ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Multivariate Optimization of Conventional Spinning Process Parameters

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Abstract

Metal spinning is a forming process that allows production of hollow, axially symmetric sheet metal components. One of the main problems of the metal spun parts production is the design of the process plan in order to achieve the appropriate properties of spun part surface and near-surface layers. Research in sheet metal spinning has increased due to a greater demand, especially in the transportation industries, for parts with very high strength-to-weight ratios with low cost. Spinning processes are efficient in producing such characteristics and there is great flexibility in the process with a relatively low tool cost.

In this paper, the effect of process parameters on the spun part surfaces characteristics, such as radial and longitudinal strain distribution have to be examined. The parts of bowl shapes made of aluminium have been taken into account.

Optimization of the process through the use of statistical analysis tools are to be applied for experimentation, analysis and optimization. This will be achieved by generating design of experiments to identify the most critical parameters for product formability and how these critical parameters affect the product quality. Optimization is achieved through Response Surface Methodology.

Keywords: optimization, Aluminum Alloy, Circular Blank, Mechanics, Spring back, Cone Spinning.

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.

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 like short production runs, a variety of symmetrical shape, smaller deformation force, less investment in equipment,
etc

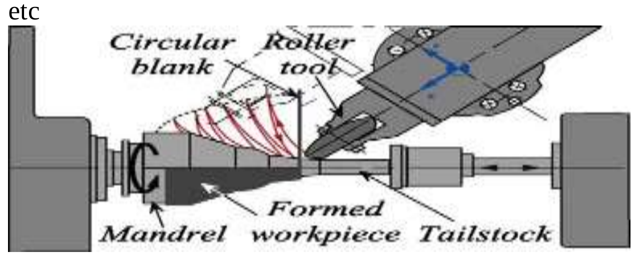

Fig: Metal spinning process

Literature survey

K Essa and P Hartley et al [1] studied Spinning processes is efficient in producing characteristics and there is great flexibility in the process with a relatively low tool cost. The objectives of investigation has define the critical working parameters in spinning, show the effects of these factors on product quality characteristics, and to optimize the working parameters. The example used is the conventional spinning of a cylindrical cup. Optimization of the process is undertaken through the use of statistical analysis tools applied to the data produced from three-dimensional finite element simulations of the process.

The results show that feed rate, relative clearance, and roller nose radius are the most important working parameters and significantly affect average thickness, thickness variation, and springback of the cylindrical cup. An additional 22 per cent improvement in the product quality characteristic is gained through using the optimum working parameters.

H. Razavi, F. R. Biglari and A. Torabkhani et al studied [2] The spinning process is an advanced plastic working technology and is frequently used for manufacturing axisymmetric shapes. Spinning forming is continuous and partial deformation, so it is very difficult to control the shape, dimensions and precision of the finished parts. Because of high stress wave speed propagation, the FE analysis of spinning process is difficult.

The magnitude of radial and hoop strains remain close to the values obtained from FE analysis for spinning process, but the observed strains do not mirror each other thus implying that there is some thickness strain.

R. Göbel , M. Kleiner and N. Henkenjohann et al observed [3] A first adaptation of the pre-selected parameters is then realized on a fuzzy-based model. In the next step, a model based optimization using statistical design of experiments is performed. For this, a new statistical approach has been developed being optimized regarding the requirements of the spinning process. In this paper, the methods used and the implementation of the approach in process planning software are described.

These results have finally been successfully transferred to similar processes, and general knowledge about metal spinning has been gained.

In this paper, a suitable multivariate optimization procedure is presented. In this cone forming process is used to determine the desired shape without a change in the wall thickness and with a deliberate reduction in diameter over the whole length or in specific areas. It is performed in a single step or multiple steps which progressively deform the sheet. Here a spinning lathe with flow forming process with a single roller. The input parameters chosen are speed of mandrel, roller feed, sheet thickness. In this a cylindrical cup with one end closed and other end open is chosen and its radial spring back is measured at zone 1 and 2

The surface finish becomes better at high speed and the optimum values of thickness reduction, strain rates and surface roughness are found to be optimum.

