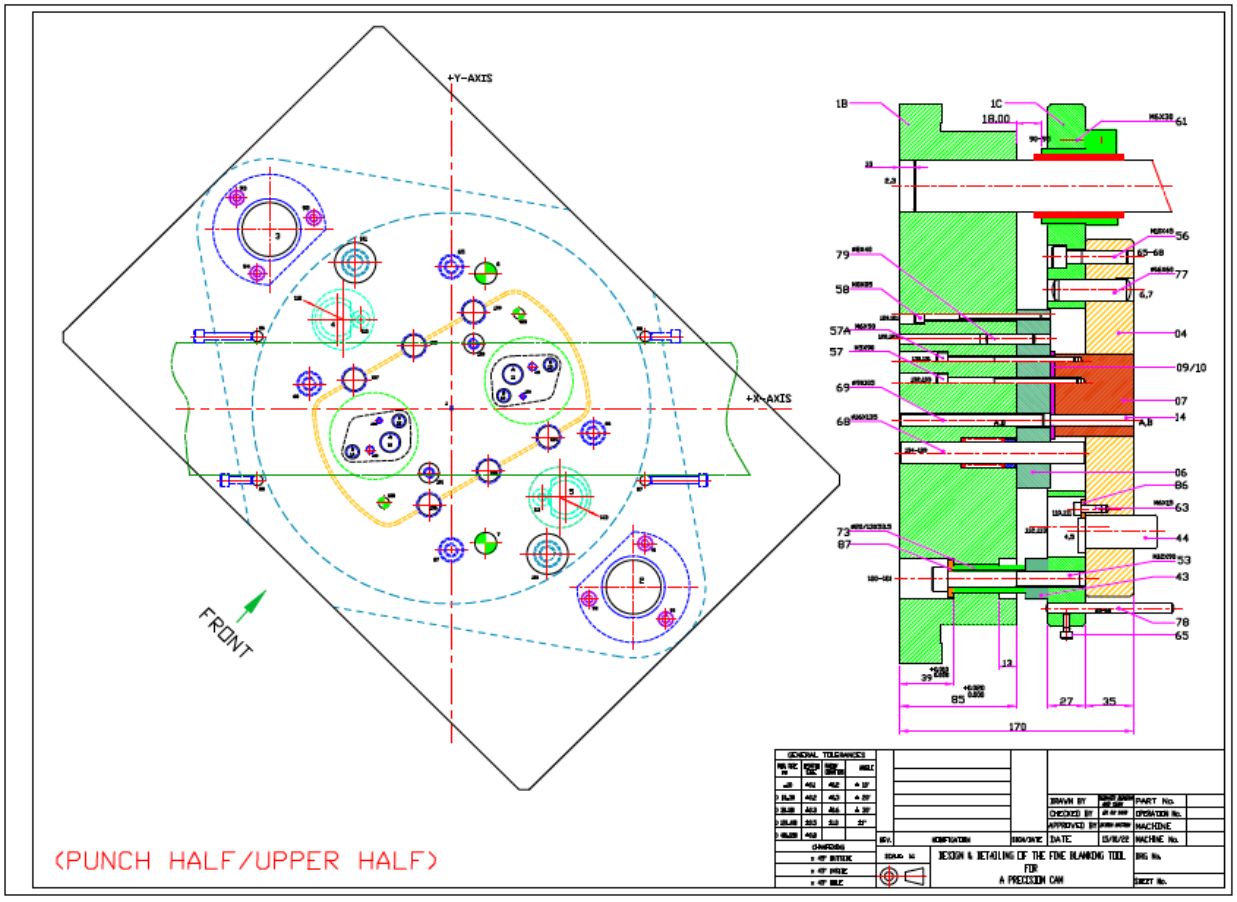
