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The Experimental Study of Combined Extrusion-Forging Process by using Modeling

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Abstract:
The present scenario of the manufacturing industries are facing many challenges to produce the products of high strength, resistance to fatigue, heat, corrosion and low production cost. To meet these challenges combined extrusion-forging process is employed to achieve improved material properties, high production rates, and less material wastage when compared with other manufacturing processes such as machining, casting, etc. Combined extrusion-forging process is the advanced metal forming process in which an initial billet is forced through the extrusion and forging die punch setup to get desired product. The flow pattern of metal mainly depends on the frictional conditions at the workpiece/die interface, the geometry of dies and the percentage area reductions. In this process, the estimation of forming load is a bit difficult because the number of process parameters involved, and complexness of analysis. It has extensive applications in automotive and aerospace industries. Present research work focuses on estimation of forming load to produce the product collet chuck holder by this process. The metal flow pattern and die cavity filling has studied in both experimental and simulation analysis. The modeling software Solid works is used for 3D modeling and Deform3D is used for the simulation process. The number of experiments has done to compare the results obtained from the simulation process. The results obtained from the experimentation and simulation analysis are in good agreement with each other.

Keywords: extrusion forging process, effective strain, effective stress, finite element analysis, forming load, metal flow pattern.

I. INTRODUCTION

For the best use of metals, it is generally necessary to shape the metals into required form. Casting is one of the processes for giving the desired shape to metals, but it is not feasible in all cases. Metal forming is another method of shaping metals to desired forms where casting is not desirable. Metal forming is a manufacturing process in which the forces are applied on the material such that stresses induced in the material is greater than the yield stress and less than the ultimate stress so that material is experiencing plastic or permanent deformation to change the shape the component as required. Metal forming can be carried out in the form of either hot working or cold working. Formation of material at a temperature less than the re-crystallization temperature is called cold working and if the material is deformed at the temperature greater than the re-crystallization temperature and less than the melting point temperature is called hot working. The main difference between cold working and hot working is that residual stresses are produced in cold working but not in hot working. For the same amount of deformation the force and energy required for cold working is higher than the hot working. In the cold working process because the component is not heated, the chances of formation of scales are less, hence closing dimensional tolerances are possible, good surface finish can be obtained and coefficient of friction during the process is less. During hot working operation because the component is heated to a higher temperature, the handling of component is difficult. Rolling, Drawing, Extrusion, Forging, Bending and sheet metal operations like Punching, Blanking, Coining etc are some of the metal forming process. Extrusion and Forging are the main metal forming processes used to shape the metal to required shape. Extrusion is a bulk metal forming used to create products of a fixed, sectional profile, where the material is drawn through a die to a desired shape at the end of the process. Large variety of complex shapes can be produced through the operation. The process also forms finished parts with an excellent surface finish. In extrusion mainly two types of processes are there. They are forward and backward extrusion processes. In forward extrusion, which is most commonly used process, the ram moves in the same direction of the extruded section and there is relative movement between the billet and the container, leading to high frictional forces. There is a reusable dummy block between the ram and the billet to keep them separated. Friction at the die and the container wall requires higher pressure than indirect extrusion. In this type of extrusion the billet does not move relative to the container, and a die fixed on a hollow ram is pushed against the billet, leading to the flow of the extruded section in opposite direction to the ram movement. The Frictional force on the billet/container interface is thus eliminated during indirect extrusion. Forging can be defined as the controlled plastic deformation of metals at elevated temperatures into a predetermined size or shape using compressive forces exerted through some type of die by a hammer, a press or an upsetting machine. By definition, forging involves the shaping of metal by the application of impact or pressure, but the primary difference between the various forging methods is the rate at which the energy is applied to the work-piece. Forging is generally employed for those components which require high strength and resistance to shock or vibration and uniform properties. The forgings have high strength and ductility and offer great resistance to impact and fatigue loads due to extra working during the process and the opportunity of aligning the grain flow. Forgings improve the structure of the metal and hence its mechanical properties. The limitations of forgings are high initial cost of dies and their maintenance cost. The rapid oxidation of metal surfaces at high temperature results in scaling which wears the dies. Open-die forging is a simple and flexible process, it is slow and resulting size and shape of work piece is dependent on the skill of the operator. Closed-die forging or impression die forging, is the shaping of hot metal completely within the walls or cavities of die that come together to enclose the work piece on all sides. Closed die forging can be classified as forging with flash and flash less forging. The flash is an excessive material, which flows out along the parting plane at the end of the operation. Flash generally serves as a part of the die. Flash less forging is used to reduce the cost. It is performed in totally enclosed impressions. The process is used to produce a near-net or net shape forging. The dies make no provision for flash. Flash is the main part in forging process which is used to remove the pressure and for easy flowing of metal. The load required for forging operation also will decrease by using flash in your die design.

