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STUDY ON DIFFERENT TYPES OF METAL FORMING PROCESS

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Abstract-In automotive industry with increase in demand to reduction in weight and manufacture complex parts easily without compromising in strength there for the hydro forming process carried out. The aim is to construct the complex part of non-uniform cross section with the help of fluid pressure under different operating condition to achieve optimum value of input parameters from which parts is manufacture. The pressurized fluid serves several purposes: (1) Supports the sheet metal from the start to the end of the forming process, thus yielding a better formed part, (2) Delays the onset of material failure and (3) Reduces wrinkle formation.

Finite element method (FEM) is used for simulating complex intricate shapes of industrial sheet forming operation. Effective physical parameters, as well as numerical solution, influence parameters of this phenomenon and its numerical prediction of results. In this review, the applications of FEM for analysing various parameters such as blank Thickness, blank holding force, Material, coefficient of Friction on specimens of materials are discussed. The numerical results are found from literature survey to be in good agreement with the experimental results and accurate thinning distributions had been predict.

The application of aluminium alloys in automotive and aerospace industries has been growing significantly in the last 20 years. Due to their high specific strength, aluminium became a strong replacement for steel particularly at automotive manufacturing. However, to deform a complex panel part from aluminium is quite challenging specifically at cold forming condition in which the formability is quite low. Many attempts have been processed to improve the formability problem of the aluminium alloy such warm forming, hot forming, superplastic forming and Hot forming and cold die quench (HFQ) processes.

This paper introduces the warm forming technology. The most appropriate applications for warm forming are discussed as well as its advantages and disadvantages compared to alternative manufacturing methods. Also a case study is cited to illustrate how large production volumes of technically demanding parts can be economically manufactured by warm forming.

Keywords-Aluminum alloys,formability, automotive industry,warm forming, press tool designs, sheet metal operations.

1. INTRODUCTION

Hydro forming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room technical and allows complex shapes with concavities to be formed, which would be difficult or impossible with standard solid die stamping. Hydro formed parts can often be made with a higher stiffness-to- weight ratio and at a lower per unit cost than traditional stamped or stamped and welded parts. Virtually all metals capable of cold forming can be hydro formed, including aluminium, brass, carbon and stainless steel, copper and high strength alloys. Hydro forming is a cost-effective way of shaping ductile metals such as aluminium, brass, low alloy steel, and stainless steel into lightweight, structurally stiff and strong pieces.

The sheet metal forming operations process between the Male (Punch) and a female (Die). The procedure is of sheet metal deformation due to the relative movement between the punch tool and the sheet, an interaction that generates friction forces occurred between the elements. It is important to understand that the FEA tool is able to control the friction generated in the forming process in order to produce good quality products. Manufacturing defects can be analysed by using this tool and the defects occurred during manufacturing are crack, shrinkage, spring back, surface defects and tool wear can be reduced by controlling the above defects in the process.

The need of light metal in the automotive and aerospace industries has been increased recently in both structural and body parts. Using aluminium alloys have fulfilled this need as a replacement of steel. Strength and formability are the main material properties, which are very crucial for industrial applications. The formability of aluminium alloys are quit low particularly at cold forming condition. Series aluminium alloys have the largest formability range and can be formed at room temperature.

Metal flow forming/forging has always played an important part in manufacturing a wide range of products for the automobile industry. In addition to conventional hot forging and cold forming, the last twenty years or so has seen an increase in the use of warm forming technologies, especially due to the cost savings achieved by near-net warm forming.

