Design and development of tooling set up for metal spinning process on traditional lathe machine

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Abstract: Metal spinning process is kind of metal forming process, in which blank rotates at a high speed and change the shape from circular blank to mandrel shape, the mandrel shape is given by roller tool to circular blank, between support unit and mandrel blank fits, tool fits in tool post section, for such operation we design and development of tooling setup. As possible we design two tool path and based on that tool and assembly designs. For our tool requirement we design developed rollers, tool fork for roller instalment, adjustment plate and tool holder this assembly for our concave tool path. For linear tool path we designed roller and tool fork. Mandrel is required cone shape based upon our requirement so we designed and manufactured such part as well as we also select material for tools, mandrel and blank.

Keywords: Metal spinning, Conventional metal spinning lathe, Tool assembly, Tool path, Material selection**.**

I. INTRODUCTION

Metal forming, is the metal working process of create metal component and objects through mechanical deformation. The work piece is refashioned without adding or removing material and overall mass of the work piece remain constant. There are many metal forming processes are available for e.g. rolling, deep drawing, extrusion etc. metal spinning is also one of the metal forming processes. Metal spinning does not for demand removal of material, as in conventional metal or wood turning process, but forming of sheet metal over an existing shape. The spinning is quiet simple process, the mandrel is attached to the driving section of the lathe. An existing size of metal blank is then clamped at an opposite side of the mandrel by a pressure pad, which is attached to the tail stock. The mandrel and work piece are then rotated together at required high speed. A localized force then applied to the work piece due to that work piece flow over the mandrel and required shape is formed. The force is generally applied via different tools like roller tool. Metal spinning is the most beneficial way to form of circular metal parts for commercial applications. Almost any material can be formed aluminium to stainless steel all material are included. Spinning machines: - sufficient speed range with high performance lathe machines are used in metal spinning process.

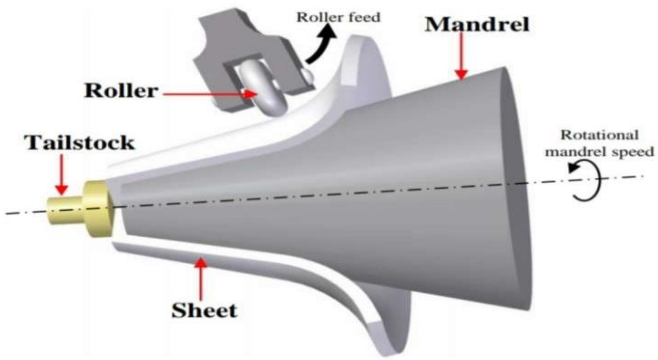

Figure1: Layout of metal spinning operation

In metal spinning process high dimensional accuracy and surface finish is possible as compared to deep drawing process. For larger parts tooling and machining cost would be very less as compared to other forming processes. every process has their pros and cons in metal spinning wrinkle defect is more while in deep drawing less.

II. TOOLING SYSTEM IN METAL SPINNING

Tools for spinning are made from several type of plastic, wood and steel, depending upon the design criteria of the component. They are define into three main categories: male, female and collapsible.

1) A male tool is the most general type of spinning tool. It clearly replicates the internal dimensions of the component. The sheet blank is shaped around the outside of the tool as the tool apply force against it. 2) A female tool surrounds the sheet blank and the final structure is taken by interior of tool. They are suitable for forming flanges and returns.3) collapsible or segmented: a collapsible male tool is necessary to remove the tool when the diameter of the work piece is decreased during forming. The collapsible tool has a portable core which fix the perimeter forming pieces while rotating is in progress.

2.1 Mandrel design

Mandrel is rotating as well as supporting part of metal spinning process. The final component take shape same as mandrel. Rear portion of the mandrel fit with chuck and front portion support the blank. Mandrel is a rigid part and various materials are used according to requirement like mild steel, aluminium, grey cast iron, magnesium, wood etc. the mandrels usually made wholly of steel and cast iron when it is required to produce the parts to close tolerance and cast iron or cored casting of steel are favoured in order to decrease the rotating weight. Mandrel is must be statically as well as dynamically balanced during the operation.