Spinning mechanics

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

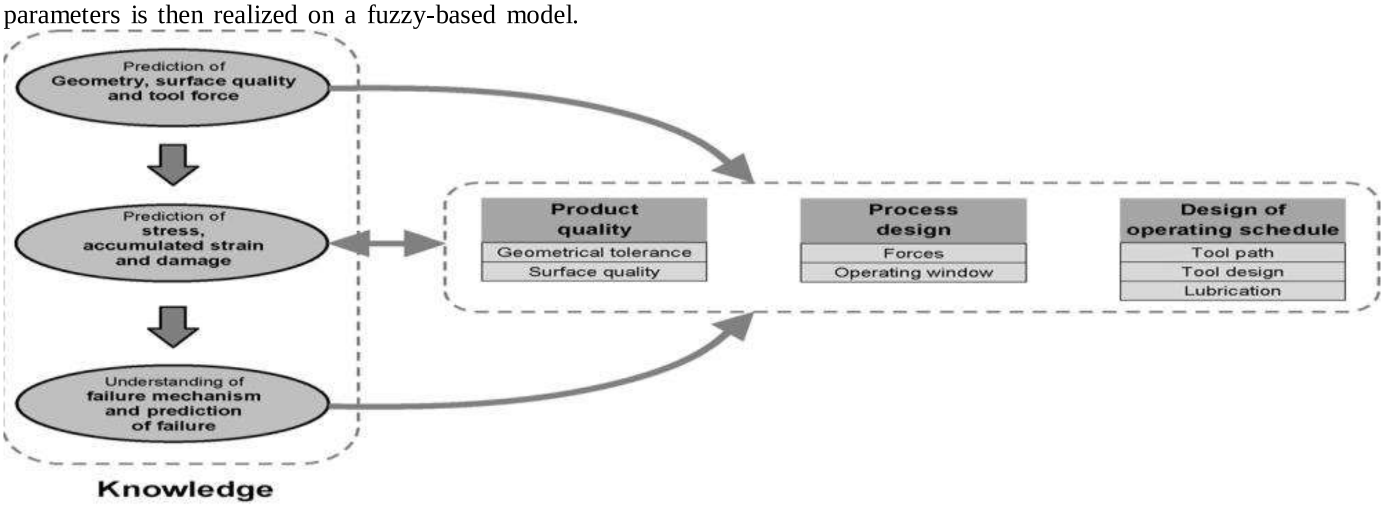

Fig. 1: Knowledge Required and Aims of Investigation

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
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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.

Types of spinnig

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 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.

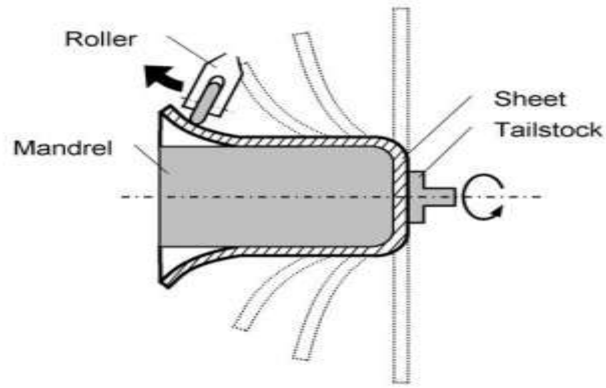

Fig 2.Cone Forming Process Using Spinning

Cone 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.

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

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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.

Description of material

All ductile material is suitable for tube spinning. We have chosen aluminum alloy as experimental work material, it is suitable for cup spinning, because pure aluminum.

Experimental procedure

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 spring back. The parameters and their levels are presented in table.

