Review on Spinning Attachment to Lathe Machine

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ABSTRACT

Abstract – Metal spinning is a method of forming rotationally symmetrical sheet metal parts. Metal spinning does not involve removal of material, as in conventional wood or metal turning, but forming of sheet material over an existing shape. It is also known as spin forming or spinning or metal turning most commonly, is a metal working process by which a disc of metal is rotated at high speed and formed into an axially symmetric part. In this project the basic principle of Metal Spinning is used. For the application of process slight desired changes have to make in regular lathe machine. By implementing the changes in lathe machine the assembly thus can be used to manufacture products. Main objective is to achieve similar working process as that of the spinning in regular lathe machine by doing its slight modification.

Keywords*: Metal Spinning, Traditional Lathe Machine, Mandrel, Live Centre, Process Parameters.*

I. INTRODUCTION

Metal spinning is a term used to describe the forming of metal into seamless, axisymmetric shapes by a combination of rotational motion and force. Metal spinning is one of the oldest methods of chipless forming, but over the years, this process has lost ground to other forming process such as deep drawing and ironing. However, due to the inherent advantages and flexibility of the process such as simple tooling and low forming loads, plus the rapid emerging trend in modern industries towards near net shape manufacturing of thin sectioned lightweight parts, spinning has undergone a renaissance in recent years and has developed into a versatile process for producing lightweight components.

Spinning is commonly known as a process for transforming flat sheet metal blanks, usually with axisymmetric profiles, into hollow shapes by a tool which forces a blank onto a mandrel, as illustrated in Fig. 1. The blanks are clamped rigidly against the mandrel by means of a tailstock and the shape of the mandrel bears the final profile of the desired product. During the process, both the mandrel and blank are rotated while the spinning tool contacts the blank and progressively induces a change in its shape according to the profile of the mandrel. As the tool is applied locally on the workpiece, the total forming forces are reduced significantly compared to conventional press forming. This not only increases the possibilities in terms of large reductions and change in shape with less complex tooling, but also reduces the required load capacity and cost of the forming machine. In addition, spinning is also known to produce components with high mechanical properties and smooth surface finish.

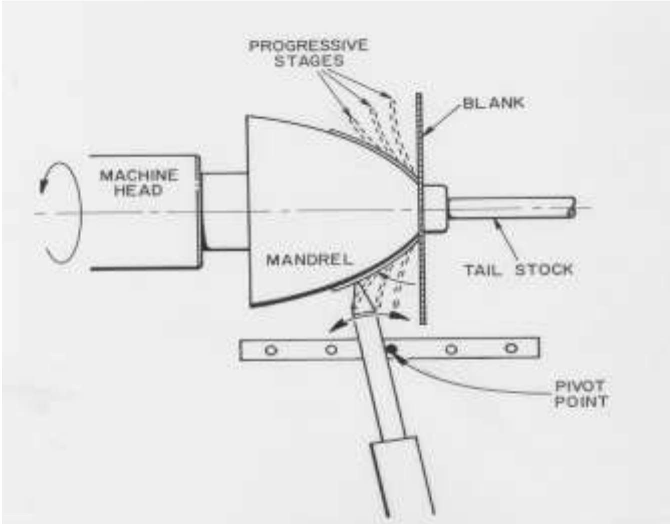

Figure 1 Conventional Manual Spinning [1].

It has been suggested that the process of metal spinning emerged from the art of potting clay using a manual-powered potter's wheel by the Pharaohs in ancient Egypt. It then travelled to China in the 10th century, then to England during the reign of Edward III and eventually to the USA in the 19th century. As the art of spinning grew significantly, spun metal parts like tea kettles and trophies were first produced in the Middle Ages. At the beginning of the 20th century, spinning was considered an art rather than science, as it required operators with considerable experience and skill.[1]

The product of metal spinning includes:

_ Bases, baskets, basins, and bowls
_ Bottoms for tanks, hoppers, and kettles
_ Canopies, caps, and canisters
_ Housings for blowers, fans, filters, and flywheels
_ Ladles, nozzles, orifices, and tank outlets
_ Pails, pans, and pontoons
_ Cones, covers, and cups
_ Cylinders and drums
_ Funnels and horns
_ Domes, hemispheres, and shells
_ Rings, spun tubing, and seamless shapes
_ Vents, venturis, and fan wheels [3,4]

Figure 2 Spinning Component [8]

The spinning process is vastly used in kitchen utensils industry and geyser tube manufacturing industry, the ends of milk, gas, etc carrying cylinders on trucks which are dome shaped are also spinned. The front nose of air craft is spinned. Applications also include rocket nose cones, cookware, gas cylinders, brass instru- ment bells, and public waste receptacles, etc.