Material selection for mandrel is based on desired mandrel life. The actual mandrel material selection should be based on the design, desired life and part material. For instance grey cast iron is used for low manufacturing volume (10 to 110 bit) spinning of soft metals, alloy cast iron for moderate volume (110 to 260 bit), for high manufacturing volume (250 to 700 bit) 52100 steel hardened to around 60HRC is used. The surface finish of the mandrel must be no less than 1.5µm.

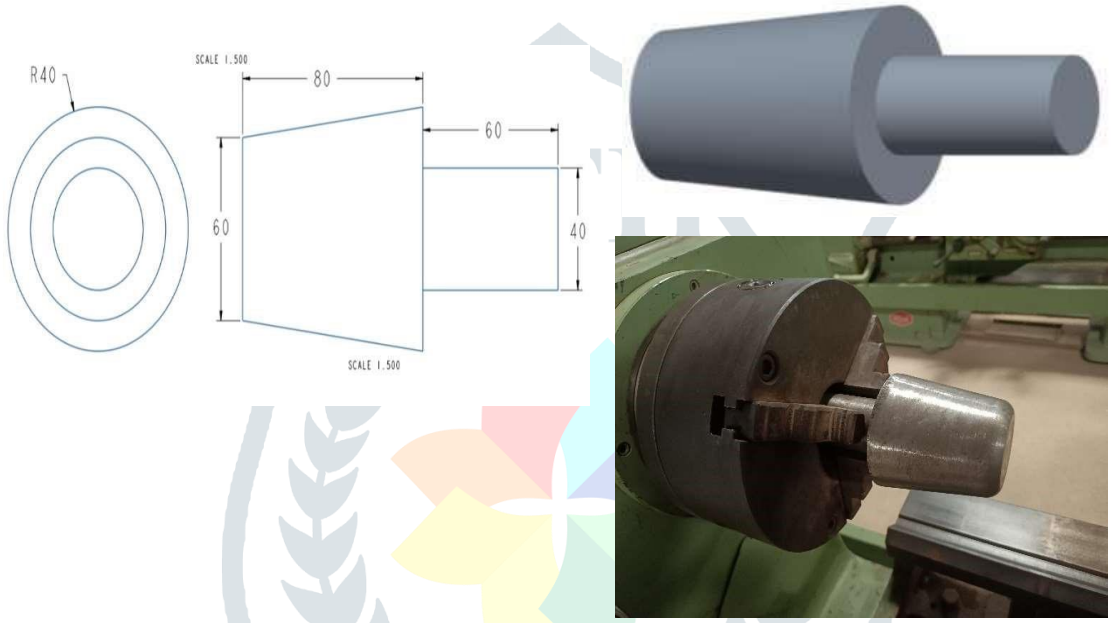

Figure 2: 2Dsketch, cad model& manufactured component of mandrel

Material selection for mandrel: - the design, part material and desired life these things consider during selection of material. Mild steel is the best suitable material for our criteria because,

- High tensile and impact strength
- Good malleability with cold forming possibilities o
- Expected life of mandrel is quite high
- Good ductility

Design dimensions of mandrel:-

- Large diameter (D) = 80mm
- Small diameter (d) = 60mm
- Slant diameter(S) = 80mm

2.2 Support unit for blank

Tail stoke live centre is a female part which used for supporting the mandrel and blank. Between mandrel and live centre there blank is fitted, length of live centre= 90mm, diameter=50mm.

