

# Experimental Set Up On Metal Spinning

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**Abstract -** For Understanding the Metal spinning process, we take trial on lathe machine because we want to check material is able to change the shape from circular blank to mandrel shape or not and with help of this trial we also find out spindle speed, feed rate, feed ratio etc. We know the formula of metal spinning from this formula we calculate diameter of blank, Roller diameter, nose radius of roller etc. For trial purpose we design cone shaped mandrel according to this component we design tailstock live centre, roller fork, roller.

## I. TRIAL NUMBER 1

### Blank Diameter

Blank diameter is a diameter of metal sheet which is used for producing spun component. Different type of blank diameter used in metal spinning according to product requirement. Generally in metal spinning cylindrical, hemispherical and cone shaped component are produced, and according to this shape and size blank diameter will change. In this trial we try to produce of cone of outer diameter 120 mm to 80 mm. Blank is required to produce cone so that first we calculate the diameter of blank.

We know that,

1. circular blank
2. Outer diameter of Cone = 120mm
3. Assume slant height = 120 mm

D = Diameter of blank

R = Large Radius of Frustum

r = Small Radius of Frustum

S = Slant height of Frustum

Surface area of blank = surface area of cone

$$\pi/4 \times (D)^2 = \pi \times (R + r) \times S$$

$$\pi/4 \times (D)^2 = \pi \times (60 + 30) \times 120$$

$$D = 208 \text{ mm}$$

From calculation prove that 208 mm blank diameter is maximum diameter of blank below this diameter we produce component.

### Roller Diameter

Roller acts as a tool which applies the force on the metal sheet over the mandrel. Rollers are available in different diameter and different thickness. This roller deforms the metal sheet over the mandrel in several no of passes. According to Hayama low mandrel speed, small roller diameter and low viscosity lubricant give low surface finish. Roller diameter can be calculated by using the following formula [4].

$$D_r = 0.1D + (120 \pm 60) \text{ mm}$$

Where,

$D_r$  = Roller diameter in mm

D = Original diameter of blank in mm

Roller acts as tool it convert blank into spun component. Roller diameter depends on blank diameter.

$D_r$  = Diameter of roller

$$D_r = (0.1 D + 120 \pm 60) \text{ mm}$$

$$D_r = [0.1 (208) + (120 + 60)]$$

$$D_r = 200.8 \text{ mm}$$

Assume, Roller diameter always less than diameter of component so we check second condition.

$$D_r = [0.1 (208) + (120 - 60)]$$

$$D_r = 81 \text{ mm}$$

We select a Roller diameter 81 mm

**Mandrel**

Cone shaped Mandrel is a Replica of product it means that shape of product is same as that of shape of cone shaped Mandrel. This Mandrel support the blank and it is also used as base . Without this Mandrel we can't produce product so that Mandrel play vital role in this trial . The dimension of component

$D$  = Large diameter = 120 mm

$d$  = Small diameter = 60 mm

$S$  = Slant length = 120mm

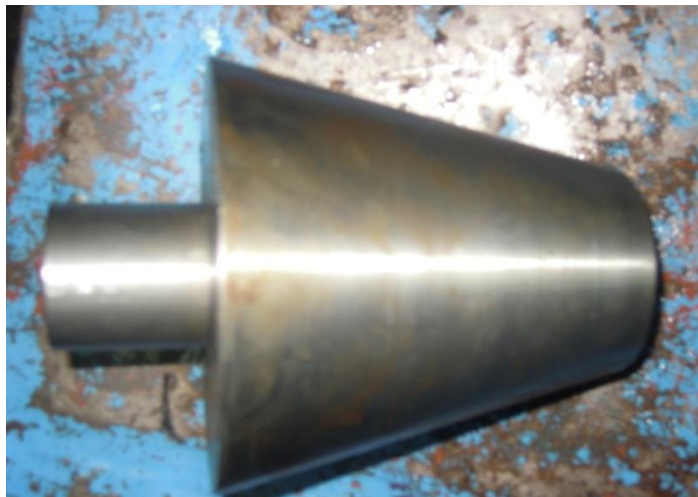


Fig.1 Mandrel

The front side of cone provide circular shaped male part having dimension  $d = 30$  mm ,and  $t = 2$  mm , this part fit in the female part of tailstock live centre. The back side of mandrel insert solid shaft having  $L = 65$  mm &  $d = 40$  mm ,this solid rod used as hold the mandrel in the spindle.

