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DESIGN AND ANALYSIS OF FLEXIBLE FIXTURE FOR SINGLE POINT INCREMENTAL FORMING PROCESS

Jigar Patel [1], Shyam Rangrej [2], Haresh prajapati [3], Umang Sharma [4]
[1,2,3,4] *Production Engineering Department, Birla Vishvakarma Mahavidyalaya, Vallabh Vidyanagar-388120*
[1]*jigarpro.001@gmail.com*
[2]*shyamrang24@gmail.com*
[3]*hpprajapati05@gmail.com*
[4]*vishal111993@gmail.com*

Abstract
This paper represents the flexible fixture design for single point incremental forming process. Fixture is one of the main component in single point incremental forming process to hold, support and clamp the blank sheet during forming. The cost of fixture designing and manufacturing is something about 10 to 20% total manufacturing system cost. Generally a single point incremental forming process is used for small and batch production. In S.P.I.F Process, To Form the every new shape and size of sheet metal component, there is need a different size of fixtures. And it will increase the cost of formed parts. To reduce the manufacturing cost, a fixture is design in such a way that as many as component can be made in single fixture. This Paper summarized that a new flexible fixture design which can be used for the forming various size and shape of component in a single fixture. For this fixture, static structure analysis also to be carried out to find out a stresses and deflection in the fixture during forming.

Keywords- *SPIF, Flexible Fixture, CAE, Sheet metal forming, CAD*

Nomenclature:-
C.A.F.D: computer aided fixture design
C.A.D : computer aided design
C.A.E : computer aided engineering
S.P.I.F: single point incremental forming.

I. INTRODUCTION

Single point incremental forming (S.P.I.F) process is die less, quick, versatile, innovative sheet metal forming technique. it is mostly used for small scale and batch production as well as at initial stage of any product development related to sheet metal.[2] in S.P.I.F process a blank sheet of the component is firmly griped or clamped in the fixture. the function of the fixture in S.P.I.F process is to hold, clamped and supports the blank sheet during forming. Design of Fixture should be simple, for easily loading and unloading of component during the process. [3] It is very crucial factor for any recent manufacturing industries to developed a variety of products within short period of time and this is achieved by flexibility. The flexibility of a whole manufacturing system is restricted by the flexibility of any of its components, including fixture systems. The cost of designing and fabricating the fixtures in an manufacturing system can amount to 10 to 20% of the total system cost [5].

1.1 Working principal of SPIF process.

The single point incremental forming process is based on layered manufacturing principles [4], where the model is divided into horizontal slices by generating a tool path . The numerically controlled (NC) tool path is prepared using contours of these slices. In the SPIF process, spherical forming tool is moved along NC controlled tool path as follows (see Fig. 1): tool moves downwards(Δz), contacts the sheet, then draws a contour on the horizontal plane, and then makes a step downwards(Δz), draws next contour, next step downwards, and next contour and so on.

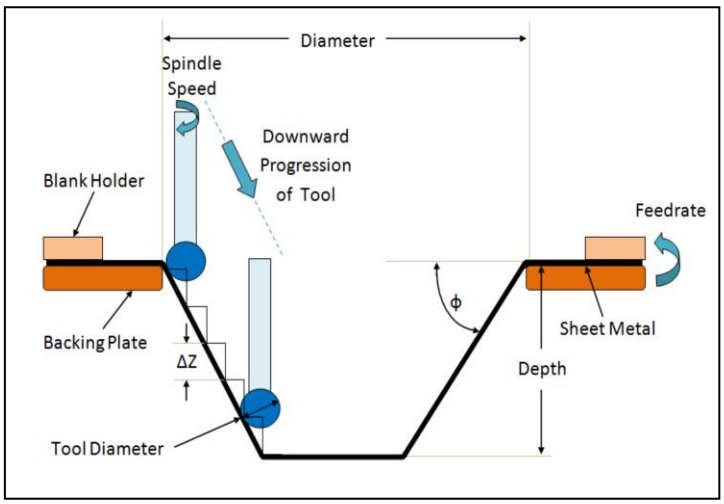

Fig 1. Working principal of SPIF process

1.2 Requirement of fixture

In SPIF process sheet is to be need a perfectly clamped during the forming of shape. for rigidly clamp and hold the sheet fixture is required. Hardik S Beravala et al[1], J. Kopac et al. [2] called a forming set up instead of forming fixture. at the time of forming, sheet is stretched from every corner, and its depend on the shape of component. for maintain the geometric accuracy of component fixture performed its function properly. in S.P.I.F process fixture is

securely clamped on the table of the machine upon which a forming of the shape is done. Deformation in fixture may cause geometrical dimensional error in component and in S.P.I.F, deformation is occurs due to forming force and clamping. Supports and locators are used to avoid this deformation, and for minimum deformation of the fixture a simulation is to be carried out using Ansys for proper location of the supports where maximum bending moments are occur.

