Design and Manufacturing of Press Tools for Compressor Shell

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Abstract**—** *The role of Sheet Metal has become very prominent with the use of Press Tools. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed of the material. Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.The project deals with Compressor Shell Lower Housing. The Compressor Shell holds all the parts of the compressor in pre-defined location for the compressor to fool proof. The component should be freed from burrs and also to dimensional accurate. The outcome component is been inspected in the Quality department so as to check the Dimensional accuracy is been achieved.*

Keywords— Compressor shell, Lower Housing Shell, Thick Hot Rolled Strip.

I. INTRODUCTION

In today's practical and cost conscious world, sheet metal parts have already replaced many expensive cast, forged and machined products. The reason is obviously the relative cheapness of stamped, mass produced parts as well as greater control of their technical and aesthetic parameters. That the world slowly turned away from heavy, ornate and complicated shapes and replaced them with functional, simple and logical forms only enhanced this tendency towards sheet metal products. The common sheet metal forming products are metal desks, file cabinets, appliances, car bodies, aircraft fuselages, mechanical toys and beverage cans. Sheet forming dates back to 5000 B.C., when household utensils and jewelry were made by hammering and stamping gold, silver and copper. Due to its low cost and generally good strength and formability characteristics, low carbon steel is the most commonly used sheet metal. For aircraft and aerospace applications, the common sheet materials are aluminum and titanium

II. DESIGN PROCEDURES

COMPONENT NAME: Lower Housing Shell
MATERIAL: Thick Hot Rolled Strip
THICKNESS: 2.67 / 2.97 mm.

2.1. BLANKING:

This operation is the first and foremost operation in the manufacturing procedure. The blank diameter is been calculated by considering the blank development procedure from Die Design Handbook.

2.2. BLANK DIAMETER:

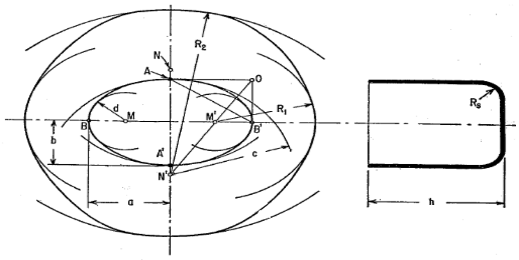

Fig.1:Blank Development for irregular shells.

$$R_1 = \sqrt{(d-R_s)^2 + R_s(d-R_s) + 2R_s{}^2 + 2d(h-R_s)}$$

$$R_2 = \sqrt{(c-R_s)^2 + R_s(c-R_s) + 2R_s{}^2 + 2c(h-R_s)}$$

c = 208.22, d = 145.94, R_s= 16.12, h = 152.73

$$R_1 = \sqrt{(145.94-16.12)^2 + 16.12(145.94-16.12) + 2(16.12)^2 + 2(145.94)(152.50-16.12)}$$

$$= \sqrt{16853.2324 + 2092.6984 + 519.7088 + 39806.5944}$$

$$= \sqrt{59339.3664}$$

= 243.45 mm.

$$R_2 = \sqrt{(208.22-16.12)^2 + 16.12(208.22-16.12) + 2(16.12)^2 + 2(208.22)(152.73-16.12)}$$

$= \sqrt{36902.41 + 3096.652 + 519.7088 + 56794.0872}$

$= \sqrt{97408.6392}$

= 312.103 mm.

Blank Diameter = Major axis + 2 (R_2 – c)

= 214.88 + 2(103.883)

= 422.646 ≈ Ø420 mm.

Strip Layout:

Strip size:

If n = No. of Blanks.

Strip Length: [from Basic Die Making (BDM) Pg- 181]

L= n×D + (n+1) G.

= (10 × 420) + (10 + 1) G

= 4200 + (11 × 5.94)

= 4200 + 65.34

= 4265.24 mm.

Table.1 : Stock Thickness

ONE-PASS SINGEL STATION DIES		
T= STOCK THICKNESS		
D (INCHES)	G OR H	SMALLEST G OR H (INCHES)
TO 1	¾ T	1/32
1-3	T	3/64
3-6	1 ¼ T	3/32
6-10	1 ¼ T	1/8
10-15	1 ½ T	1/8

Where,

D= Blank Diameter.

G= Bridge Scrap.

= 2T.

= 2×2.97 = 5.94 mm.

T= Thickness of the Stock.

Strip Width:

W_s= D+2H.

