

## Incremental Sheet Forming

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### ABSTRACT

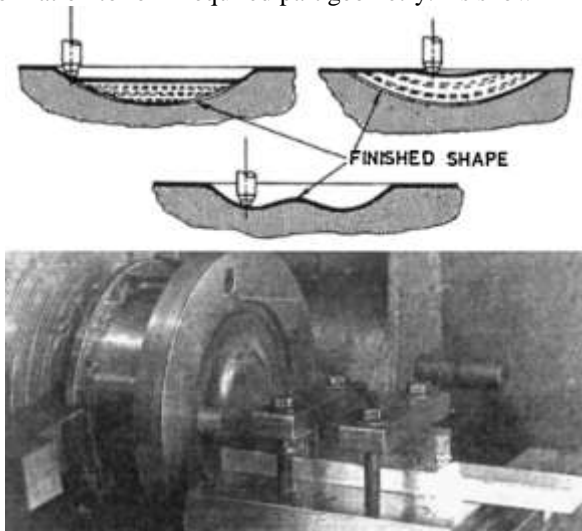
*Incremental sheet forming is non-traditional method of sheet forming from ductile material. Most preferable materials are aluminium, copper and bronze. In Incremental Sheet forming (ISF) the sheet is hold in holding devices and revolving tool to form a localize deformation of sheet to get desired component. This paper is gives brief review about Incremental sheet forming also it emphasis on behaviour of material during ISF also FE approach has been discussed.*

**Keywords:** *Incremental Sheet Forming (ISF), FE Analysis, etc.*

### 1. INTRODUCTION

There is slight difference between spinning and incremental sheet forming. In 19th century spinning was first introduced in market. The spinning process patent is taken by Leszak patent [US 3342051]& The Berghahn patent [US 3316745]. In spinning process blank is clamped in holder & it is rotates while stationary tool comes in to contact to formed a required shape.

Mason (1978) of the University of Nottingham has proposed spherical tool is used as spinning tool so that easy to control x, y & z movement blank should be stationary. Tool is moves in each pass incremental forward and backward to get small localized deformation to form required part geometry. As shown in fig. 1



**Fig. 1** First true ISF setup by Mason [1]

Later on first development is taken place in Japan by Iseki in 1989. They use CNC machine to carry out the ISF & to form non-axis symmetrical part as shown in fig. 2

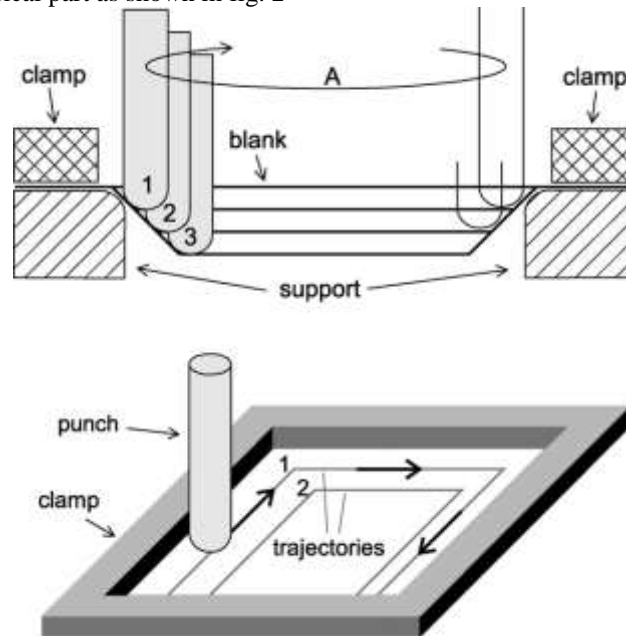


Fig. 2 Principle of SPIF for a non-axis symmetric part [1]

In 20th century people identified some limitation of incremental sheet forming that complicated, deep part cannot be form by ISF so the invention of two point incremental forming takes place [1, 2]