II. METHODOLOGY

Methodology is a well systematic planned approach / strategy, that outlines the way in which the whole task is to be complete and it consist the following details

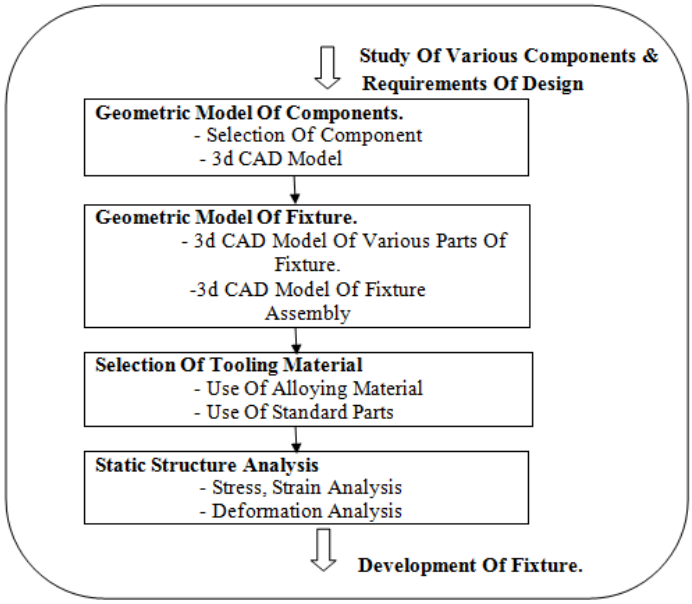

Fig 2. Basic Structure of Methodology

- **Study of the components**: study of the components is a preliminary task by any designer. purpose of study is to extract the necessary information, and from studying the various components shape and size. it is finalized that for any sheet metal component which is formed by S.P.I.F process is in rectangular or square shape.
- **Geometric models of the components**: creating the model of any component based on requirements, is a secondary step of the any fixture design. For designing this fixture various sheet metal components are to be selects and makes the geometric models.
- **Geometric model design of the fixture**: component design is consider as a base for any fixture design. for complete full proofing design of fixture various parameters are considers like principles of degree of freedom, location of clamping, guiding and locating elements. Geometric Dimensioning and tolerances also provided during model design of fixture.
- **Selection of the tooling materials**: selection of the material for the fixtures is based on the application of various components used in fixture at particular area. for complete fixture, proper material selection and proper alloy combination in varying percentage is used.
- **Static structure analysis**: during application of the fixture, due to forming load stresses are generated and due to which deformation of fixture is occur. Combined effect of stress and deflection of fixtures geometrical errors are to be produce in component. to avoid this problem before any manufacturing of the fixture analysis is to be carried out.

III. FLEXIBLE FIXTURE DESIGN

3.1 Why flexible fixture required in SPIF process?

Recent trend in manufacturing industries is to rapidly change its products according to customer requirements, increasing the product range, high frequency in changing the production program, shortening the production time and decreasing the manufacturing cost.[6] and SPIF is used for batch and job production in sheet metal industries. To formed the every new shape and size of component by SPIF process needs a special setup or fixture to hold the sheet, and it increase the cost per piece, and time spend for making set up or fixture is also more. and to resolved this problem a flexible fixture is design (as shown in fig.9)

For designing a fixture for SPIF process certain points to be kept in mind,

- Component size and shape.
- Clamping conditions(easily load and unload the work piece).
- Table range of machine in 'x','y', and 'z', direction.
- No of component to be produced.
- Fool proofing.
- Cost.

3.2 Various components of Flexible Fixture

Various components of fixture, assembly and material selection are explained below.

3.2.1 Fixture Top Frame.

Fixture top frame is mounting on the height adjusting block (Fig. 6), and it is guided on guide pillar (fig. 5) for height adjustment. the main function of Fixture top frame is to hold the Flexible Frame block(Fig. 4).