II. LITERATURE REVIEW

Present manufacturing industries are facing many challenges to produce the products of high strength, resistance to fatigue, heat, corrosion and low production cost. To meet these challenges combined extrusion forging process is employed to achieve improved material properties, high production rates, and less material wastage when compared with other manufacturing processes such as machining, casting, etc. Many researchers have performed a series of investigations on combined extrusion forging process. To gain some necessary knowledge, implementation of process and methodology used for combined extrusion forging literature review has done. The literature reviews followed during this research work to make the required product using combined extrusion forging are given below. Farhoumand et al. [7] had investigated that the effect of geometrical parameters such as gap height and fie corner radii and process parameter like friction factor. He concluded that an increase in gap height or die corner radii causes the material flow into radial direction.. Plancak et al. [8] had investigated radial extrusion of gear like components. He observed that there is a steep load rise during the last phase of load stroke diagram. Also, he observed that at the tooth part and center portion of the billet the highest strain values and lowest strain values had been obtained respectively. Jafarzadeh et al. [9] had analyzed the lateral extrusion process of gear like components. He observed that the gap height influences the forming load but friction factor does not have a large influence on forming load. He concluded that by decreasing the billet diameter the effective strain becomes heterogeneous and by increasing friction coefficient the effective strain increasing. Also, the degree of barrelling decreases with decrease of friction coefficient and with increase of billet height. Brayden et al. [10] had analysed the cold – die extrusion/forging process. He found that neutral radius is the critical factor in the analysis and which occupy a position to achieve minimum energy dissipation state. Also, the initial pressure and sudden rise in pressure during extrusion process due to internal shear is also related to the behaviour of neutral radius. Buschausen et al. [11] had found that the simulation results show that the proposed test is able to evaluate friction quantitatively and as well as qualitatively. Also, he found that the test conditions are close to those found in industrial production i.e. they exhibit a high interface pressure and large amount of deformation.Hu et al. [12] had modelled the deformation of rectangular billet using finite element method. He concluded that the numerical result show good agreement with those obtained in experiment in terms of deformed geometry. Wu et al. [13] had studied the influences of various die shapes on extrusion forging using finite element method. He found that the draft angle and fillet radius affect the extrusion load, strain, and flow deformation at various levels. Vickery et al. [14] had found that the die hole size influence the behaviour of the workpiece material. The material having a larger die hole will fill first and transition also occurs first. Narayan Swamy et al. [15] had done an experimental investigation on barreling of aluminum alloy billets during extrusion-forging using different lubricants. He concluded that all values of stress increases with the increase in approach angles under plane and triaxial conditions. Straight line behaviour is observed between hoop strain and axial strain. The rate of change of barrelling radius w.r.t. hydrostatic stress is different for different approach angle. Paltasingh et al. [16] had done an investigation on lateral extrusion of hexagonal head and concluded that the forming load increases with increase in thickness and cross sectional area of the die cavity. Also, observed that the load increases abruptly during filling of corners of die cavity. Kim et al. [17] had done an experimental investigation on upper bound analysis of the torsional backward extrusion process. He developed a kinematically admissible velocity field by using stream function. The deformation force reduced by 30% when compared with conventional backward extrusion. Hur et al. [18] had done finite element analysis for cold backward extrusion process and Diameter ratios and interferences have been determined by the proposed design method. Also, concluded that the final punch stroke was 10 mm, but the maximum pressure on the wall of the die insert was found at the punch stroke 7.3 mm in the extrusion. Groenbaek et al. [19] had done investigation on cold forging die design and found that die defections due to the working pressure from the part forming can be minimised by the application of high stiffness containers. For gear-shaped dies where tolerances are very critical, the die defection can be reduced by 30-50%.Giardini et.al [20] had done an experimental investigation on the influence of die geometry and friction conditions on formability in extrusion-forging. Upon investigation, he suggested that the designer uses raft project to identify the most critical zone in dies.

