ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

Experimental Investigation on Spinning of Aluminum Alloy 19500 Cup

G.Venkateshwarlu[1], K. Ramesh kumar[2], T.A.Janardhan Reddy[3], G.Gopi[4].
[1](Mechanical Engineering Department, University college of Engineering, Osmania University, Hyderabad 500007, India).
[2 &4](Defence Research development and Laboratory, kanchanbagh, Hyderabad-58, Andhra pradesh, India)
.[3(]Mechanical Engineering Department, C.V.R college of Engineering, JNTU, Hyderabad-501510, India)

Abstract : Spinning technology is widely applied in the production of the axisymmetric industrial parts. The application of spinning technology in tube forming is increasing recently corresponding to the increased usage of the tubular parts. In the present work, an attempt is made to find experimental facts regarding the effects of some process variables aluminum alloy19500 as work material. The experiments were carried out on Spinning Lathe. The effect of process parameters on mandrel speed, feed of roller and roller nose radius and on surface finish of formed cups were studied. The dimensional accuracy of spinned aluminium cups like spring back, wall thickness, inside diameter, outside diameter were also studied with respect to process parameters. From the experimental investigations, it was found that surface finish is better with high speeds of formed cup. Surface finish is found to be better at lower feed rates. Radial spring back at the top of cup is higher as compared to bottom of the cup with respect to the above process parameters.

Index Terms –**Aluminum Alloy 19500, Circular Blank, Mechanics, Springback, Cup Spinning.**

NOMENCLATURE

t_o	Thickness of the blank (mm)
D	Blank dia (mm)
L	Mandrel length (mm)
d	Mandrel dia (mm)
D_r	Roller diameter (mm)
r	Corner radius (mm)
S	Speed (rpm)
F	Feed (mm/min)
d_1	Diameter of Mandrel (mm)
d_2	Inside Diameter of cup at bottom (mm)
d_3	Inside Diameter of cup at Top (mm)
H	Total height of cup (mm)
t	Cup wall thickness (mm)
Γ_b	Radial spring back at Bottom (mm)
Γ_t	Radial spring back at Top (mm)

I. INTRODUCTION

The term metal conventional spinning is different from shear and flow forming in terms of deformation characteristics, the set of process variables governing conventional spinning also determines the qualities of a shear or flow formed product. There are numerous process variables that contribute to the successful production of a spun product. In conventional spinning, the wall thickness remains nearly constant throughout the process, so the final wall thickness of the formed part is equal to the thickness of the blank. Industrial buyers and designers always have the problem of deciding the most economical method for obtaining a cylindrical product. Most of researchers among their many considerations must be price, quality, tooling charges and delivery time.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

After evaluating all the above factors they found that metal spinning and flow forming as one of the best method available of manufacturing cylindrical product. Spinning has many advantages short production runs, a variety of symmetrical shape, smaller deformation force, less investment in equipment, etc. The usage of tube is increasing in many manufacturing fields because a tube has high flexural rigidity and torsional rigidity in regard to its weight [3, 4]. Spinning is suitable for the tubular products and many other axisymmetric components in its many advantages, such as short production runs, Lange [5] had found out that conventional spinning as a tensile-compressive forming process, grouping with the sheet forming processes of bending, deep drawing and collar drawing. Shear spinning on the other hand, is classified as a compressive forming process, along with the bulk forming processes of rolling. Kalpakjian [6] has invented the classification of all forming processes as sheet or bulk forming, and places both conventional and shear spinning in the group of sheet metal forming processes, together with bending, stretching and deep drawing. Avitzur and Yang [7] have carried out an experiments on the mechanism of deformation in shear spinning is found to be not pure shear, but a combination of shear and bending deformation at large wall angles closer to pure shear. Sortais [8] has concluded that the mechanics of the two processes is similar and study shear spinning under various conditions to comprehend the mechanics of conventional spinning. Quigley and Monaghan [9] discussed the first pass in conventional spinning is in fact a shear spinning process, based on observations made with experiments, analytical and numerical models. Kawai and Hayama [10] the paper of reports that even in conventional spinning, the tool path geometry influences the final sheet thickness. In the similarity between shear and conventional spinning, the mechanics of tube spinning is quite different from both processes, as pointed out by Gur and Tirosh [11] the tube spinning as a combination of extrusion and rolling. Kalpakcioglu [12] talks on shear spinning and tube spinning shows that the metal flows. Therefore mode of deformation in the two is different material flow in tube spinning resembles that of extrusion. The aim of the present work involves experimental investigations on surface finish, radial spring back and dimensional accuracy of spinned aluminum cups. The process parameters mandrel speed, feed of roller and roller nose radius effect on surface finish of the formed cup was studied.