Dedicated spinning machine are also available in industries which are available both in vertical and horizontal spindle type.

The project spinning attachment to lathe involves use of traditional lathe of around 4 feet size. Spinning involves plastic flow of sheet metal which is malleable. The operation requires high speeds of rotation (above 2100 rpm). The tradition lathe has usually 900 rpm maximum. Hence certain changes are to be made in driving mechanism of lathe such as changing the gears or changing belt drive to obtain high speed on chuck.

The process is to spin a glass shape out of aluminium/stainless steel from a circular blank of about 0.8mm to 1mm. The design involves change in:

A) A mandrel of the shape of glass

B) Modified live centre with a pad to hold the sheet against the mandrel

C) A blunt tool and a trimming tool

Before we conclude it is to mention that the lathe which is slightly modified for spinning operation is easily brought back to its original specifications and standard setup by replacing its original parts. No damage is done to the lathe.

a. II. EXPERIMENTAL SETUP

During the spinning process, the blank is clamped between the mandrel and back plate; these three components rotate synchronously at a specified spindle speed. Materials used in the spinning process include non-alloyed carbon steels, heat-resistant and stainless steels, non-ferrous heavy metals and light alloys. The process is capable of forming a workpiece with a thickness of 0.5 mm to 30 mm and diameter of 10 mm - 5 m. Due to its incremental forming feature, metal spinning has some unique advantages over other sheet metal forming processes. These include process flexibility, non-dedicated tooling, low forming load, good surface finish and improved mechanical properties of the spun part. Hence, the sheet metal spinning process has been frequently used to produce components for the automotive, aerospace, medical, construction and defence industries.[4]

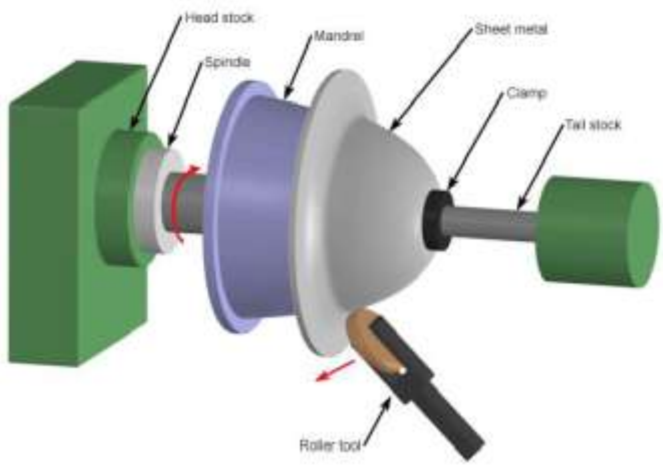

Figure 3 Experimental Setup[4]

III. EXPERIMENTAL SPINNING COMPONENTS

1] Mandrel

Mandrel is a supporting as well as a rotating member in the metal spinning set up. The shape of final component is same as that of the designed mandrel. According to requirement of shape of final component mandrel is designed. With the help of mandrel the sheet metal is rotated and this metal sheet is deformed over the mandrel with the help of roller by applying force on it. The mandrel is a solid part and material used for mandrel is cast iron, mild steel, Aluminium, Magnesium and plastic coated wood. When it is necessary to produce a parts to close tolerances, the mandrels are typically made entirely of steel and cast iron, cored casting of steel or cast iron are preferred in order to reduce the rotating weight. Mandrels must be statically balanced, and when used at high speed and the mandrels should also dynamically balanced.