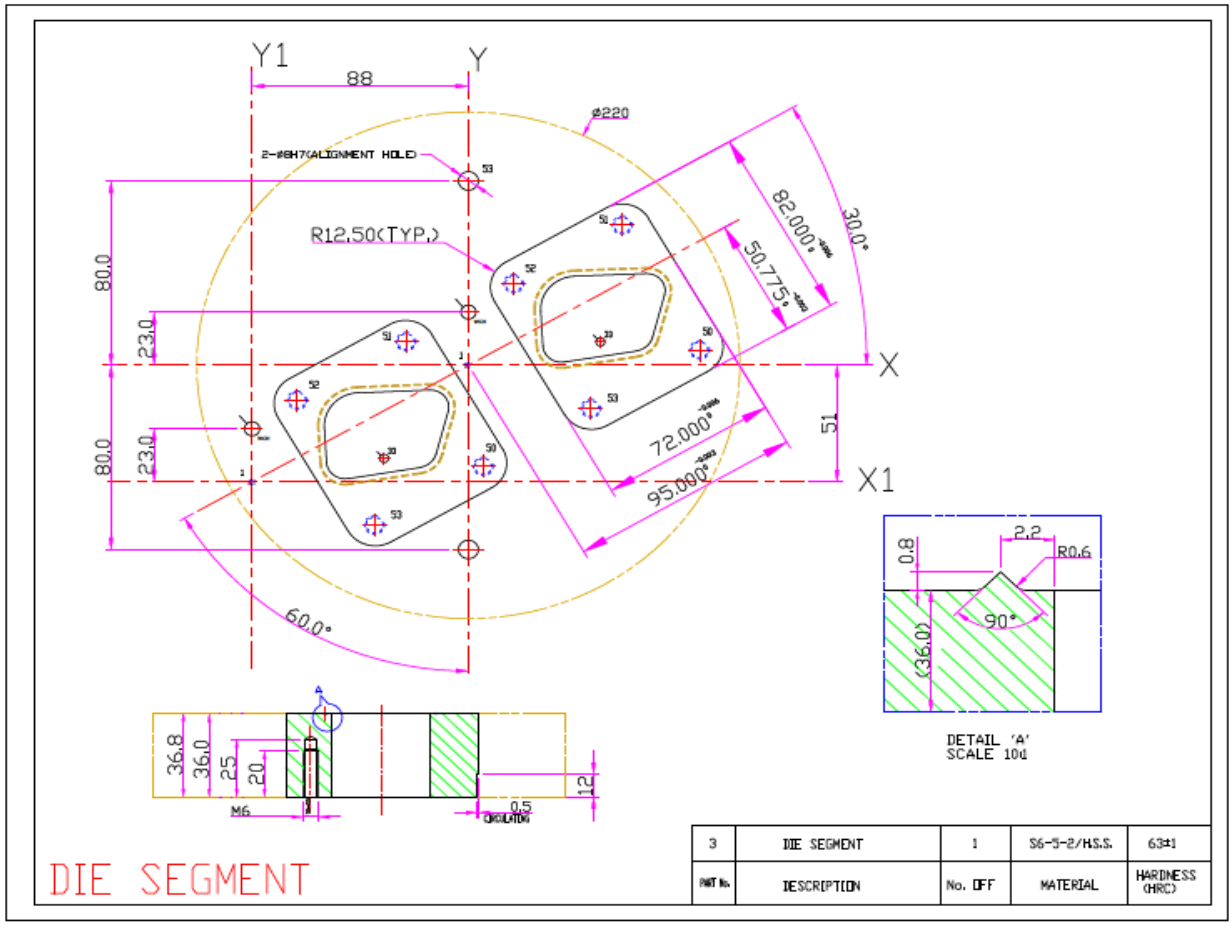


