International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 12, December-2018

INVESTIGATION ON INFLUENCE OF ANNEALING TEMPERATURES IN FORMABILITY AND DIMENSIONAL ACCURACY IN SPIF PROCESS ON STAINLESS STEEL 304

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Abstract: Incremental forming is a sheet metal forming process characterised by high flexibility. This process is requires in-depth studies to know the influence and the optimization of certain process parameters. This paper is focused on matter formability in incremental forming. The different staring situation in the material and accordingly to the determination of forming limit diagrams for progressive forming operation.

This paper presents the investigation on influence of annealing temperatures in formability and dimensional accuracy in single point incremental forming process in stainless steel grade 304 of 0.5 mm thickness is used for measuring strains. Screen printing method by circular grid mark was used for measure strains. These strains uses for generating forming limit curves stainless steel grade 304. total work is complete by forming cone shape by CNC milling machine for measuring strains, surface roughness, dimensional accuracy, shear thinning and forming time in the overall geometry.DOE have been read the effect of forming dimentions such as: Annealing temperatures, tool diameter ,step size, feed rate and spindle speed these are the input parameters. Here in this process the deformed tools with hemispherical shapes are used.

Investigation on influence of annealing temperatures in formability and dimensional accuracy in single point incremental forming process on stainless steel grade 304. The hardness of the stainless steel 304 is more so to reduce the hardness heat treatment process (process annealing) is performed at 550°C, 575°C, 600°C and 625°C. Results are analyzed with ANOVA to know the influence of input parameters to output responses and TOPSIS and GRA multi objective optimization methods are used to predict the optimum results.

Keywords: CATIA, Stainless Steel, Screen Printing and generating limit curves.

I.INTRODUCTION

To meet the demands of customer requirements innovative methods called Incremental Sheet Forming methods have been developed. Here in ISF sheet be deformed into final work part by sequence of little incremental deformations and it is applicable to composites and polymers. These ISF methods are performed on CNC machining centres, CNC milling & Robots etc. In CNC milling a deformed tool is incrementally deform sheet into desired part without any much dedicated tooling. The main aim of the process is to reduce lead time of tooling design, development & costs involved in it. Using above process more difficult components can be formed without any dedicated tools & expensive set up. This process is used with variety of materials such as steels, aluminium alloys, polymers, thermoplastics, etc. These ISF methods are performed on CNC machining centers, CNC milling & Robots etc. In CNC milling a deformed tool is incrementally deform sheet into desired part without any much dedicated tooling. The main aim of the process is to reduce lead time of tooling design, development & costs involved in it.

II .LITERATURE REVIEW

This chapter discusses on the literature review related to fixture development, static analysis of fixture, CAD model of fixture, development of SPIF process using CNC milling machine, comparison of FLD for truncated square pyramid and cone shapes, types of grid markings, methods for grid markings, comparison of grid marking methods, advantages of each method and finally optimum conditions for minimum surface roughness & profile accuracy, DOE methods for optimization