Factor	Low	Intermediate	High
Roller feed rate(mm/min)	1	2	3
Mandrel revolution(rpm)	100	200	300
Sheet thickness(mm)	0.7	0.8	0.9

Present study is cylindrical cup with one end closed and other end is open its overall dimensions. As this cylindrical blank is molded, it requires finished marching to final surface finish and radial spring back is measured at zone1 and zone2 as shown in fig [4a] and fig [4b]

Fig 4a.cone formed cup(Top-view)

Fig 4b.cone formed Cup Radial Spring back measurement zone

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 1 mm/min. and mandrel speed of 100 rpm 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. At the speed of 100 rpm, 200 rpm, and 300 rpm and feed rate of 1mm/min. Again the performs were subjected to spinning by varying feed rates at 1mm/min,2mm/min,3mm/min at same speed of 100 rpm,200 rpm,300 rpm roller and

ISSN: 2277-9655
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sheet thickness is 0.7mm,0.8 mm,0.9 mm in dry condition.

Results and discussion

TABLE. Feed and Speed and Surface Roughness

Run	Feed rate(mm/min)	Speed(s)	Sheet thickness(ts)	Thickness reductions(tr)	Strain rate(sr)	Roughness(ra)
1	2	100	0.8	0.14	0.56	2.94
2	3	100	0.9	0.26	0.47	2.98
3	2	200	0.7	0.12	0.43	2.89
4	3	100	0.7	0.28	0.56	3.50
5	1	300	0.7	0.30	0.50	3.31
6	1	200	0.9	0.37	0.51	3.36
7	3	300	0.9	0.23	0.50	2 .83
8	2	200	0.9	0.17	0.53	2.36
9	3	200	0.7	0.14	0.50	2.50
10	3	200	0.9	0.31	0.50	2.76
11	3	100	0.8	0.25	0.56	3.09
12	1	100	0.8	0.25	0.50	3.36
13	2	300	0.7	0.23	0.56	2.58
14	2	200	0.8	0.19	0.49	3.39
15	1	300	0.8	0.45	0.43	2.09
16	1	100	0.7	0.21	0.50	2.29
17	3	300	0.7	0.19	0.53	2.86

GRAPHS:

Main effects plot for ra

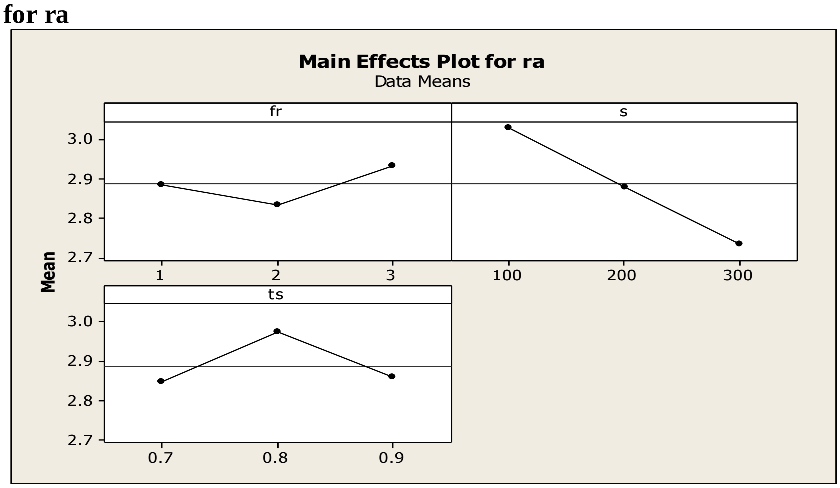

Figure: Main effects plot for ra

Figure: Ra is low
feed rate(fr) =2mm/min
Speed(s) =300rpm
Sheet thickness(ts)=0.7mm