2.TERMS

a. Hydro Forming
b. FEA application for sheet metal forming analysis
c. Forming process on aluminium alloy
d. Warm Forming3.LITERATURE REVIEW

A. HYDROFORMING

A. ANALYSIS OF WATER HAMMER FORMING ON THE SHEET METAL(2011). (RAVINDER KUMAR ET AL., 2011 Here In this paper Ravinder Kumar et al. considers relationship between the energy applied and extent of Deformation as Well as the variations of the radial strains, hoop

strains along the radius under Different Hydraulic

mediums are studied. They perform one experiment on cup to analysis the Relation between energy applied and deformation takes place. From the experimental data and Graphs for radial strains it is observed that the radial strains and hoop strains are almost Negligible in the flange region of cup compared to the region near to the center. They provide Different suggestion to overcome the stretch effect in center of cup. They suggested that step Should be machined in the die holder. The cylinder should rest directly only on the step Machined on the die holder and the sheet metal gets effective sealing and contact only through The rubber “O” rings arranged at the bottom of the pressure cylinder.[2]

B. FEA APPLICATION FOR SHEET METAL FORMING ANALYSIS

Finite element analysis (FEA) is powerful tool to simulate complex draw of sheet metal forming operation; the accurate and reliable application of this technique to spring-back has not been widely demonstrated.

The physical parameters can be predicted numerical values. In this paper, the effect of formed part thickness, blank holding force, formed surface grain structure, and the spring-back of specimens’ part are discussed. The role that all the above parameters play in the spring-back is assessed through finite element simulations. Process conditions, such as Tool geometry, working temperature have an obvious effect on spring-back. Simulations are conducted with varying blank holding force, Materials, blank thickness, and coefficient of frictions to assess its role in spring-back of the formed part. In this paper, a spring-back prediction has compared their simulation results

with experimental work. From this simulation study optimum blank has introduced. [1]

In sheet metal the drawings parameters like punch and dies radius, clearance, lubrication, blank holding force and its trajectories are studied. These tools need to designing drawing involves lots of trial and error steps. These trial and errors have reduced by simulation by using finite element tool. This simulation results give numerical results and approximate solutions. The given set of punch, die and working conditions has been applied to find an optimum blank holding force for reducing the wrinkles and at same time stresses induced in the forming part has been reduced. They are suggested Hyperform tool is feasible tool for forming problem. In this study Steel material grades selected for Punch and die block like HCHCr (High carbon High Chromium) & OHNS (Oil Hardening non Shrinkage) having EDD (Extra Deep Draw).They are recommended blank holding pressure (30Ton) for a defect-free component [2].

C. FORMING PROCESS ON ALUMINIUM ALLOY

Cold-rolled steel sheet is the traditional manufacturing process for automotive body panels. In the past few years, there are many attempts by automotive manufacturers to use and aluminium alloys in manufacturing automotive components in order to reduce the weight of their models For Age hardened aluminium alloy sheet components are normally formed either in the condition (solution heat treated and quenched), followed by artificial ageing for higher strength, or in the condition (solution heat treated, quenched and artificially aged).In this process, the material is heated to its Solution Heat Treatment (SHT) temperature and then held for a sufficient period of time, and all precipitates are taken into the matrix giving one single phase. The heat-treated material is rapidly cooled to room temperature to freeze this super-saturated state within the material. Once the material has been thermally treated and modified to the required mechanical properties, it is cold-deformed in the condition into the required shape.

D. WARM FORMING

Metal flow forming/forging has always played an important part in manufacturing a wide range of products for the automobile industry. In addition to conventional hot forging and cold forming, the last twenty years or so has seen an increase in the use of warm forming technologies, especially due to the cost savings achieved by near-net warm forming.For certain automotive components warm forming, usually combined with cold forming, has become a very economical manufacturing alternative especially where annual volumes are quite large such as those in the USA, Europe, Japan and Korea. We will discuss here the most appropriate applications for warm forming as well as its characteristics, special requirements and its advantages and disadvantages compared to alternative manufacturing methods. Finally, we will cite a case study to illustrate how large production volumes of technically demanding parts can be economically manufactured by warm forming. [4]

4.APPLICATION

A. HYDROFORMING

One of the largest applications of hydro forming is the automotive industry, which makes use of the complex shapes possible by hydro forming to produce stronger, lighter, and more rigid anybody structures for vehicles. This technique is particularly popular with the high-end sports car industry and is also frequently employed in the shaping of aluminium tubes for bicycle frames.

