International Journal of Scientific Research and Management Studies (IJSRMS)
ISSN: 23493771 **Volume 2 Issue 2, pg: 87-96**

REDUCTION OF PRODUCT DEVELOPMENT CYCLE TIME BY PERFORMING FORMING ANALYSIS IN DESIGN STAGE

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ABSTRACT

During the development of the Die, a reduction in the number of trials would directly influence the cycle time for development. A shorter cycle time can be planned with due utilization of software tools that would predict the trial results without actually conducting the same. The simulation offered by the software during the process of stamping lends important insights into the modifications needed in the die and/or the component to effect a simplified and productive die. Normally, a Forming die (including Draw die) calls for refined design parameters for ensuring a smooth passage through the trial phase of the developed Die normally accompanied by crucial review inputs over the design of the component too. The study of the papers offers enough inputs to take up the project work in identifying a `process-oriented' solution that could be used as a reference for academicians and the corporate entities while faced with the challenges associated with the elusive process of `Forming'. The forming operation for panel used in Solar Cooker needs to be undertaken for development. This forming process poses challenges for processing the component using conventional design practices. The time required for development through this iterative process is high. Consequently, the development time is longer for realizing a defect-free component matching the design specifications. The current component design features a formed shape with flanges along the side and a large curvature over its central region. Ribs are required to be formed in a single stage along-with the forming operation. The component is expected to be accomplished in a single stroke of the press.

KEYWORDS: *Forming, HyperForm, Sheet-metal, Solar Cooker Panel, Thinning*

I. INTRODUCTION

A large variety of metallic parts of automobiles, aircrafts, building products and domestic appliances are produced by deformation processing. This comprises manufacturing methods that are used to create the primary shape of products by plastically deforming the material. Well-known examples are forging, rolling, extrusion, sheet metal forming and hydro forming. Sheet metal forming is a special class of deformation processes in which blanks, with the thickness being much smaller than the other dimensions, are formed into the desired shape. Sheet metal forming is one of the most widely used manufacturing processes for the fabrication of a wide range of products in many industries. The reason behind sheet metal forming gaining a lot of attention in modern technology is due to the ease with which metal may be formed into useful shapes by plastic deformation processes in which the volume and mass of the metal are conserved and metal is displaced from one location to another.
Sheet metal forming operations consists of simple bending, ironing, wheeling, press brake forming, stretch forming, roll forming, rubber-pad forming, stamping, flanging, spinning, embossing, bulging, hyper plastic forming, peen forming, explosive forming, magnetic-pulse forming and deep drawing of complex parts Indeed, the sheet metal products have become current also due to low price, accuracy of dimensions, durability and favorable physical properties. In today’s industry, where the cost play a

very important role, the sheet metal products have replaced many products made by forming process. They have replaced also many complex composed products.

Forming is also a process of forming sheet metal through a forming die with a punch. Metal in the area of the die shoulder undergoes a lot of stress, and will result in wrinkles if a blank holder is not used to control the flow of material into the die. Material is usually thickest in the area where the metal loses contact with the punch - the punch radius - and thinnest in the areas where stresses are greatest. Forming is often used to produce metal objects that are more than half their diameters in height. The metal is stretched around a plug and then moved into the die.

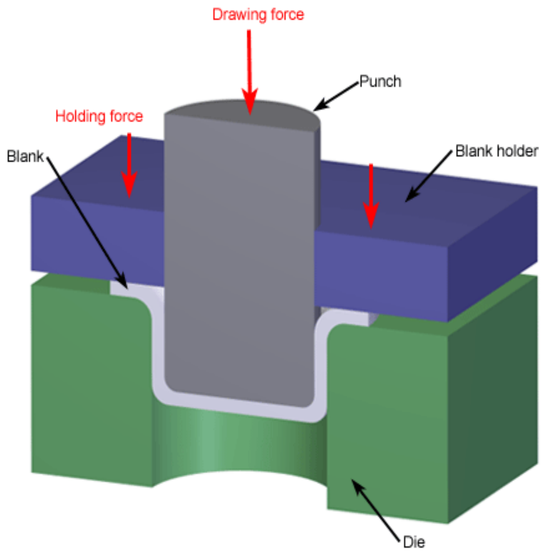

Fig.No.1 Typical Forming Construction (Deep Drawing)