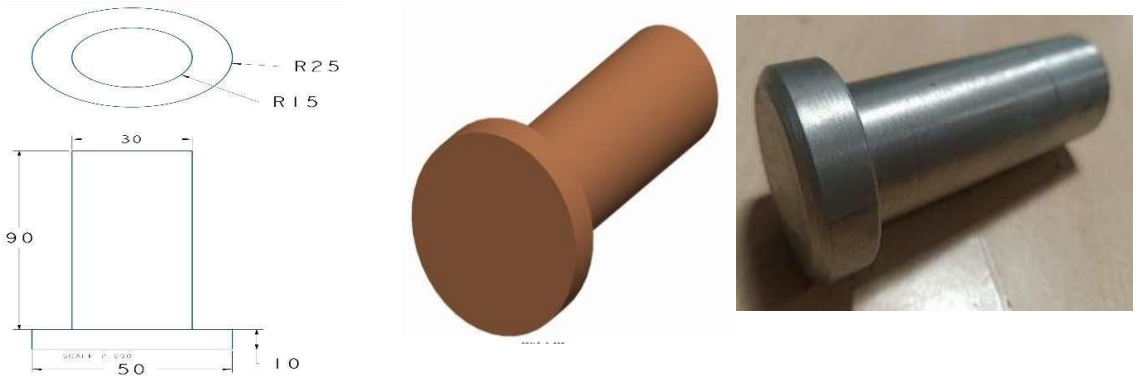

Figure 3: 2D Sketch, cad model &manufactured component of support unit

2.3 Design of tooling assembly

2.3.1 Design of tool based on tool path

A) Concave tool path

B) Linear tool path

A) below all the tool assembly based on concave tool path

1) Design of roller

Roller pushes the sheet metal towards mandrel at high speed and several number of passes that is how component is being formed. Various things of roller effects on component like nose radius of roller, total diameter of roller, surface smoothness of roller. According to study small roller diameter, speed of mandrel and low viscous lubricant give low surface finish.

Nose radius of roller: - nose radius of roller has an outstanding effect on dimensional accuracy. Low surface roughness and uniform thickness distribution are the results of large nose radius. For a spinning operation nose radius and roller diameter has a remarkable outcome on tangential force component and get a good surface finish quality by using a larger nose radius.

$$Nr = 0.1D+ (D\pm R) \text{ mm}$$

By using this formula we can calculate nose radius where,

Nr = Nose radius (mm)

D = Blank diameter in mm

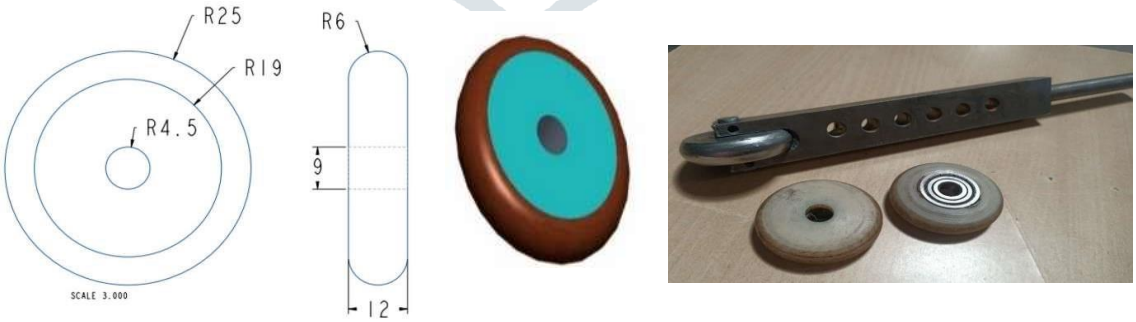

Figure 4: 2D Sketch, cad model & manufactured component of roller

Roller dimensions:-

- Diameter of roller=50mm
- Width=12mm
- Nose radius=6mm

There another same tool is made with 5mm nose radius that also made of mild steel and Teflon material

Material selection for roller:-

This roller is made of two material:-

1.1) Mild steel

- Good ductility
- High impact and tensile strength
- Mild steel contain very less carbon, passive to heat treatment

1.2) Teflon

- High flexural strength
- Low coefficient of friction
- Good resistance to heat

2) Roller tool fork

Roller tool fork is made of mild steel. width of the fork is 32mm, roller is fitted at the front of the tool by 9mm shaft and bearing install, effective length of the tool is 200mm and for the smooth operation overall length can be extended for that 15mm diameter rod is given, there total 6 holes (10mm diameters each) are given for adjustment plate install.