III . FINITE ELEMENT METHOD

Metal forming is particularly attractive in cases where the part geometry is moderate complexity and the production volume are large, so that tooling costs per unit product can be kept low. The Finite element analysis (FEA) is a numerical technique to find the approximate solutions of partial differential equations. It consists of a computer model of a material or design that is stressed and analyzed for specific results. This process is adopted to design the new products and improve the existing design. Traditionally, the metal forming process that produces an acceptable product has been accomplished by extensive previous experience and an expensive and time consuming cycle of trails, evaluations and redesign. Such a traditional forming design approach is rapidly being replaced by more efficient computer simulation. There are various metals forming analysis software that can realistically simulate material forming processes. In our present analysis DEFORM®3D is used to simulate the forming (combined extrusion and forging) process to get the proposed product shape. The simulation software mainly consists of three major components pre-processor, simulation and post processor. The pre-processor is used for giving the input parameters such as temperature, coefficient of friction, material data, etc. The geometries such as billet (specimen), punch and die have modelled in Solid works 3D modelling software. After modelling the geometries are saved as .stl files. These .stl files of geometries have directly imported for forming analysis. The pre-processor generates a database file using the input geometries and data, which is used in the simulation process. Initially, the units have changed to SI system using simulator control icon. Lagrangian incremental type simulation has followed during the analysis. In this section we should give starting and stopping criteria for the simulation process. In the 'step' section the number of simulation steps required to complete the product should give to process the simulation. The length of punch travel or number of simulation steps has taken as stopping criteria. The post-processor is used to view and extract data from the simulation results in the database file.

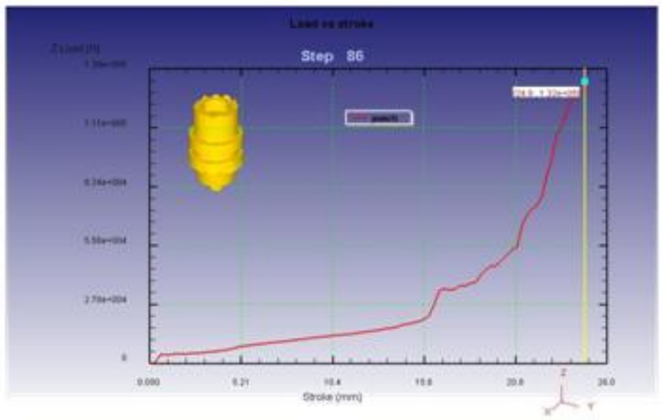

Figure.1. Variation of load with stroke

IV. CONCLUSION OF FEM

Finite element based simulation analysis has been implemented for the combined extrusion-forging process to make the product Collet chuck holder. The simulation process has given an idea and visualization of the product before conducting the experimentation. The punch load and length of punch travel gives an idea to design the die set up and experimental procedure. The characteristics such as effective strain, effective stress, total velocity and metal flow patterns have been analysed for different length of punch movements.

V. EXPERIMENTAL SETUP

The experimentation has done on Universal Testing Machine of maximum capacity 600kN using cylindrical aluminium billet. The components of the experimental setup have thoroughly cleaned, and lubricant (in this case it is grease) should applied to the inner surface of the dies and die holders, punch and sleeve. Also, the specimen is lubricated and placed inside the die cavity, and punch has placed above the aluminium specimen (billet). Now, the container is placed on the die holder, and it is fixed by using bolts. Finally, the sleeve is placed inside the container chamber, and main punch has placed inside the container sleeve. The setup has now finished, and it has placed on the lower table of the universal testing machine of maximum capacity 600kN (shown in Fig. 4.1). Now switch on the machine and set the parameters such as anvil height, strain rate, the diameter of billet, the maximum load and length of punch travel. In this research work the anvil height is 54 mm, diameter of the billet is 15 mm, length of punch travel as 24.6 mm and the punch speed as 1 mm/min have taken. As we have given the length of punch travel as 24.6 mm, the machine stops the process after reaching it. The punch load has recorded for every 30sec of punch travel. After completion of the experiment, the punch dies setup has dissembled, and the die sets containing the final product have removed by applying the gradual load. Finally, the desired product collet chuck holder has produced by using combined extrusion forging process. Experiments have conducted for different lengths of punch travel to investigate the metal flow pattern and die cavity to fill.