5.4 Die Segment



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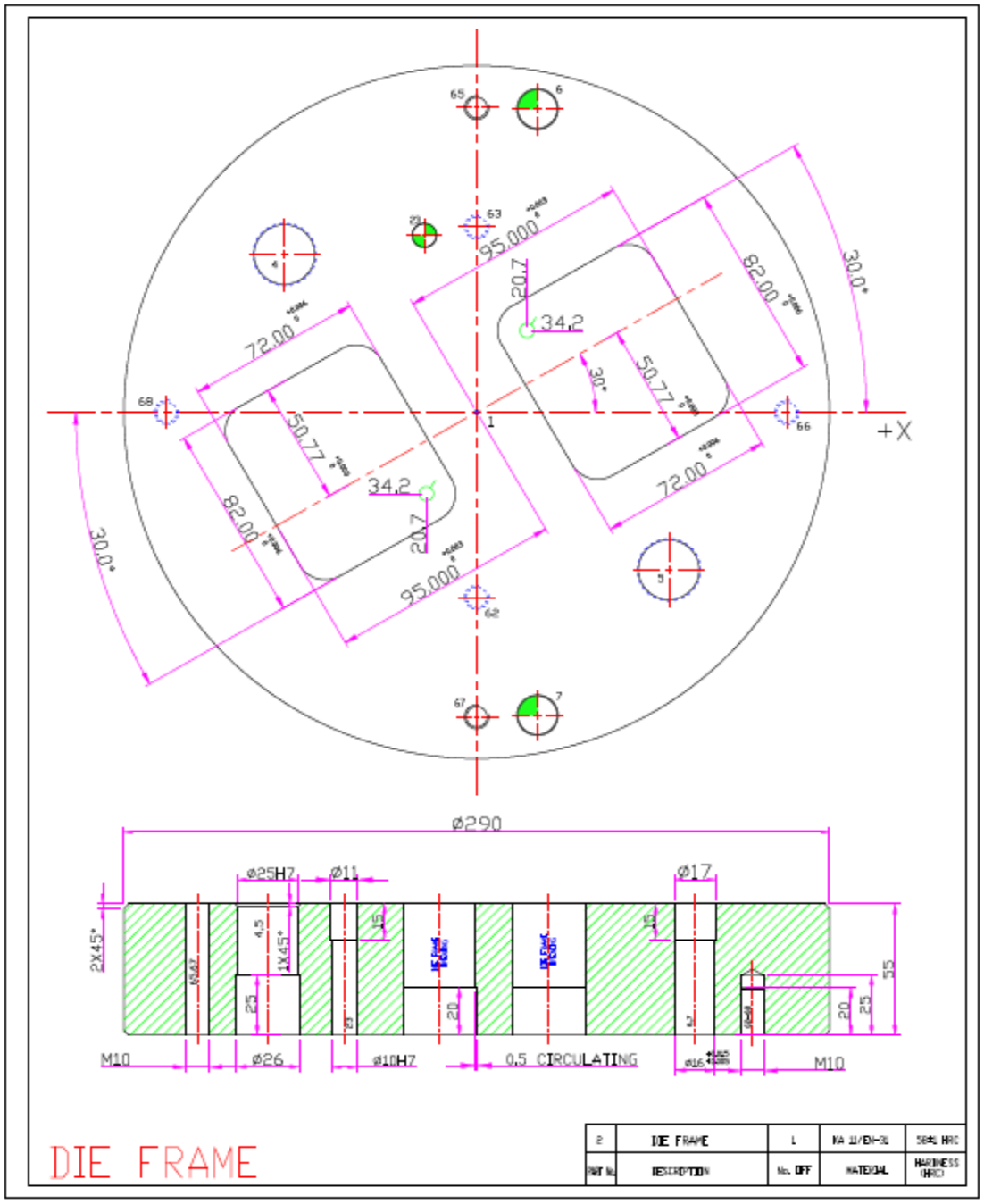
For making the V-Ring on the HSS material ,such reverse V-Ring is made on cupper electrode and the electrode is used in EDM of the HSS die segment. The blanking profile hole is made by wire cut EDM. The segments avail by cut out of the stock with the help of wire EDM operation. While making the die segment it should be focused on blanking profile as well as the segment outer cut profile.
For maintaining the accuracy of the segment size, it should be followed the grinding operation to achieve it.

