Optimizing the Lead Time and Cost of Progressive Tool

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Abstract— The aim of the project is to optimize the lead time and cost of Progressive tool. The progressive tool is the master pattern for producing the brake components. Manufacturing of this tool takes a long time which results in high machining cost due to long running of machines. Hence the main objective of this project is to analyze the production process thoroughly and approach a different method to reduce the total machining time in manufacturing Progressive tool. The paper reveals with understanding and gathering a lot of information about the production process that involves studying the industrial Blue prints in manufacturing this tool and how to develop the project from initial stage to final stage with the help of company professionals. Based on the study and calculations, ABC Analysis and PERT charts are made in order to achieve the goal of the project.

Key words: Lead time, Progressive tool, Machining time, Tool design

I. INTRODUCTION

In a Progressive tool the final component is obtained by progressing the sheet metal or strip in more than one stage. At each stage the tool will progressively shape the component towards its final shape, with the final shape normally being cut off. Press working from the optimum die design and its making has been the purpose of mass production in the manufacturing field. The design and manufacture of press tools, or punches and dies, is a branch of production technology that has extended into many lines of engineering manufacture over the past seventy years. There is no doubt that the accuracy can be achieved by new ideas in design and construction applied by the press tool designer. Also coupled with increased speed and rigidity of the presses etc, used have all contributed towards maintaining this form of metal tooling well to the force as a means of obtaining pleasing, yet strong, durable articles that can withstand severe day-to-day usage. Four factors are essential contributions to first-class press work.

1) Good operation planning
2) Excellent tool design
3) Accurate tool making
4) Knowledgeable press setting.

II. TOOL ROOM

The tool room can refer to three related concepts. The concepts have evolved over the past two centuries as technology itself has evolved. Tool Room (TR) is industrial setup where the specialized tools, dies, press tools, jigs, fixtures are designed and manufactured. These tools are used for mass productions. Many companies have their own captives of TR or they can assign the work to the professionally managed TRs. The work flow starts in the tool room once it receives the product model or the product design and drawings.

Before accepting the model the TR professionals check the manufacturing feasibility of the tool for the product.

A. Press Tool

Press tools are commonly used in hydraulic, pneumatic and mechanical presses to produce components at high volumes. Generally press tools are categorized by the types of operations performed using the tool such as blanking, drawing, piercing, bending etc. The press tool can also be specified as a blanking tool, drawing tool, piercing tool, progressive tool.

B. Drawing Tool

Drawing tool transform flat sheets of metal into cups, shells or other drawn shapes by subjecting the material to severe plastic deformation. This type of press tool is used to perform only one particular operation therefore classified under stage tools.

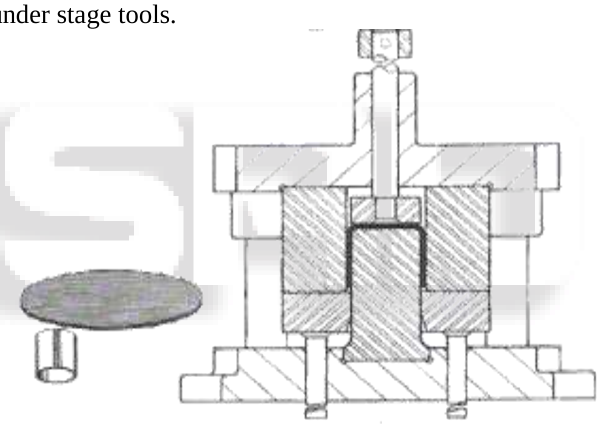

Fig. 1: Drawing tool

In an ideal Rankine cycle the pump and turbine would be isentropic, i.e., the pump and turbine would generate no entropy and hence maximize the network output. Processes 1-2 and 3-4 would be represented by vertical lines on the T-S diagram and more closely resemble that of the Carnot cycle. The Rankine cycle shown here prevents the vapour ending up in the superheat region after the expansion in the turbine, which reduces the energy removed by the condensers.

C. Piercing Tool

Piercing tool involves cutting of clean holes with a resulting scrap slug. The operation is called die cutting and can also produce flat components where the die and the shaped tool is pressed into a sheet material employing a shearing action to cut holes. This method can be used to cut parts of different sizes and shapes in sheet metal, leather and many other materials.