Figure.2. Photographic view of experimental setup with main components

VI. REFRENCES

[1]. Kalpakjian S, Schmid R. Manufacturing Engineering and Technology, 5th ed. Pearson Education, 2006.

[2]. Lovatt A M, Shercliff H R, and Withers P J. Material Selection and Processing, London: Technology Enhancement Programme, 2000.

[3].Lange K. Hand Book of Metal Forming. 1st ed. Michigan: Society of Manufacturing Engineers, 1985.

[4].Lankford W T, Samways N L, Craven R F, and McGannon H E. The Making, Shaping, and Treating of stee, 10th ed. Pittsburgh: United States Steel Co., 1985.

[5].Dieter G E. Mechanical Metallurgy. 3rd ed. London: McGraw-Hill, 1988.

[6]. Altan T, Tekkaya A E. Sheet Metal Forming Processes and Applications, United States of America: ASM International, 2012.

[7].Farhoumand A, Ebrahmi R. Analysis of forward backward-radial extrusion process, Materials and design, 30 (2009): pp. 2152-2157.

[8]. Plancak M, Rosochowska M, Skakun P. Radial extrusion of gear like components – Numerical and experiment, Tehnicki vjesnik, 20: 5 (2013): pp. 891-896.

[9].Jafarzadeh H, Faraji G, Dizaji A F. Analysis of lateral extrusion of gear – like form parts, Journal of mechanical science and technology, (2012): pp. 3243-3252.

[10].Brayden L, Monaghan J. An analysis of closed – die extrusion/forging, Journal of material processing technology, 26 (1991): pp. 141-157

[11].Buschausen A, Weinmann K, Lee J Y, and Altan T. Evaluation of lubrication and friction in cold forging using a double backward – extrusion process, Journal of material processing technology, 31 (1992): pp. 95-108.

[12].Hu W, Hashmi M S J, and Liu P. Study of metal flow in extrusion forging of rectangular billets, Journal of material processing technology, 43 (1994): pp. 51-59.

[13].Wu C Y, Hsu Y C. The influence of die shape on the flow deformation of extrusion forging, Journal of material processing technology, 124 (2002): pp. 67-76.

[14].Vickery J, Monghan J. An investigation of the early stages of a forging/extrusion process, Journal of material processing technology, 43 (1994): pp.37-50.

[15].Narayan Swamy R, Baskaran K, arunachalam S, and Muralikrishna D. An experimental investigation on barrelling of aluminium alloy billets during extrusion forging using different lubricants, Journal of Materials and Design, 29 (2005): pp. 2076-2088.

[16].Paltasingh U C, Sahoo S K, Nayak K C. FEM analysis and experimental investigation for lateral extrusion of hexagonal head, international journal of engineering research and applications, 3:4 (2013): pp.1265-1271

[17].Yamin H, Zhouyi L, and Yuchung Z. The study of cup rod combined extrusion forging process of magnesium alloy (AZ61A), Journal of Material Processing Technology,187-189 (2007): pp. 649-652.

[18].Hur K D, Choi Y, Yeo H T. A design method for cold backward extrusion using FE analysis, finite element in analysis and design, 40:2 (2003): pp. 173-185.

[19].Groenbaek J, Birker T. Innovations in cold forging die design, Journal of materials processing technology, 98 (2000): pp.155-161.

[20].Giardini C, Ceretti E, and Maccarini G. Formability in extrusion-forging: The influence of die geometry and friction conditions, Journal of Material Processing Technology, 54 (1995): pp. 302-308.

[21].Hasan S, Jahan R. On the measurement of friction coefficient utilizing the ring compression test, Tribology International, 32 (1999): pp. 327–335.

[22].Hasan S, Hasan G, Jahan R. Determination of Friction Coefficient by Employing the Ring Compression Test, the American society of mechanical engineers, 123 (2001): pp. 338-348.

[23].Male A T, Cockcroft M G. A method for the determination of the coefficient of friction of metals under condition of bulk plastic deformation. J. Inst. Metals, 93 (1965): pp. 38-46.

[24].Raviteja V, Sahoo S K. Experimental Investigation and 3D Analysis of Combined Extrusion-Forging Process, Rourkela: ethesis.nitrkl.ac.in, (2014), pp. 15-54.