Interaction plot for ra

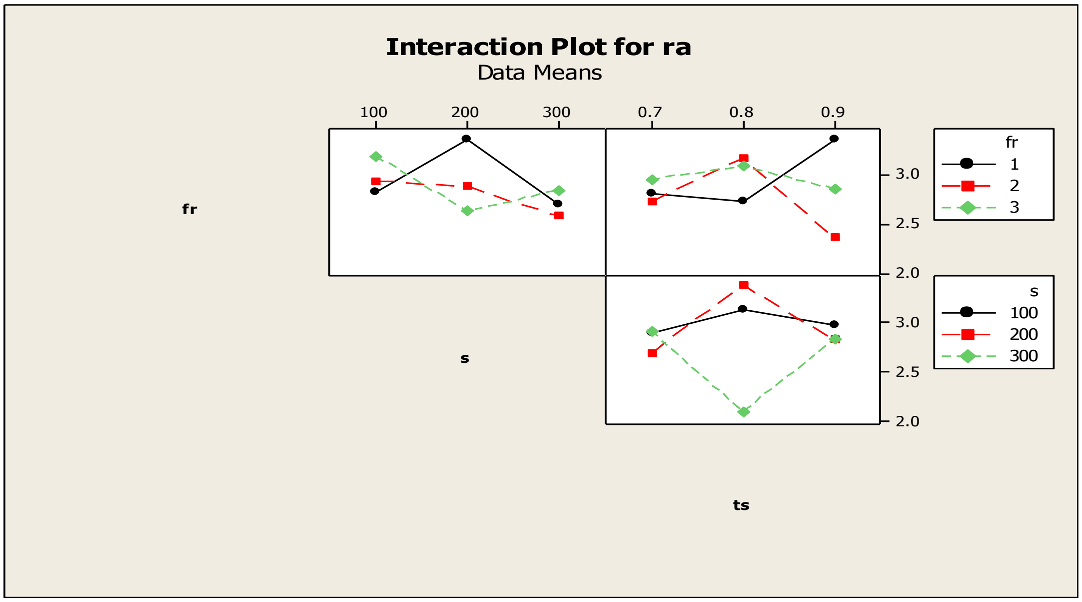

Figure: Interaction plot for ra

Figure : Strain rate is maximum at, speed vs feed rate
Speed=200rpm, Feed rate=1mm/min,
Strain rate is maximum at, sheet thickness vs feed rate
Feed rate = 1mm/min , Sheet thickness = 0.9mm
Strain rate is maximum at, speed vs sheet thickness
Speed=200rpm, Sheet thickness=0.8mm

Main effects plot for tr

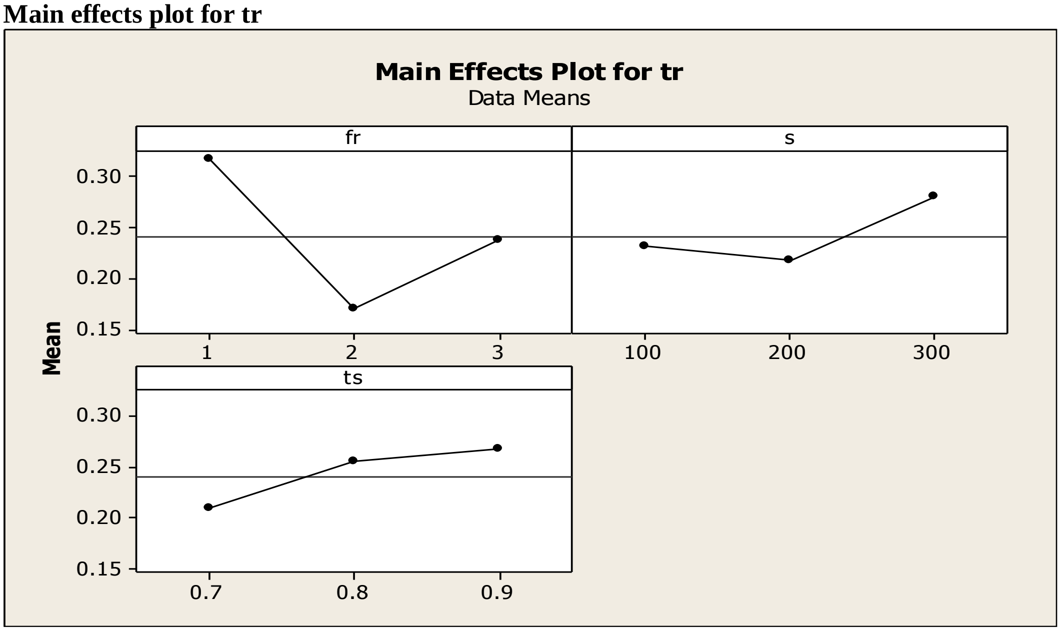

Figure: Main effects plot for tr

Figure : Thickness reduction is low at
Feed rate=2mm/min, Speed=200rpm,Sheet thickness=0.7mm