### 1.1 Incremental sheet forming is classified in two types

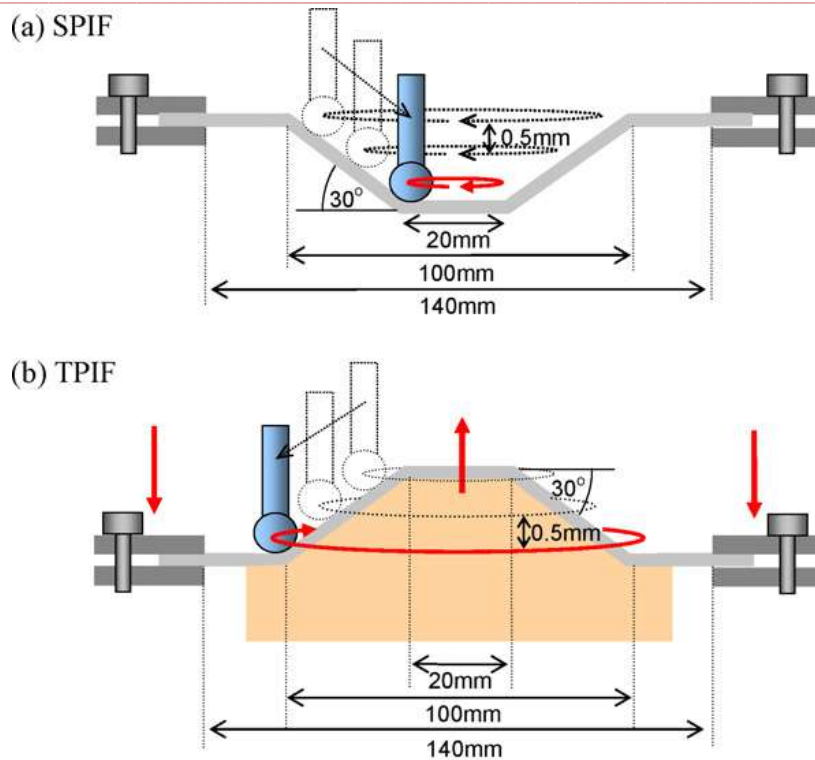
- 1) Negative Incremental sheet forming
- 2) Positive Incremental sheet forming

Negative ISF-

In negative ISF sheet is clamp in fixture it has no support from bottom side so sheet forming takes place in negative Z direction. It is also known as Single Point Incremental sheet forming. As shown in figure 3