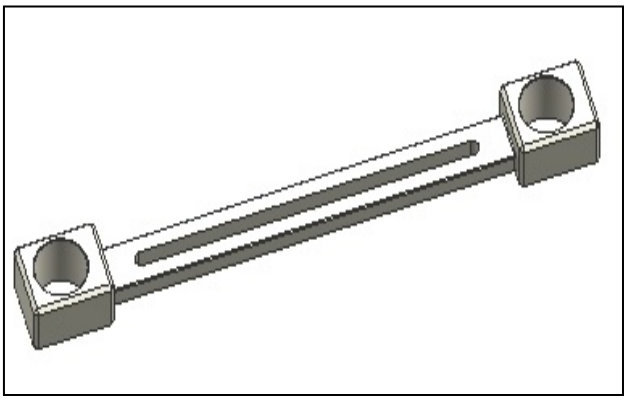

Fig 3. Fixture top Frame

3.2.2 Flexible frame Block

Flexible frame Block (fig. 4) is mounted on the Fixture top frame (fig. 3) and, it is fixed at any position by fastening it by using fasteners on the frame. its main function is to hold the top pressure plate, blank sheet, and bottom plate during the forming. A no. of holes are provided for getting the flexibility in y direction for verity of components.

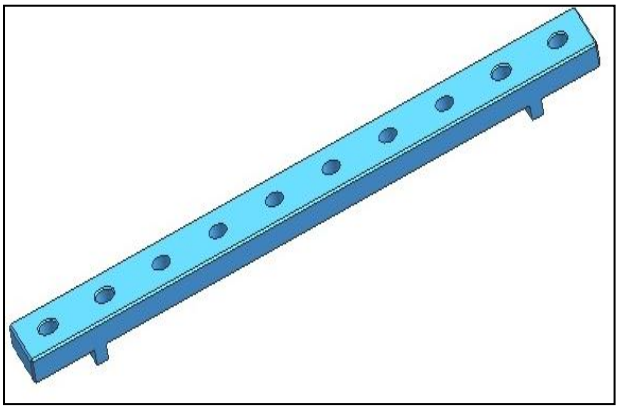

Fig 4. Flexible frame Block

3.2.3 Guide Pillar and Guide Bush Assembly

The purpose of using Guide pillar and guide bush (Fig. 5) in this fixture is for moving the whole fixtures top parts in vertical plane , to making it flexible for height adjustment. all the top parts of fixture are move vertically without losing its position accuracy in the horizontal plane. a guide pillar is press fit with guiding element holding block and guide bush is press fitted with the fixture top frame(fig. 3), and the guiding element holding block is fitted with the machine bed by using the fasteners.

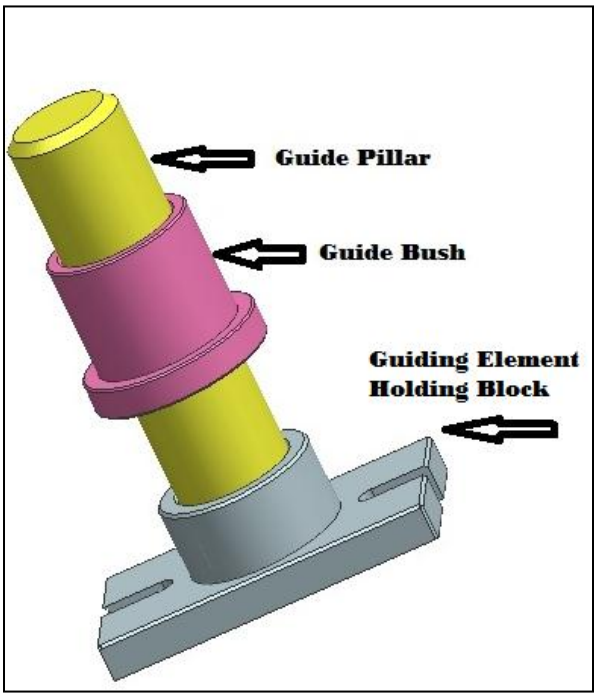

Fig 5. Guide Pillar and Guide Bush Assembly

3.2.4 Height Adjusting Block

Height adjusting block is a Assembly of Main block and Quick replacing Block (Fig.6). its main purpose is to give the support to prevent the fixture frame from bending because fixture frame is hanging like simply supported beam, and also for height adjustment in vertical plane. Here in assembly quick replacing block (Fig. 6) is add or removed from main block to maintain height. height adjusting block is fixed by fasteners with the machine bed

