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Study of Accuracy in Incremental Sheet Forming Of Aluminium

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***Abstract* – The Incremental Sheet Forming process is quickly developed as it is capable of delivering custom made parts or batch products economically as per the market needs. In this process the tool imparts local plastic deformation on sheet and tool movement along the sheet forms it into the required shape. In present study the accuracy of the single pass incremental sheet forming is tested experimentally on a commercial grade aluminium alloy. It was found that 20° wall inclination is not possible to form with the single pass forming. The results show that the single pass incremental sheet forming is not much accurate as there was differences between theoretical and measured diameters of sheet.**
***Keywords* – Incremental Sheet Forming, Springback, Aluminium, Accuracy, Forming depth.**

I. INTRODUCTION

During last few years Incremental Sheet Forming (ISF) process is quickly developed due to the fact that this method is capable of delivering custom made products economically. This process is carried out at room temperature on a CNC machine and requires only a spherical headed or roller mounted tool with a simple arrangement to clamp the sheet that is being formed. The tool imparts local plastic deformation on sheet and tool movement along the sheet forms it into the required shape. This process is also called as die-less process as it does not uses any dedicated dies. It is suitable for prototyping and batch production. Due to sheet springback and tool deformation actual part geometry is different from theoretical one. Geometric accuracy is one of the weak aspect of incremental sheet forming. Higher depth can be achieved in single point incremental forming as compared to two point incremental forming but with loss of geometrical accuracy. [1] Multistage forming can yield an increase in accuracy than single stage forming. [2] The lubricant used affects the geometrical accuracy of the component.

In single point ISF, there is unavoidable & unintended bending in the region between the current tool position and fixture which leads to significant geometric inaccuracies. The new method in incremental forming double sided incremental forming (DSIF) with novel tool path which uses two tools and deformation is imparted as squeezing between the two tools is discussed by authors and found to be accurate than single point increment forming. [3] In present study the accuracy of the single pass incremental sheet forming is tested experimentally.

II. EXPERIMENTAL WORK

A. Material

The material used during the study is a commercial grade aluminium alloy containing minimum 99% of pure aluminium. The different material properties of the alloy are mentioned in Table 1.

TABLE I
MATERIAL PROPERTIES

Parameter	Value
Sheet Thickness	0.5 mm
Young Modulus	70 GPa
Density	2710 Kg/mm3
Poisson Ratio	0.33

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Yield Strength	105 MPa
Tensile Strength	110 MPa
Shear Strength	69 Mpa
Fatigue Strength	41 Mpa
% Elongation	12

B. Plan Of Experiment

The geometry chosen for the study is a truncated cone. The diameter of base of the cone is 130 mm. Three different wall inclination angles with different forming parameters were experimentally tested to study the accuracy of the process. NX 7.5 software package was used for CAD modelling and CNC program generation. The geometry in its top view and front view is shown in Fig. 1.

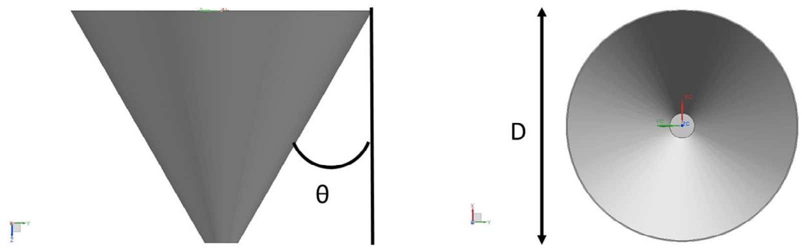

Fig. 1. Front view & top view of cone geometry

The experiments were planned according to the Taguchi L9 array to minimize the number of experiments. The feed rate in all the experiments was kept at constant value of 800 mm/min. The 20W40 grade oil was used for lubrication purpose. The different wall inclination along with other forming parameters are mentioned in Table 2.

TABLE III
PLAN OF EXPERIMENTS

Experiment No.	Wall Inclination (Degrees)	Step Size (mm)	Tool Diameter (mm)	Rotational Spindle Speed (RPM)
A	20	0.1	8	100
B	20	0.5	10	1000
C	20	1	10	500
D	30	0.1	10	500
E	30	0.5	10	100
F	30	1	8	1000
G	40	0.1	10	1000
H	40	0.5	8	500
I	40	1	10	100

The Fig. 2 show half section of formed sheet. The measurements are taken at 1 mm along the edge of the sheet geometry as shown. The required diameter is calculated theoretically with formula Z = Y – [Sin θ X Depth] for all the three wall inclination under consideration.