II. SPINNING MECHANICS

The fig [1] shows to the examination of spinning, a knowledge map for the process is proposed.

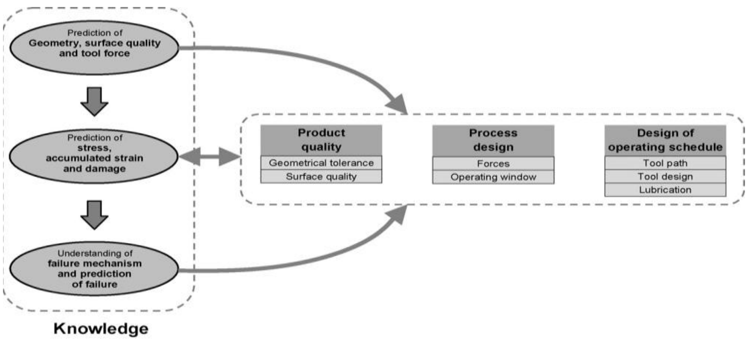

Fig 1. Knowledge Required and Aims of Investigation [1]

Which gives the connection between analytical understanding of process mechanics shown as knowledge and the application of that knowledge to achieve goals, we had the complete knowledge required to predict. The resulting product geometry, surface quality and associated tool forces. The evolution of stresses, strains and damage during process. The onset of failure by wrinkling, cracking or surface damage, if we had such knowledge, it could be applied to make a particular product to a particular tolerance and quality, it would be possible to specify the required equipment. Given particular equipment and an operating schedule, it would be possible to assess whether a particular part in some material could be made and to predict the quality of any part that could successfully be made. The aim of research into spinning is to satisfy both of the above requirements. Given boundary conditions about tool shapes, stiffness and motion, it is relatively easy to predict the consequent product geometry. It is more difficult to predict the evolution of stress, strain and damage during processing and it is currently relatively difficult to predict with certainty when the process will fail. However, such analytical knowledge is not useful to practitioners wanting to spin products.

III. SPINNING CLASSIFICATION

The term metal spinning classified as three processes: 1. Conventional spinning 2.Shear spinning and 3.Tube spinning. A common feature of the three processes is that they allow production of hollow, rotationally

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013
symmetric parts. The main difference between the three is apparent in the wall thickness of the formed part. In conventional spinning, the wall thickness remains nearly constant throughout the process, so the final wall thickness of the formed part is equal to the thickness of the blank. In contrast, the wall thickness is reduced in shear spinning and tube spinning; in shear spinning, part thickness is dictated by the angle between the wall of the component and the axis of rotation; in tube spinning, the final thickness is defined by the increase in length of the work piece. Furthermore, while in conventional spinning and tube spinning parts can be formed in a single step or a number of steps, in shear spinning, forming is done in a single step. The classification of spinning into conventional spinning, shear spinning and tube spinning is widely accepted. However, the only formal standard classification is that of the German DIN Standard 8582, in which processes are classified according to the instantaneous internal stresses which cause yielding in the material.

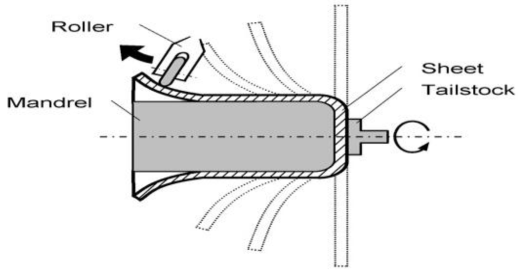

Fig 2.Cup Forming Process Using Spinning [1].

IV.TUBE FORMING PROCESS

In conventional spinning a sheet blank is formed into a desired shape without a change in the wall thickness and with a deliberate reduction in diameter either over the whole length or in specific areas Fig [2]. It is performed in a single step or multiple steps which progressively deform the sheet.

V. EXPERIMENTAL WORK

A robust lathe was used to perform the Spinning lathe, the present investigation was performed on a flow forming machine with a single roller. The flow forming machine used in this research work is shown in fig [3a] and fig [3b].The roller travels parallel to the axis of the mandrel. Compressive and axial loads are given by the roller, which is fitted to the arm of the machine. The feed rate and depth of cut are maintained by high torque servomotors fitted to the four arms of the machine and these servomotors are driven by a hydraulic power pack.