= 420 + 2 × 5.94

= 431.88 mm. ≈ 428.9 mm.

Where,

D = Blank Diameter.

H = Front Scrap = T

Weight of Raw Material:

$W_r = L \times W_s \times t \times \rho \times 10^{-6}$

$= 4265.34 \times 428.9 \times 2.97 \times 7.85 \times 10^{-6}$

$= 42651647.3 \times 10^{-6}$

= 42.65 kg.

Where,

L= Length of the strip.

W_s= Width of the strip

t = Thickness of the component.

ρ = Density.

$= 7.85 \times 10^{-6}$ kg/mm^3 (for Steel)

Net Weight of Component:

$W_c = A \times t \times \rho \times 10^{-6}$

$= 3.14 \times (210)^2 \times 2.97 \times 7.85 \times 10^{-6}$

$= 3228452.07 \times 10^{-6}$

= 3.228 kg.

Where,

A = Area of Blank.

$= \frac{\pi}{4} d^2 mm^2$

t = Thickness of the component.

ρ = Density.

$= 7.85 \times 10^{-6}$ kg/mm^3 (for Steel)

Percentage of Utilization:

$\%U = \frac{W_c \times n}{W_r} \times 100$

= (3.228 × 10) / (42.65) × 100

= 75.6%

Where,

W_c = Weight of the component.

W_r= Weight of the Raw material.

n = No. of Blanks

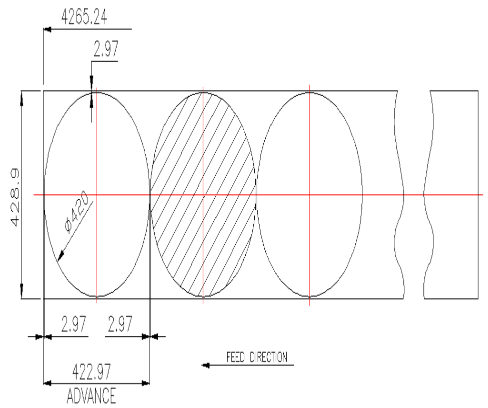

Fig.2: Strip Layout.

Component Name	AW Lower Housing of Compressor Shell
Material	Thick H.R.S
Strip Size	4265.24 x 428.9 mm.
No. of Blanks	10
Weight of Raw Material	42.65 kgs.
Net Weight of the Blank	3.228 kgs.
Percentage of Utilization	75.6%

Perimeter:

P = 2πr (For Circular Blank)
= 2 × π × 210
= 1318.8 mm.

Where,
r = Radius of Blank

Tonnage: [from Tool Parameters Pg – 07]

Shear Force = $F_{sh} = \frac{k \times l \times t \times S_{sh}}{1000}$

$= \frac{1.3 \times 1318.8 \times 2.97 \times 36}{1000}$

= 183.307 tons

≈ 500 tons (this value is considered according press availability)

Where,
F_{sh} = Shear force in tons.
k= Factor of Safety (1.3 – 1.5)
l = Length of the Periphery.
t = Thickness of the component.
S_{sh} = Shear strength
= 36 $^{kg}/_{mm^2}$(for Steel)

Clearance:

• Recommended clearance can be calculated by:$c = a \times t$

Where,
c = clearance.
a = allowance.
t = stock thickness.

• **Allowance 'a' is determined according to type of metal:**

Table 2: Metal group.

Metal group	a
1100S and 5052S aluminum alloys, all tempers	0.045
2024ST and 6061ST aluminum alloys; brass, soft cold rolled steel, soft stainless steel.	0.060
Cold rolled steel, half hard; stainless steel, half hard and full hard.	0.075

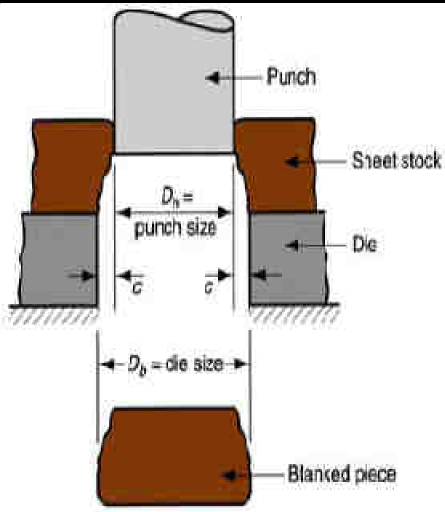

Fig.3 Clearance.