Interaction plot for tr

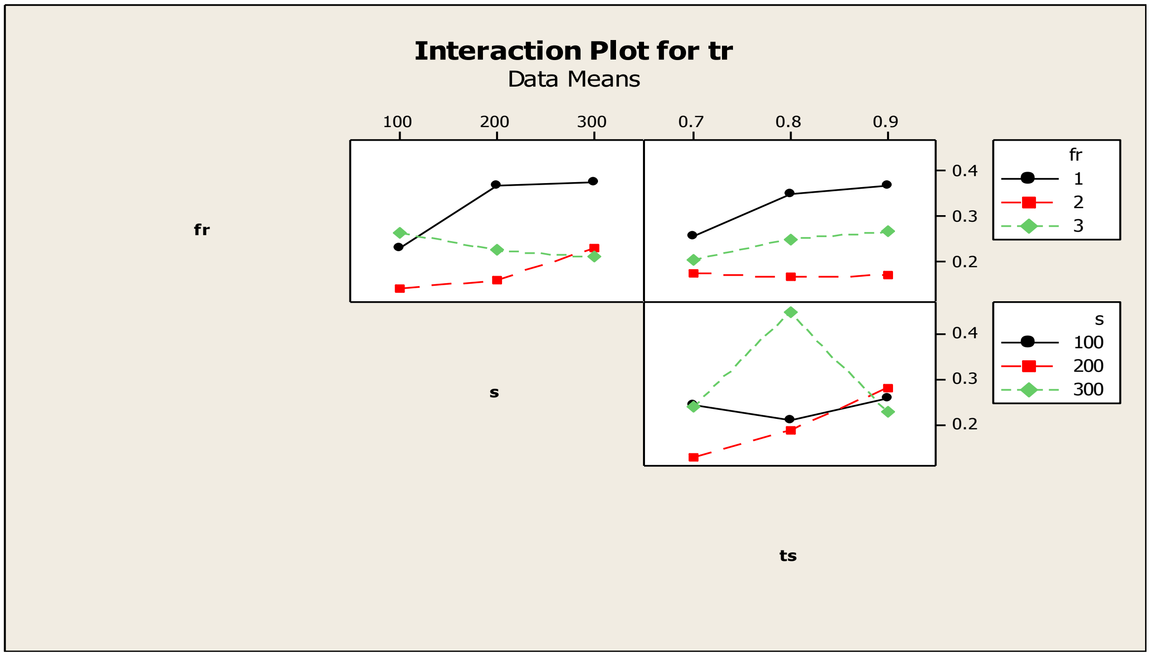

Figure: Interaction plot for tr

Figure : Strain rate is maximum at, speed vs feed rate
Speed=300rpm, Feed rate=1mm/min,
Strain rate is maximum at, sheet thickness vs feed rate
Feed rate = 1mm/min , Sheet thickness = 0.9mm
Strain rate is maximum at, speed vs sheet thickness
Speed = 300rpm, Sheet thickness = 0.8mm