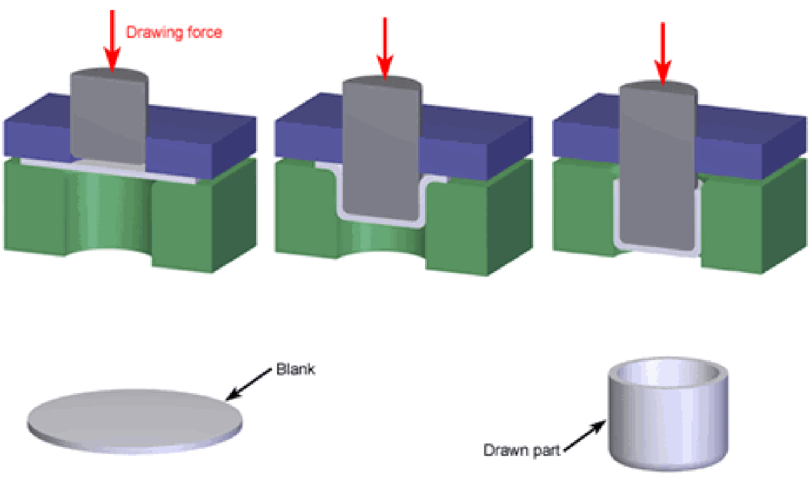

Fig.No.2 Deep Drawing sequence

Items often made by forming include cupped baking pans, like muffin pans, and aluminum can cylinders. However, irregular items, like fire extinguishers and enclosure covers for oil filters in trucks are also made this way - as is your kitchen sink! Products made by forming are deep and seamless. The finished shape produced by a forming press depends on the position in which the blanks are pushed down. Only malleable metals that are very resistant to damage by tension and to stress can be used in this process.

Fig.No.3 for representation of a forming operation

Industries where forming is often used include the dairy industry, pharmaceuticals, plastic manufacture, and the auto industry, aerospace and lighting. Companies making parts by forming need expensive presses and operations put together by trained engineers, as well as plates, molds, and other accessories. Unlike metal stamping, forming uses a single piece blank, not a continuous stream of blanks.

The productivity of the stamping process in the industry yields better quality product at a economic price. The dissertation work is relevant in the context of developing a cost effective die with a lower lead time through the phase of Design, Development, Trials and Testing, Pilot lot production & Regular supply. The forming process being critical to evaluate offers higher scope for study and research while addressing the most suitable design for the forming Die.

II. PROBLEM STATEMENT

Sheet metal forming is one of the most commonly used processes in industry. Throughout the years, the sheet metal forming industry experienced technological advances that allowed the production of complex parts. However, the advances in die design progressed at a much slower rate, and they still depend heavily on trial-and-error and the experiences of skilled workers. During the development of the Die, a reduction in the number of trials would directly influence the cycle time for development. A shorter cycle time can be planned with due utilization of software tools that would predict the trial results without actually conducting the same. The simulation offered by the software during the process of stamping lends important insights into the modifications needed in the die and/or the component to effect a simplified and productive die. Normally, a Forming die (including Draw die) calls for refined design parameters for ensuring a smooth passage through the trial phase of the developed Die normally accompanied by crucial review inputs over the design of the component too. The study of the papers offers enough inputs to take up the project work in identifying a `process-oriented’ solution that could be used as a reference for academicians and the corporate entities while faced with the challenges associated with the elusive process of `Forming’

The forming operation for panel used in Solar Cooker needs to be undertaken for development. This forming process poses challenges for processing the component using conventional design practices. The time required for development through this iterative process is high. Consequently, the development time is longer for realizing a defect-free component matching the design specifications. The current component design features a formed shape with flanges along the side and a large curvature over its central region. Ribs are required to be formed in a single stage along-with the forming operation. The component is expected to be accomplished in a single stroke of the press.

Also the direct material cost is one the important factor. Challenges are to

The problems anticipated during the development process are as below:

1) Wrinkling
2) Tearing
3) Thinning
4) Spring back

2.1 Probable Solution

Forming analysis done in design stage reduces iteration based on trial and error. However, the advances in die design progressed at a much slower rate, and they still depend heavily on trial-and-error and the experiences of skilled workers. During the development of the Die, a reduction in the number of trials would directly influence the cycle time for development. A shorter cycle time can be planned with due utilization of software tools. The software during the process of stamping gives important input to the modifications needed in the die and/or the component to effect a simplified and productive die. This leads reduction in process time.

