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Experimental and Numerical Investigations on Sheet Metals through the Metal Spinning Process.

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Abstract: Spinning is a majorly used technique in producing axisymmetrical parts that are produced by rotating metal sheets at a higher speed. The spinning process is carried out by two methods, one by manually and other by a CNC lathe. Components that are made by this process are mostly used in aircraft and missile industries as these units required low weight and high strength materials for the manufacturing.

The various parameters to be investigated and studied from this analysis are the evaluation of various force components in all directions, surface finish, determination of blank thickness, blank diameter after the deformation, considering various spinning speeds, the formability of sheet metals, spinning ratio, spin ability, different nose radius of rollers and the diameter of mandrel, study of the process parameters like rate of feed, speed of the spindle and feed ratio.

In this paper, the materials to be considered are s, copper and brass. This work is been carried through experimental investigations and finite element analysis simulation. The evaluation results are correlated with the results of finite element analysis simulation. The variation of experimental and numerical simulation will be obtained within the range of 10-12%.

***Index Terms* - Conventional Spinning, Process Parameters, Spinnability, FEAnalysis.**

I. INTRODUCTION

Spin forming processes are of three type's namely conventional, shear and tube spinning. In Spin forming process a metal plate is spun at a high speed and then moulded into an axisymmetrical metal part with the external force applied over the rotating mandrel. While in the shear forming a reduction in wall thickness occurs. In the rolling process, a small roller and mandrel are used where roller applies force on the metal sheet placed on the mandrel to deform the sheets, plastically into conical or other shapes of the circular cross-section of any size and shape is spin forming as shown in figure 1. In conventional metal spinning, manual force is applied for metal spinning. Generally, this metal forming is performed at lower temperatures but sometimes this work can be carried out at warm temperatures too.

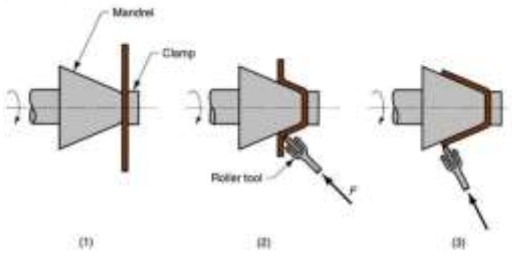

Figure 1: Metal Spinning used roller too; (1) Sheet metal Clamped to the machine; (2) Roller metal is used to shape the sheet by applying pressure upon sheet against mandrel; (3) Deriving complete shape.

In brief, spinning is used to convert a metal sheet into a required shape cup of any size by using a mandrel. Unlike the metal turning, metal spinning doesn't remove any material which gives an edge over other metal forming processes.

In this paper, conventional type of spin forming is been conducted on a lathe where a metal sheet is required that has the same wall thickness as of the finished part. The experiment is conducted on two materials Brass and Copper of same thickness. Two different roller nose radius is used for metal forming.

II. PROCESS PARAMETERS

There are many process parameters like radius of roller nose, diameter of the mandrel, study parameters like feed rate, speed of the spindle and feed ratio. In this experiment, roller nose radius and sheet material as varying input parameters as described in table 1 while forming force, surface roughness, strain are studied as output parameters and the number of experiments conducted are mentioned in table 2.

TABLE 1: Input Parameters

Material	Thickness	Rollers	Roller nose radius
Brass	0.6mm	1.	3.5mm
Copper	0.6mm	2.	10.5mm

TABLE 2: Experiments conducted

Trial	Material	Roller nose radius
1.	Brass	3.5mm
2.	Brass	10.5mm
3.	Copper	3.5mm
4.	Copper	10.5mm

III. EXPERIMENTATION

Experiment has been conducted manually on lathe machine, on which spin forming setup is done. The tool and mandrel are made of EN10 material, with brass and copper as work piece materials. As per the requirement of metal shape, the shape of mandrel is opted for providing a wide range of conditions. A metal sheet of maximum diameter 50 mm is chosen and is modeled into a cup with an inner section of a circular surface of diameter 30 mm. The shape is very close to that of investigation of working forces in conventional metal spinning. The forming force are found out using lathe tool dynamometer and surface roughness values are calculated using surface roughness tester.

Figure 2: Initial Sheet

Figure 3: Spin Forming Setup

Figure 4: Spun Component (Copper)

Figure 5: Spun Component (Brass)

Table 3 below gives the values of the output parameters from the experiment.

TABLE 3: Output parameters

Trials	Forming force (kgf)	Surface Roughness (µm)	Strain
1.	50.98	9.3852	0.37
2.	81.57	6.5305	0.41
3.	66.28	4.7213	0.39
4.	91.77	8.8454	0.44

Figures 2,3,4,5 shows the spin forming setup and initial sheet and final spun components of both the materials.

IV. FINITE ELEMENT ANALYSIS OF SPIN FORMING PROCESS

Finite Element Analysis is carried out using FEA software which are shown from Fig 6 to Fig 11.