**Tailstock Live Centre**

Tailstock live centre is used as supporting member to the mandrel & Blank. On tailstock live centre provide female part and this part match with male part of mandrel .The total length of live centre is 100 mm and  $D = 60$  mm and  $d = 30$  mm



Fig 2 Tailstock Live Centre

**Process**



Fig 3 Experimental Setup of Trial No 1

Sheet metal spinning is one of the metal forming processes, where a flat metal blank is formed into an axisymmetric part by a roller which gradually forces the blank onto a mandrel, bearing the final shape of the spun part. As shown in Figure ,during the spinning process, the blank is clamped between the mandrel and back plate; these three components rotate synchronously at a specified spindle speed.

In fig, mandrel is hold in the chuck and tailstock live centre hold in the tailstock. Chuck are used to rotate the mandrel with certain speed & tailstock live centre support the mandrel. Tool post are used to hold the tool & travel the tool in direction of workpiece. Roller act as tool and it is hold in tool post. The blank is clamp between mandrel male and live centre female part. When spindle speed is given to mandrel then mandrel and blank start rotating together along with live centre at high speed. When roller press on the blank, forces are generated due to this material of workpiece i.e. blank flow over mandrel and get shape same as that of mandrel. During this process thickness of blank is reduced so this process comes under of shear spinning.

#### ***Final Component of Trial No.1***



Fig 4

#### ***Reason of Failure***

- Spinning Ratio: - Spinning ratio is defined as ratio of blank diameter to mandrel diameter. Higher the spinning ratio more difficult is spinning process [6].

$$\text{Spinning ratio} = \frac{\text{Blank Diameter}}{\text{mandrel Diameter}} = \frac{208}{120} = 1.733$$

spinning ratio must required less than 1.65 but obtained spinning ratio from calculation is 1.733 which is greater than 1.65 so that our component get fractured.

- Nose Radius of Roller :- Using large nose radius provide high surface quality. Increasing the roller nose radius resulted in small reduction in wall thickness and good surface finish. If the nose radius of roller is small then axial thrust force of the roller can generate very high tensile stress in the blank which will cause crack[4].





Fig 5

We design roller having nose radius 7 mm which is less due to this nose radius poor surface finish and crack appeared on the final spun component.

- **Mandrel corner Radius :-** A Fracture occurred in final component at the beginning of the process close to the tailstock over the mandrel radius due to small corner radius of mandrel .
- **Feed Ratio :-** Feed ratio is defined as it is ratio of roller feed rate to spindle speed. High feed ratio help to maintain original blank thickness. It also lead to material failures & rough surface finish. Low Feed ratio is better for spinning process because good surface finish obtained and no failure of component take place.

Model	Feed Rate (mm/min)	Spindle Speed (rpm)	Feed Ratio (mm/rev)	Result
Model 1	800	500	1.6	Wrinkling
Model 2	1000	800	1.3	Wrinkling

5. **Diameter & Thickness of Blank :-** Diameter and Thickness of the workpiece had the most significant effects on the wrinkling failures of the spinning process. In general thinner blank and larger diameter of workpiece would increase the possibility of wrinkling failures.

## II. MODIFICATIONS FOR TRIAL 2

### **Modified Mandrel [1]**

Mandrel is a supporting as well as rotating part in the metal spinning set up. As we are trying to produce a component having a shape cone so we design cone shaped mandrel. Blank is clamped between the mandrel and tailstock and this blank is deforming over the mandrel by applying the force with the help of roller. When we take a trial fork of the roller tackle with tailstock so we have to remove tailstock for that we make the threaded drill on the front face of mandrel to remove the tailstock. Cracks also appear on the component due to corner edge of the mandrel this problem is also removed by giving a corner radius to the mandrel. Both old and modified mandrel are shown in Fig 6(a) and 6(b)