5.4 Die Frame



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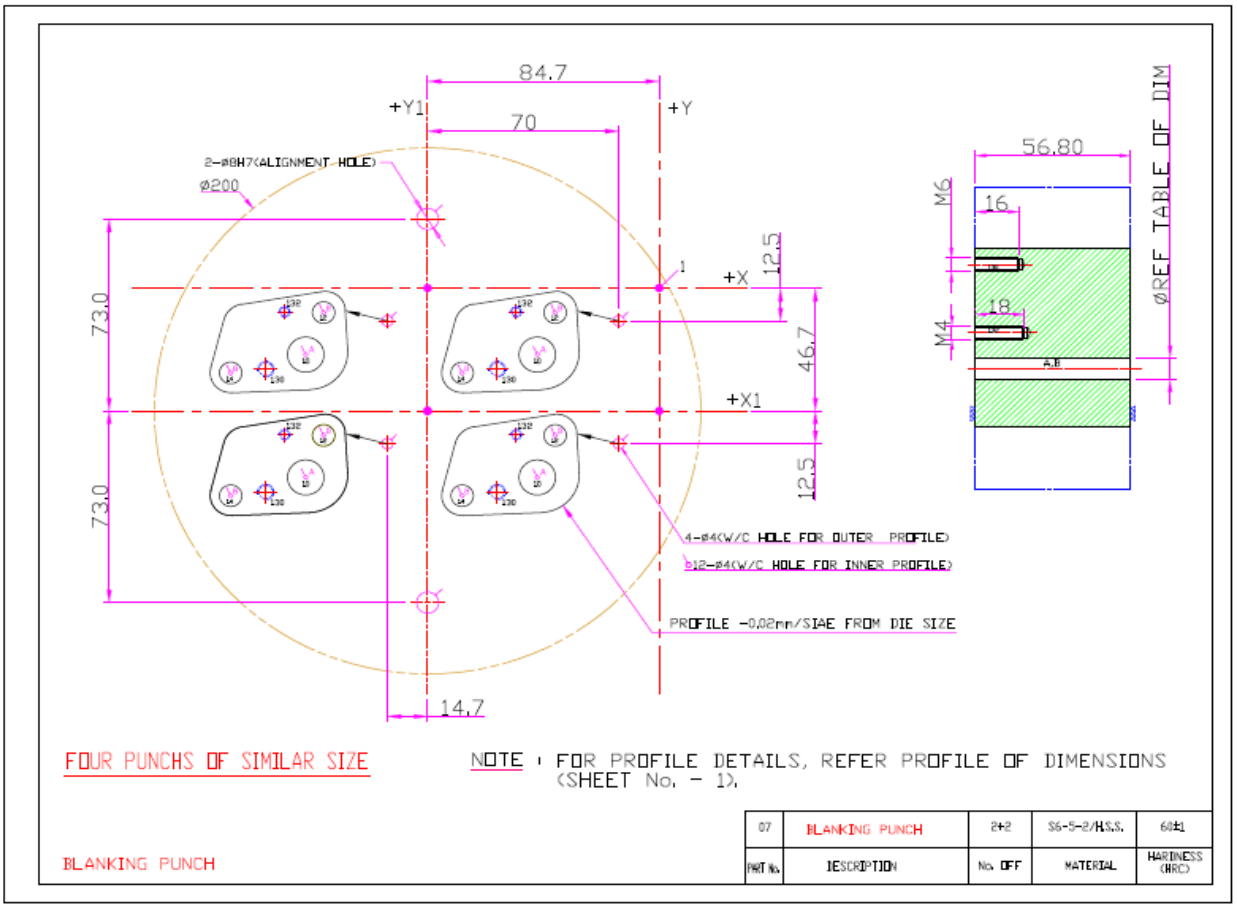
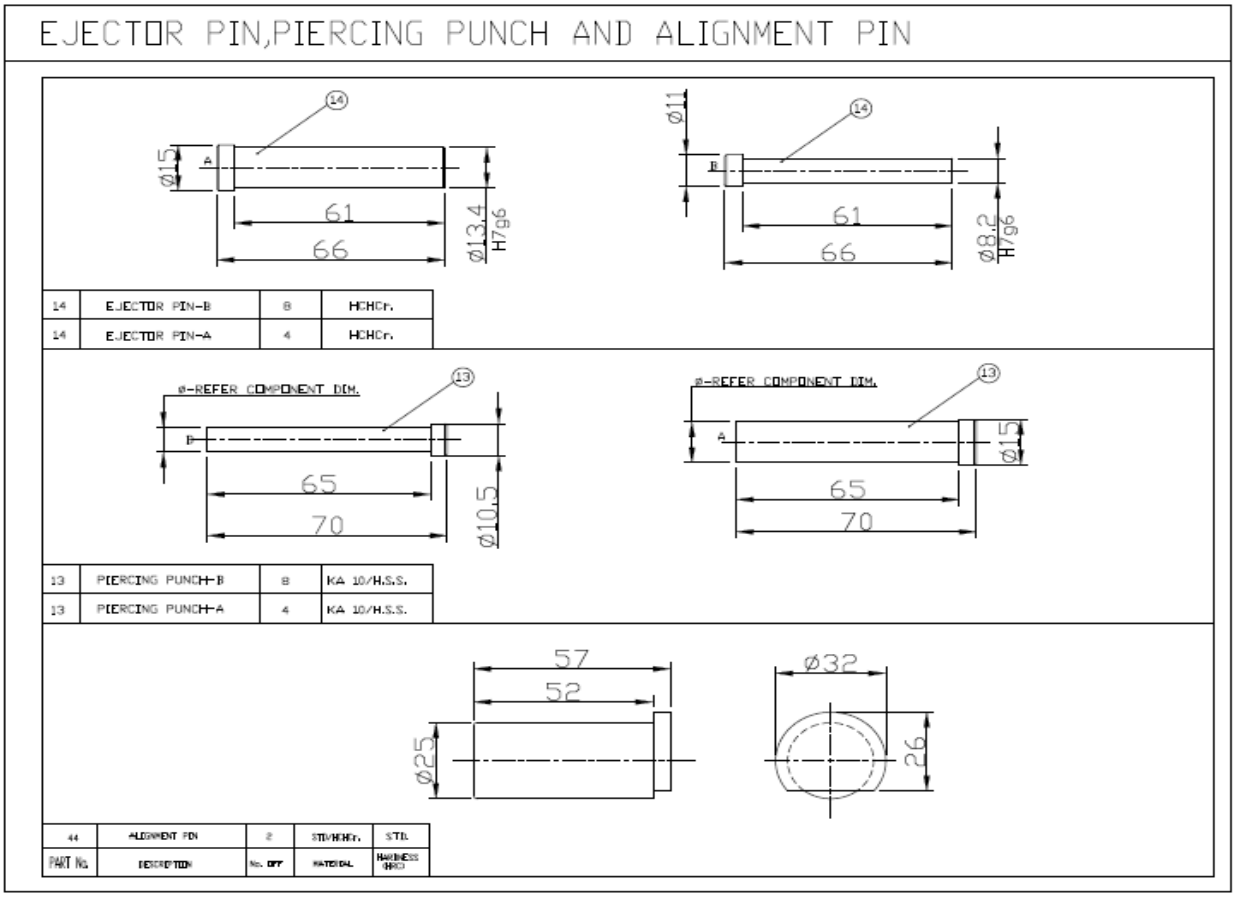
5.4 Blanking Punch



