"Parametric Investigation of Single Point Incremental Forming For Al 8011A H-14"

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ABSTRACT

There are many forming processes, being used in the global market for a long time. Many conventional sheet forming processes are tedious, time taking in development and design as well. In order to solve these problems Single Point Incremental Forming (SPIF) is introduced which is a modern method for metal sheet forming, where parts can be formed without the use of dedicated dies. In this review forming process particularly single point incremental forming is focused to carry out short summary for new researchers who want do work on this process. Single point incremental forming (SPIF) is one of the prominent rapid prototyping technique that enable to make prototypes quickly. This work tends toward establishing parameters values for SPIF with regards to geometric accuracy, strain and thinning of Al 8011A H-14 sheet material.

Keywords: *Single point incremental forming, geometric accuracy, Strain generation, thinning.*

1. Introduction:

Originally, Die-less rapid prototyping process was introduced in 1960s in Japan; offer an operational solution to difficulties in forming process with procurement of die for low quantity production or sheet metal prototype. It was not get general use in industry at that time. Though, the last five and score years has shown leaning towards the progress of DLRP process and make it appropriate for the industrial uses.

Principle of SPIF operation: In sheet incremental forming, blank edge is usually firmly clamped and the sheet is deformed by a hemi-spherical tool following the required shape in space by a CNC controlled incremental tool movement. ISF is defined as a family of sheet forming processes where the deformation is highly localized, without drawing in of material from the surrounding area and using a fully clamped blank, where the final shape is determined by the XYZ movement of some tool part without the need for a die.

Basically Die less rapid prototyping can be done by using any Vertical milling machine with having minimum 3-axis CNC control. Basic requirements for die-less rapid prototyping are sheet material which intended for forming, simple fixture or clamping device to hold the sheet material, simple forming tool without cutting edge (blunt tool) and the forming machine with Computer Numeric Control system.

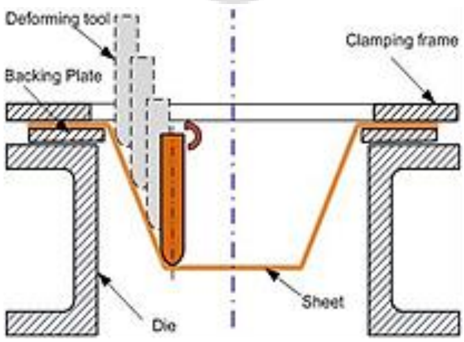


Fig-1 Principle of Incremental Sheet Forming presented by Le Van Say (2009);

2. Methodology:

For Single point incremental forming, vertical milling NC machines are essentially used because of their competences to control tool motion in all three directions. This offers litheness to manufacturing a part having symmetric as well as asymmetric shapes on the same machine with similar set up. So, this technique is frequently named as asymmetric incremental sheet forming (AISF). In this process, finished sheet metal works can be made directly from a 3D CAD model. Hence, old-fashioned intermediate stage of tool design and manufacturing can be eradicated. Thus, a new part can be manufactured in an hours rather than days. A graphical illustration for the step of manufacturing of sheet metal part using SPIF process is described in Fig-2.