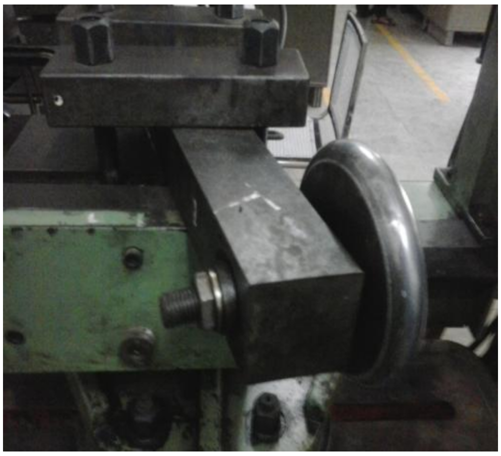

Fig 3a.spinning lathe with single roller

Fig 3b.Final spinned cup

Spinning roller is mounted on tool holder and which in turn is tightly secured on the saddle. Contact surfaces and cross slide were initially cleaned. It is ensured that the roller axis is parallel to the mandrel surface with help of dial gauge and the vertical height of the roller axis to that of spindle axis. Accurate adjustment of the cross slide was then effected so that the gap between the point of contact of the roller and the mandrel was the desired wall thickness of formed cup, in this case there is no change in wall thickness. The templates were fixed to the copy attachment. These templates ensure that the circular blank is transformed into cup in number of passes with step by step to prevent wrinkles and breakage of cup.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

VI. DESCRIPTION OF MATERIAL

All ductile material is suitable for tube spinning. We have chosen aluminum alloy 19500 as experimental work material, it is suitable for cup spinning, because pure aluminum. The chemical composition of this alloy is shown in table 1. It has an ultimate tensile strength of 100 MPa.

TABLE1. The Chemical Composition of Aluminum Alloy 19500

Elements	Cu	Si	Fe	Mn	Al
Weight (%)	0.01	0.11	0.19	0.01	95.5

VII. EXPERIMENTAL PROCEDURE

Table 2 and 3 gives the Selection of process parameters and dimensions of blank, mandrel and roller.

TABLE 2.Selection of process parameters and dimensions of blank

Thickness of the blank	t_o	= 2.3 mm
Blank dia	D	= 125 mm
Mandrel length	L	= 150 mm
Mandrel dia	d	= 75 mm
Roller diameter	D_R	= 150 mm
Roller corner radius	r	= 4mm

The input parameters are chosen for the experiments are (1) Speed of mandrel (rpm), (2) Roller feed (mm/min), (3) Roller nose radius (mm), while the response function is the surface roughness and radial springback. The parameters and their levels are presented in table 3.

TABLE 3.Parameters and Their Levels

Parameters	Level 1	Level 2	Level 3
Speed(rpm)	220	270	375
Feed (mm/min)	174	586	761
Nose radius(mm)	4	4	4

Present study is cylindrical cup with one end closed and other end is open its overall dimensions are shown fig [6a]. As this cylindrical blank is molded, it requires finished marching to final surface finish and radial springback is measured at zone1 and zone2 as shown in fig [6b] and fig [6c], and the radial springback is calculated by the following equations.

Radial springback at bottom $\Gamma_b = (d_2-d_1)/2$------------------- [1].

Radial springback at top $\Gamma_t = (d_3-d_1)/2$-------------------- [2].

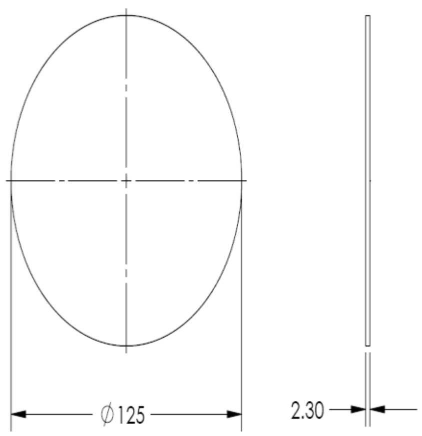

Fig 4a.Specimen Circular blank

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

Fig 4b.Tube formed Cup (Top-view)

Fig 4c.Tube formed Cup Radial Spring back measurement zones

The circular aluminum blank is held against the mandrel by means of pressure Exerted by tail stock of the lathe. A saddle feed rate of 174mm/min. and mandrel speed of 220rpm was selected. The cross slide was then moved to the starting position of the template where the roller just made the contact with the circular blank. Spinning is commenced by engaging the saddle feed when the desired mandrel is achieved, with the help of copying attachment moving along the templates. With the final pass of the template it is completed. In dry condition was performed at the speed of 220rpm and feed rate of 174mm/min. Again the performs were subjected to spinning by varying feed rates at 174mm/min,586mm/min,761mm/min at same speed of 220rpm roller and nose radius is kept constant (4mm) in dry condition.