5.5 Piercing Punch, Ejector Pin and Alignment Pin



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5.6 List of Parts

PART LIST

S.No.	DESCRIPTION	No. OFF	MATERIAL	HARDNESS (HRC)	COATING	FINISH MATERIAL SIZE	REMARKS (STD.)	STD.NO.
19	DISTANCE PLATE	1	KA 08/HCHCr.	56±2		ø220X12		
18	DIE SEG.PAD	2	HCHCr	58±1		ø220X16		
17	PIER.PUNCH RET.PLATE	1	HCHCr	58±1		ø220X5		
16	EJECTOR PAD	2	HCHCr.	58±2		ø200x8		
15	PRESSURE PIN PAD	2	HCHCr.	56±2		ø63x22		
14	EJECTOR PIN-B	8	HCHCr.	56±2		ø1.1X66		
14	EJECTOR PIN-A	4	HCHCr.	56±2		ø1.5X66		
13	PIERCING PUNCH-B	8	H.S.S.	60±1		ø10.5X70		
13	PIERCING PUNCH-A	4	H.S.S.	60±1		ø15X70		
12	REGRINDING SHIM DIE	2	HCHCr.	56±2		ø220X5		
11	REGRINDING SHIM DIE	2	HCHCr.	56±2		ø220X3		
10	REGRINDING SHIM PUNCH	2	HCHCr.	56±2		ø64.5X5		
9	REGRINDING SHIM PUNCH	2	HCHCr.	56±2		ø64.5x3		
8	EJECTOR	2	HCHCr	58±1		ø200X39.8(For4pc)		
7	BLANKING PUNCH	2+2	H.S.S.	60±1		ø200x56.8(For4pc)		
6	PUNCH PRESSURE PAD	1	HCHCr	54±2		ø190X25		
5	BASE	1	HCHCr	54±2		ø220X68		
4	GUIDE	1	HCHCr	58±1		ø290X35		
3	DIE SEGMENT	1	H.S.S.	63±1		ø220x36.8		
2	DIE FRAME	1	HcHcr	58±1		ø290X55		
1H	BEARING CAGE	1	STD.			ø48/ø40X90L		
1G	BEARING CAGE	1	STD.			ø46/ø38X90L		
1F	BEARING BUSH	2	EN-353	62±1		ø65x94		
1E	GUIDE BUSH	2	EN-353	62±1		ø62x56		
1D	GUIDE PILLAR	2	EN-353	62±1		ø40/ø38x295		
1C	GUIDE PLATE	1	M.S.	–		480x330x27		
1B	UPPER SHOE	1	M.S.	–		480x330x85		
1A	LOWER SHOE	1	M.S.	–		480x330x81		
1	DIE SET	↓	↓	↓	↓	↓	↓	↓

GENERAL TOLERANCES

MIN SIDE m	LENGTH SIZE	HOLE DIAMETERS	ANGLE
..10	±0.1	±0.2	± 10'
> 10..30	±0.2	±0.3	± 20'
> 30..120	±0.3	±0.6	± 30'
> 120..400	±0.5	±1.0	±1°
> 400..1000	±1.0		

CHAMFERING
x 45° OUTSIDE
x 45° INSIDE
x 45° HOLE

REV. | MODIFICATION | SIGN/DATE

SCALE

DESIGN & DETAILING OF THE FINE BLANKING TOOL FOR A PRECISION CAM

FINE BLANKING TOOL DESIGN

DRAWN BY	[illegible]	PART No.	
CHECKED BY	[illegible]	OPERATION No.	—
APPROVED BY	[illegible]	MACHINE	
DATE	24/03/22	MACHINE No.	

DRG. No.

SHEET No.

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5.6 Position of Wire EDM holes with respect to origin (0,0)

HOLE POSITION NUMBER & COORDINATE VALUE FOR WIRE-EDM

POS. NO.	X	TOL.	Y
1	0.0		0.0
2	132.5826		-132.5826
3	-132.5826		132.5826
4	-83	±0.005	66
5	83		-66
6	25		100
7	25		-100
8			
9			
10	-44.625	±0.005	-25.296
11	44.625		25.296
12	-38.108		-9.362
13	38.108		9.3617
14	-72.117		-32.302
15	-72.117		32.302
16			
17			
18			
19			
20			
21			
22			
23	-21.50		74.00
24			
25	-141.25		-53.35
26	-141.25	±0.05	53.35
27	141.25		-53.35
28	141.25		53.35
29			
30			
31			
32			
33	53.40		10.15
34	54.20	±0.05	33.90
35	-54.20		-33.90
36	-53.40		-10.15
37			
38			
39			
40			
41			
42			
43			