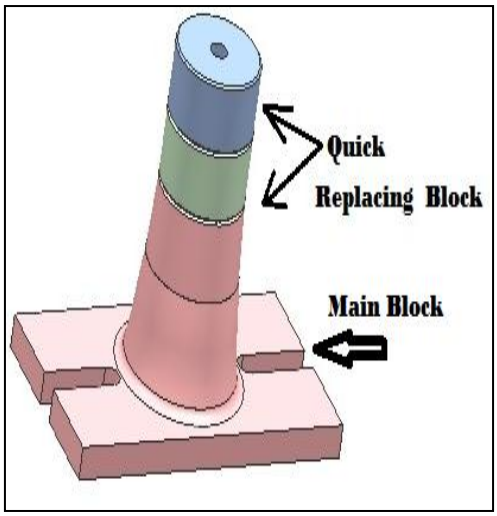

Fig 6. Height Adjusting Block

3.2.5 Quick Clamp

Quick Clamp is used in Fixture for holding and clamps the blank sheet in between the top pressure plate (Fig.7). and Flexible Frame (Fig.4) during the forming. quick clamp transfer pressure through pressure plate for clamp the sheet. it is design for quick clamp and unclamp the sheet for reduction of the set up and process time in the SPIF process.

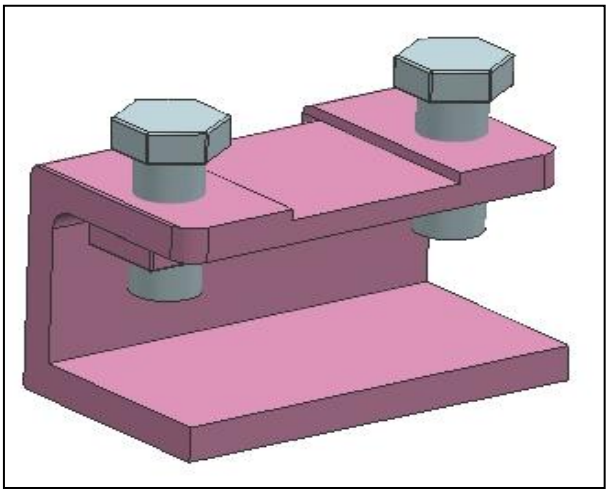

Fig 7. Quick Clamp

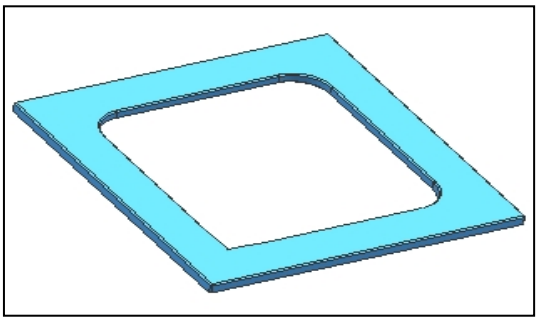

Fig 8. Pressure Plate

3.2.6 Pressure Plate

Pressure plate (Fig. 8) used in flexible fixture for holding the blank sheet during the forming .its shape is changed when the shape of component and its periphery of profile is changed.