VIII. RESULTS AND DISCUSSION

TABLE 4.Speed Vs Surface Roughness

Speed (rpm)	Surface Roughness(µm) R_a
220	0.72
270	0.7
375	0.65

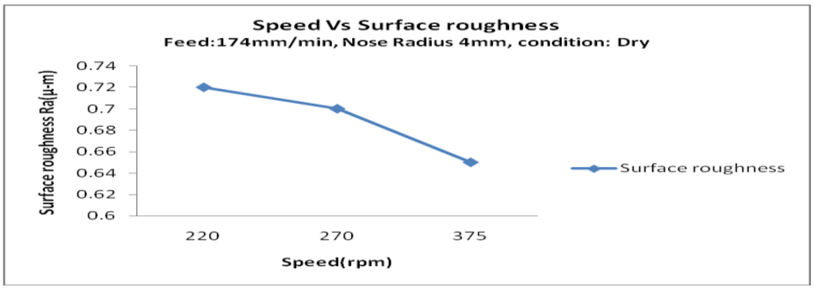

Fig 5.Speed Vs Surface Roughness

Effect of speed on surface roughness in a Aluminum cup forming at the three chosen levels as per Table 4 and the results are plotted as shown in fig [5]. From figure it is observed that the increase in spindle decreases the surface roughness.

TABLE 5.Radial spring back Vs Speed

S (rpm)	d_1 (mm)	d_2 (mm)	$\Gamma_{b=}$ $(d_2-d_1)/2$ (mm)	d_3 (mm)	$\Gamma_{t=}$ $(d_3-d_1)/2$ (mm)
220	75	75.83	0.415	75.5	0.25
270	75	75.05	0.025	75.6	0.3
320	75	75.06	0.03	75.5	0.25

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

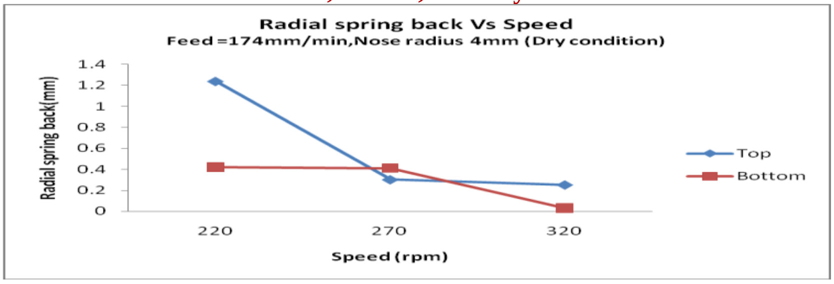

Fig 6.Radial Spring Back Vs Speed

Fig [6] shows that at intermediate values of passes, the radial spring back is best, whereas at lower and higher passes, it is found to increase. The reason is that at optimum level of passes, Speed of the mandrel is directly proportional with the surface finish spinned product. Radial spring back at top of the cup decreases with speed.

TABLE 6.Surface Roughness Vs Feed

Feed (mm/min)	Surface Roughness(µm) R_a
174	0.71
586	0.81
761	0.90

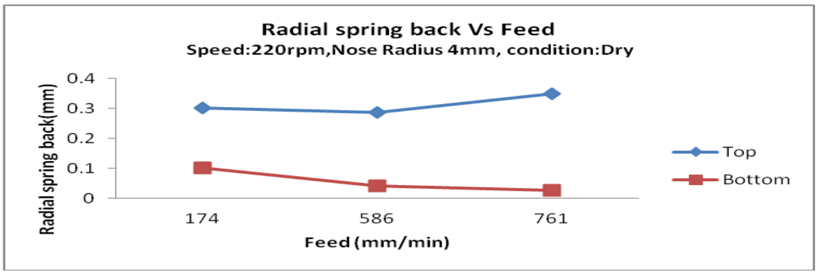

Fig 7.Effect of Feed on Surface Roughness

Fig [7] shows that at lower values of feed rate the surface finish is much better. At higher values due to fast rubbing action, the Ra values are found to be increasing.