Main effects plot for sr

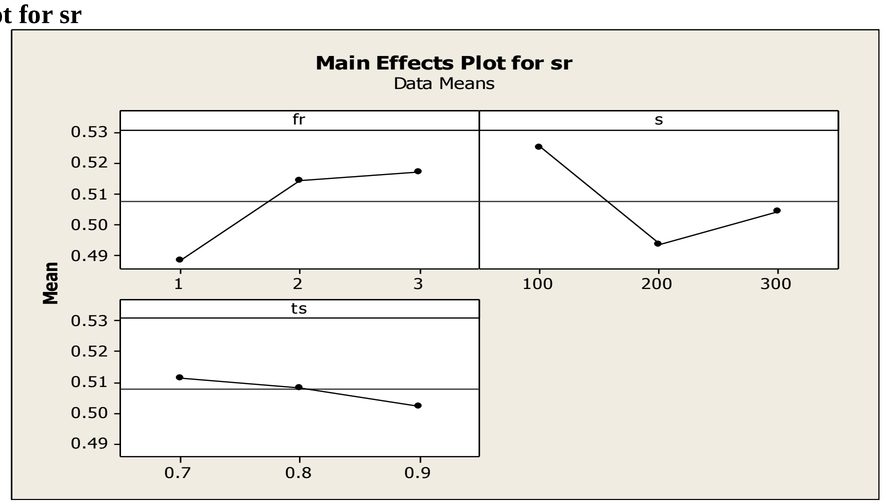

Figure: Main effects plot for sr

Figure : strain rate is low at
Feed rate (fr) = 1mm/min, Speed (s) = 200rpm, Sheet thickness (ts) = 0.9mm

Interaction plot for sr

ISSN: 2277-9655
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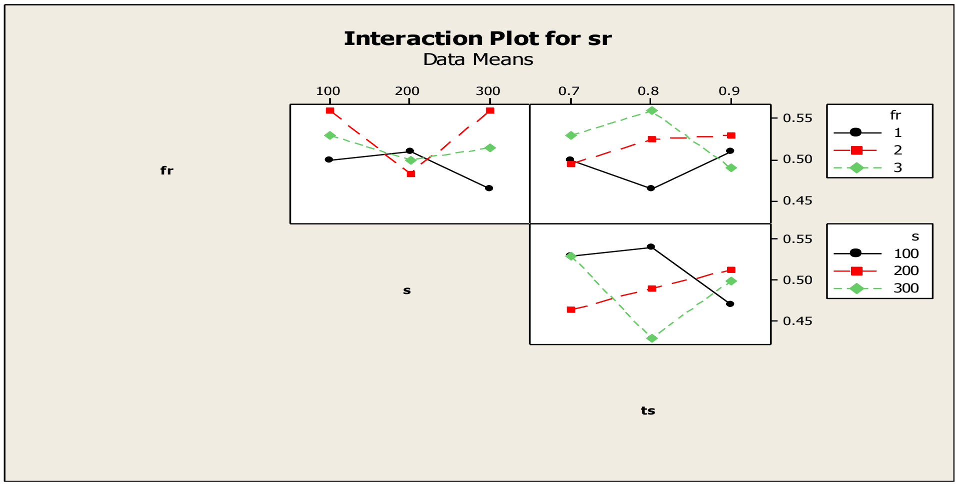

Figure: Interaction plot for sr

Figure: Strain rate is maxi mum at, speed vs feed rate
Speed = 300rpm, Feed rate = 2mm/min,
Strain rate is maxi mum at, sheet thickness vs feed rate
Feed rate = 3mm/min, Sheet thickness = 0.8mm
Strain rate is maxi mum at, speed vs sheet thickness
Speed = 100rpm, Sheet thickness = 0.8mm

General Regression Analysis:

Regression Equation of thickness reduction

tr =-0.36941-0.16846 * fr-9.18257E-004 * s+1.61896* ts-5.33480E-004 * fr * s-0.16687* fr * t+1.59586E-003 * s * ts+0.09110* fr^2+2.70018E-006 * s^2-0.74605 * ts^2

Analysis of Variance

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	3	0.033011	0.0330113	0.0110038	1.70129	0.0215776
fr	1	0.013680	0.0150873	0.0150873	2.33264	0.0150645
S	1	0.004471	0.0060364	0.0060364	0.93328	0.0351640
ts	1	0.014860	0.0148604	0.0148604	2.29755	0.0153511
Error	13	0.084083	0.0840828	0.0064679		
Total	16	0.117094				