D_b determines blank size
D_h determines hole size

- Distance between the punch and die
- Typical values range between 4% and 8% of stock thickness
- If too small, fracture lines pass each other, causing double burnishing and larger force
- If too large, metal is pinched between cutting edges and excessive burr results

III. ANGULAR CLEARANCE

It is the enlarged section below the die opening that allows the blank to fall from the die. Its purpose is to allow slug or blank to drop through die.

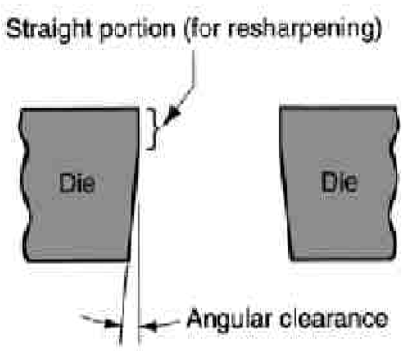

Fig.4: Angular Clearance

Typical values: 0.25° to 1.5° on each side

3.1 Design of Blanking tool:

Theoretical Valves:

Thickness of Die plate (t_d) = $\sqrt[3]{F_{sh}}$
= $\sqrt[3]{200}$= 58.5mm.

Thickness of Punch Holder (t_h) = 0.5 × t_d
= 29.25 mm.

Thickness of Top Bolster (t_t) = 1.25 × t_d
= 73.125 mm

Thickness of Stripper plate (t_s) =0.5 × t_d.
= 29.25mm.

Thickness of Bottom Bolster (t_b) = 1.75 × t_d = 102.37 mm.

3.2 Practical Valves:

Thickness of Die plate (t_d) = 19 mm.
Thickness of Punch Holder (t_h) = 30 mm.
Thickness of Top Bolster (t_t) = 60 mm.
Thickness of Stripper plate (t_s) = 13 mm.
Thickness of Bottom Bolster (t_b) = 70 mm.

3.3 Press Availability

Table.3: Blanking Press Details

Tonnage	500 tons
Bed Area	1800 x 1200 mm
Stroke Length	200
Strokes per Min	25 mm/sec
Shut Height	600

Fig.5: Blanking Tool

3.4 Draw tool Design Procedure

Fig.6: Drawn Shell.

3.5. No. of Draws:

$\lambda = h/d$
= 152.73/214.88
= 0.71 mm

Where,
h = Inside cup height.
d = Mean diameter of the shell.

λ	No. of draws
<0.75	1
0.7 - 1.5	2
1.5 - 3.0	3
3.0 - 4.7	4

Table 4: Number of Draws.

Since the value of 'λ' is <0.75
Therefore, suggested no. of draws from above table is 1.

3.6 Die Radius:

$R_d = 0.035(50 + (D - d))\sqrt{t}$
(Or)
= (4 to 8) (t)
= 4 × t
= 4 × 2.97
= 11.88 mm.

3.7. Draw Ratio:

$\beta = \frac{D}{d}$
$= \frac{420}{214.88}$
= 1.95 mm.

Where,
D = Diameter of the Blank.
d = Inside Diameter of the Shell.

3.8. Condition for Requirement of blank Holder:

$\frac{D-d}{t} < 18$ (Blank holder is not necessary)
$= \frac{420-214.88}{2.97}$
= 69.06 mm.

Hence blank holder is necessary.

3.9. Die Punch clearance:

$c = t(1 + 0.035(\beta - 1)^3)$
= 2.97 (1 + (0.035 (1.95-1)^3))
= 2.97 (1 + 0.03)
= 3.059 mm.

But practically 0.5 mm clearance is given
Therefore, die punch clearance = 2.97 + 0.5 = 3.47 mm.

3.10. Speed of Drawing:

For Steel = 15 – 20 m/min.

3.11. Drawing Force:

$F_d = c \times t \times S_u \times \sqrt{A}$
= 1.5× 2.97 × 38 × 1216.22
= 205.63 tons.
= 250 tons. (By considering the availability of press)

Where,

c = 0.5 to 2.0
A = Forming Area (or) Deformed Area.
S_u = Ultimate Tensile Strength in (kg/mm^2).
= 38 (kg/mm^2) for Steel.

3.12. Theoretical Valves:

Thickness of Die plate (t_d) = $\sqrt[3]{F_d}$
= $\sqrt[3]{250}$= 62.9 mm.

