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# Analysis of Various Sheet Incremental Metal Forming Processes: A Review

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**Abstract- Conventional, Single, Two and Multipoint Incremental Forming (CIF, SPIF, TPIF and MPIF) Processes is an innovative forming approach for sheet materials. In conventional metal forming process the product are produced by dedicated tools i.e. die and punch but SPIF is a die less and other is with die metal forming technique applied mostly applied for small batch and custom made products of various shapes and dimensions. To take advantages these two techniques, a hybrid process has been developed. The forming experiments are performed on 3 axes CNC machines. Future work will apply this approach to other alloys used in Denture base, aeronautic or automotive applications.**

**Keywords:-** Incremental forming, SPIF, MPIF, Numerical Simulation, denture base, Tool path Design

## I. INTRODUCTION

These are various unconventional processes except from Hammering, spinning, stamping etc.

### *A. Incremental Sheet Metal Forming*

Incremental sheet metal forming process using single point tool was created by Leszak in 1967 [1] which later on well known as Die less forming. Later in 1994 Matsubara [2] had developed an incremental backward bulge process, where sheet is clamped on downward movable rig, at the centre of blank is supported by a post as shown in figure 2. Forming tool is control by CNC providing tool movement that describes trajectories to obtain final desired part in either symmetrical or nonsymmetrical geometry.

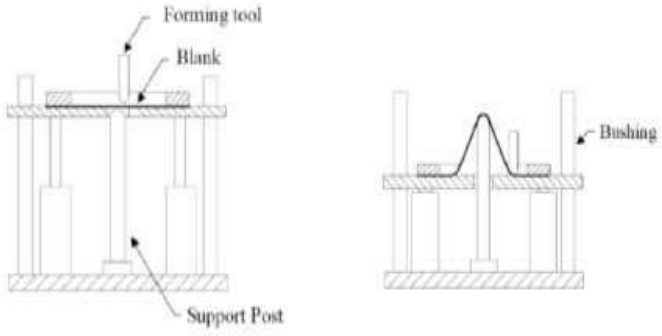


Figure 1: Incremental Sheet Metal Forming

### *B. Multipoint Incremental Forming*

Multi-point forming (MPF), Multi-point die forming or Multi-point Press Forming technology is flexible 3-D manufacturing processes for varied large sheet which similar to forming process of solid dies. In two opposite solid die (upper and lower) are used to press onto a blank and form into particular shapes. Instead MPF used matrix punches with specific shape that could adjust height by mean of line actuator. Due to rapid change of two element group several special MPF techniques are impossible in conventional forming has been investigated. For instance spring back is compensated cycle by cycle large deformation could be obtained and large size of sheet can be formed in small scale MPF equipmentby Premika Suriyaprakan et al [3].

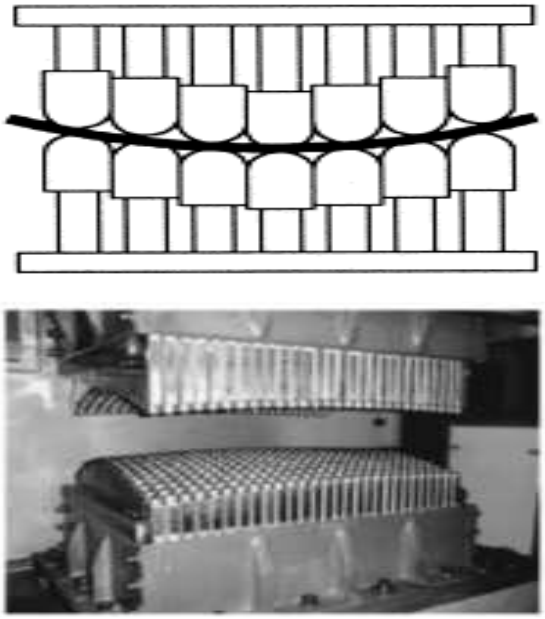

Figure 2: Multipoint Incremental Forming

### *C. Single Point Incremental Forming*

SPIF is a relatively new die less sheet metal forming process. In contradiction to traditional deep drawing and stretch forming, where the sheet formed in a single step operations with a shaped punch and die it is formed incrementally in a

multi-pass procedure using a single point, rotating tool pin with a spherical tip MB silva et al [4].