III. LITERATURE REVIEW

3.1 Present Theories

Hole punching and other cutting operations require specific and carefully maintained clearances between the punch (male component) and the die (female component). The setting of the required clearances is determined by both the stock thickness and temper. In general, die clearances increase as the stock thickness increases. The depth of punch penetration into the sheet metal stock will also increase as softer stock is used.

Forming, involves forcing a blank deeply into a die cavity and shaping it into the shape and contour of the punch face and sides. Without sufficient formability qualities, drawn blanks are subject to wrinkling, thinning, and fracturing. Draw forming requires an addition to the die set called a blank holder. The function of the blank holder, usually a ring through which the punch and ram pass, is to control the metal flow as it is forced into the die cavity. In practice, the blank holder must exert less pressure against the blank than the punch, so metal can flow into the die; yet it must exert enough pressure to prevent the material from wrinkling.

Die making is as much of an art as a science. When all the dynamics of stamping are taken into account, the resulting part may not meet all expectations. To help fine tune the stamping process and finalize die design, die makers use an analytical tool called Circle Grid Analysis, or CGA. The application of CGA involves the etching of a pattern of small circles on the surface of the blank. This pattern deforms along with the blank as it is formed, providing point-to-point calculations of the deformation that occurred. Analyzing this stamped grid pattern suggests the location and type of rework that must be performed on the dies to produce easily manufactured parts. The CGA process is repeated on the die until an acceptable part is produced. For the above, the Design team relies heavily on trials and testing and seldom use any forecasting tool for their own design. Without the simulation offered by the software, the designer is in no good position to evaluate his design in advance and anticipate the outcome of the forming process.

This dissertation work would focus on eliminating the Design problems arising out of incorrect selection of values for the variables / parameters. The parameters affecting the quality of the component produced could be listed as:

1) Blank holding pressure
2) Radii at Die entry
3) Material of the component
4) Thickness of sheet
5) Depth of Form/ Draw
6) Use of Mechanical or Hydraulic Press

3.2 Present work

Sheet metal forming is an effective process for producing complex three-dimensional shape sheet metal parts. At present, retiary sheet metal is widely applied in aviation, electronics system and medical engineering. Especially in the medical engineering field, titanium alloy retiary sheet is considered as an excellent biomaterial, because of its corrosion resistance, low allergic problems, stable chemical performance and satisfactory biocompatibility. In the near future, the demand for this titanium alloy retiary sheet will increase. For example, titanium alloy cranial prostheses, which are based on the shape and place of the absent cranium, are made from titanium alloy retiary sheet. The forming is difficult by common forming modes because of the poor forming performance of titanium alloy and different shapes of the different absent crania. Traditionally, the customized 3D curved surface is produced by Pressing titanium alloy retiary sheet into a mould or by hand, requiring much time and high cost. Nowadays, it can be formed by hand or rapid prototyping techniques. For most, the 3D surface is unsatisfactory, because it is imprecise. The application of retiary sheet is counteracted by titanium alloy cranial prosthesis with an inaccurate shape .The application of the multi-point forming technique can solve this difficult problem. Using the flexible characteristic of MPF, one can adequately shape the 3D curved surface of customized numerical prosthesis with good quality using the MPF system, and this titanium alloy cranial prosthesis has been used extensively in clinical practice.[2]

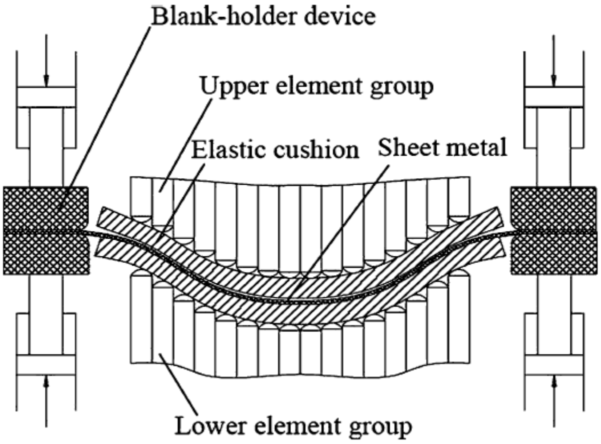

Fig.No.4 Schematic diagram of MPF with the blank holder

A. Franken, L.Kwiatkowski. al. Studied on the realization of a simple and kinematic tool set up for incremental sheet metal forming. It allows as a similar geometrical accuracy like a full specific support, but minimizes the tool setup and increases the process flexibility at the same time. In incremental sheet metal forming different process variant are in use.