Thickness of Top Bolster (t_t) = 1.25 $\times\ t_d$
= 78.625 mm.

Thickness of Bottom Bolster (t_b) = 1.75 $\times\ t_d$
= 110.075 mm.

3.13. Practical Valves:

Thickness of Die plate (t_d) = 54 mm.
Thickness of Top Bolster (t_t) = 60 mm.
Thickness of Bottom Bolster (t_b) = 70 mm.
Thickness of Blank Holder = 50 mm.
Thickness of shedder = 50 mm.
Thickness of shedder back plate = 10 mm

3.14. Press Availability:

Table.5: Drawing Press Details

Tonnage	250 tons
Bed Area	2000 x 1500 mm
Stroke Length	500
Strokes per Min	13mm/sec
Shut Height	565

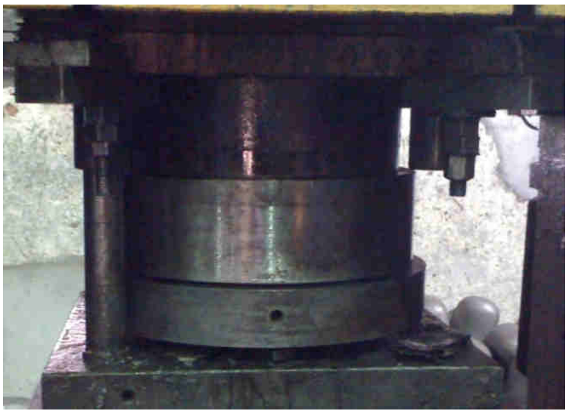

Fig 7: Drawing Tool

Shell trimming tool design :

Fig 8: Trimmed shell.

3.15. Shearing Force :

Shearing force, $F_{sh} = \frac{k \times l \times t \times S_{sh}}{1000}$

$= \frac{1.3 \times 129.0622 \times 2.97 \times 36}{1000}$

= 17.939

≈ 100 tons (according to press availability).

Where,
F_{sh} = Shear force in tons.
k= Factor of Safety (1.3 – 1.5)
l = Length of the Periphery.
t = Thickness of the component.
S_{sh} = Shear strength.
= 36 $^{kg}/_{mm^2}$ (for Steel).

3.16. Theoretical Valves:

Thickness of Die plate (t_d) = $\sqrt[3]{F_d}$
= $\sqrt[3]{100}$= 46.4 mm.

Thickness of Top Bolster (t_t) = 1.25 $\times\ t_d$
= 58 mm.

Thickness of Bottom Bolster (t_b) = 1.75 $\times\ t_d$
= 81.2 mm.

3.17. Practical Valves:

Thickness of Die plate (t_d) = 42 mm.
Thickness of Top Bolster (t_t) = 60 mm.
Thickness of Bottom Bolster (t_b) = 70 mm.
Thickness of Locator = 20 mm

3.18. Press Availability:

Table 6:Trimming Press Details.

Tonnage	100 tons
Bed Area	750 x 560 mm
Stroke Length	600
Strokes per Min	22 mm/sec
Shut Height	500

Fig 9: Trimming Tool.

3.19. Hole Flanging & 3.50 Flaring Tool design:

Fig 10: Hole Flanged Shell

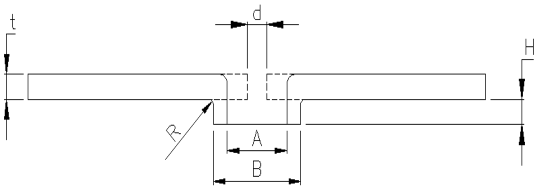

Fig: 11 Hole Flanging.

$B = A + \frac{5t}{4}$ for t < 1.2 mm.

$= A + t$ where t > 1.2 mm.

$B = 9.6 + 2.97$

$= 12.57$ mm.

$H = t$ where t < 0.9 mm.

$= \frac{4t}{5}$ where t is 0.9 to 1.25 mm.

$H = \frac{3t}{5}$ when t > 1.25 mm.

$H = \frac{3 \times 2.97}{5}$

$= 1.782$ mm.

But, H = 3.175 mm. (from component drawing)

$R = \frac{t}{4}$ when t < 1.20 mm.

$= \frac{t}{3}$ when > 1.2 mm.

$R = \frac{2.97}{3}$

$= 0.99$ mm.