Figure 3 presents the basic components of the process (i) the sheet metal blank (ii) The blank Holder (iii) the backing plate and (iv) the rotating single point forming tool.

Main process parameters in SPIF are: tool radius, sheet thickness, drawing angle ψ and downward step size per revolution. In case of multistage operations the strategies of forming direction in subsequent forming steps (inwards- up and outwards-down) also plays an important role.

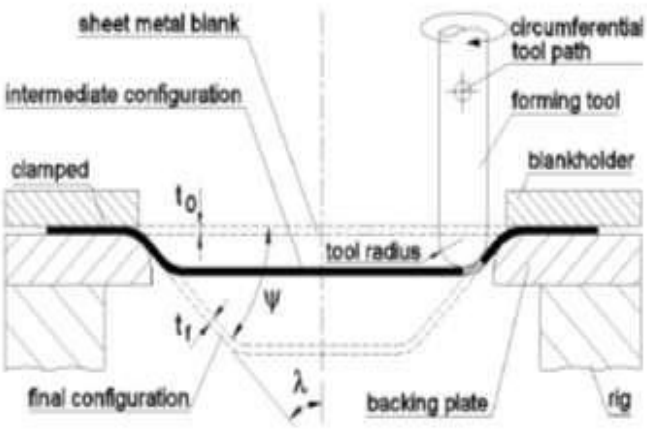


Figure 3: **.** Single Point Incremental Forming

Figure 2 shows the component of SPIF which has backing plate, blank holder, forming tooland some important parameters explain later in the next chapter. In this no die support is used

The incremental sheet forming mainly divided into three types, Single Point Incremental forming (SPIF), Incremental forming with counter tool and two point incremental forming (TPIF) which will explained later in the following section.

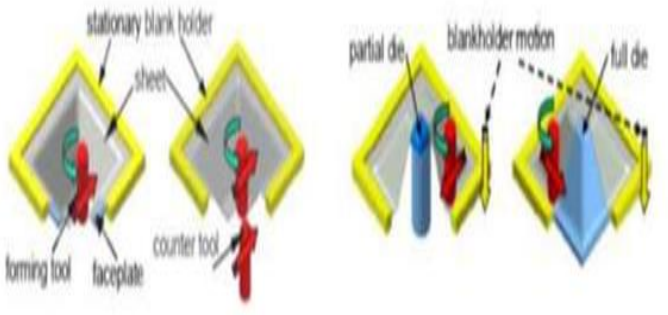


Figure 4: (a) Single Point Incremental Forming(b) Incremental Forming With Counter Tool (c) Two Point Incremental Forming (Partial Die) (d) Two Point Incremental Forming (Full Die)

Regarding SPIF there is some advantages as shown below [5].

1. Small force due to incremental nature of process;
2. Conventional CNC Machine can be used to perform ISF;
3. Final desired part produce directly from CAD file;
4. No positive or Negative die are requested;
5. Increasing Material formability;
6. Parts dimension can only be limited by machine tools;
7. Good surface finish quality;
8. The operation is quit and relatively noise free.

On the other hand there are some disadvantages included below [6].

1. SPIF takes longer forming time that conventional deep drawing process;
2. SPIF have less geometry accuracy specially at bending edges area and convex radius. Comparing to other Incremental process
3. Process is restricted by small size production batches;
4. To achieve vertical angle, it can only be by multistage strategies;
5. Spring back occurs even though it can be minimized by some correction algorithms;

## II. APPLICATIONS

Mostly incremental sheet metal forming application can split into two categories: Rapid Prototype for automotive industry. In the field of automobile, heat or vibration shield, reflective surface of headlights, solar oven and silencer housing for trucks are manufactured by incremental sheet metal forming.