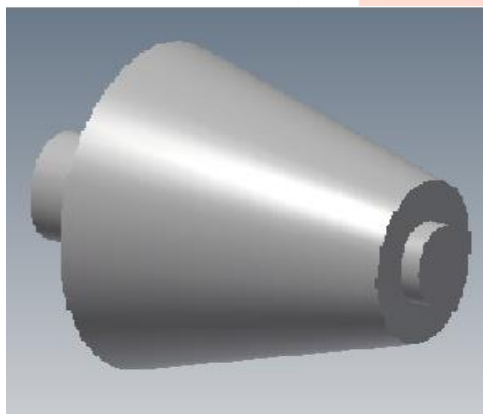


Fig 6(a) Old mandrel

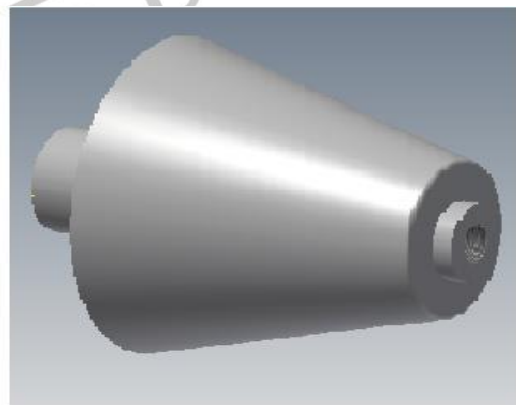


Fig 6 (b) Modified mandrel

### **Modified Roller [1]**

Roller acts as a tool in a metal spinning set up which apply the force on the metal sheet which deform over the mandrel. Roller are available in different diameter , different roller nose radius and thickness. Roller nose radius is a most important parameter which affect the surface quality of the product. For trial we design a roller having a diameter 81 mm and roller nose radius 7mm by using this roller we take a trial but the rough surface quality of the component get appeared. This rough surface is occurred on the surface is due to small nose radius. Therefore to get a good surface quality of the product we design a roller having a full nose radius. Both the roller are shown in Fig 7(a) and Fig 7(b)

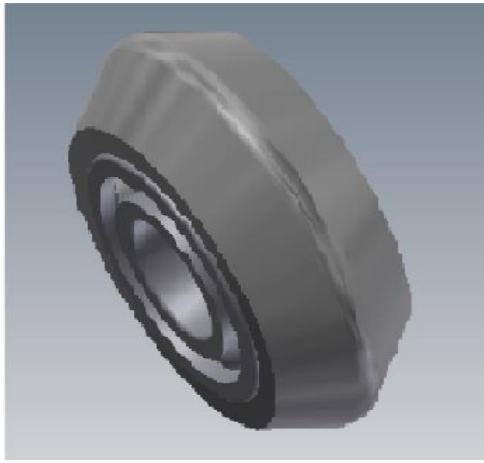


Fig 7 (a) Old Roller

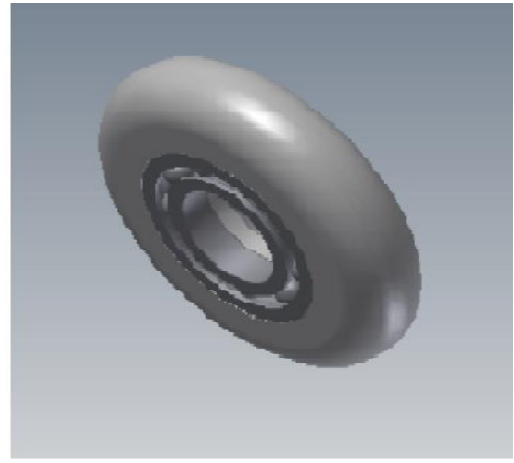


Fig 7 (b) Modified Roller

### **Modified Fork [1]**

Fork is the part which helps to hold the roller when applying the force. By using this roller and fork assembly we apply the force on to the blank and mandrel but when we applying force the fork of the roller tackle with the tailstock live support due to this required angle and required force will not be occur. Due to this problem component get fail. Both fork are shown in Fig.8 (a) and Fig.8(b)

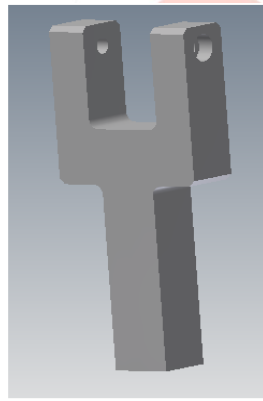


Fig 8 (a) Old Fork

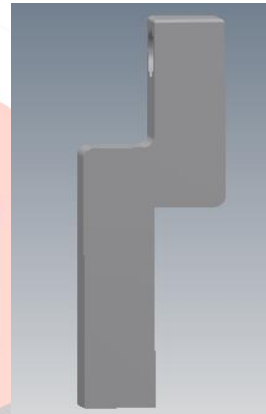


Fig 8 (b) Modified Fork

### **Stepped Washer Instead of Tailstock Live Centre**

Tailstock is the supporting part in the metal spinning setup which supports the blank. This blank is clamped between the mandrel and tailstock live centre. This whole assembly rotates synchronously during the process. The total length of live centre is 100 mm and  $D=60$  mm and  $d=30$  mm. When we take trial tailstock live centre and fork of the roller tackle with each other due to this required angle of the roller is not obtained. Due to this problem the component gets failed. To remove this difficulty we design a new stepped washer instead of the tailstock live centre. With the help of this washer blank is clamped between mandrel and washer. Both the tailstock and stepped washer are shown in Fig 9(a) and 9(b).