3.20. Pre- Pierced Hole Size (d):

$$d = \sqrt{\frac{tB^2 + 4tA^2 + 4HA^2 - 4HB^2}{9t}}$$

$$= \sqrt{\frac{2.97(12.75)^2 + 4(2.97)(9.6)^2 + 4(3.175)(9.6)^2 - 4(3.175)(12.57)^2}{9(2.97)}}$$

$$= \sqrt{27.162}$$

= 5.21 mm

≈ Ø5 mm. (By Practical Analysis)

3.21. Force required for direct piercing & flanging (with single stepped punch):

$F_{t} = (2\text{-}2.5)\ \pi\ d\ t\ s_{sh}$

Where,

d = pre- pierced hole.

t = thickness of the shell.

S_{sh} = Shear strength.

= 36 kg/mm^2 (for Steel).

Force required for hole flanging after pre- piercing the hole:

$F_t = (1.5\text{-}2)\ \pi\ d\ t\ S_{sh}$

Where,

d = pre- pierced hole.

t = thickness of the shell.

S_{sh} = Shear strength.

= 36 kg/mm^2(for Steel).

For Outside Hole Flanging first Piercing and then Flanging operation is done.

For Inside Hole Flanging both Piercing and Flanging operations are done in single operation.

Since in the component drawing the hole to be flanged is inside we prefer both the operations to be done in a single stage.

Therefore,

$F_t = 2.5(3.141 \times 2.97 \times 5.21 \times 36)$

$= 4.374 \times 5.21$

= 22.78 tons ≈ 63 tons (by press availability).

3.22. Theoretical Valves:

Thickness of Die plate (t_d) = $\sqrt[3]{F_d}$

$= \sqrt[3]{63} = 39.7$ mm.

Thickness of Top Bolster (t_t) = $1.25 \times t_d$

= 49.62 mm.

Thickness of Bottom Bolster (t_b) = $1.75 \times t_d$

= 69.47 mm.

Thickness of Punch Holder (t_h) = $0.5 \times t_d$

= 19.85 mm.

3.23. Practical Valves:

Thickness of Top Bolster (t_t) = 60 mm.

Thickness of Bottom Bolster (t_b) = 70 mm.

Thickness of Punch Holder = 20 mm

3.24. Press Availability:

Table.7: Hole Flanging Press Details

Tonnage	63 tons
Bed Area	500 x 800 mm
Stroke Length	100
Strokes per Min	45 mm/sec
Shut Height	315

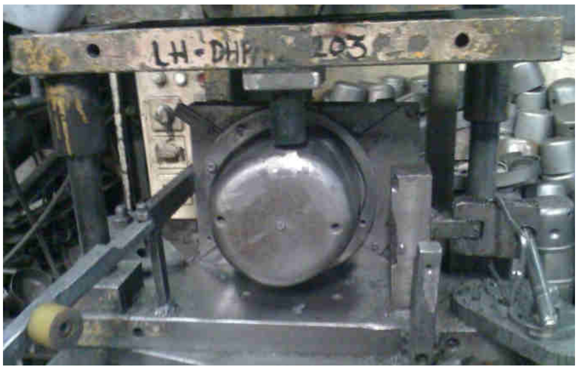

Fig 12: Hole Flanging Tool.

IV. MANUFACTURING PROCEDURE

Manufacturing of the tools involved the different machinning operations which is given below .

- Turnning
- Milling
- Grinding
- Boring
- Drilling
- Tapping

4.1 *Manufacturing procedure of Blanking tool.*

S.NO : 01
DESCRIPTION : TOP BOLSTER & BOTTOM PLATE.
MATERIAL : MILD STEEL
RAW MATERIAL SIZE : 75x760x910mm

4.1.1. Procedure:

1. Mill right angle at one side & maintain length and width on Horizontal milling machine.
2. Rough Milling top and bottom faces of plate on vertical milling m/c.
3. Reference grinding at one side on surface grinding m/c.
4. Grinding on top and bottom surfaces on surface grinding m/c.
5. Centre drill for all holes on CNC Milling machine.
6. Boring of all holes i.e. pillar, pillar bushes, seating holes & fixed holes on jig boring m/c.
7. Drill and C' bore & tapping to suit die housing by using taps, drills & reamers.
8. Inspection report of plate.
9. Assembly.