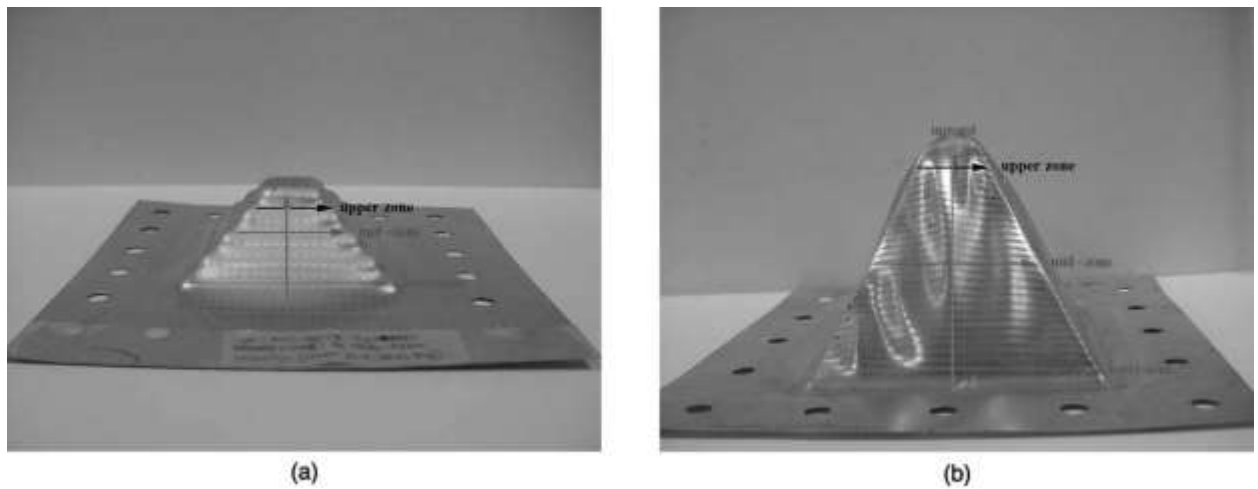
Positive ISF-

Sheet is clamped in fixture & it is supported by replica of desired geometry so forming takes place in positive Z direction. It is also known as two point incremental sheet forming. As shown in figure 3



**Fig. 3 Forming processes (a) SPIF (b) TPIF [2]**

The two component frustum of pyramid is form by SPIF & TPIF as shown in figure 4



**Fig. 4. Forming frustum of pyramid (a) by negative forming, (b) by positive forming [3]**

In this experiment it is found that in positive ISF is better than negative ISF .In positive ISF forming capabilities increases as the plane strain mode of transform is more introduced. In ISF sharp corner can not form due to crack formation at corners easily due to biaxial stress.

## 1.2 Experimental setup

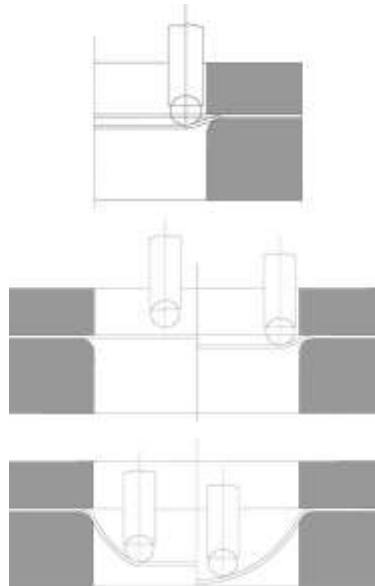
The aluminum sheet is clamped in blank holder. The spherical head tool tip is used as a tool. It is made up of hard steel so it should not be deform while forming. The tool is placed in tool holder & proper program is feed in the CNC machine for spindle movement in x, y & z direction. Oil is used as lubricant to avoid friction & heat dissipation during forming. Experimental setup is shown in figure 5



**Fig. 5 Incremental forming of an aluminium sheet on CNC milling machine [3]**

### 1.3 Forming by Impression

In this process the forming tool having spherical ball at its end is used. In incremental sheet forming tool is exert small force so localize deformation takes place at each point of sheet to form final part geometry. As shown in figure6