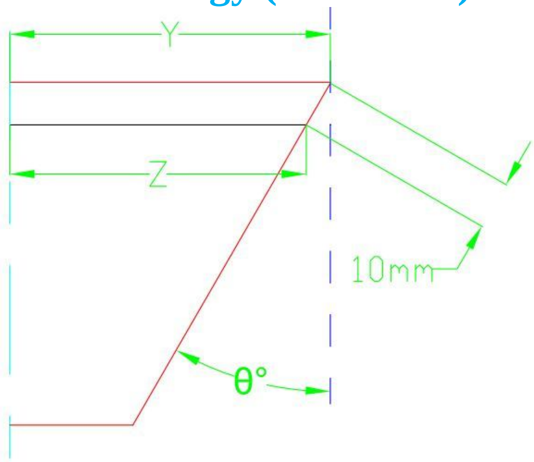

Fig. 2. Theoretical diameter calculation

III.RESULTS AND DISCUSSION

The experiments were carried out as per the above mentioned plan. The method used for measurement of diameter of the formed sheets is shown in Fig. 3. The measurements were taken with the digital Vernier Caliper. Cracks were initiated in some cases prior to achieving the desired depth.

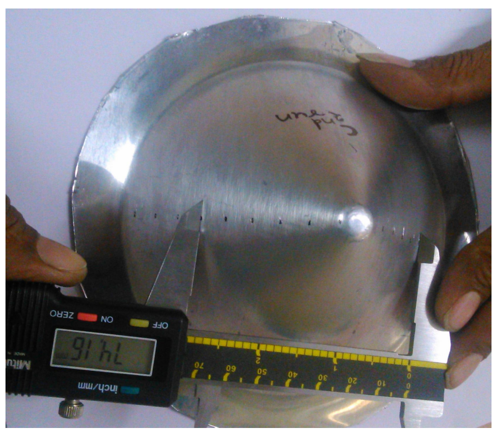

Fig. 3. Method of diameter measurement

The maximum depth reached for the formed sheets is summarized in Table 3. The results show that five of the nine sheets were cracked prior to reaching the desired depth.

TABLE IIIII
MAXIMUM DEPTH ACHIEVED

Experiment No.	Maximum depth Reached / Crack Initiated at (mm)
A	8.52
B	9.34
C	9.11
D	94.04
E	97.38
F	68.72

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G	68.93
H	70.81
I	23.09

In any sheet forming process the total deformation is a combination of plastic deformation and elastic deformation. The plastic component is permanent but elastic component is recoverable causing the component to Spring-back resulting in off target shape. One of the most used methods to compensate for this springback is to use an additional operation known as Restrike. In incremental forming, when tool passes over the sheet it induces local plastic deformation in sheet. Depending upon the step size the tool induces plastic deformation at a certain point number of times. This can be understood as when tool passes over a particular point the plastic stresses are induced in small zone. Thus if any particular point is in two or more such zones (the smooth tool path trajectory will create such infinite zones) it is comparable to the restrike operation in conventional forming. Thus the springback in incremental sheet forming is very less.

The Fig. 4 is a graph in which diameter value is plotted against the forming depth. It compares the actual measured diameter of cones with theoretical one. As evident from graph the actual values are differing from the theoretical ones by a large amount in many regions indicating a poor geometric accuracy. It can be seen from first graph that sheet with wall inclinations 20° were unable to reach the desired depth. It was found that in all the three cases the cracks were developed below 10 mm of forming depth thus we can conclude that sheets with wall inclinations 20° cannot be formed with single point incremental forming.

For 30° wall inclination as seen from the graph, slope of actual diameter curves is in accordance with theoretical diameter curve but there is difference in values of the two. As seen from 40° wall angle graph, the actual diameter and theoretical diameter values are almost similar except for some little difference at bottom of formed component. From these three graphs it is evident that with increase in the wall angle the measured diameter curves approaches the theoretical diameter curves. The reason for the mismatch observed can be springback in the component, machine or programming inaccuracy. The small component of mismatch may be due to measurement error. Further work can be done in comparing the accuracy of single pass and multi pass forming.