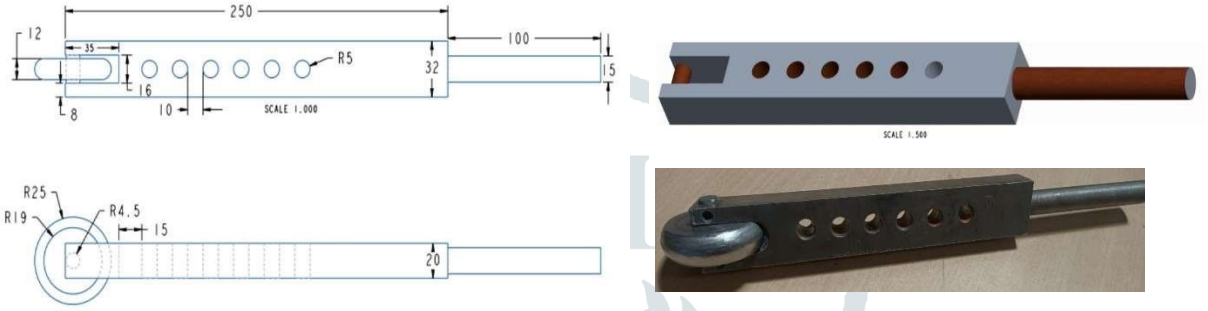

Figure 5: 2d sketch, cad model &manufactured component of tool fork

3) Tool adjustment plate

Tool adjustment plate has two pin upper and lower, upper pin fits with the roller tool fork and lower fits with tool holder length and diameter of pin is 20mm and 9.5mm respectively. Effective length of the plate is 35mm and rest of the tool length is 150mm and it can be extended for smooth operation because there is plenty of room to work the blank down the length of tool. Handle can be extend unto requirement.

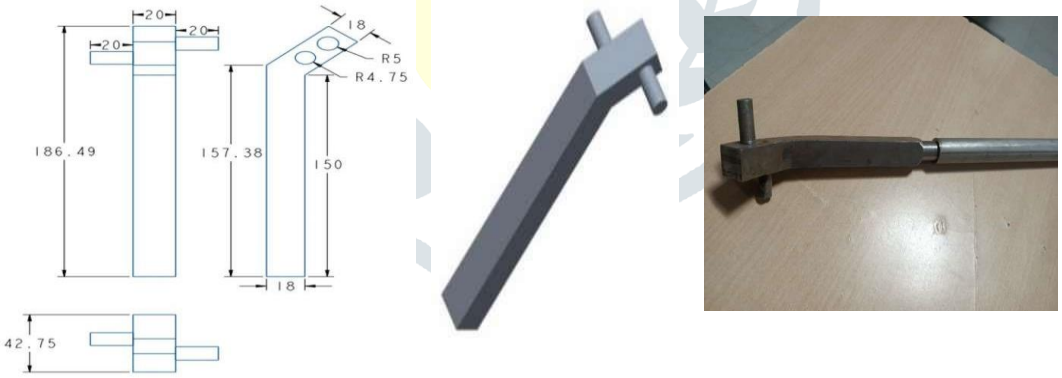

Figure 6:- 2D sketch, cad model & manufactured component of adjustment plate

4) Tool holder

Tool holder has total 8 holes (10mm diameter each), pin of adjustment plate fits in the hole of tool holder and it gives support to adjustment plate and roller tool.