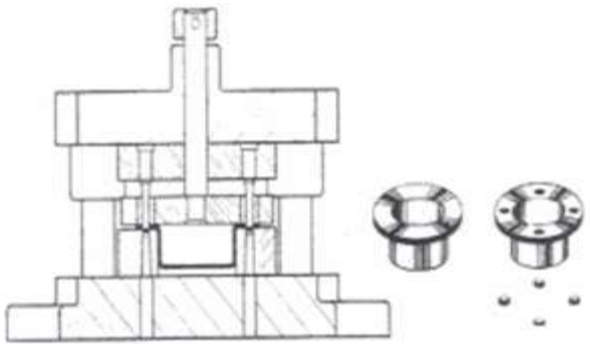

Fig. 2: Piercing tool

D. Progressive Tool

Progressive tool differs from a staged tool in the following respect: in a progressive tool the final component is obtained by progressing the sheet metal or strip in more than one stage. At each stage the tool will progressively shape the component towards its final shape, with the final stage normally being cutting off.

1) Components of Progressive Tool

- The components involved in Progressive tool are:
- SHANK: It is used to locate the press tool in the holder for alignment purpose.
- TOP BOLSTER: It is used to hold top half of the press tool with press slide.
- PUNCH BACK PLATE: This plate prevents the hardened punches penetrating into top plate.
- PUNCH HOLDER: This plate is used to accommodate the punches of press tool.
- PUNCHES: To perform cutting and non-cutting operations either plain or profiled punches are used
- DIE PLATE: Die plate will have similar profile of the component where cutting dies usually have holes with land and angular clearance and non-cutting dies will have profiles
- DIE BACK PLATE: This plate prevents the hardened die inserts penetrating into bottom plate
- GUIDE PILLAR &: Used for alignment between top and bottom halves of GUIDE BUSH the press tools.
- BOTTOM BOLSTER: It is used to hold bottom half of the press tool with press slide.
- STRIPPER PLATE: It is used to strip off the component from punches.

2) Stages of Operation on Sheet

1) Stage1: Pierce
2) Stage2: Pierce dimple
3) Stage3: Gimp dimple
4) Stage4: Trimming
5) Stage5: Trimming
6) Stage6: Burr coin
7) Stage7: Piercing
8) Stage8: Parting

III. CALCULATION OF MACHINING TIME

A. Milling

$$Tm = \frac{A+L+O1+O2}{F}$$

$$A = \sqrt{H(D-H)}$$

Where

- L=Length of the job in mm
- A=cutter approach in mm
- F=feed rate mm/rev
- O1, O2=over travel in mm
- H=depth of cut in mm

B. Wire Cut

$$Tm = \frac{\text{perimeter} \times \text{thickness}}{\text{feed}}$$

Perimeter of square =4×length
Perimeter of rectangle =2(base + height)
Perimeter of triangle = a +b +c
Perimeter of circle =2πr
Perimeter of parallelogram =2(base + height)
Perimeter of rhombus =4×length
Perimeter of ellipse = $\frac{2\pi\sqrt{r1^2+r2^2}}{2}$
Perimeter of trapezium =A+B+C+D

C. Turning

$$Tm = \frac{\text{length of the job}}{\text{feed/rev} \times \text{rpm}}$$

D. Reaming

$$Tm = \frac{\text{length of the job}}{\text{feed/rev} \times \text{rpm}}$$

E. Jig Boring

$$Tm = \frac{\text{length of the job}}{\text{feed/rev} \times \text{rpm}}$$

F. Facing

$$Tm = \frac{\text{length of the job}}{\text{feed/rev} \times \text{rpm}}$$

G. Surface Grinding

$$Tm = \frac{\text{length of the job}}{\text{feed/rev} \times \text{rpm}}$$

H. Chamfering

$$Tm = \frac{A+L+O1+O2}{F}$$

IV. CALCULATIONS

A. Top Bolster

Milling:

1) Operation A: Rough milling -1 for Thickness:

$$A=\sqrt{H(D-H)}$$

H=3mm O1=150mm

$$=\sqrt{3(250-3)}$$

D=250mm O2=150mm
A= 27.22 L=1080mm F=2mm/rev

$$Tm = \frac{A+L+O1+O2}{F} \text{ Sec}$$

$$= \frac{27.22+1080+150+150}{2} \text{ Sec}$$

Tm = 11.726mins

- Time of completion for 1 pass Tm=11.726mins
- Time of completion for 5 passes Tm=58.63mins