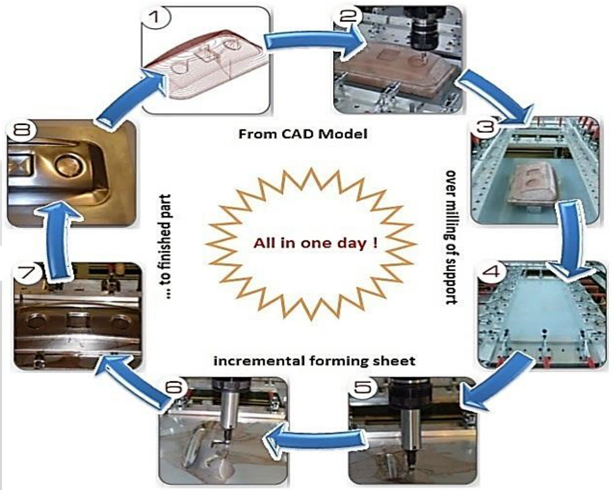


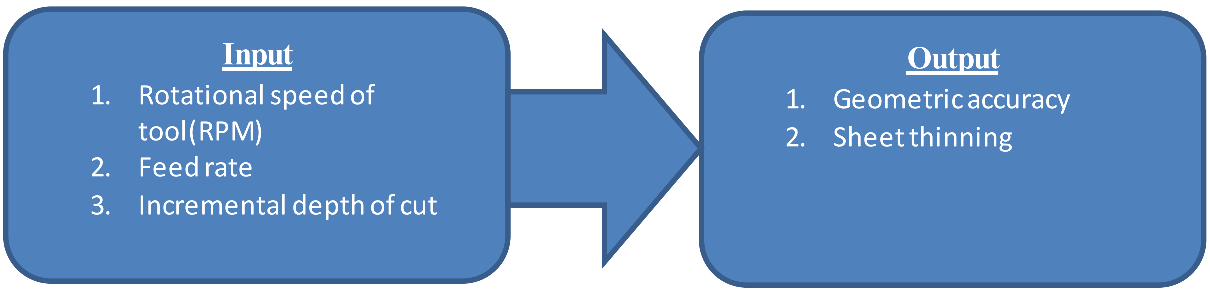
Fig-2 Steps in SPIF process offered by Le Van Say (2009).

Earlier studies reported by Hamilton and Jeswiet (2010); Ham et al. (2007); Jeswiet et al. (2005); Hagan and Jeswiet (2004); Ambrogio et al. (2003); confirmed that many factors such as feed rate, step size of incremental motion of tool, speed of tool rotation, relative motion between sheet and tool, tool radius, shape of tool and thickness of sheet to be formed, lubrication type and method likely to be contribute to the internal and external surface of the component formed by SPIF process. Hence, the objective of the present article is decided to investigate the effect of feed rate, tool rotation speed and incremental depth geometrical accuracy and thinning of the component formed by SPIF process.

In this research work similar methodology adopted for performing SPIF for process parameters decided in next chapter.

3. Experimentations:

From literature survey, following three Input parameters and their values decided for experimental study.



For performing experiments, following parameters were fixed:

1. Material of Sheet: Aluminium 8011A-H14
   a. Chemical Composition:
      Al – 98.49%
      Si – 0.57%
      Fe – 0.83%
   b. Mechanical Property:
      Tensile strength: 155 Mpa
      Yield strength: 126 Mpa
      Elongation: 6%
2. Sheet thickness, mm: 0.55
3. Material of Tool: HSS
4. Tool radius, mm: 8
5. Height of cone, mm: 12
6. Major Diameter of cone, mm: 30
7. Minor Diameter of cone, mm: 26

3.1 CAD model and tool path for experiments:

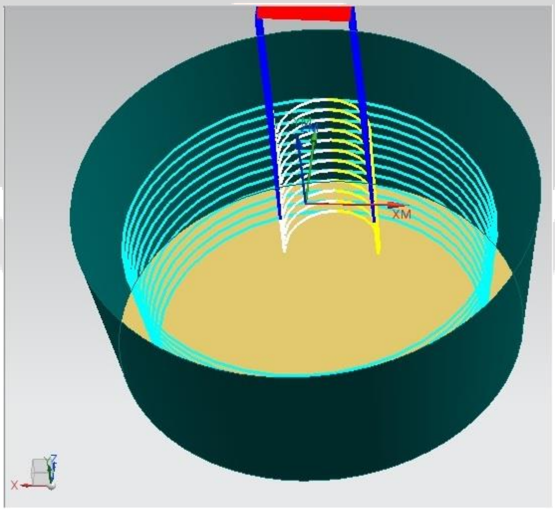


Fig-4 Model of cup and tool path generated using CAD software

4. Measurement Method

For measuring geometrical parameters general instruments like vernier calliper, micro meters are used. To measure thinning of sheet metal, formed cone required to be cut in two half and measurement of sheet thickness was carried out. For measuring cone angle, CMM measuring system was utilized.