TABLE 7.Radial spring back Vs Feed

F (mm/min)	d_1 (mm)	d_2 (mm)	$\Gamma_b = (d_2-d_1)/2$ (mm)	d_3 (mm)	$\Gamma_t = (d_3-d_1)/2$ (mm)
174	75	75.2026	0.1013	75.6034	0.3017
586	75	75.0828	0.0414	75.5724	0.2862
761	75	75.0543	0.0271	75.7005	0.3502

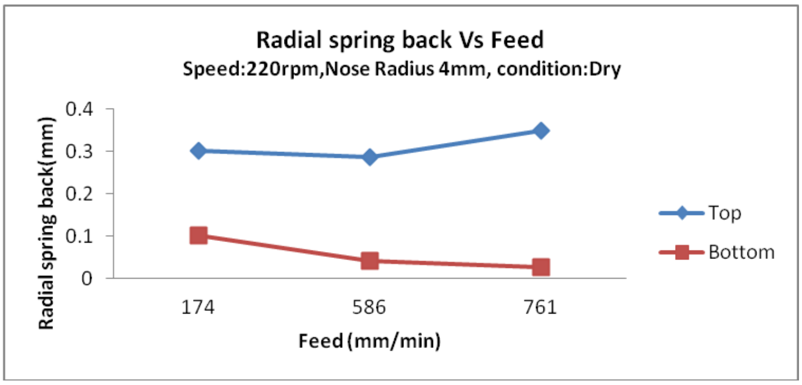

Fig 8.Radial Spring Back Vs Feed

Fig [8] shows that the lower feed rates the surface finish is better. Radial spring back at bottom of the cup is minimum at high feed rate.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

IX. CONCLUSION

The surface finish is better at high speed in dry condition. The radial springback at top and bottom of the cup is optimum at the speed of the mandrel is 270 rpm and roll nose radius is kept constant 4mm. At the lower feed rates the surface finish is better. Radial springback at bottom of the cup is minimum at high feed rate.

- Speed of the mandrel is directly proportional to the surface finish spinned product. The radial springback at top of the cup decreases with speed.
- As speed is increased from 220rpm to 375rpm, the surface roughness decreased is 10%.
- Radial springback on the bottom side of the cup is about 0.025mm, when the speed was 270rpm.
- Radial springback on the top side of the cup is 0.025mm, when the speed was 320rpm.
- As the feed rate increased from 174mm/min to 761mm/min there is 14% increase in radial springback at top of the cup.

It is concluded that when speed is maintained at 270 rpm with nose radius of 4mm, the component produced showed overall minimum radial springback. Springback is one of the significant factor in which the mandrel design has a great influence on the final shape of work piece. So, it is important to study the springback for the precise forming.

ACKNOWLEDGEMENT

The first author wishes to thank MED, UCE, O.U, Hyderabad, India, for providing all the facilities for carrying out the experiments and the scientists of DRDL, Hyderabad for their support and cooperation to have carried out this work.

REFERENCES

[1] O. Musica, J.M. Allwooda, K. Kawaib A review of the mechanics of metal spinning, Journal of Materials Processing Technology, 210 (2010) 3–23

[2] Yao Jianguo, Murata Makoto An experimental study on paraxial spinning of one tube end, Journal of Materials Processing Technology 128 (2002) 324–329.

[3] J.C. Prouheze, et al., Saving weight with more steel tube components, Tube Int. 18–99 (1999) 343–345.

[4] D. Colla, et al., An investigation into the performing of tubes, Int. J. Mech. Sci. 39–5 (1997) 507–521.

[5] Lange, K., 1985. Handbook of Metal Forming. SME publications.

[6] Kalpakcioglu, S., 1964. Maximum reduction in power spinning of tubes. Journal of Engineering for Industry Transactions of the ASME, 86, 49–54.

[7] Avitzur, B., Yang, C.T., Analysis of power spinning of cones,Journal of Engineering for Industry Transactions of the ASME, 82, 231–245.

[8] Sortais, H.C., Kobayashi, S., Thomsen, E.G., Mechanics of conventional spinning, Journal of Engineering for Industry Transactions of the ASME, 85, 346–350.

[9] Quigley, E., Monaghan, J., Using a finite element model to study plastic strains in metal spinning. In: 9th International Conference on Sheet Metal, Leuven Belgium, pp. 255–262

[10] Hayama, M., Study of lubrication in shear spinning. Bulletin of the Faculty of Engineering, Yokohama National University, 20, 61–69.

[11] Gur, M., Tirosh, J., Plastic flow instability under compressive loading during shear spinning process. Journal of Engineering for Industry Transactions of the ASME, 104 (1), 17–22.

[12] Kalpakcioglu, S., on the mechanics of shear spinning. Journal of Engineering for Industry Transactions of the ASME, 83, 125–130.