POS. NO.	X	TOL.	Y
44			
45			
46		±0.05	
47			
48			
49			
50	93.65		6.65
51	62.35		60.85
52	18.30		35.40
53	49.60	±0.05	-18.75
54	-18.30		35.40
55	-49.60		18.75
56	-93.65		-6.65
57	-62.35		-60.85
58			
59			
60			
61			
62	0	±0.05	- 77.5
63	0		77.5
64			
65	0		127.5
66	127.5	±0.05	0
67	0		-127.5
68	-127.5		0
69			
70			
71			
72			
73			
74			
75		±0.01	
76			
77			
78			
79			
80			
81	-64.70		-15.50
82	64.70	±0.01	15.50
83	-60.60		-25.85
84	60.60		25.85
85			
86			

POS. NO.	X	TOL.	Y
87			
88			
89			
90	156.25		-156.25
91	141.25		-100.25
92	100.25	±0.05	-141.25
93	-156.25		156.25
94	-141.25		100.25
95	-100.25		141.25
96			
97			
98			
99			
100	70.0	±0.05	-108.0
101	-70.0		108.0
102			
103			
104			
105		±0.05	
106			
107			
108			
109			
110	-66.0		66.0
111	66.0	±0.05	-66.0
112	-79.0		66.0
113	79.0		-66.0
114			
115			
116			
117			
118			
119			
120	16.30	±0.05	48.00
121	-16.30		-48.00
122	-49.00	±0.02	-70.00
123	49.00		70.00
124			
125			
126			
127			
128			
129			

POS. NO.	X	TOL.	Y
130	-59.20		-30.85
131	59.20		30.85
132	-52.30		-9.00
133	52.30		9.00
134	70.75		-21.20
135	27.20	±0.05	-46.40
136	-16.20		-71.50
137	-70.75		21.20
138	-27.20		46.40
139	16.20		71.50
140			
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GENERAL TOLERANCES

NOM. SIZE IN	LENGTH SIZE	HOLE DIAMETER	ANGLE
≤3	±0.1	±0.2	± 30'
> 3 ≤ 30	±0.2	±0.3	± 20'
> 30 ≤ 120	±0.3	±0.5	± 30'
> 120 ≤ 400	±0.5	±1.0	± 1°
> 400 ≤ 1200	±1.0		

CHAMFERING
× 45° OUTSIDE
× 45° INSIDE
× 45° HOLE

FINE BLANKING TOOL DESIGN

DRAWN BY — PART No:
CHECKED BY — OPERATION No.
APPROVED BY — MACHINE
REV. — MODIFICATION — SIGN/DATE — DATE 28/03/22 — MACHINE No.
SCALE - — DESIGN & DETAILING OF THE FINE BLANKING TOOL FOR A PRECISION CAM — DRG. No. — SHEET No.

GENERAL TOLERANCES

NOM. SIZE IN	LENGTH SIZE	HOLE DIAMETER	ANGLE
≤3	±0.1	±0.2	± 30'
> 3 ≤ 30	±0.2	±0.3	± 20'
> 30 ≤ 120	±0.3	±0.5	± 30'
> 120 ≤ 400	±0.5	±1.0	± 1°
> 400 ≤ 1200	±1.0		

CHAMFERING
× 45° OUTSIDE
× 45° INSIDE
× 45° HOLE

FINE BLANKING TOOL DESIGN

DRAWN BY — PART No:
CHECKED BY — OPERATION No.
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REV. — MODIFICATION — SIGN/DATE — DATE 28/03/22 — MACHINE No.
SCALE - — DESIGN & DETAILING OF THE FINE BLANKING TOOL FOR A PRECISION CAM — DRG. No. — SHEET No.