S.NO : 02
DESCRIPTION : PUNCH & DIE HOLDER.
MATERIAL : MILD STEEL.
RAW MATERIAL SIZE : Ø660 x 115

1. Rough turning on lathe m/c.
2. Thickness milling on milling m/c.
3. Thickness grinding on surface grinding m/c.
4. Boring on CNC milling m/c.
5. Pocket milling on milling m/c.
6. Centre drill on CNC milling m/c.
7. Drill and C' bore & tapping to suit bottom bolster by using taps, drills & reamers.
8. Inspection report of plate.
9. assembly.

S.NO : 03
DESCRIPTION : PUNCH & DIE INSERTS.
MATERIAL : HIGH CARBON HIGH CHROMIUM STEEL.
RAW MATERIAL SIZE : 315 x 70 x 55
PROCEDURE:

1. Mill right angle at one side & maintain length and width on horizontal milling machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. Reference grinding at one side on surface grinding m/c.
4. Grinding on top and bottom surfaces on surface grinding m/c.
5. Centre drill for all holes on CNC Milling machine.
6. Angular milling, radius milling on CNC Milling m/c.
7. Angular grinding on surface grinding m/c.
8. Drill and C' bore & tapping to suit die holder by using taps, drills & reamers.
9. Inspection report of plate.
10. Heat treatment.
11. Finish sizes by using CNC Milling and surface grinding.
12. Inspection report before assembly.
13. Assembly.

S.NO : 04
DESCRIPTION : GUIDE PILLARS.
MATERIAL : EN31.
RAW MATERIAL SIZE : Ø70 x 355
PROCEDURE:

1. Rough turning on lathe m/c.
2. Heat treatment.
3. Grinding on cylindrical grinding m/c.
4. Inspection report of plate.
5. Assembly.

S.NO : 05
DESCRIPTION : GUIDE BUSHES.
MATERIAL : EN31.
RAW MATERIAL SIZE : Ø90 x 160.
PROCEDURE:

1. Rough turning & drilling on lathe m/c.
2. Heat treatment.
3. ID and OD grinding on cylindrical grinding m/c.
4. Inspection report.
5. Assembly.

ASSEMBLING:

1. Fix guide pillars in bottom plate & guide bushel in top plate for die set assembly.
2. Fix die inserts in die holder & fixed it into bottom plate.
3. Fix punch inserts in punch holder & fixed it into top plate.
4. Check alignment of punch and die.
5. Tool inspection report.
6. Tool trail report.
7. Tool ready for production.

4.2. Manufacturing procedure of drawing tool*:*
S.NO : 01
DESCRIPTION : TOP BOLSTER & BOTTOM PLATE.
MATERIAL : MILD STEEL.
RAW MATERIAL SIZE : 75x760x910mm
PROCEDURE:

1. Mill right angle at one side & maintain length and width on horizontal milling machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. Reference grinding at one side on surface grinding m/c.
4. Grinding on top and bottom surfaces on surface grinding m/c.
5. Centre drill for all holes on CNC Milling machine.
6. Boring of all holes i.e. Pillar, pillar bushes, seating holes & fixed holes on jig boring m/c.
7. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
8. Inspection report of plate.
9. Assembly.

S.NO : 02
DESCRIPTION : DIE HOUSING PLATES (TOP, MIDDLE & BOTTOM).
MATERIAL : MILD STEEL.
RAW MATERIAL SIZE : [DIE HOUSING TOP: Ø400x100, DIE HOUSING MIDDLE: Ø400x75 & DIE HOUSING Ø400x95]
PROCEDURE:

1. Maintain OD on lathe machine.
2. All holes and ID boring on jig boring machine.
3. Elliptical profile wire cut on CNC wire cut machine.
4. Step milling (maintain deep as noted in drg 's) on CNC vertical milling m/c.
5. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
6. Inspection report of plate/bar.
7. Assembly.

S.NO : 03
DESCRIPTION :SHEDDER (Ø220 x 80).
MATERIAL : EN-31.
RAW MATERIAL SIZE : Ø220 x 80
PROCEDURE:

1. Maintain OD on lathe machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. All holes and ID boring on jig boring machine.
4. Elliptical profile wire cut on CNC wire cut machine.
5. Step milling (maintain deep as noted in drg 's) on CNC vertical milling m/c.
6. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
7. Heat treatment.
8. Surface grinding and maintain height on surface grinding m/c.
9. Inspection report of plate/bar.
10. Assembly.