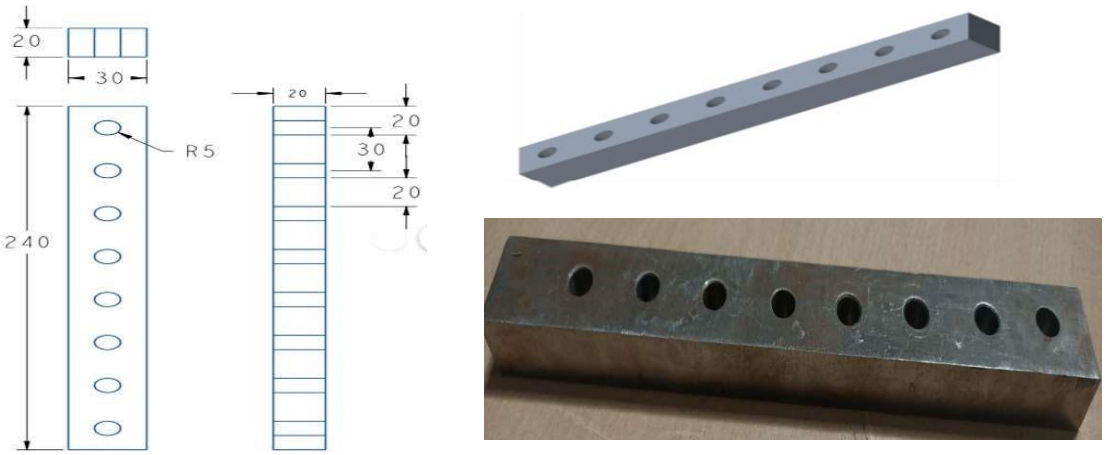

Figure 7: 2D sketch, cad model &manufactured component of tool holder

B) Linear path tool

This tool is designed as a linear path movement during the operation, this tool fit in tool post and then move toward the blank and apply force according. for this type of tooling system there require one roller, one fork, one centre shaft for hold centre roller and a long shaft for move the tool effectively.