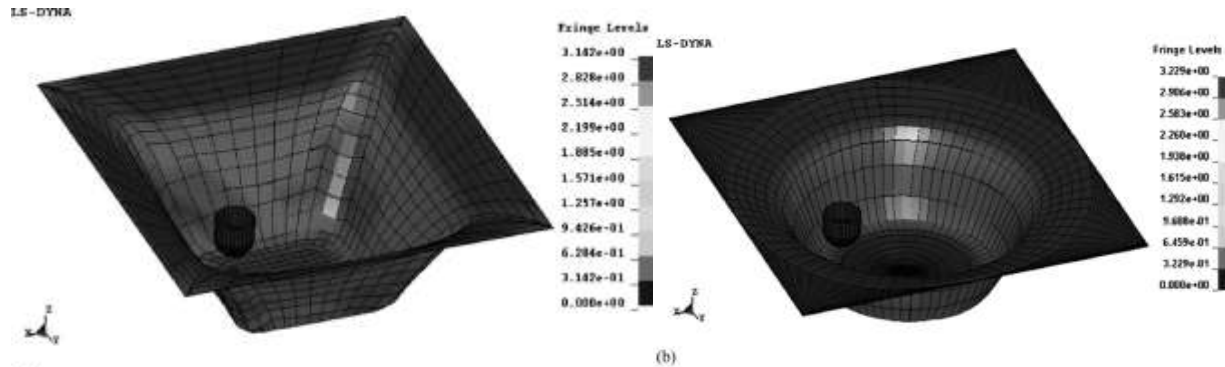
**Fig. 6 Forming with impression [4]**

## 2. FINITE ELEMENT ANALYSIS

FE analysis carried out of Frustum of pyramid & Frustum of cone in LS-DYNA software for these geometry adaptive mesh style used. Different zones formed after plastic deformation. For the punch a rigid material behaviour has been used & for sheet Shell element has been used. a material able to be deformed has been assigned,

fixing the density, the Young’s modulus and the Poisson’s ratio and the parameters of the power law, K and n, in order to assess the material behaviour.

Simulation has been carried out for frustum of pyramid 45° wall angle & for frustum of cone 50° wall angle as shown in figure 7. Simulation is carried out for different wall angle. It has been possible to reach some conclusions that will be evaluated for the extreme cases, respectively, of 63° and 66°

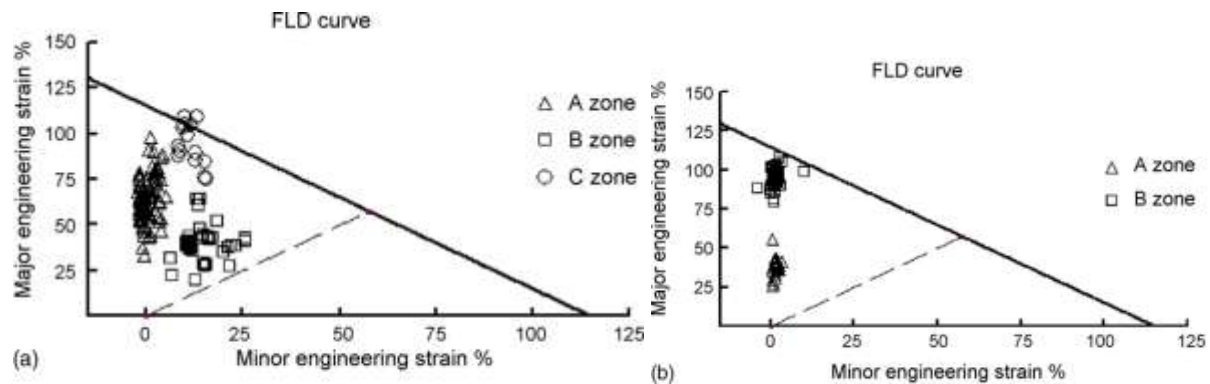


**Fig. 7. Incremental forming process in LS-DYNA software. (a) Deformations for the frustums of pyramid and (b) deformations for the frustums of cone. [5]**

As A, B & C zones form in this case A zone is form at uni-axial stress condition that means at edges , B & C zone formed at biaxial stress condition that means at corner or curvature of geometry.

### 2.1 Forming Limit Diagram

A, B & C zones form in this geometry due to changes in major strain & minor strain the location of point in graph shows that they are in safe zone. If point goes beyond the Forming Limit Curve (FLC) the fracture will occur.



**Fig. 8 Forming limit diagrams in LS-DYNA. (a) FLD for the frustums of pyramid and (b) FLD for the frustums of cone [5]**

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### 3. CONCLUSION

A study of evolution of maximum wall angle is carried out it gives idea that maximum slope angle of frustums of pyramid and cone is up to 660 In case of frustum of pyramid fracture occurs at corner & in case of frustum of cone fracture occurs at circumference due to biaxial stress.

Forming limit diagram gives the idea how forming in incremental Sheet Forming is good as compared to traditional forming

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