5.6 Description of Standard Parts used

STANDARD ELEMENTS PART NO AND DESCRIPTION

	DESCRIPTION	No. OFF	MATERIAL	HARDNESS (HRC)	COATING	FINISH MATERIAL SIZE	REMARKS (STD)	DRG. No/REF
99								
98								
97								
96								
95								
94								
93								
92								
91	PRESSURE SPRING	2	STD.					
90								
89								
88								
87	WASHER	2	STD.			$\frac{14^{-0.2}}{OUT-28}$X4		
86	WASHER	2	STD.			$\frac{14^{-0.4}}{OUT-28.5}$X1.6		
85								
84								
83								
82								
81								
80								
79	DOWEL PIN	2	STD.			Ø8X40		
78	DOWEL PIN	4	STD.			Ø8X90		
77	DOWEL PIN	2	STD.			Ø16X60		
76	DOWEL PIN	2	STD.			Ø16X80		
75	ALIGNMENT PIN	1	STD.			Ø10X100		
73	DISTANCE PIPE	2				Ø20/13X53.5		
70	PRESSURE PIN	4	STD.			Ø8X69		
69	PRESSURE PIN-B	4	STD.			Ø11X105		
69	PRESSURE PIN-A	2	STD.			Ø15X105		
68	PRESSURE PIN	6	STD.			Ø16X135		
67								
66								
65	HEXAGOCHICAP SCREW	4	STD.			M5X10		
64	HEXAGOCHICAP SCREW	2	STD.			M5X10		
63	HEXAGOCHICAP SCREW	2	STD.			M6X15		
61	HEXAGOCHICAP SCREW	6	STD.			M6X30		
60	HEXAGOCHICAP SCREW	2	STD.			M10X100		
59	HEXAGOCHICAP SCREW	8	STD.			M8X100		
58	HEXAGOCHICAP SCREW	2	STD.			M8X85		
57A	HEXAGOCHICAP SCREW	2	STD.			M6X90		
57	HEXAGOCHICAP SCREW	2	STD.			M4X95		
56	HEXAGOCHICAP SCREW	4	STD.			M10X45		
55	HEXAGOCHICAP SCREW	4	STD.			M10X90		
53	HEXAGOCHICAP SCREW	2	STD.			M12X90		
49	SHOULDER DOWEL SCREW	2	STD.			M6X20/M5		
48								
47								
46								
44	ALIGNMENT PIN	2	STD.			Ø10X58		
43	SAFETY DEVICE	2	MS.			Ø30x15		
42								
41								
40								
39								
38								

GENERAL TOLERANCES

NOM. SIZE IN	LENGTH SIZE	HOLE DIAMETER	ANGLE
≤3	±0.1	±0.2	± 30'
> 3 ≤ 30	±0.2	±0.3	± 20'
> 30 ≤ 120	±0.3	±0.5	± 30'
> 120 ≤ 400	±0.5	±1.0	± 1°
> 400 ≤ 1200	±1.0		

CHAMFERING
× 45° OUTSIDE
× 45° INSIDE
× 45° HOLE

FINE BLANKING TOOL DESIGN

DRAWN BY — PART No:
CHECKED BY — OPERATION No.
APPROVED BY — MACHINE
REV. — MODIFICATION — SIGN/DATE — DATE 10/04/22 — MACHINE No.
SCALE - — DESIGN & DETAILING OF THE FINE BLANKING TOOL FOR A PRECISION CAM — DRG. No. — SHEET No.

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CONCLUSION

Fine Blanking process will provide close dimensional tolerance of the component(Cam).The fine blanked surface can be clean cut up to 99% over it's entire sheet thickness. Though the initial equipment cost(i.e. Tool cost) may be high but it is very useful for mass production.

In this study, the fine blanking technology of cam is analyzed, blank layout is prepared, the fine Blanking force is calculated,press capacity is decided,net weight and gross weight is shown in the layout design, The fine blanking compound die structure were designed, the materials list of each part and heat treatment specifications of fine blanking die work parts are mentioned. By adopting fine blanking technology, not only improve product quality, but also significantly reduce the mechanical processing time. Thus the product cost would be lowered and theproduction efficiency increased.

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FUTURE SCOPE

1. We can make 3D modeling of each parts and do assembly of lower half and upper half portion of the compound fine blanking die of the Cam for better understood.
2. We can do FEA of die segment, die frame,punchs for prior prediction and improvement of life.
3. We can add Bolster Plate design arrangement for both die halves which to be fitted with press beds for more clear understanding the function of die operation.

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