In this paper, the author presents a simple method to upgrade a conventional milling machine with a dynamic die (Dyna- Die). Taking into account that the forming mechanism for ISF are not completely clarified at present the construction of a specialized machine is quite complex. The setup showed in the following article does not required high investment costs and allow the production of simple part in order to investigate and design the KISF process.

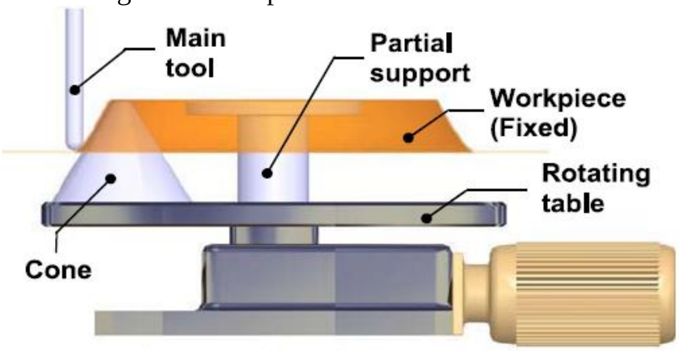

Fig.No.5 Experimental Set-up –Dyna-Die

The realized dynamic die is shown in detail in Fig 2.5. The additional tool movement is achieved by rotating table. As a matter of course, only rotational symmetric parts can be produced. In the presented can the second tool is realized as a cone, which is mounted on the rotating plate. The produced conical parts have a diameter of 168 mm at the top and height of 40mm, the flange angel is 60. During forming the contact zone between both tools moves from the cone's top down to the plate. The cone tool can be mounted at four different radii, so different part diameter can be achieved. Since, the second tool exchangeable other part geometries can be produced. The shown setup includes an additional unspecific support in the centre of the plate which can also be removed. The experiments have been carried out on a conventional 3- axes CNC milling machine. In this case, the NC machining suite, which is included in CATIAV5R17, has been used to generate the unidirectional tool path. The author's preferred a unidirectional tool path without any correction methods. This way the deviations of the different processes is not influenced by optimized tool path

The accuracy achieved with the Dye-Die is similar to ISF using a full specific support. The deviation is the range of approximately 1.2 mm (in total). The process variant with partial support and no support showed less accurate results. Fig shows a comparison between the results of the parts manufactured by the described process variants. The deviation depicted in the figure is scaled by factor ten. The deviation of the part manufactured by Dyna-Die compared to the part manufactured with a full specific support, shows the deviations is in similar range but in opposite direction at the flange area. The full specific support does not allow a negative deviations and the manufacturing of parts which are similar than used die. Increased deviations in the parts centre observed. This could be caused by the influence of the bending at the edge of the part. A partially support like used lead to increased deviations. Here an even stronger bending effect has been observed which is caused by less support of the sheet during forming process. Support has been use during incremental forming process.

In this paper, involves a simple tool setup, which can be used as upgraded for conventional milling machine. The experiment has been shown that the described kinematic ISF process is capable for producing parts in an equal quality and accuracy as the ISF full static support. The author assumed that tool path correction methods, like surface reconstruction and optimization strategies, will improve the accuracy of the manufacturing parts. [8]

Hou Ying KeYu Zhong-qi & Lee Shu-Hui studied the on the Galling failure in the sheet metal forming process. Author wants to investigate the galling failure in SMF operation under different conditions via finite element analysis and experimental test. A further investigation objective to develop a numerical methodology to study the galling failure problem in SMF processes. Major factors that influence the galling failure, including materials properties of the sliding couples, process parameters and frictional coefficient are modelled in finite element analysis (FEA) model.SMF process is characterized by three main nonlinearities: surface interactions between the blank and the tool, geometric nonlinearity due to bulk Plastic deformation and material plasticity. Therefore, the problem of galling failure in SMF operation of galling failure in SMF operations is a complicated system controlled by highly non linear equations for the stress, strain and displacement. Thus, an effective way to obtain the distributions of temperature and normal content force field distribution is to use non-linear numerical analysis.