B. FEA APPLICATION FOR SHEET METAL FORMING ANALYSIS

It is use for finding out to various stress analysis in sheet metal and in forming process. It is also use in plastic moulding and forming process. It helps to study in proper die and tool setting systems.

When the die and tool setting is not proper during the forming process or metal sheet is not available in specific thickness or in material as required during the sheet metal forming operation then there are chances of wrinkles are occur on operational parts and also the chances of shear, necking and fracture on operational parts. By using FEA and calculations we can take the manufacturing decision on forming process, so which help to increase the productivity.

C.FORMING PROCESS ON ALUMINIUM ALLOY

Aluminum will play a significant role in future car generations as its material properties have many advantages and open the way for new applications in the automotive industry (Sulaiman [1]; Kleiner et al. [2]). Indeed, developments in the aluminum industry, including improving the mechanical properties of aluminum alloys by adding various alloying elements has opened a wide field of applications for these alloys, particularly in the automotive and aerospace industries (Kleiner et al. [3]).The application of aluminum alloy in the automotive industry has increased more than 80% in the past 5 years. In 1996 a total of 110 kg of aluminum alloys were used in a vehicle. This amount is predicted to increase to 250 or 340 kg regardless of the structural applications (Miller et al. [4]).New developments in aluminum alloys have opened a wide range of applications of wrought aluminum in place of aluminium castings. Wrought aluminum alloys are produced from cast ingots, which are prepared for subsequent mechanical processing (Polmear [5]).

D. WARM FORMING

Lightweight of vehicle body has been a key method to improve automotive fuel economy. Aluminum alloys are important technological materials for the application on lightweight design and development of vehicle body with the advantage of strength-weight ratio, corrosion resistance. Aluminum alloys are also weldable and recyclable. Due to the high price and poor formability at room temperature with the comparison to steel, aluminum alloys have limited applications in the automotive industry.

5.THEORY

A. HYDROFORMING

Hydro forming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room technical and economic potential to sheet metal manufacturers. The achievement of beneficial component characteristics using this process is only possible where temperature working material into a die. Hydro forming allows complex shapes with concavities to be formed, which would be difficult or impossible with standard solid die stamping. Hydro formed parts can often be made with a higher stiffness-to-weight ratio and at a lower per unit cost than traditional stamped or stamped and welded parts. Virtually all metals capable of cold forming can be hydro formed, including aluminium, brass, carbon and stainless steel, copper and high strength alloys. Hydro forming is a cost-effective way of shaping ductile metals such as aluminium, brass, low alloy steel, and stainless steel into lightweight, structurally stiff and strong pieces. One of the aims of the sheet-metal processing industry is the minimization of costs and the optimization of its products concerning weight, strength characteristics and rigidity. In search for alternative production processes, hydro forming – the manufacture of hollow bodies with complex geometries by means of fluid pressure – has been shown to offer an interesting component and process configuration is selected by considering the overall system design. [1]

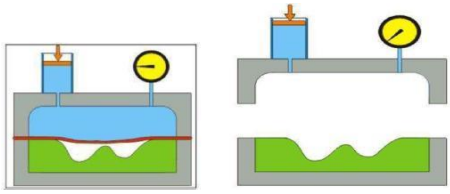

Figure 5.1: Sheet Hydroforming Process. [1]

HIGH PRESSURE HYDRO FORMING (HPH)-This process avoids pinching by intentionally designing the tube periphery to be smaller than the desired finished product. This pressure is significantly higher, typically 60to80 percent higher than that used in single-stage pressure sequence hydro forming (PSH). The maximum pressure needed for PSH is 7000 psi, compared with 35,000 psi used in HPH.