Fig 9 (a) Tailstock live centre

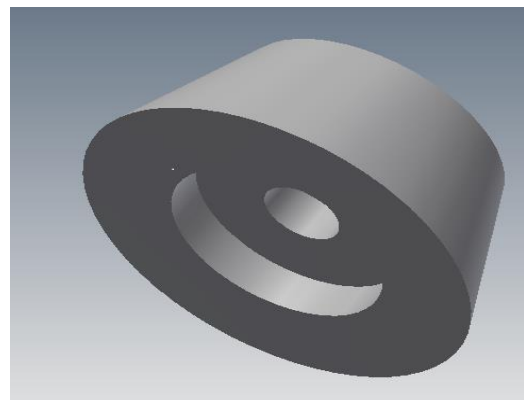


Fig 9 (b) Stepped Washer

### **Correction in Process Parameter**

- Feed ratio [2]:- Feed ratio is defined as it is ratio of roller feed rate to spindle speed. Variation of feed ratio has considerable effect on the tool forces, wall thickness, Spinability, Surface finish & spring back of the metal spinning process. Low Feed ratio is better for spinning process because good surface finish obtained and no failure of component take place. For Aluminium feed ratio is 0.9 mm/rev and for mild steel feed ratio is 1.8 mm/rev.
- Feed rate [3]: - The roller feed rate, which is one of the important parameter affecting the formability and forming quality. Due to the high feed rate rough surface finish & wrinkling may be occur. A decrease in feed rate will improve the surface finish while increase in feed rate will make a work piece fit to mandrel and the finish of work piece will become coarse. In order to realize synchronous motion control of mandrel and roller, the number of pulse signal for mandrel rotation, mandrel feed and roller feed are maintained constant for a given time interval.
- Spindle speed [2]: - The best quality for most components is achieved when spinning at high speed. The influence of rotational speed on the variation of axial and radial forces is negligible. For aluminium material we take Spindle speed 800 to 900 rpm

#### **Spinning Ratio [4]**

Spinning ratio is defined as ratio of blank diameter to mandrel diameter. According to wang lin this spinning ratio should be less than the 1.6 but when we take a trial this spinning ratio is above the 1.6 so that the component get fractured. For Second trial we take blank diameter 120 mm .

$$\text{Spinning ratio} = \frac{\text{Blank Diameter}}{\text{mandrel Diameter}} = \frac{120}{120} = 1$$

Therefore, the spinning ratio is less than 1.6 so that product can't fracture.

#### **Experimental Setup of Trial 2**

Sheet metal spinning is one of the metal forming processes, where a flat metal blank is formed into an axisymmetric part by a roller which gradually forces the blank onto a mandrel, bearing the final shape of the spun part. As shown in Figure, during the spinning process, the blank is clamped between the mandrel and back plate; these three components rotate synchronously at a specified spindle speed. But when we take trial of the process the fork of the roller tackle with the tailstock live centre also designed roller have a small nose radius due to this reason the trial 1 get failed.

So we make modification in the mandrel, roller, roller fork, and process parameter. With the help of this modifications in the setup we take a trial. This experimental setup is shown in Fig 10.