The material used for the mandrels for cone spinning are selected primarily on the basis of the desired mandrel life. The actual mandrel material selection depends on the design, part material and desired life. For example, gray cast iron can be used for the low volume (10 to 100 pieces) spinning of soft metals, and alloy cast iron for spinning 100 to 250 pieces; the mandrels can be hardened in areas of high wear. For high production volume (250 to 750 pieces) 4150 or 52100 steel hardened to approximately 60HRC can be used. The tool steels such as O6, A2, D2 or D4 hardened to 60HRC or slightly higher are more suitable for high volume production. The surface finish of the mandrels should be at least 1.5µm. the mandrel dimensions should be machined so that they are within ±0.025mm of being concentric with each other.[4]

The dimension of component

D = Large diameter = 60 mm

d = Small diameter = 45 mm

S = Slant length = 71.589 mm

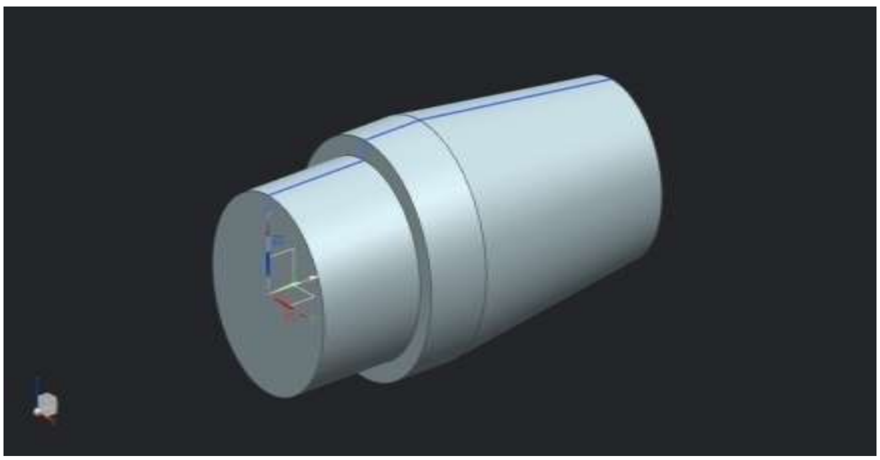

Figure 4 CAD view of Mandrel

Figure 5 Mandrel

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Figure 6 Mandrel in Setup

2] Blank
Blank Material -

To produce a component in metal spinning sheet metal is used . Almost all metal are available in the form of sheet, but following metal are generally used in this process like aluminium, stainless steel ,copper , brass, tin , silver, gold.

A) Aluminium :-
1. Aluminium is very ductile material among all the type of material and there are different type of grade present in aluminium.
2. It is elastic in nature and does not required any heat treatment.
3. Low Specific Gravity.
4. Corrosion Resistance.
5. Ease of Fabrication.
6. High thermal conductivity
Following are the grade of aluminium ,
a) 1100- H14 :-
i. This type of aluminium is pure in nature.
ii. It is soft metal among all type of aluminium grade.
iii. The percentage of elongation is 60% which is greater than all type of aluminium grade.
iv. It has 99% aluminium and 1% alloy.
b) 3003- H14:-
i. This type of aluminium harder than 1100-H14 because it contain 98% Al, 0.12% cu and 1.2 % Mn.
ii. The percentage of elongation is 30%
c) 5052- H32 :-
i. This type of aluminium harder than 3003- H14.
ii. It is hard to deform, it contain 97% Al, 2.5% mg , 0.25% Cr.
iii. The percentage of elongation is 25%.
d) 6061- T6 :-
i. This type of aluminium harder than all type of all type of Aluminium.
ii. The percentage of elongation is 25%.
Aluminium are most widely used in metal spinning because it has ability to easily deform.

B) Stainless steel :-

1. It is also in elastic nature and stretch before tearing .
2. The percentage elongation is 50-68% but disadvantage of stainless steel is it require more force to deform the metal.
3. Stainless steel have higher strength, hardness and toughness.
4. High corrosion resistance.
5. Stainless steel retain their strength and hardness at elevated temperature.