FEA is performed using Abacus. In order to simulate the SMF process, asymmetric model of U – SHAPE parts established. The sheet, punch, die and binder are molded as deformable surfaces. The sheet material is 0.7mm cold rolled high strength steel and tool material is cast iron, which commonly used as tool material in automotive industry. The sheet material is modelled using CPE4RT elements, with four through the thickness. The factors that influence the galling failure (such a material coefficient and the blank holder force(BHF)) can be molded in FEA model In that the deltoid 30 mm and the initial temperature of the tool and sheet is 30°C.[4]

M.Tisza, et al studied on the Integrated Process Simulation and Die –Design in Sheet Metal Forming. In this paper, the integration of various CAE techniques as Knowledge and simulation Based System (KSBS) will be described through the examples of sheet metal forming practices. The forming simulation in sheet metal forming technology and it's industrial applications have greatly impacted the automotive sheet metal product design die developments, die construction and tryout, and production stamping in the past decades. In today's die stamping industry, the simulation for virtual validations of die developments before production trials is a critical business for lead –time reduction, cost reduction and quality improvement. The global competitions driver higher quality requirement, lower cost, and shorter lead-time. All these new trends create new challenge for stamping simulation and production application.

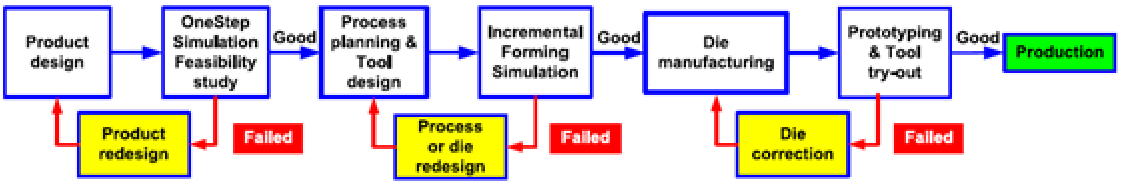

Fig.No.6 The work flows in simulation based process planning and die design

Due to the global competition – and this is particularly valid for the automotive industry there is an overall demand to improve the efficiency in the both the process planning and in the die design phase, as well as to reduce the time and product development costs and to shorten the lead times. It requires the efficient use of simulation techniques from the earliest stage of product development, to give feedback from each step to make the necessary corrections and improvement when it make the necessary corrections and improvement when it takes the least cost. This principle is illustrated in the schematic flow chart of simulation based process planning and die design. However, even with this approach, there is some further shortfall in the die design process since most of the simulation programs do not provide die construction in sufficient details, which can be easily used in most of the CAD system to complete the design task. This shortage overcome by integrating the CAD and FEM systems through a special interface module, which can be provide a smooth continuous and reliable data exchange between the two important part of design process.

The application of various methods of computer aided engineering has a vital and central role in the recent development in the sheet metal forming concerning the whole product development cycle. The application of various methods and technique of CAE activities resulted in significant development, the formerly trial and error based workshop practice has been continuously driven engineering solution.

In this paper, an integrated approach for the application of knowledge based system and finite element simulation is introduced. Applying this knowledge and simulation based concept for the whole product development cycle – from the conceptual design through the process planning and die design as an integrated CAE tool provides significant advantages both in the design and in the manufacturing phase. Sheet metal forming simulation results today are already reliable and accurate enough that even tryout tools and the time consuming tryout process may be eliminate or at least significantly reduce. Thus the integrated solution described in this paper result in significantly shorter lead times, better product quality and as a consequences' more cost effective design and production.[7]

IV. Scope Of The Work

- Evaluate the part design for formability
- Review the existing die designs for similar components
- Generate a General Layout for the Die for the subject part
- Analyze the part for Form operation using appropriate CAE software for Forming/ Draw simulation
- Interpret the results
- Design the die and finalize the specifications
- Conduct trials for experimentation
- Document the results for validation
- Record the savings over the time of development process

V. Methodology

- Data collection for Historical data of forming/ draw Dies
- Blank development for the part design / General layout for the Die Design
- Analysis for Component to be drawn
- Final Die Design
- Trials/ Experimentation

VI. EXPERIMENTATION

Experiments are to be conducted on a press of a suitable type and capacity. The die would be mounted on the bolster plate of the press and the speed of the ram would be set based on the historical data as well as the input received from the analysis data (simulation).

Forming problems can be predicted before tool fabrication through the use of software that can be integrated into production routes which rely increasingly on computer technology. The prediction of forming difficulties at the component design stage ensures that the chosen geometry is compatible with the formability of steel. Forming has become a highly technical process, and the development of a steel forming route no longer involves simple trial and error methods. Close collaboration between component designers, forming engineers and steelmakers guarantees the industrial feasibility of new parts with very short development times. The parameters influencing the form operation as evident during the trials are

- Type of material
- Thickness of the component
- Mechanical properties, especially the Limiting Draw Ratio
- Use of lubricant
- Blank size and development
- Blank holding pressure
- Speed of the operation

For this work, the critical parameter/s (one or two) shall be identified and modified to realize a desired response.