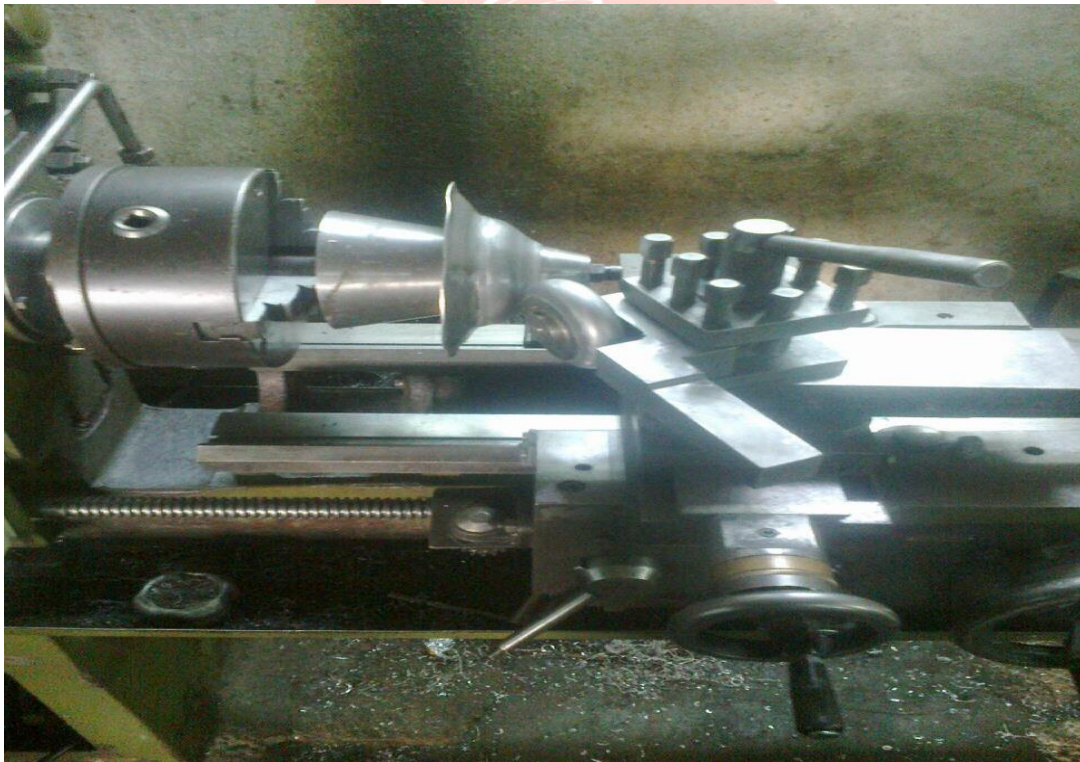


Fig 10 Experimental setup of trial 2

#### **Final Component**

By making the modification in the setup we take a trial and produce final component without any crack and wrinkle. The final component is shown in Fig 11.



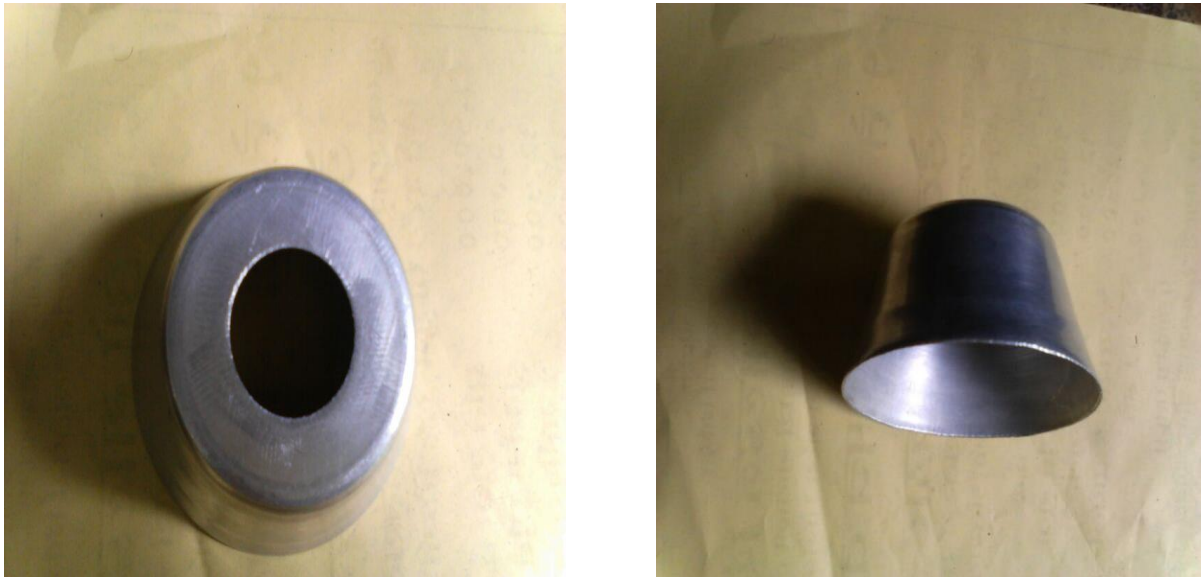


Fig 11 Final component

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