C) Copper:-

1. The main property of copper is good in formability.
2. Copper possesses excellent thermal and electric conductivity.
3. It can be easily cast, machined and brazed.
4. It has good corrosion resistance
5. Have double its tensile strength when work hardened.
6. It is hardened before the part is finished then the part must required to annealed to prevent cracking. it contain 99% Cu.
7. The percentage of elongation of copper is about 60%.

D) Brass:-

1. Brass is a copper zinc alloy and has a same properties to Cu.
2. It contain 65% Cu and 35% Zn.
3. Brass has excellent corrosion resistance
4. Brass has better machinability.
5. Brass has good thermal conductivity.
6. The strength and ductility of brass depends upon the zinc content.
7. The tensile strength of brass is higher than that of copper.
8. Brass is cheaper than copper.

It require the more force to deform and it works hardens less.[4]

Blank Diameter and Thickness -

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 60 mm to 45 mm. Blank is required to produce cone so that first we calculate the diameter of blank.

We know that,

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

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

$\pi/4 \times D^2 = [\pi\times(30 + 22.5)\times 71.589] + [\pi\times 22.5^2] + [\pi\times 60\times 20]$

D = 147.85 mm

From calculation prove that 147.85 mm blank diameter is maximum diameter of blank below this diameter we produce component .

Blank thickness is nothing but thickness of blank .The process of metal spinning is capable of forming workpiece with thickness of 0.5 mm to 30mm.

3] Tailstock Live Centre -

A revolving center, also known as a live center in some countries, is constructed so that the 60° center runs in its own bearings and is used at the non-driven or tailstock end of a machine. It allows higher turning speeds without the need for separate lubrication, and also greater clamping pressures. Tailstock live centre is used as supporting member to the mandrel & Blank.

Live Centre Specifications:-
Outer Diameter - 60 mm
Bore Diameter - 40 mm
Taper - MT3 Taper

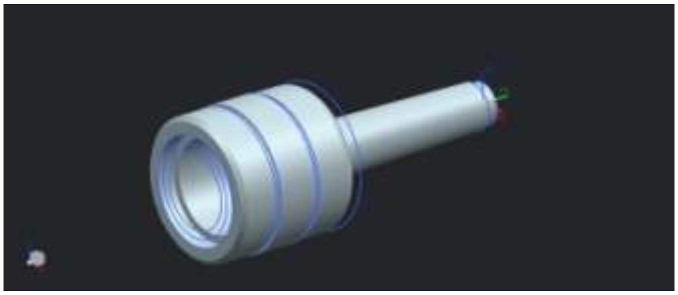

Figure 7 CAD view of Live Centre Bore

Figure 8 Live Centre in Setup

4] Pulley -

Spinning involves plastic flow of sheet metal which is malleable. The operation requires high speeds of rotation (above 2100 rpm). The tradition lathe has usually 900 rpm maximum. Hence certain changes are to be made in driving mechanism of lathe such as changing the gears or changing belt drive to obtain high speed on chuck. In this project we changed the pulley of traditional lathe to obtain higher rpm.

Original Dimensions of Pulleys (D_1, D2) - 100 mm and 200 mm
Speed of motor (N_1) - 1400 rpm

$N_1D_1 = N_2D_2$

Therefore, Speed of Driven Pulley (N_2) - 700 rpm

But, we want higher rpm for Spinning.
For N_2 = 1400 rpm, D_1 should be equal to 200 mm.
Hence pulley of Outer Diameter 200 mm is selected.