Regression Equation of strain rate

sr =+0.50765

Analysis of Variance

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	3	0.0040065	0.0040065	0.0013355	0.78561	0.0523035
fr	1	0.0023059	0.0022506	0.0022506	1.32393	0.0270614
s	1	0.0011126	0.0012551	0.0012551	0.73830	0.0405771
ts	1	0.0005880	0.0005880	0.0005880	0.34589	0.0566528
Error	13	0.0220994	0.0220994	0.0017000		
Total	16	0.0261059	0.0261059			

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Regression Equation of roughness

ra =+3.16501+0.017984* fr-1.45431E-003 * s-0.042043* ts

Analysis of Variance

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	3	0.23848	0.23848	0.079494	0.39704	0.0757365
fr	1	0.00952	0.00375	0.003746	0.01871	0.0893303
s	1	0.22876	0.22810	0.228098	1.13925	0.0305232
ts	1	0.00020	0.00020	0.000204	0.00102	0.0975024
Error	13	2.60282	2.60282	0.200217		
Total	16	2.84131				

Conclusion

The surface finish is better at high speed in dry condition. The radial back at top and bottom of the cone cup is optimum at the speed of the mandrel is 100 rpm,200rpm,300rpm and the sheet thickness is 0.7mm,0.8mm,0.9mm. At the lower feed rates the surface finish is better. Radial spring back at bottom of the cone cup is mini mum at high feed rate.

The optimum values of Thickness Reduction(tr),Strain Rate(sr),and Surface Roughness(ra) were found to be Tr=0.2739004 and optimum values of Sr=0.50851857 and the optimum values of Ra=3.744483096. By taking three process parameters, i.e, speed, feed rate, sheet thickness the optimum values are determined by using regression equations of Tr. Sr, Ra.

References

1. K Essa and P Hartley optimization of conventional spinning process parameters by means Of numerical simulation and statistical analysis, journal of material processing Technology (2010)
2. R. Göbel, M. Kleiner and N. Henkenjohann, New Approach for Process Planning andOptimization in Sheet Metal Spinning, journal of material processing technology (2005)
3. Sandeep kamboj, Bharat Atray, Neeraj Kumar, Analysis the effects of different types of toolon metal spinning process, journal of material processing technology(2014)
4. Dr. R. uday kumar, A Study on deep drawing and spinning process in sheet metal forming, Journal of material processing technology (2013)
5. Matthais kleiner, Roland Ewers, jochim Kunert, Nadine Henkenjohann, Corinna Auer, Optimization of the shear forming process by means of multivariate statistical methods, Journal of material processing technology(2014)
6. Mahesh shinde, Suresh jadhav, Kailas Gurav, Metal Forming By sheet metal spinning Enhancement of mechanical properties and parameter of metal spinning, journal of Material processing technology (2014)
7. M.Jurkovic, z.jurkovic, M.Mahmic ,An analysis and modeling of spinning process without Wall-thickness reduction, journal of material processing technology(2013)
8. Eamonn Quigley, John Monaghan, Metal forming an analysis of spinning processes,journal of manufacturing engineering (2000)
9. G.Venkateswarlu, k.Rameshkumar, T.A.janardhanReddy, G.Gopi, Experimental Investigation on spinning of alluminium Alloy 19500 cup, journal of engineering science And innovative technology (2013)
10. Jana Sugarova, Peter sugar, petar Zemko, Analyzing the properties of surface layers Generated by sheet metal forming operations, journal of material processing Technology
11. B.P.Bewlay, Spinning, journal of journal of material processing technology (2006)
12. H.Razvi, R.Biglari and A.Torabkhani, Study of strains distribution in spinning process Using FE simulation and experimental work, journal of manufacturing engineering, (2005)
13. Alexandra C.Filip and Ion Neagoe, An overview on incremental sheet forming, a methodFor rapid manufacturing of hollow metal parts, journel of manufacturing engineering, vol 8 (2010)
14. K.Devaki devi, S.Gajanana and N.Vishweshwar, Development of satellite component through flow forming process. Journal of IJMRAE, vol.3.No. IV (2011)