2) Operation B: Rough milling -2 for Thickness:

$$A=\sqrt{H(D-H)}$$

H=2.5mm O1-150mm

$= \sqrt{2.5(250-2.5)}$
D=250mm O2-150mm
A=24.87 L=1080mm F=2 mm/rev

$$Tm = \frac{A+L+O1+O2}{F} \text{ Sec}$$
$$= \frac{24.87+1080+150+150}{2} \text{ Sec}$$
$$Tm = 11.707\text{mins}$$

- Time of completion for 1 pass Tm=11.707mins
- Time of completion for 5 passes Tm=58.536mins

Total time for completion = M/c time + setting time + Inspection time + cleaning time
= 117.16+30+30+30
Total Time for reducing thickness =207.16mins

3) Operation C: Rough milling -1 for Length:

$A=\sqrt{H(D-H)}$
H=3mm O1-25mm
$= \sqrt{3(50-3)}$
D=50mm O2-25mm
=11.87
L=1080mm F=2 mm/rev

$$Tm = \frac{A+L+O1+O2}{F} \text{ Sec}$$
$$= \frac{11.87+1080+25+25}{2} \text{ Sec}$$
$$Tm = 9.515\text{mins}$$

- Time of completion for 1 pass Tm=9.515mins
- Time of completion for 22 passes Tm=209.34mins

4) Operation D: Rough milling -2 for Length

$A=\sqrt{H(D-H)}$
H=1.5mm O1-25mm
$= \sqrt{1.5(50-1.5)}$
D=50mm O2-25mm
A=8.53
L=1080mm F=2 mm/rev

$$Tm = \frac{A+L+O1+O2}{F} \text{ Sec}$$
$$= \frac{8.53+1080+25+25}{2} \text{ Sec}$$
$$Tm = 9.48\text{mins}$$

- Time of completion for 1 pass Tm=9.48mins
- Time of completion for 22 passes Tm=208.73mins

Total time for completion = M/c time + setting time + Inspection time + cleaning time
= 418.07+30+30+30
Total Time for reducing length =508.07mins

5) Operation E: Rough milling -1 for Width:

$A=\sqrt{H(D-H)}$
H=7.5mm O1-25mm
$= \sqrt{7.5(50-7.5)}$
D=50mm O2-25mm
A=17.85
L=810mm F=2 mm/rev

$$Tm = \frac{A+L+O1+O2}{F} \text{ Sec}$$
$$= \frac{17.85+810+25+25}{2} \text{ Sec}$$
$$Tm = 7.26\text{mins}$$

- Time of completion for 1 pass Tm=7.26mins
- Time of completion for 17 passes Tm=123.42mins

6) Operation E: Rough milling -2 for Width:

$A=\sqrt{H(D-H)}$
H=2.5mm O1-25mm
$= \sqrt{2.5(50-2.5)}$
D=50mm O2-25mm
A=10.89
L=810mm F=2 mm/rev

$$Tm = \frac{A+L+O1+O2}{F} \text{ Sec}$$
$$= \frac{10.89+810+25+25}{2} \text{ Sec}$$
$$Tm = 7.2\text{mins}$$

- Time of completion for 1 pass Tm=7.2mins
- Time of completion for 17 passes Tm=122.4mins

Total time for completion = M/c time + setting time + Inspection time + cleaning time
= 245.82+30+30+30
Total Time for reducing width =335.82mins

7) CNC Positioning: (10Secs/hole)

Total no. of holes = 202
Time for positioning = 33.66mins
Total time for CNC Positioning = M/c time + setting time + Inspection time + cleaning time
= 33.66+30+30+30
Total time for CNC Positioning = 123.66mins = 2.061 hrs

8) Drilling: (5mm/min)

Hole ‘a’:Ø11×48=9.6×27=259.2mins
Hole ‘b’:Ø18×20=4×27=108mins
:Ø14×33=6.6×12=79.2mins
:Ø12×35=7×12=84mins
Hole ‘c’:Ø15×68=13.6×12=163.2mins
Hole‘d’:Ø28×68=13.6×22=299.2mins
Hole ‘e’:Ø32×49.3=9.86×50=493mins
Hole ‘f’:Ø15×68=13.6×12=163.2mins
Hole ‘g’:Ø10×68=13.6×1=13.6mins
Hole ‘h’:Ø22×48=9.6×4=38.4mins
Hole ‘j’:Ø18×48=9.6×12=115.2mins
Hole ‘k’:Ø10×30=6×12=72mins
Hole ‘m’:Ø10×30=6×6=36mins
Hole ‘n’:Ø10×30=6×16=96mins
Hole ‘p’:Ø10×30=6×8=48mins
:Ø12×38=7.6×8=60.8mins.
Hole ‘q’:Ø20×40=8×8=64mins
Total time for Drilling = M/c time + setting time + Inspection time + cleaning time
=2193min +30min+30min+30min
Total time for Drilling =2283mins =38.05hrs