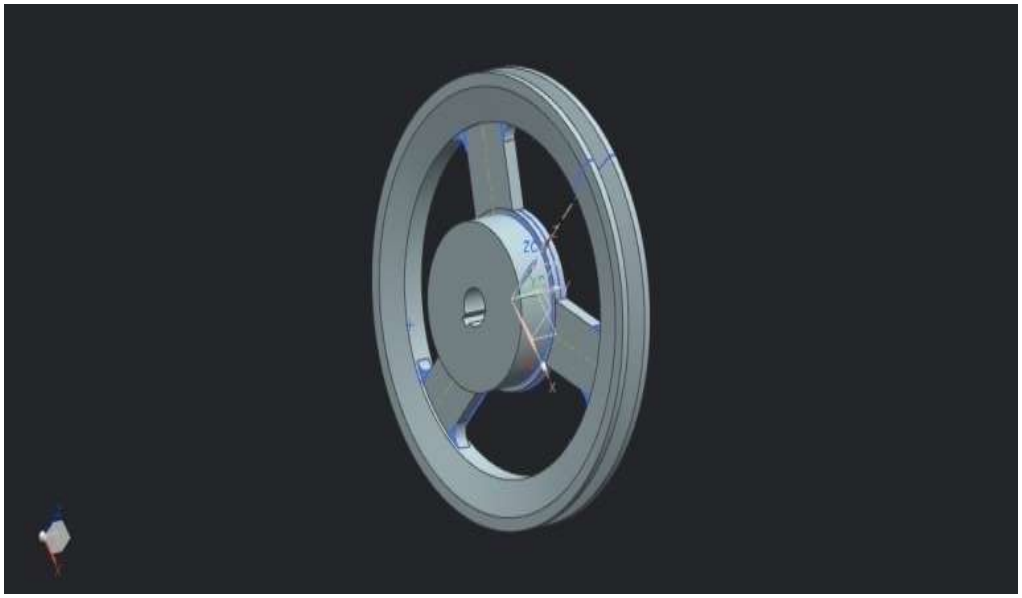

Figure 9 CAD view of Pulley

Figure 10 Pulley

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Figure 11 Drive Mechanism Before and After

5] Tool -

There are an infinite variety of tool profiles that can be forged in mild steel for spinning the material into different shapes. A long handle provides ample leverage to work the material down the mandrel in smooth efficient strokes. The wooden butt of the tool is placed in one's armpit such that one's body weight provides the force and one's arms are free to guide the tool in a smooth and precise manner. The tool is usually about three (3) feet long with a one (1) inch diameter steel rod forged into the preferred tool point. The tool post is essentially a rounded pin protruding from a boring bar mounted on the crossfeed such that the pin acts as a fulcrum around which the hand tool can be leveraged. The tool post is moved as the part forms down the mandrel so that a consistent lever arm is maintained.

Figure 12 Tools and Tool post for Metal Spinning

IV. PROCESS PARAMETERS

1] 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 leads to material failures & rough surface finish. Variation of feed ratio has considerable effect on the tool forces, wall thickness, Spinability, Surface finish & spring back of the metal spinning process. When higher feed ratio is applied, tool forces will increases. Low feed ratio would result in excessive material flow in the outward direction, which unnecessarily reduces thins the blank but due to low feed rate better surface finish obtained. 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.

2] Feed Rate -

The roller feed rate, which is one of the important parameter affecting the formability and forming quality. It is a Distance of the tool advances into or along the work piece each time is called as feed rate. It is measure in mm/sec or mm/ min. 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 coarser. 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. During 1 path spinning the roller move from mandrel slope is set to 2.4 mm/sec.

3] Spindle Speed -

The best quality for most components is achieved when spinning at high speed. According to hayama the effect of mandrel speed on to the tool forces is negligible. He point out that the effect of the mandrel speed is negligible, and gives a wide range of feasible mandrel speed. The influence of rotational speed on the variation of axial and radial forces is negligible.

$N = (9500 \sim 320000) / D_0$

Mandrel speed is calculated by using this formula where,

N= mandrel speed in rpm

D_0= original blank diameter in mm

4] Temperature -

The use of elevated metal temperatures is sometimes required during metal spinning to reduce the flow stress and increase the ductility of the component, particularly if the machine capacity is insufficient for cold forming the component or if the alloy ductility is too low. Spinning process are typically performed cold, but for thick part and high strength material, heating is sometime applied to reduce the forming forces. In this method heating of the sheet metal is done by hand held oxyacetylene flame. Sometime hot air is used to heat the blank.

5] Lubricant -

A lubricant is almost always used during spinning. The fluid used serves as both a lubricant and coolant. A Water based coolant, such as an emulsion of soluble oil in water ,is most commonly used, and in large quantities because of large amount of heat generated .When spinning aluminium, stainless steel ,or titanium, the work pieces or mandrels or both are sometimes coated with the lubricant before spinning. An increase in the forming temperature can lead to a reduction in the flow stress and increase in the ductility of the preform; this is sometimes required if the load capacity of the spinning machine is not sufficient for cold forming the preform or if the room-temperature ductility of the work metal is too low. When operating at elevated temperatures, great diligence must be exercised in the selection and use of an appropriate lubricant.