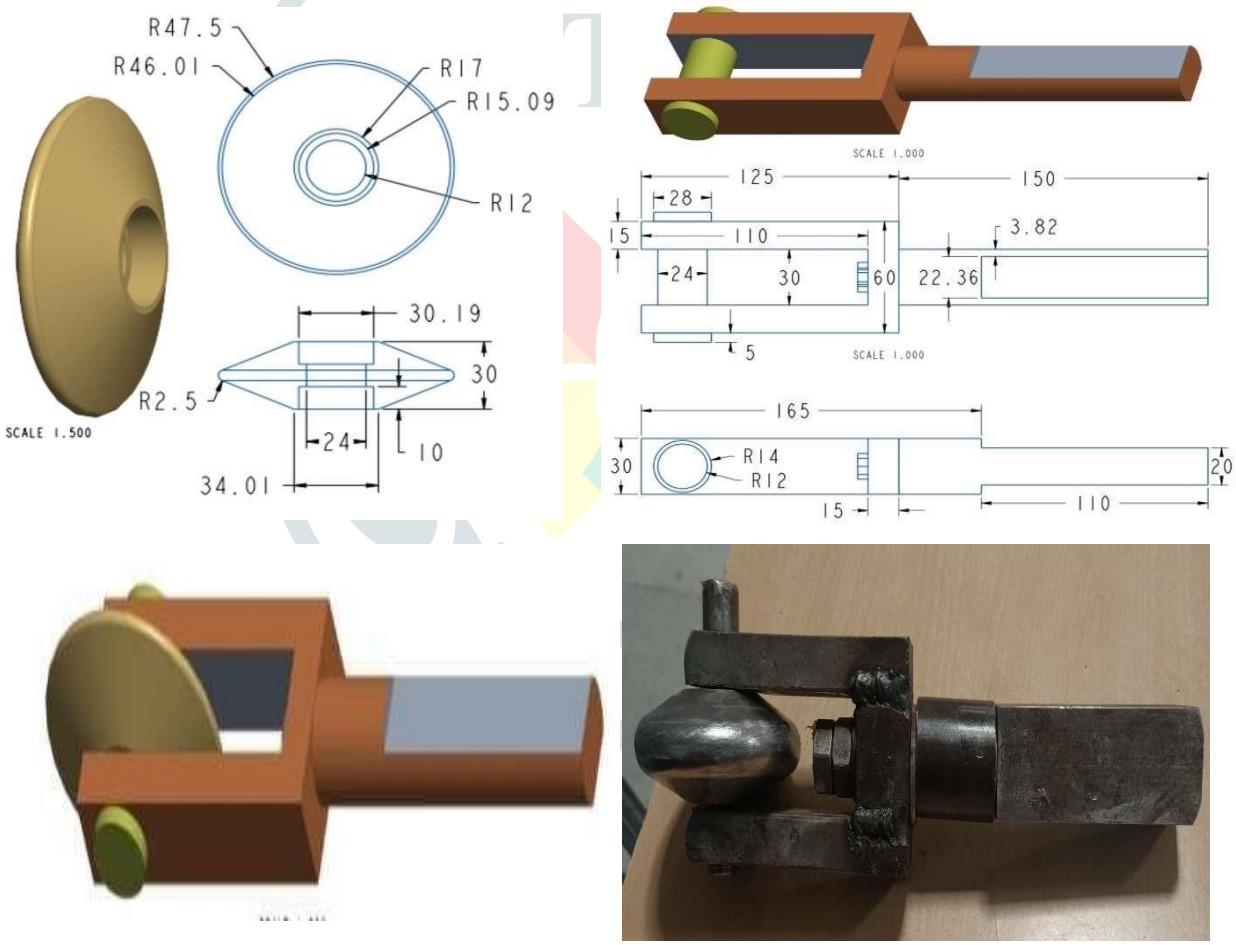

Figure 8: 2DSketch&cad model of roller, 2D Sketch and model of tool fork, whole tool model assembly, and manufactured tool assembly

III. MATERIAL SELECTION FOR BLANK

There is a sheet metal is used to produce a component in metal spinning. Generally all the materials are available in the form of sheet. There some material are best suit for metal spinning operation like aluminum, copper, stainless steel, brass, tin etc.

3.1) Aluminium AA 1100 H-14

Aluminum alloy AA 1100 H-14 Is a popular grade of aluminum for general purpose sheet metal works where moderate strength is the requirement. AA1100 is also known for its excellent corrosion resistance, high ductility and reflective

finish. Fabrication of this material like machinability is poor while workability is excellent. Elongation of this material is highest among all the grade materials Properties of Aluminum AA 1100 H-14.

Table 1: Properties of Aluminum AA 1100 H-14

PROPERTIES	VALUE
Proof stress	95Min MPa
Tensile strength	110-145 MPa
Hardness brinell	32HB
Density	2.71g/cm3
Modulus of elasticity	68GPa

3.2) Stainless steel- 202

Grade 202 stainless steel is a type of Cr-Ni-Mn stainless steel in this material chromium is 17-19%, nickel is 4-6%, manganese 8-10% and iron (Fe) 68%. Toughness of grade 202 at low temperatures is excellent. Stainless steel is elastic in nature and stretch before shred. The main concern of stainless steel is that it requires more force to deform. Properties of SS 202.

Table 2: Properties of SS 202

PROPERTIES	VALUE
Tensile strength	515MPa
Yield strength	275MPa
Elastic modulus	207GPa
Poisson's ratio	0.27-0.30
Elongation at break	40%

3.3) Design of blank

Generally, in metal spinning cone, cylindrical and hemispherical component are being produced. In this going to use cone shape component for two material.

- Large diameter of component(R) =80mm
- Small diameter of component(r) =60mm
- Slant height(S) =80mm

Surface area of blank = surface area of component

$\pi/4\times (D)\ ^2$ = $\pi\times (40+30)\times 80$

Thickness of blank The range of 0.5mm to 30mm thickness of blank can be formed in metal spinning process.

- Weight of SS blank = 145 grams
- Weight of aluminum blank = 300 grams

IV. PARAMETER SELECTION FOR EXPERIMENTATION

We already developed all the tools blanks and required component, our further work is to perform experiment for that we require some parameters like input as well as output parameters. Based on our experimentation requirement we selected some parameters like

1) Input parameters: - roller material, roller nose radius, angle of inclination, spindle speed, roller tool path.

2) Output parameters: - thickness of sheet, strain measurements, surface roughness, out of roundness.

V. CONCLUSION

In this paper, the main aim is that design and development of metal spinning tool, material selection to get a better output in form of a good surface finish and quality of our product we have to decrease the failures and defects like buckling crakes and wrinkles.

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