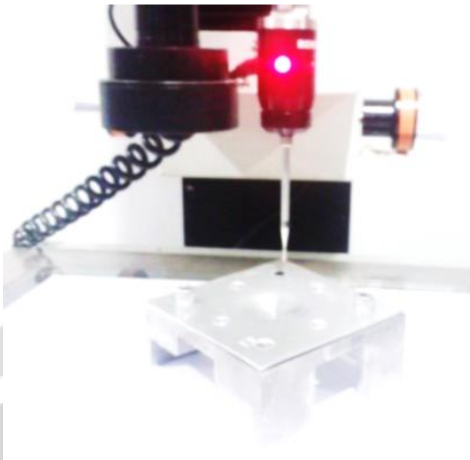


Fig-5 CMM measuring system for cone angle measurement

5. Parameter selection:

Based on literature survey, following value were decided for Investigation of effect of incremental depth on geometric accuracy and thinning of sheet

Constant parameters	
Feed rate (mm/min)	50
Rotational speed of tool (rpm)	1250
Variable parameter	
Incremental Depth in negative	0.2, 0.3, 0.4, 0.5, 0.6, 0.7,

Table-1 Parameters selection

6. Results and Discussion

The results of the experiments conducted to form frustum of cone with 12 mm height and 80° cone angle are presented in the present section. Percentage error is calculated using following equation:

$$\% \, Error = \frac{Designed \ value - obtained \ value}{Designed \ value} * 100$$

Depth of cut	Cone angle	% Error in cone angle	Cone Height	% Error	Thinning	Remarks
0.2	79.88	0.15	12.154	1.27	39.96	Formed
0.3	79.95	0.06	12.114	0.94	39.77	Formed
0.4	79.89	0.14	12.134	1.10	40.1	Formed
0.5	79.86	0.18	12.146	1.20	40.32	Formed
0.6	---	---	---	---	---	Fractured
0.7	---	---	---	---	---	Fractured
0.8	---	---	---	---	---	Fractured