ASSEMBLING:

1. Fix guide pillars in bottom plate & guide bush in top plate for die set assembly.

2. Fix die inserts in die holder & fixed it into bottom plate.
3. Fix punch inserts in punch holder & fixed it into top plate.
4. Check alignment of punch and die.
5. Tool inspection report.
6. Tool trail report.
7. Tool ready for production.

4.3. Manufacturing procedure of shell trimming tools

S NO: 01
DESCRIPTION :TOP PLATE (Ø220 x 80).
MATERIAL : EN-31.
RAW MATERIAL SIZE : Ø220 x 80
PROCEDURE:

1. Maintain OD on lathe machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. All holes and ID boring on jig boring machine.
4. Elliptical profile wire cut on CNC wire cut machine.
5. Step milling (maintain deep as noted in drg 's) on CNC vertical milling m/c.
6. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
7. Heat treatment.
8. Surface grinding and maintain height on surface grinding m/c.

Inspection report of plate/bar.

S NO: 02
DESCRIPTION : SPACER (Ø155 x 120).
MATERIAL : EN-31.
RAW MATERIAL SIZE : Ø220 x 80
PROCEDURE:

1. Maintain OD on lathe machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. All holes and ID boring on jig boring machine.
4. Elliptical profile wire cut on CNC wire cut machine.
5. Step milling (maintain deep as noted in drg 's) on CNC vertical milling m/c.
6. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
7. Heat treatment.
8. Surface grinding and maintain height on surface grinding m/c.

Inspection report of plate/bar.

S NO: 03
DESCRIPTION : CUTTER (Ø220 x 80).
MATERIAL : D2.
RAW MATERIAL SIZE : Ø225 x 20
PROCEDURE:

1. Maintain OD on lathe machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. All holes and ID boring on jig boring machine.
4. Elliptical profile wire cut on CNC wire cut machine.
5. Step milling (maintain deep as noted in drg 's) on CNC vertical milling m/c.
6. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
7. Heat treatment.
8. Surface grinding and maintain height on surface grinding m/c.

Inspection report of plate/bar.

S NO: 04
DESCRIPTION :PROFILE GUIDE FOLLOWER (Ø220 x 80).
MATERIAL : EN-31.
RAW MATERIAL SIZE : Ø225 x 145
PROCEDURE:

1. Maintain OD on lathe machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. All holes and ID boring on jig boring machine.
4. Elliptical profile wire cut on CNC wire cut machine.
5. Step milling (maintain deep as noted in drg 's) on CNC vertical milling m/c.
6. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
7. Heat treatment.
8. Surface grinding and maintain height on surface grinding m/c.

Inspection report of plate/bar.

4.4. Manufacturing procedure of Piercing & Flaring tools

S.NO : 01 & 02
DESCRIPTION : TOP BOLSTER & BOTTOM PLATE.
MATERIAL : MILD STEEL.
PROCEDURE:

1. Mill right angle at one side & maintain length and width on horizontal milling machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. Reference grinding at one side on surface grinding m/c.
4. Grinding on top and bottom surfaces on surface grinding m/c.
5. Centre drill for all holes on CNC Milling machine.

6. Boring of all holes i.e. Pillar, pillar bushes, seating holes & fixed holes on jig boring m/c.
7. Drill and C'bore & tapping to suit die housing by using taps, drills & reamers.
8. Inspection report of plate.
9. Assembly.

S.NO : 03 & 04
DESCRIPTION : PUNCH HOLDER & DIE HOLDER
MATERIAL : MILD STEEL

1. Rough turning on lathe m/c.
2. Thickness milling on milling m/c.
3. Thickness grinding on surface grinding m/c.
4. Boring on CNC milling m/c.
5. Pocket milling on milling m/c.
6. Centre drill on CNC milling m/c.
7. Drill and C' bore & tapping to suit bottom bolster by using taps, drills & reamers.
8. Inspection report of plate.
9. assembly.

S.NO : 07
DESCRIPTION : GUIDE PILLARS.
MATERIAL : EN31.
PROCEDURE:

1. Rough turning on lathe m/c.
2. Heat treatment.
3. Grinding on cylindrical grinding m/c.
4. Inspection report of plate.
5. Assembly.

S.NO : 08
DESCRIPTION : GUIDE BUSHES.
MATERIAL : EN31.
PROCEDURE:

1. Rough turning & drilling on lathe m/c.
2. Heat treatment.
3. ID and OD grinding on cylindrical grinding m/c.
4. Inspection report.
5. Assembly.