VII. VALIDATION

The appropriate capacity press can be selected by knowing the forming load. Working with the presses of higher capacities may lead to many types of defects such as cracks and tearing. Blank holder pressure needs to optimize over a given range for optimized geometry. The coefficient of friction needs to be optimized for the new geometry. The actual trials performed over the component would directly reflect over the ease of `Forming operation' realized for the said Die design

Phases for Project Work:

Phase I -Review the Design for the Sheet-Metal Part

Understand the context for the Part Design in terms of its function and criticality of features while comparing the same with the research work done over the subject till date.

Phase II–Subject the component design to CAE Analysis

This phase would highlight the critical issues to be dealt with at the Design Stage. The areas of concern are normally made evident by the result of analysis in the form of pictorial graphs and tabular data.

Simulation done through the Software HyperForm. Output of simulation is interpreted based on observation, changes are made in the process and tool-build parameters. Several iterations are carried out till satisfactory solution is reached. During the observation stage the component is investigated for various parameters like:

- Formability (FLD) i.e. cracks, wrinkles, loose material.
- % Thickness reduction.
- Major and minor strains distribution.
- Pressure distribution.

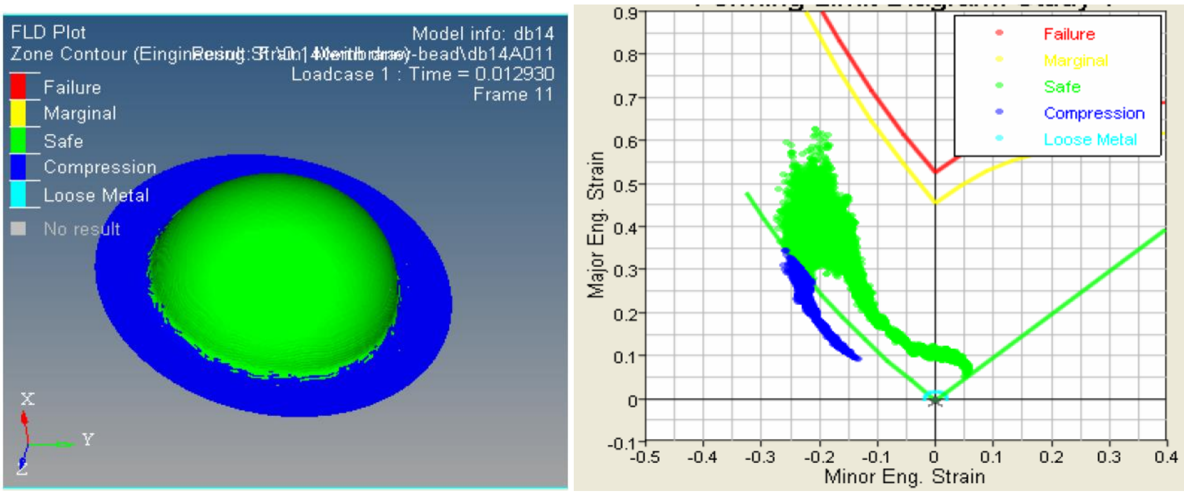

Fig. No.7 FLD diagram (for reference only)

Phase III - Propose new Design by considering the factors affecting Formability

The inputs might necessitate reviewing the design of the component itself. On the other hand useful insights can be gained over the Design of the Form Die for affecting defect-free component. The response factor in this case is the absence of Wrinkling/ Thinning/ Tearing on the component realized after the Die Design is complete and the Die is ready for pilot lot of samples.

Phase IV–Design Validation – Trials and Testing

The Die once ready through the Development phase shall be mounted on an appropriate press machine (Mechanical/ Hydraulic) with a suitable tonnage. The Die would be loaded on the Press and `set' by inching.

Appropriate blank holding pressure is determined by the helical compression springs mounted in the Die over the stripper plate. The generous radius of the Die block where the component flows into the cavity plays an important role in effecting a good quality component (without wrinkles/ torn areas). The values for these parameters is attempted to be verified through this trial phase. This is to eliminate the noise introduce by the process parameters. The die design shall be considered as validated upon realizing a near defect-free component.