HYDRO FORMING PROCESS CONTROL-A typical hydro forming system would include a press capable of developing necessary forces to clamp the die valves together when internal pressure acts on fluid; a high pressure water system to intensify water pressure for forming component, looking including aerial cylinder and punches, depending on component and a control system for process monitoring. Since the entire process of operation takes place inside a closed die, one cannot see what actually happens during forming. Therefore the controller plays a vital role in displaying, monitoring and controlling the different parameters of forming in real time.

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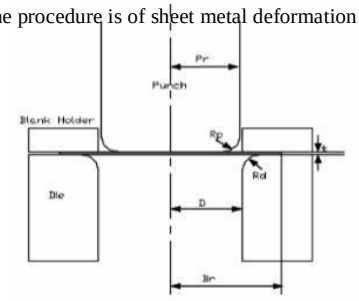

Figure 5.2 Geometrical and Material Parameters. [3]

Finite element analysis (FEA) is powerful tool to simulate complex draw of sheet metal forming operation; the accurate and reliable application of this technique to spring-back has not been widely demonstrated. The physical parameters can be predicted numerical values. In this paper, the effect of formed part thickness, blank holding force, formed surface grain structure, and the spring-back of specimens' part are discussed. The role that all the above parameters play in the spring-back is assessed through finite element simulations. Process conditions, such as tool geometry, working temperature have an obvious effect on spring-back. Simulations are conducted with varying blank holding force, materials, blank thickness, and coefficient of frictions to assess its role in spring back of the formed part.

In this paper, a spring-back prediction has compared their simulation results with experimental work. From this simulation study optimum blank has introduced. In sheet metal the drawings parameters like punch and dies radius, clearance, lubrication, blank holding force and its trajectories are studied. These tools need to designing drawing involves lots of trial and error steps.

These trial and errors have reduced by simulation by using finite element tool. This simulation results give numerical results and approximate solutions. The given set of punch, die and working conditions has been applied to find an optimum blank holding force for reducing the wrinkles and at same time stresses induced in the forming part has been reduced. They are suggested hyper form tool is feasible tool for forming problem. In this study Steel material grades selected for Punch and die block like HCHCR (High carbon High Chromium)
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material properties, which are very crucial for industrial applications. The formability of aluminium alloys are quit low particularly at cold forming condition. Series aluminium alloys have the largest formability range and can be formed at room temperature. In addition, it has the lowest strength; While some aluminium alloys have higher strength than but very difficult to form at room temperature. Forming at elevated temperature either warm or hot forming is developed in order to increase the formability, allowing forming of complex parts while maintaining the required mechanical properties. Forming at elevated temperature is not an easy task; the processes involves heating system , control of blank and die temperatures, challenges in cycle times transfer system and lubrication. The aim of the work is to introduce the different forming techniques of aluminium alloys sheets, providing a critical survey on the advantages and drawbacks of each technique. [4]

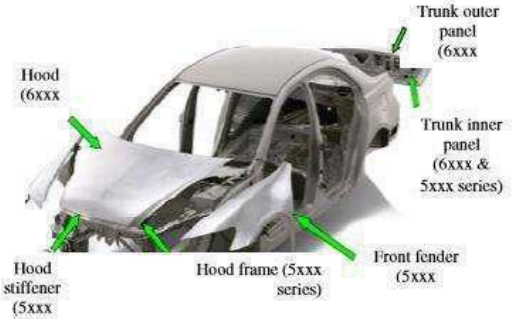

Figure 5.3 Application of aluminium alloy in automotive components

Traditional Cold Forming -Cold-rolled steel sheet is the traditional manufacturing process for automotive body panels. In the past few years, there are many attempts by automotive manufacturers to use and aluminium alloys in manufacturing automotive components in order to reduce the weight of their models For Age hardened aluminium alloy sheet components are normally formed either in the condition (solution heat treated and quenched), followed by artificial ageing for higher strength, or in the condition (solution heat treated, quenched and artificially aged).In this process, the material is heated to its Solution Heat Treatment (SHT) temperature and then held for a sufficient period of time, and all precipitates are taken into the matrix giving one single phase. The heat-treated material is rapidly cooled to room temperature to freeze this super-saturated state within the material.