9) Tapping: (5mm/min)

Hole ‘k’:M10×25=5×12=60min
Hole ‘m’:M10×25=5×6=30mins
Hole ‘n’:M10×25=5×16=80mins
: M20×35=7×8=56mins
Total time for Tapping = M/c time + setting time + Inspection time + cleaning time =226min +30min+30min+30min
Total time for Tapping =316mins =5.26hrs

10) Jig Grinding:

Hole ‘p’:

$$T= \frac{\text{length of the job}}{\frac{\text{feed}}{\text{rev}}\times\text{speed}} \text{min}$$
$$= \frac{30}{0.02\times1000}$$

Tm= 1.5min (for 1hole)
For 8 holes =12mins
Hole ‘b’:

$$T=\frac{\text{length of the job}}{\frac{\text{feed}}{\text{rev}}\times\text{speed}}\text{min}$$
$$=\frac{35}{0.02\times1000}$$
Tm= 1.75min (for 1hole)

For 12 holes =21mins

Total time for Jig Grinding = M/c time + setting time + Inspection time + cleaning time

= 33+30+30+30

Total time for Jig Grinding = 111mins= 2.05hrs

11) Chamfering:

$$A=\sqrt{H(D-H)}$$

H=7mm O1-20mm

$$=\sqrt{7(25-7)}$$

D=25mm O2-20mm

A=11.22

L=5mm F=2 mm/rev

$$Tm=\frac{A+L+O1+O2}{F}\ \text{Sec}$$
$$=\frac{11.22+5+20+20}{2}\ \text{Sec}$$
Tm = 0.468min

Time of completion for 1 pass Tm=0.468min

Time of completion for 10 passes Tm=4.68mins

Time of completion for 12 chamfers = 56.16mins

Total time for chamfering = M/c time + setting time + Inspection time + cleaning time

= 56.16+30+30+30

Total time for chamfering = 146.16mins

12) End Milling for U-slot:

13) Operation A:

$$A=\sqrt{H(D-H)}$$

H=3mm O1-25mm

$$=\sqrt{3(25-3)}$$

D=25mm O2-25mm

A=8.12

L=85mm F=2 mm/rev

$$Tm=\frac{A+L+O1+O2}{F}\ \text{Sec}$$
$$=\frac{8.12+85+25+25}{2}\ \text{Sec}$$
Tm = 1.192min

Time of completion for 1 pass = 1.192min

Time of completion for 10 passes =11.92mins

14) Operation B:

$$A=\sqrt{H(D-H)}$$

H=4mm O1-25mm

$$=\sqrt{4(25-4)}$$

D=25mm O2-25mm

A=9.16

L=55mm F=2 mm/rev

$$Tm=\frac{A+L+O1+O2}{F}\ \text{Sec}$$
$$=\frac{9.16+55+25+25}{2}\ \text{Sec}$$
Tm = 0.951min

Time of completion for 1 pass = 0.951min

Time of completion for 10 passes =9.51mins

Time taken for 4 U-slots = 85.72

Total time for End Milling U-slot = M/c time + setting time + Inspection time + cleaning time = 85.72+30+30+30

Total time for End Milling U-slot = 175.72mins

Total time for completing Top Bolster=70.68hrs

B. Calculated Components:

The rest of the components are calculated similarly to the above mentioned components using the same formulas.