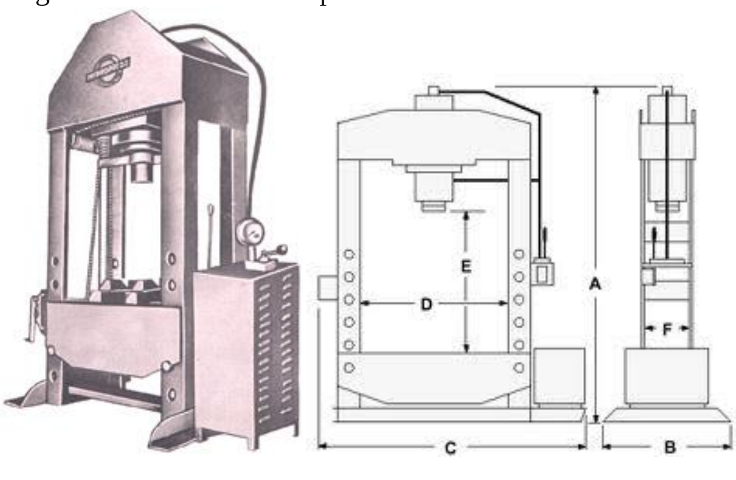

Fig.No.8 Experimental Set Up

VIII. Conclusion

The sheet metal forming operation poses challenges for defects including Tearing, Wrinkles, Spring-back, Thinning, etc. Use of Finite Element Modelling can help to reduce the development time for trials and the associated costs for the project. Use of Altair HyperForm as a CAE tool is predominant in the industry for simulating the process and predicting the defects. This work shall primarily include F.E.Modeling techniques for finding alternative solutions. Trials and testing shall be considered towards the concluding phase of the project work for validating the solution proposed during Analytical phase of the work.

REFERENCES

1) Shiwen Wang & Weimin Zhuang & Jian Cao & Jian Cao "An investigation of spring back scatter in forming ultra-thin metal-sheet channel parts using crystal plasticity FE analysis Received: 10 March 2009 / Accepted: 19 May 2009 / Published online: 3 June 2009 Springer-Verlag London Limited 2009"
2) Tan Fuxing& Li Mingzhe, Cai Zhongyi & Li Xiangji "Formability analysis on the process of multi-point forming for titanium alloy retiary sheet Received: 15 January 2008 / Accepted: 25 April 2008 / Published online: 19 June 2008 Springer-Verlag London Limited 2008"
3) G. L. Damoulis& E. Gomes & G. F. Batalha "New trends in sheet metal forming analysis and optimization trough the use of optical measurement technology to control spring back Received: 12 May 2009 / Accepted: 15 June 2009 / Published online: 1 September 2009 Springer/ESAFORM 2009"
4) Hou Ying-ke ,Yu Zhong-qi & Lee Shu-Hui "Galling Failure Analysis in Sheet Metal Forming Process Shanghai Jiaotong University & Springer- Verlag Berlin"
5) K. Y. Choi, M. G. Lee and H. Y. Kim "Sheet Metal Forming Simulation Considering Die Deformation - International Journal of Automotive Technology, Vol. 14, No. 6, pp. 935−940 (2013)"
6) G. M. Bramhakshatriya, S. K. Sharma& B. C. Patel "Influence of Lubrication and Draw Bead in Hemispherical Cup Forming"
7) M.Tisza ,Zs.Lukacs &G.gal " Integrated Process Simulation and Die Design in Sheet metal forming- Springer "
8) V.Franzen,L.K.Kwiatkowski,G.Sebastiani,R.Shankar,A.E.Tekkaya&M.Kleiner"Dyna-Die:TowardsFull kinematic Incremental forming-Springer"
9) Amul Biradar& M.D Deshpande "Finite Element Analysis of Spring back of a Sheet Metal International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Impact Factor (2012): 3.358"
10) Mr.Amit D.Madake,Dr.Vinayak R. Naik & Mr.Swapnil S. Kulkarni " Development of a sheet metal component with a forming die design tools for design validation and improvement" International Journal of Modern engineering Research Vol.3,Issue.3,2013
11) Mr.Manoj S. Kulkarni & S. Y. Gajjal "Review of Sheet Metal Forming Analysis" SSRG International Journal of Mechanical Engineering (SSRG-IJME) – volume 2 Issue 1–January 2015

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