of forming process parameters, investigation of forming forces on various input parameters, different Optimization techniques used in SPIF for analyzing the formability of the sheets by different authors.
Vishal et al[2017] This method is implemented using traditional CNC milling machine, also CAD/CAM system to plans the tool path. SPIF is carried to get the responses for forming forces. In the experimental result effect of all the process parameters on the output responses were noticed. Forming force with increase in tool diameter and sheet thickness. As the spindle speed increases forming forces decreases and increasing in step size also increases the induced forming forces [1].
RJ Alves de Sousa et al [2016] mentioned different paths for tool, different shapes formed by using ISF processes, and also discussed various forming parameters such as forming tools, sheet thickness, feed rate, speed and step size. SPIF processes can be implemented on CNC milling machine, robotic arm or purposely built machines. The advantages of using these CNC machines are easy in working with SPIF process, quick found in industry, significant stiffness and large productivity rate. Conducted numerical simulations on ISF process for prediction of forming forces during the process and reduce the quantity of material spent to test normal solutions [2].
The optimum conditions for minimum surface roughness and maximum profile accuracy are step depth is 0.2mm, tool diameter 12mm and feed rate 1000mm/rev. Here the tool diameter is found to be most significant factor and baking plate helps in improving profile accuracy of the parts formed by SPIF [3].
V.Mugendiran et al[2014] This FLC indicates the formability of the sheet metal. For drawing FLC grid marking is required, here electrochemical etching method is used for grid marking. The diameter of the grid pattern circle is 3mm.Major strain and minor strains for both the components are measured by using Mylar tape. After determining the major and minor strains FLD graph is plotted. Finally cone is having higher forming limit curve compared to truncated square pyramid [4].
Fahrettin Ozturk et al[2009] . This curve indicates the formability of the Sheet blank.
In this paper, they explained about different types of applicable grid markings like square grid, butted –circle grid, single circle grid, checkerboard grid, solid square grid and solid/wide square grid marking. There are number of methods are available for grid marking such as electrochemical etching, chemical etching, laser etching and screen printing process. Here they gave explanation about each process and finally comparison of each process with other process is done. With the help of this process grid marking is done on the sheet blanks for calculating the strains in the deformed circles into ellipses. Each process has its own advantages and disadvantages depend on the marking procedure.
Finally different methods for measuring grids, those are automatic and manual methods. A ruler, divider or Mylar tapes and traveling microscopes are used for measuring the strains manually. GOM TRITOP, ARAMIS, PONTOS and ARGUS these are the automatic strains measuring techniques. Each grid marking has its own advantages and disadvantages depending on the accuracy, quality, resolution, contrast, durability, cost and required time [6].
Shakir Gatea et al [2007] in this work, an experimental set up is developed for measuring the forces in three directions, i.e. X Y & Z directions. This measurement of forces are mainly focused on the influence of four input process parameters, those are vertical step, tool diameter, thickness and wall angle. Experiments are carried out by using CNC vertical milling machine. The fixture is mounted on the bed of CNC machine, and the material used for fabrication of fixture is steel. For measuring the forces in all three directions a table type force sensor was mounted between fixture and cnc milling machine. A cone shape is selected for determining the forces induced during the forming a cone shape using milling machine. Standard parameters used are 180mm initial diameter, 40mm cone depth, feed rate of 2000mm/min and 12.7mm of tool diameter are used for this experimental study on force measurements.
Graphs were plotted for each input parameters vs. force components. Force components are Fp (peak forming force), Fs average force. From the plotted graphs it is observed that as the tool diameter, step size, sheet thickness and wall angle are increases accordingly forces induced also increases [7].

III. PARAMETERS OF SINGLE POINT INCREMENTAL FOMING PROCESS

A. Fixture:

The fixture consists of totally 7 parts, which are finally assembled to get the desired fixture arrangement. This fixture is designed in CATIA V5 R20. This is one of the modeling software that can be used to design the components dimensions with 150mm*150mm*12mm, 150*150mm*10mm.