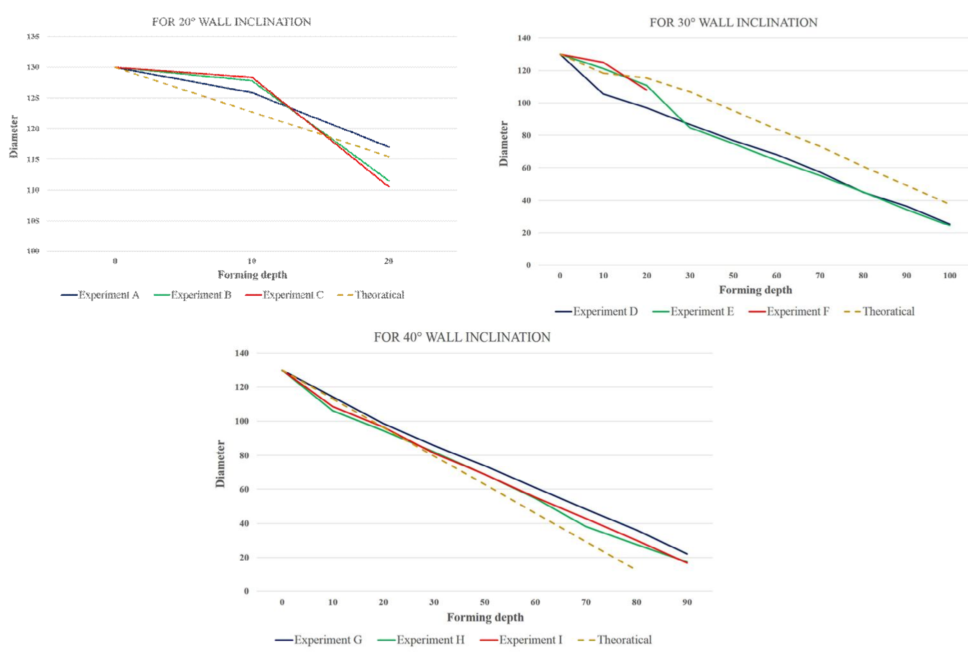

Fig. 4. Graph of Diameter vs. Forming depth

IV. CONCLUSIONS

The experiments were performed according to the plan and results were analyzed. Depending upon these results following conclusions can be drawn.

Sheets with wall inclinations 20° cannot be formed with single point incremental forming.

For 30° wall inclination the slope of theoretical and actual diameter curves are in accordance but there is some difference in between the values.

With increase in the wall angle the measured diameter curves approaches the theoretical diameter curves.

V. ACKNOWLEDGMENT

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REFERENCES

[1] A. Fiorentino, A. Attanasio, R. Marzi, E. Ceretti, "On forces, formability & geometric error in incremental sheet forming," International Journal of Materials & Product Technology, vol. 40, issue 3, 2011.

[2] Markus Bambach, B. Taleb Araghi, G. Hirt, "Stratergies to improve the geometric in asymmetrical single point incremental forming," Journal of Production Engineering, vol. 3, issue 2, pp. 145-156, June 2009..

[3] Rajiv Malhotra, Jian Cao, Fang Ren, Vijitha Kiridera, Z. C. Xia, "Improvement of geometric accuracy in incremental forming by using a squeezing tool path stratergy with two forming tools," Proc. MSEC, Oregon, USA, vol. 1, pp. 603-611, Jan. 2011.

[4] H. Meier, B. Buff, R. Laurischkat and V. Smukala, ''Increasing the part accuracy in dieless robot-based incremental sheet metal forming,'' CIRP Annals - Manufacturing Technology, vol. 58, pp. 233–238, 2009.

[5] Julian M. Allwood, Daniel Braun, Omer Music, "The effect of partially cut-out blanks on geometric accuracy in incremental sheet forming,'' Journal of Materials Processing Technology, vol. 210, pp. 1501–1510, 2010.

[6] Haibo Lu, Yanle Li, Zhaobing Liu, Sheng Liu and Paul A. Meehan, ''Study on step depth for part accuracy improvement in incremental sheet forming process,'' Advanced Materials Research, vol. 939, pp. 274-280, June 2014.

[7] V. Mugendiran, A. Gnanavelbabu and R. Ramadoss, ''Parameter optimization for surface roughness and wall thickness on AA5052 Aluminium alloy by incremental forming using response surface methodology,'' in Proc.GCCM, paper 97, pp.1991-2000, 2014.