V. COST CALCULATIONS AND COMPARISON

A. Standard Costs:

Conventional Machining =75 Rs./hour

CNC Positioning =300 Rs./hour

Wire Cutting =225 Rs./hour

1) Top Bolster:

Conventional Machining =68 hrs 38mins×75 = Rs.5100

CNC Positioning =2hrs 4 mins×300 = Rs.600

2) Bottom Bolster:

Conventional Machining =67 hrs 46mins×75 = Rs.5082.5

CNC Positioning =2hrs 2mins×300 = Rs.610

Wire cutting =31hrs×225 = Rs.6975

3) Bottom Backing:

Conventional Machining =28 hrs50min×75= Rs.2162.5

CNC Positioning =1hr 53min×300= Rs.565

Total no. of Bottom backing (3) = Rs.8184

4) Bottom Spacer:

Conventional Machining =39hrs42min×75 = Rs.2977.5

CNC Positioning =1hr 35min×300= Rs.474

5) Die Plate:

Conventional Machining =95hrs 40min×75= Rs.7175

CNC Positioning =1hr10min×300= Rs.650

Wire Cutting =46hrs35mins×225= Rs.10556.25

Total no. of Die plates (3) = Rs.50146

6) Stripper Plate:

Conventional Machining =90hrs 24mins×75= Rs.6778.78

CNC Positioning =1hr 54mins×300= Rs.570

Wire cutting =1hr30min×225= Rs.337.5

Total no. of Stripper plates (3) = Rs.23061

7) Stripper Backing:

Conventional Machining =79hrs54mins×75= Rs.5997

CNC Positioning=1hr 52mins×300= Rs.560

Wire cutting=4hrs 48mins×225= Rs.1080

Total no. Stripper backing (3) = Rs.22911

8) Punch Holder:

Conventional Machining =36hrs 44mins×75= Rs.2753.75

CNC Positioning=1hrs 57mins×300=Rs.585

Wire cutting=2hrs×225= Rs.450

Total no. of Punch Holder (3) = Rs.11367

9) Punch Backing:

Conventional Machining =92hrs 54mins×75= Rs.6972.5

CNC Positioning =1hr 54 mins×300= Rs.570

Total no. of Punch backing (3) = Rs.22630

10) Parallel Block:

Conventional Machining =44hrs 38mins×75= Rs.3346.25

CNC Positioning =1hr36mins×300= Rs.480

11) Gimp Cutting Die:

Conventional Machining =1hrs 36 mins×75= Rs.120

Wire cutting =3hrs46mins×225= Rs.847.5

Total no. of dies (3) = Rs.968

12) Strip Guide:

Conventional Machining =3hrs2mins×75= Rs.230

CNC Positioning =0.5 hrs×300= Rs.150

Total no. of strip guides (3) = Rs.380

13) Strip Guide:

Conventional Machining =5hrs46mins×75= Rs.432.5

CNC Positioning =0.5hrs×300= Rs.150

Total no. of strip guides (3) =Rs.583

14) Piercing Punch:

Conventional Machining =1.9hrs×75= Rs.142.5
Total no. of piercing punches (16) = Rs.2288

15) Notching Punch:

Conventional Machining =3hrs25mins ×75 = Rs.262.5
CNC Positioning =20mins= Rs.99
Total no. of notching punches (3) = Rs.789

16) Guide Pin:

Conventional Machining =1hrs 36mins×75= Rs.120
Total no. of guide pins (31) = Rs.3720

17) Standard Components:

Small size components = Rs.10000
The Existing cost of Machining Components for 60 days = Rs.2, 21,847.50
The Cost of proposed method for Machining Components in 45 days = Rs.1, 82,673.50
Total Cost saved by reducing the M/c time and days = Rs.39, 174

B. Cost Comparison

The estimated cost of machining for 45 days and the existing process of 60 days followed in the industry are compared. As the existing process follow random machining operation, it takes many days to complete the final product as mentioned above. As a result the cost was increased. In our new estimation after calculating the machining hours, the ABC Analysis is worked out and using PERT chart the machining hours are reduced and as well as the days taken are reduced. Hence the cost of manufacturing the progressive tool is less than the existing method.

VI. CONCLUSION

The various parameters of the circumferential headers are planned to optimize the lead time and cost of producing Progressive press tool and these are all compared with actual machining methods. To overcome the huge time production difficulties and to automate the process, we are introducing the way of manufacturing approach for producing the press tool with significant period. We have used Engineering aspects theoretically from various resources. We have also mentioned various calculations and techniques like ABC analysis and PERT. With the help of these techniques it is possible to reduce the production time from 60 days to 45 days. The cost for existing process in industry is Rs.2,21,847.50 and the cost of proposed method for manufacturing is Rs.1,82,673.50.And the cost saved by proposed method is Rs.39,174.

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