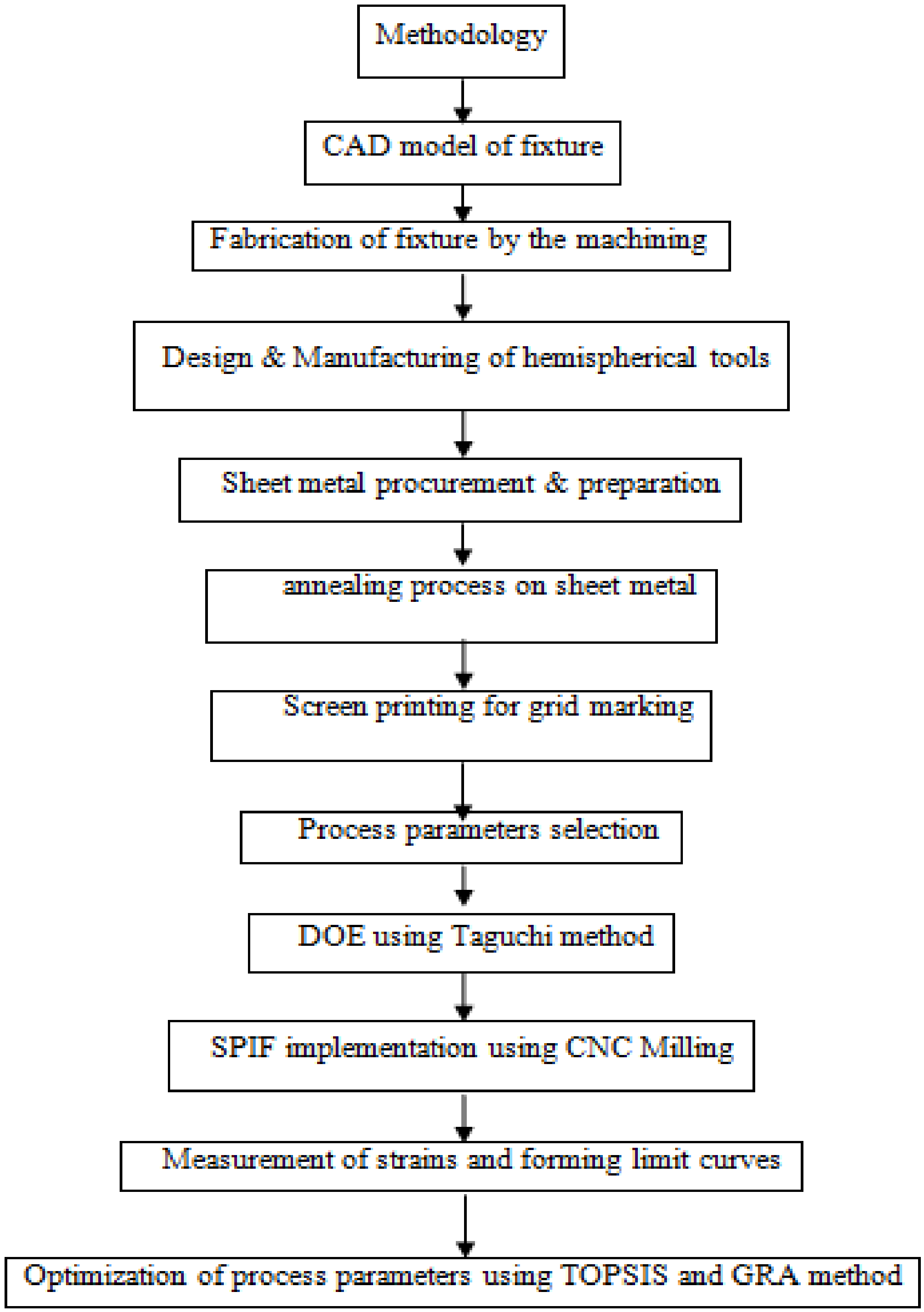
B. Sheet blanks

The materials selected for this work is Stainless steel 304 with 0.5 thickness. Stainless steel of blank size 150mm×150mm×0.5mm has been used for current experimental study.

C. CNC milling machine

CNC factories are sorted by their number of hub and are generally customized utilizing a lot of codes that speak to explicit capacities. by utilizing the single point gradual framing with the assistance of MTAB XL MILL CNC processing machine. In this instrument moves the pre-characterized way and last shape.

IV. MEHTODOLOGY



Initially the fixture arrangement is designed in CATIA, by using the machining iron fixture arrangement. Hemispherical shape tools are designed in CATIA, and these tools are manufactured in lathe machine. Stainless steel sheets are taken and these are prepared according to the requirement sizes and screen printing process is done on the back surface of the sheet blanks for measuring major and minor strains for constructing forming limit curves. DOE is choose from Taguchi method, L9 OA is selected and performed on CNC milling machine, a cone shape is developed which is used for studying the behavior of alloy and optimization is done using TOPSIS & GRA.

V. EXPERIMENTAL SETUP

It is a 3-axis CNC milling machine and is used to make the SPIF procedure for deforming the sheet into final product by using hemispherical tool with the help of program given by the computer and it is shown in the below figure.

Fig.1:MTAB XL Mill CNC milling machine set up

The fabricated parts of fixture are assembled to get the final assembly of fixture arrangement. This is the main element in SPIF process and is used for holding the sheet blank during the process.