Figure 5: (a) Heat and Vibration Shield for Automobile


Figure 5: (b) Reflective Surface of Head Light

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Figure 6 (a) Solar Oven

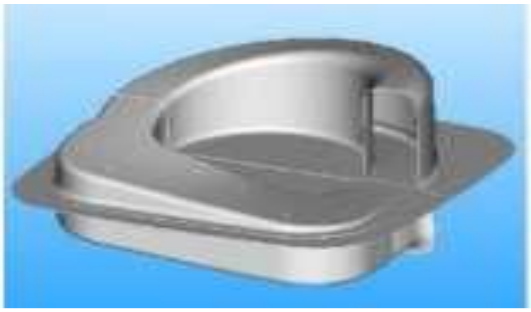

Figure 6 (b) Silencer Housing

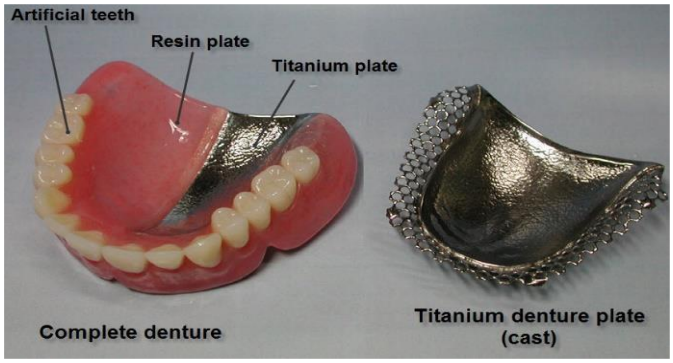


Figure 6 (c) complete denture base

## III. RESULT AND DISCUSSION

In fig. (d) Shows the original denture base and the replicas made by SPIF technology from carbon and stainless steel. After forming, visual control is performed first and goal to detect potential defects and estimate surface finish. On the both plate the only problem identified was slight increase in roughness of internal surface in the zone of the maximum deformation. The rest of internal surface was smooth and without tool marks.

In hybrid process, the tested part has complex geometry. The corresponding tool path is presented in the fig. (d). The forming tool starts by forming the upper box having a 10 mm height and then it moves to the middle 10 mm cylinder to finally from the lower box. The overall height of the part is 30 mm. The spring back effect is less pronounced in the presence of the interpolator.


Figure 6 (d) Influence of the Elastomer Interpolator

## IV. CONCLUSIONS

This paper is fully demonstrates the capability and diversity of use of SIF technology. Here it was successfully applied in dentistry field for producing a metal base of complete denture, heat and vibration shield solar oven silencer housing etc. By applying reverse engineering CAD and CAM techniques, product and process design is done in an easy and effective way. Spring back is a difficult phenomenon due to nonlinearity and also that a small angular spring back could result in large deformations of the hole part and have the simulation software specially when deals with complicated geometries. From present study it is concluded that: (i) The SPIF process is a time consuming process. (ii) The greater deformation of sheet metal is possible in SPIF small tool size is preferred to get the required shape at the faster rate, but the possibilities of failure due to localized stress are bigger.

A new hybrid process combining the MPF and TPIF processes was investigated in this paper its feasibility was validated by using a prototype designed and realized by authors. Successful standard and complex products were successfully obtained by using this process. The main advantages of the MPIF are its great card saving especially for small batch or single production in addition to the wide range of products that could be manufactured by using this process. The main geometrical defect in the fabricated parts is dimples causes by the pin tips. Through the introduction of an elastomeric interpolation between the reconfigurable die and the sheet, this defect could be reduced and even eliminated. Future research will focus on the effect of the process on the enhancement of the geometrical accuracy and the forming limits. The numerical model will be also developed by the introduction of the appropriate damage law in order to predict the failure of the part.

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