3.3 Assembly of Flexible Fixture

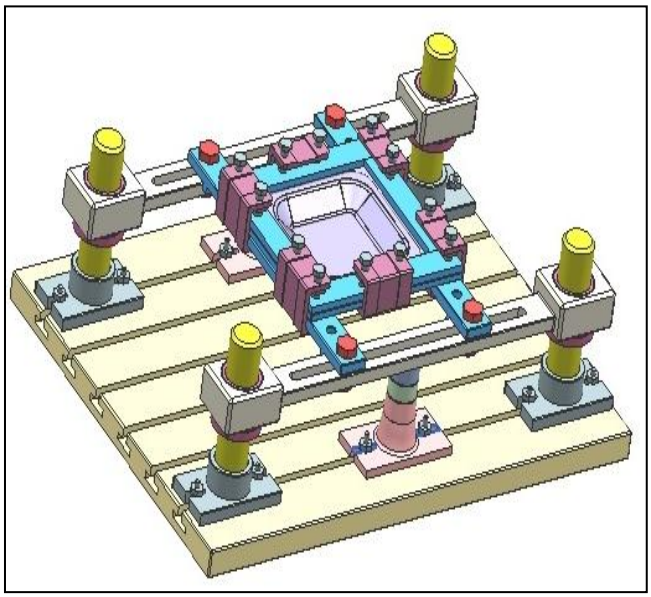

Fig 9. Assembly of Flexible Fixture

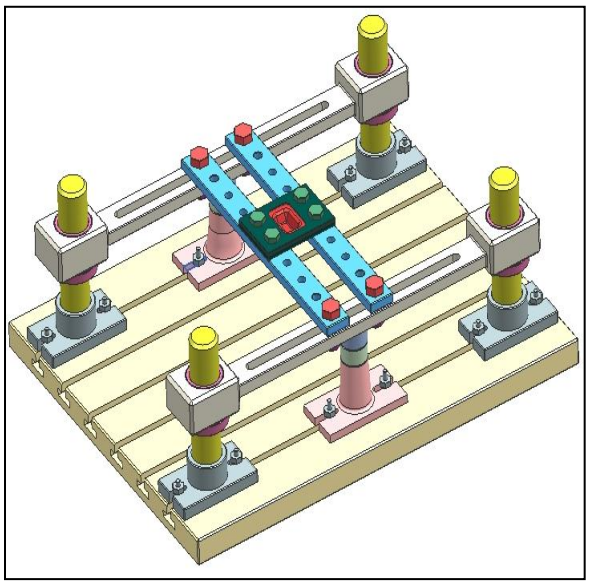

Fig 10. Assembly of Flexible Fixture

3.4 Material Selection for Flexible Fixture

Material used for the flexible fixture is shown in below table.

Sr. No.	Parts	Type of Fit	Designation
01	Guide pillar and guide bush	sliding fit	H7g6
02	Guiding element and Guiding Element Holding Block	Press fit	H7r6

***Table 1.* Fits**

Sr. No	Description	Qty	Material	Remarks.
01	Fixture top frame	02	Mild Steel	-----
02	Flexible Frame Block	02	Mild Steel	-----
03	Guide pillar	04	EN353	Case Harden 1.5mm Depth
04	Guide Bush	04	EN353	Case Harden 1.5mm Depth
05	Guiding Element Holding Block	04	Mild Steel	-----
06	Height Adjusting Block	02	Mild Steel	-----
07	Quick Clamp	As per required	Mild Steel	-----
08	Pressure Plate	01	Mild Steel	-----
09	Fasteners	As per required	STD.	

Table 2. Bill of Material

IV. Analysis of Flexible Fixture

4.1 Static Structure Analysis

It is necessary to make the fixture more rigid and error free, if it is not then it's affect on geometrical accuracy of the formed component. for this flexible fixture, static structure analysis is to be carried out in ansys software to find out stress, strain and deflection in the fixture because fixture is like simply supported beam, and the load during forming is acted upon the blank sheet.

For carried out this analysis maximum load 5000N is used at the point where forming is occurs and its effect shown in fig. 11.

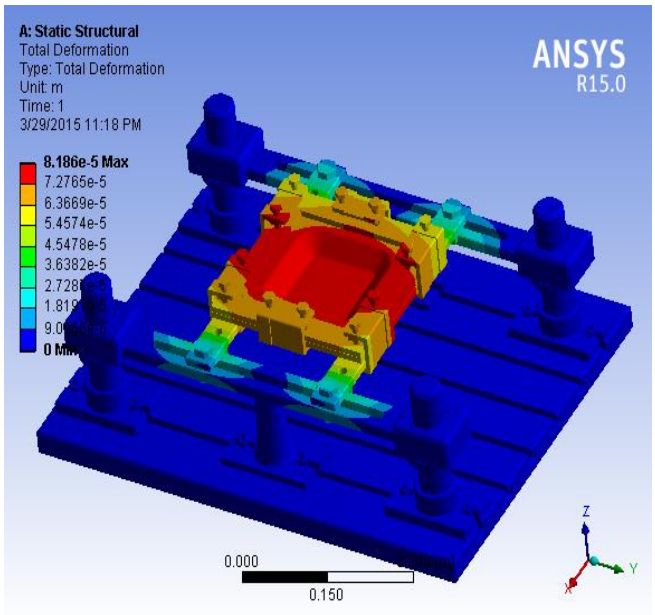

Fig 11. Static Structure Analysis of Flexible Fixture

V. CONCLUSION

It is concluded that fixture rigidity and it's deflection is within permissible limit (7.2765 X 10^{-5} m). The designed Fixture can be used to form wide range of components from size of 45 X 70 to 300 X 350 within a single set up. The use of this fixture is also reduces time in clamp and unclamp of blank sheet during forming. As per requirement of different height of the component , the fixture can be fixed at appropriate height.

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