Lubricants generally need to be used in all metal-spinning operations, regardless of the preform composition or shape or the type of metal-spinning tools that are used. Lubricants are typically required both before and during forming. The need for lubrication during spinning depends on the tenacity of the lubricant used and on the rotational speed of the preform. The lubricant must continue to adhere to the rotating preform during spinning. Ordinary cup grease is often used. It can be heated to reduce its viscosity, for ease of application. Other lubricants used for metal spinning include soaps, waxes and pigmented drawing compounds; in the selection of the most suitable lubricant, the ease of removal of the lubricant after forming has to be considered.[7]

V. RESULTS

By making the modification in general lathe machine by spinning attachment we can take a trial and produce final component without any crack and wrinkle.

Figure 13 Desired Final Component

VI. FUTURE SCOPE

Future scope for this research is to provide the in depth guidance for the process study and designing the set up of spinning on traditional lathe machine to minimize cost of production, defects and failure of the component.

VII. CONCLUSIONS

In this paper, the principles and developments of spinning operation on traditional lathe machine have been reviewed. It can be seen that although spinning can be a very complicated process in terms of deformation characteristics, they have a great potential in the development, for the manufacture of complex shapes which are being required in increasing numbers by global manufacturing industries. The metal spinning parameter is directly affected to the workpiece surface finish, tool life, workpiece failure, wrinkling failure. Using these design parameters we have to reduce the defect & failure occurs in metal spinning operation performed on general lathe. By using spinning attachment to traditional lathe machine instead of spinning machine cost of product is minimized.

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REFERENCES

[1] C.C. Wong , T.A. Dean, J. Lin, "A review of spinning, shear forming and flow forming processes", International Journal of Machine Tools and Manufacture, Vol. 43, 2003, pp.1419-1435.

[2] Seth Hamilton, Hui Long, "Analysis of Conventional Spinning Process of a Cylindrical Part Using Finite Element Methods", Special Edition of Steel Research International, 2008 79(1), pp. 632-639.

[3] B.P. Bewlay, D.U. Furrer, "Spinning", ASM Handbook, Volume 14B, Metalworking: Sheet Forming (#05120), 2006.

[4] Mahesh shinde, Suresh Jadhav, Kailas Gurav, "Metal Forming By Sheet Metal Spinning Enhancement of Mechanical Properties and Parameter of Metal Spinning", International Journal of Engineering Development and Research (IJEDR), Volume 2, Issue 2, 2014, pp.1352-1357.

[5] Mahesh shinde, Suresh Jadhav, Kailas Gurav, "Experimental Set Up On Metal Spinning", International Journal of Engineering Development and Research (IJEDR), Volume 2, Issue 2, 2014, pp.2684-2690.

[6] Akshay Satpute, Shubham Shirbhate, Rohit Bomale, Akshay Sharma, "Design and Fabrication of Metal Spinning Components", International Journal of Research In Science & Engineering (IJRISE), Volume 2, Special Issue: 1-ICRITE, pp.28-33.

[7] Amol Jadhav, Dr.Sharad Chaudhari, "Design of Metal Spinning Parameters for General Lathe", International Journal of Engineering Development and Research (IJEDR), Volume 2, Issue 3, 2014, pp.3195-3200.

[8] Mr. Mayur Tapase, Mr. M.B. Patwardhan, Mr.K.V.Gurav, "Metal Spinning- Design Consideration and parameter of spinning process and its terminology", International Journal of Engineering Development and Research (IJEDR), Volume 2, Issue 3, 2014, pp.3004-3009.

[9] G.Venkateshwarlu, K. Ramesh kumar, T.A.Janardhan Reddy, G.Gopi, "Experimental Investigation on Spinning of Aluminum Alloy 19500 Cup", International Journal of Engineering Science and Innovative Technology (IJESIT), Volume 2, Issue 1, 2013, pp.357-363.