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so has seen an increase in the use of warm forming technologies, especially due to the cost savings achieved by near-net warm forming.

For certain automotive components warm forming, usually combined with cold forming, has become a very economical manufacturing alternative especially where annual volumes are quite large such as those in the USA, Europe, Japan and Korea.

We will discuss here the most appropriate applications for warm forming as well as its characteristics, special requirements and its advantages and disadvantages compared to alternative manufacturing methods.Finally, we will cite a case study to die temperature. In this process Fig.6 the aluminium alloy blank is heated between (240-260℃) and then formed in a conventional hydraulic press at room temperature. In a recent study conducted for Automotive Research, non-isothermal elevated temperature forming technology was used in a situation that required only heated sheet metal and room temperature dies. The purpose of the study was to optimize the technology in terms of production data and part cost. The study showed an Al 5182 door inner could be formed successfully at about 250 c.

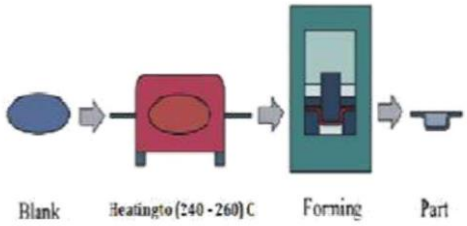

Figure 5.4: Illustration of warm stamping in cold dies process. [4]

5. ADVANTAGES AND DISADVANTAGES

A. HYDROFORMING

Advantages: Hydro forming tubular components offer several advantages, including 1. Part consolidation. 2. Weight reduction through more efficient section design and tailoring of the wall thickness. 3. Improved structural strength and stiffness. 4. Lower tooling cost as a result of fewer parts. 5. Fewer secondary operations.6. Tight dimensional tolerances and low spring back. 7. Reduced scrap. Disadvantages: Hydro Forming Also Has Some Drawbacks, Including 1.Slow cycle time. 2. Expensive equipment. 3. Lack of extensive knowledge base for process and tool design

B. FEA APPLICATION FOR SHEET METAL FORMING ANALYSIS

Advantages and Disadvantages -The solution gives us technical support for taking manufacturing decisions through this we can improve productivity and quality of the product. The day by day the customer needs and wants are increased and also due to the competition of the manufacturing as well as selling price of the products in the market are reducing continuously in the market through this study we can satisfy our customers by selling our product in a affordable price to the customers. This tool gives us a `numerical or approximate solution for our product and for getting required solution their number of iteration will be increased.

C.FORMING PROCESS ON ALUMINIUM ALLOY

There are significant drawbacks of the traditional method for forming aluminium alloys panel parts. First is the poor formability of the material due to the hardening and strengthening processes carried out on the material, even in forming. Secondly, after forming, if young's modulus is low, the component is more likely to be affected by spring back and wrinkling problems. This means extra effort is needed to compensate for these problems.

D. WARM FORMING

Advantages-Lesser amount of heat energy requirement, Better precision of components, Lesser scaling on parts, Lesser decarburization of parts, Better dimensional control, Better surface finish, Lesser thermal shock on tooling, Lesser thermal fatigue to tooling, and so greater life of tooling.

Disadvantages-Lesser loads on tooling and equipment, Greater metal ductility, Fewer number of annealing operation (because of less strain hardening)

CONCLUSION

Every technological method, which takes part on production of final component, brings in the component specific proprieties that influence its proceeding in whole assembling. With this presentation we understand the various method of obtaining object from different forming process method like warm forming, hydro forming. And study the finite element analysis [FEA] of forming process.

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