Table-2 Effect of depth of cut on Cone angle, cone height & thinning

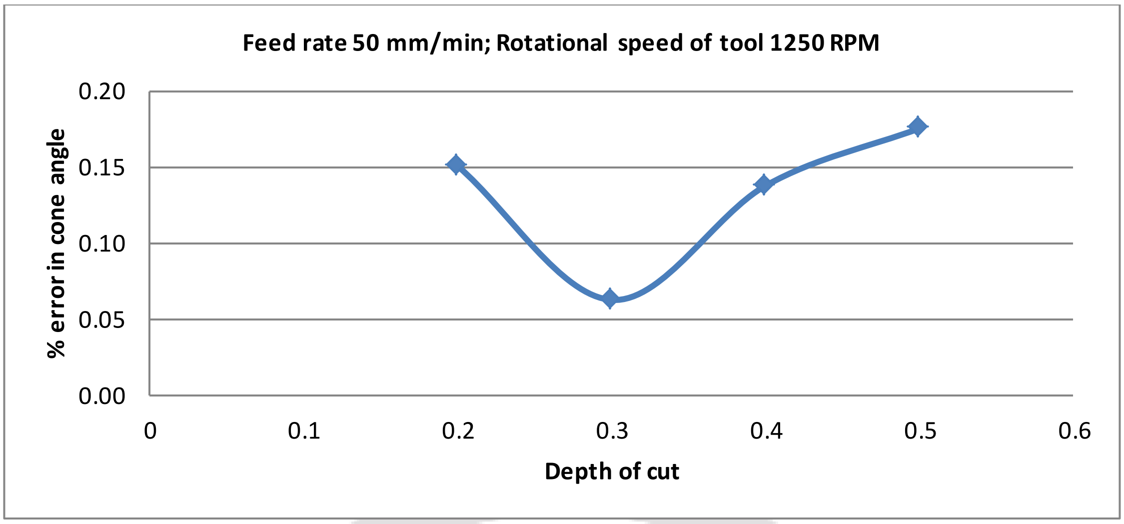


Chart-1 Effect of Depth of cut on Cone angle

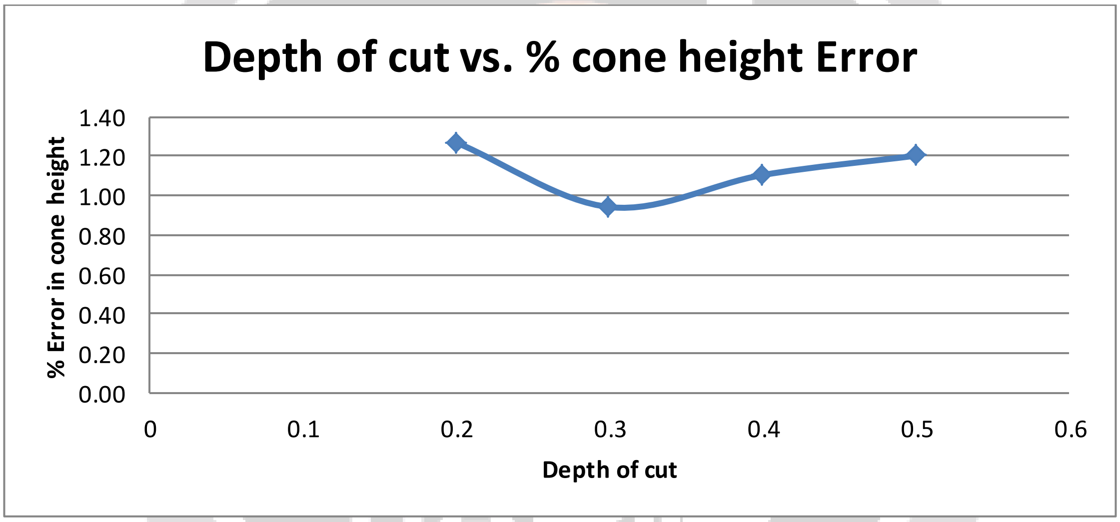


Chart-2 Effect of Depth of cut on Cone height

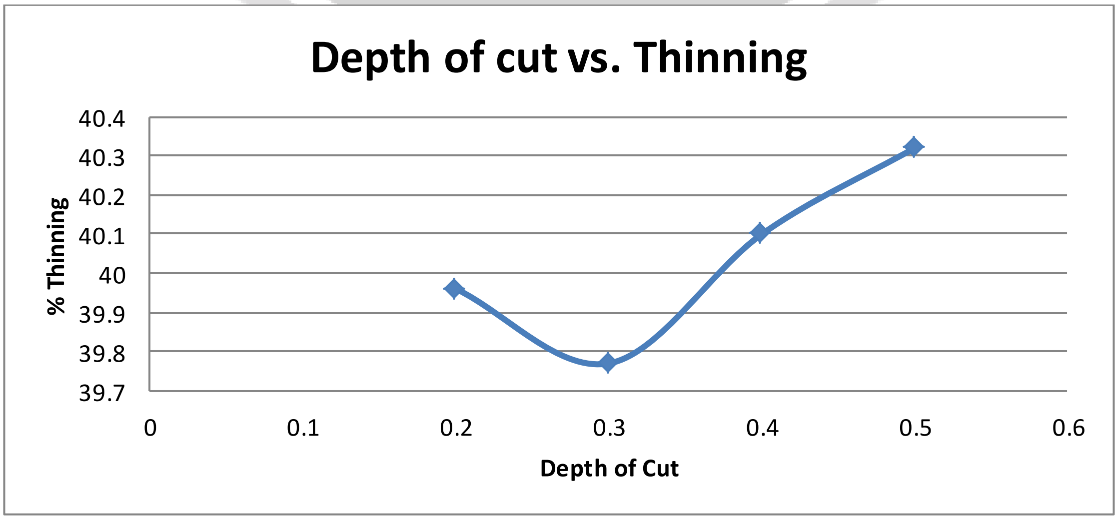


Chart-3 Effect of Depth of cut on thinning

7. Conclusion:

In present work, Effect of depth of cut on cone angle, cone height and thinning of sheet studied. From the results obtained can be summarized as follow:

It was noted that at certain level of incremental depth of cut, % error in cone height and cone angle decreased. After that it showed adverse effect.

For the selected material type and thickness, depth of cut 0.3mm. RPM 1250 and feed rate 50mm/min was best combination for further study.

8. Future work:

It is desirable to extend this work to study effect of variation in other parameters like tool rotation speed, feed rate.

All these parameters can be studied for another material like steel or copper.

Another variation that can be made is variation in sheet thickness

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