Fig.2: Iron fixture arrangement

The major and minor axis lengths for deformed grids on the surface of the sheet blanks are measured by tool maker's microscope with Mylar tape. These are used for measuring major and minor axis lengths deformed grids after forming shape of the component. These values are measured from bottom most part to the top of the cone by taking each grid on the vertical line of the formed cone. After calculating the major & minor axis lengths, major strain & minor strains are calculate using the formulae. The original circle diameter is 3mm in each case of strains measurement.

$$\text{Major strain along X-axis} = \frac{\textit{Major axis length} - \textit{Original circular diameter}}{\textit{Original circular diameter}}$$

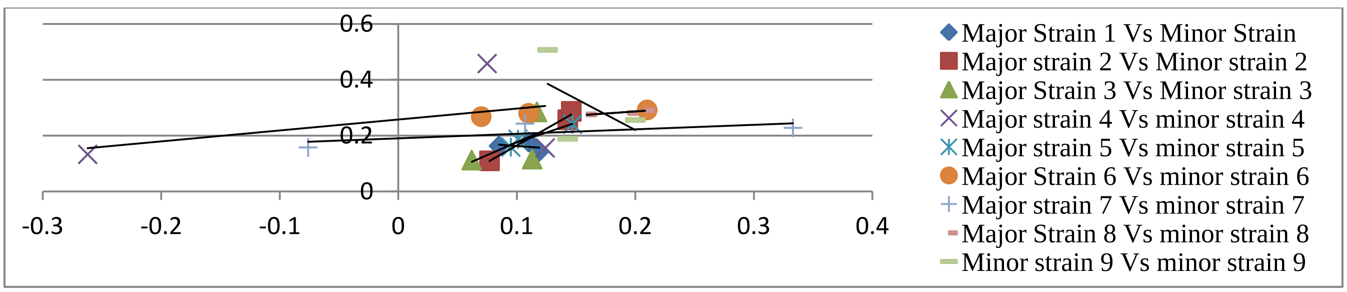
$$\text{Minor strain along y-Axis} = \frac{\textit{Major axis length} - \textit{Original circular diameter}}{\textit{Original circular diameter}}$$

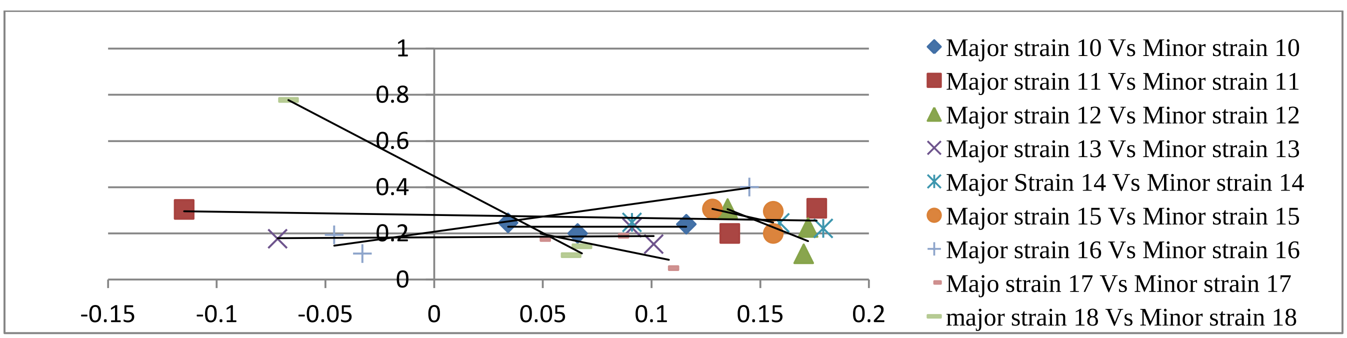
The major axis lengths, minor axis lengths are measured by taking the grids at 4 different points from bottom of the part to top of the cone and these values major strain and minor strains are calculate grid measurements shown in Fig.3