S.NO : 09 & 10
DESCRIPTION : PUNCH & DIE.
MATERIAL : HIGH CARBON HIGH CHROMIUM STEEL.
PROCEDURE:

1. Mill right angle at one side & maintain length and width on horizontal milling machine.
2. Rough milling top and bottom faces of plate on vertical milling m/c.
3. Reference grinding at one side on surface grinding m/c.
4. Grinding on top and bottom surfaces on surface grinding m/c.
5. Centre drill for all holes on CNC Milling machine.
6. Angular milling, radius milling on CNC Milling m/c.
7. Angular grinding on surface grinding m/c.
8. Drill and C' bore & tapping to suit die holder by using taps, drills & reamers.
9. Inspection report of plate.
10. Heat treatment.
11. Finish sizes by using CNC Milling and surface grinding.
12. Inspection report before assembly.
13. Assembly

V. PROCESS PLANNING SHEET

<table>
<tr><td colspan="3">Part No.: AWX – 1678 – 05</td><td colspan="4">Core Team:</td><td colspan="3">Control Plan
Page No.:1 of 1</td></tr>
<tr><td colspan="3">Part Name/ Description:
Lower Housing -2.83 Thick.</td><td colspan="4"></td><td colspan="3"></td></tr>
<tr><td rowspan="3">Part/ Process No.</td><td rowspan="3">Process Name/ Operation</td><td rowspan="3">Machine</td><td colspan="2">Characteristics</td><td colspan="5">Methods</td></tr>
<tr><td rowspan="2">No.</td><td rowspan="2">Product</td><td rowspan="2">Product Specific./ Tolerance</td><td rowspan="2">Evaluation</td><td colspan="2">Sample</td></tr>
<tr><td>Size</td><td>Freq.</td></tr>
<tr><td rowspan="3">01</td><td rowspan="3">Blanking</td><td rowspan="3">500T</td><td>1</td><td>Thickness</td><td>2.83+/-0.10</td><td>Micrometer</td><td>2 sheets</td><td>pallet</td></tr>
<tr><td>2</td><td>Diameter</td><td>420+/-1.0</td><td>Tape</td><td>2 sheets</td><td>pallet</td></tr>
<tr><td>3</td><td>Appearance</td><td>Free from Matrl.</td><td>Visual</td><td>100%</td><td>Cont.</td></tr>
</table>

					Defects			
02	Drawing	200T/250T	1	Total Height	179mm.	Height Gauge	2 nos.	2 hrs.
			2	Major Axis	214.38-214.88	Profile Gauge	2 nos.	4 hrs.
			3	Minor Axis	186.18-186.68	Profile Gauge	2 nos.	4 hrs.
			4	Appearance	Free from weak zones	Visual	100%	Cont.
03	Trimming	100T	1	Total Height	160mm.	Height Gauge	2 nos.	2 hrs.
			2	Appearance	Free from steps & dents	Visual	100%	Cont.
04	Hole Flanging	100T	1	D.c Hole Location	60 deg.+/- 1.0 deg.	Receiver Gauge	2 nos.	2 hrs.
			2	D.c Hole Dia.	8.03-8.13	Plug Gauge	2 nos.	2 hrs.
			3	D.c Hole Height	125.43+/- 1.60	Receiver Gauge	2 nos.	2 hrs.
			4	Appearance	Free from burr, cracks, bend & dents.	Visual	100%	Cont.
05	Final Inspection	Manual	1	Major Axis	214.38-214.88	Profile Gauge	100%	Cont.
			2	Minor Axis	186.18-186.68	Profile Gauge	100%	Cont.
			3	Total Height	156.85-157.5	Height Checking Gauge	100%	Cont.
			4	Height at Sides	152.08-152.73	Height Checking Gauge	100%	Cont.
			5	D.c Hole Dia.	8.03-8.13	Plug Gauge	100%	Cont.
			6	D.c Hole Location	60 deg.+/- 1.0 deg.	Receiver Gauge	100%	Cont.
			7	Condition	Free from rust, burr.	Visual	100%	Cont.

VI. CONCLUSION

During the course of the project, a systematic approach has been followed in the design and development of all 5 tools. The design and development has been successfully completed. The finished component is inspected and is within all tolerances. The component is approved by the customer, now the manufacturing of the component is in progress. At the manufacturing of tools having slit changes occurred while producing the shell.

REFERENCES

[1] Tool design data book
[2] Design data book
[3] Manufacturing book