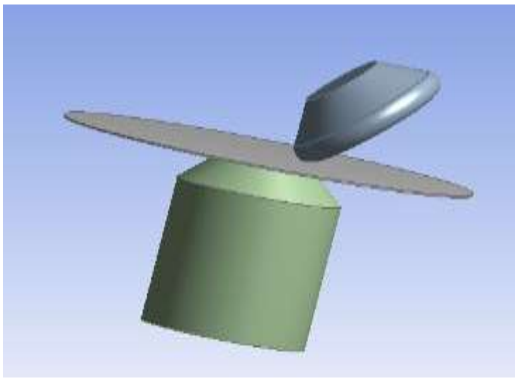

Figure 6: 3D view of the Spin Forming Process

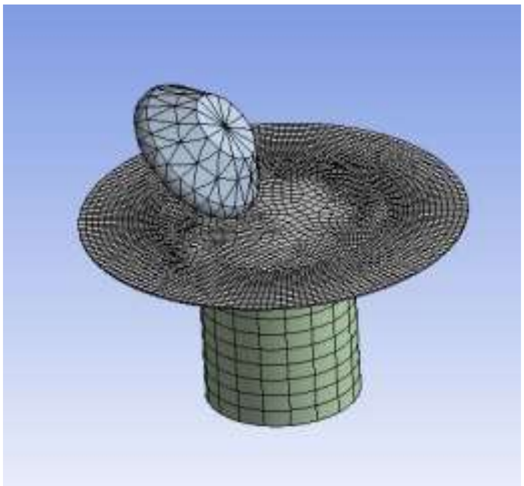

Figure 7: Analysis of Spin Forming Process (initial position)

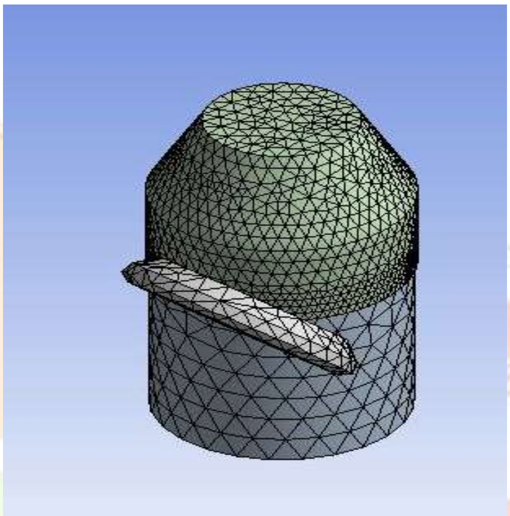

Figure 8: Analysis of copper sheet with 3.5mm roller

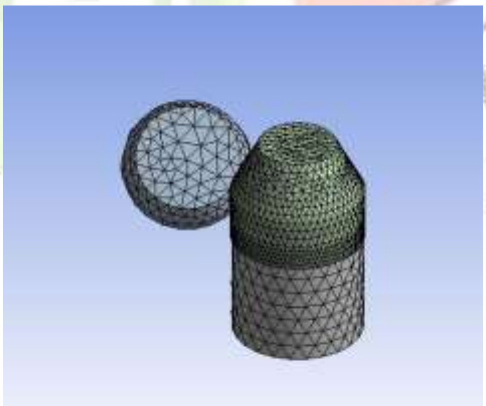

Figure 9: Analysis of copper sheet with 10mm roller

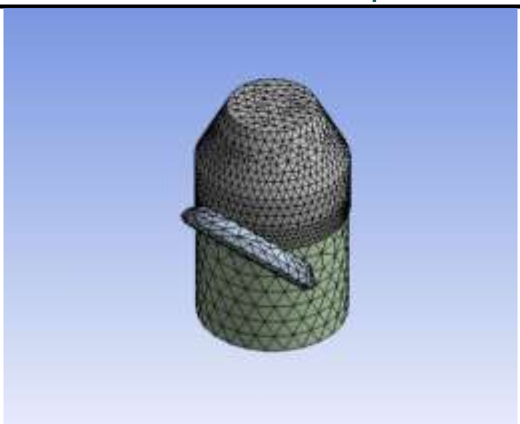

Figure 10: Analysis of brass sheet with 3.5mm roller

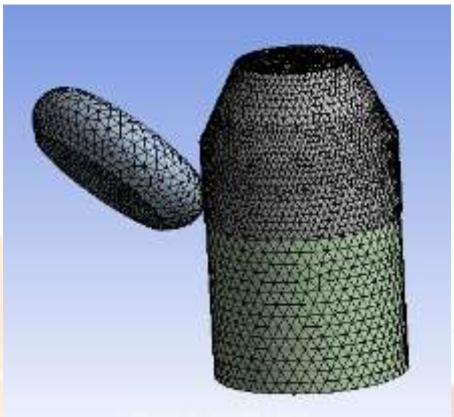

Figure 11: Analysis of brass sheet with 10mm roller

The output from the FE analysis are tabulated in Table:4

TABLE 4 : FEA RESULTS OF STRESS

Trial	Stress
1.	$1.562*10^5 N/mm^2$
2.	$1.986*10^5 N/mm^2$
3.	$1.687*10^5 N/mm^2$
4.	$2.931*10^5 N/mm^2$

V. RESULTS AND DISCUSSIONS

The result the experiment carried out with different forces applied by nose radius are simulated analytically and are studied as well. The maximum spin forming forces play a vital role in the design a working machine.

In the analytical study done above, four cases with the different sheet material, roller nose radius were used and the results are tabulated in Table 4.

VI. CONCLUSION

The metal spinning is simple in conducting the process. The experimental analysis is compared to the results of a simulation that are been performed in Ansys software which show a good tendency on loading. Calculations obtained from the conventional spinning have fewer strains than the strains involved in shear forming. Thus the works carried out to indicate the deformation with the help of dynamic explicit finite element method which is available informing the process. This demonstrates that the results obtained by simulation of processing parameters have resulted in the maximum error to be not more than ±15%.

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