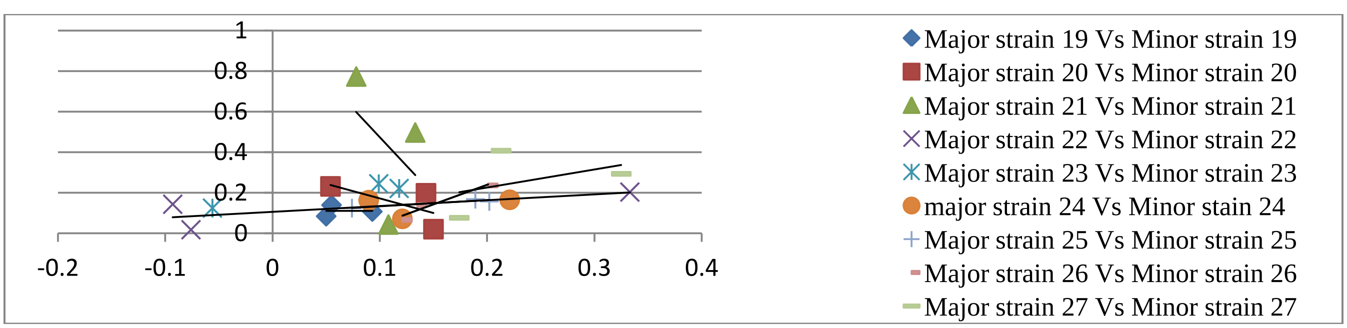
Fig.3: Cone shape using SPIF process

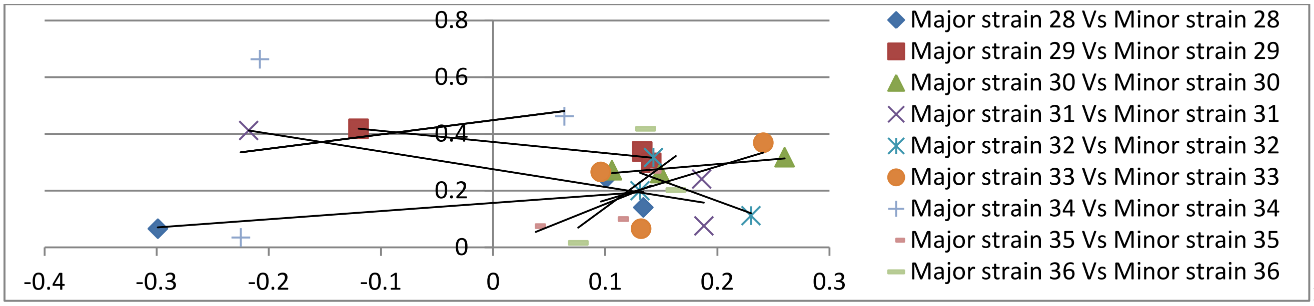
VI. RESULTS& DISCUSSION

Forming limit curves are construct for all 36 objectives and the graphs are .









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Graph,1: Forming limit curves for 1-36 experimental runs

VII. CONCLUSION

The Stainless steel 304with 0.5mm thickness sheet is used to perform the SPIF processes using CNC milling machine. Based on the L9 orthogonal array, tool diameter, step size, feed rate and spindle speed are taken as input parameters. The following conclusions are drawn from this experimental work. Forming limit curves are generated for all 36 investigational run and the greatest formability is practical at tool diameter 6mm, step size 0.4, feed rate of 50mm/min and 1500 rpm spindle speed and minimum formability of the stainless steel sheet with 0.5m thickness is observed at tool diameter 6mm, step size 0.3, feed rate of 75 mm/min and 1500 rpm spindle speed. greatest and least major strains during the SPIF procedure are 0.462mm, 0.0318mm correspondingly. Maximum, and minimum minor strains during the SPIF process are 0.325mm, -0.218mm correspondingly. Nature of the strains are both compressive and tensile.

ANOVA analysis is conducted and multiple regression equations are developed. By using Topsis, optimum values are obtained. The optimum conditions obtained using Topsis are 4mm tool diameter, 0.6mm step size, 100mm/min feed rate and 1579 rpm with surface roughness 0.91 µm, dimensional accuracy 88.267, forming time 1786.6 seconds and 0.283mm sheet thinning

Table1:Annealing effects on different temperatures

S.no	Parameters	550^{O}C	575^{O}C	600^{O}C	625^{O}C
1	Final thickness(mm)	0.3933	0.3667	0.36	0.3
2	Surface roughness(µm)	2	1.28	2.32	2.65
3	Depth(mm)	3	3.5	5	4.2

from the above table maximum final thickness 0.3933mm at 550^{O}C,minimum surface roughness 1.28 µm at 575^{O}Cand maximum depth 5mm at 600C achieved. And also at 575^{O}C annealing temperature moderate results are observed.

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