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MODEL STUDY OF COLD WORKING PROCESS WITH: NEW HORIZON IN FORMING TECHNOLOGY

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ABSTRACT

Cold working process is mainly used metal forming process with lots of advantages which to be used to achieve better surface finish, closer dimensional tolerances and improved mechanical properties as compared to hot working processes. Because of widely increasing competition with the advent of globalization it has become very important to keep and improve efficiency of this type of process in manufacturing industries with in terms of optimization with minimum resources and improve product quality. In view of this different models have been proposed and validated using experimental results over a long period of time. The demands in the automobile industries, energy sectors and mining sectors have led to several modifications in this cold working process. In this paper, details of cold –working process, major analytical, experimental and numerical studies reported in literature have been seen.The review focuses on highlighting the developments associated with the drawing technology that includes improvement in tool design, modification in product geometry, process optimization etc. with the use of FEM method to achieve the process related objectives.

Keywords: Cold-working, optimization, Product geometry, Tool design, optimization, FEM

I. INTRODUCTION

Batter and suitable quality and high precision products can be produced with the help of metal forming process and other suitable methods such as extrusion, drawing, rolling etc. Metal forming is the large group of manufacturing processes in which plastic deformation is used to change the shape of metal workpieces [1].The factors that determine of the forming or for that matter any other process are maximum utilization of resources with high quality output in cold working process Both extrusion and drawing are net shape metal forming processes which have high material optimize and produces parts without changing metallurgical and material properties. This paper is review on cold working process include cold-drawing process with a focus on the developments associated with the drawing process that includes improvement in tool design, modification in product geometry, process optimization etc. with the use of modern techniques like FEM to obtain the process related objectives.

II. COLD DRAWING PROCESS-AN OVERVIEW

The Cold drawing is metal forming operations and has major industrial significance. It is the process of reducing the cross- sectional area and the shape of a rod, tube, bar or wire by pulling through a die. This process allows excellent surface finishes and closely controlled dimensions to be obtained in long products that have constant cross sections. It is classified as under:

- Wire and Bar Drawing: Cross-section of a bar, rod, or wire is reduced by pulling it through a die opening (Fig. 1 a) It is similar to extrusion except work is pulled through the die in drawing. Both tensile and compressive stress deforms the metal as it passes through the die opening.

- Tube Drawing: It is a metalworking process to size tube by shrinking a large diameter tube into a smaller one, by drawing the tube through a die (Fig. 1 b). It is so versatile that it is suitable for both large and small scale production.

The drawing process improvement has been an area of extensive research over a long period of time due to its commercial significance as it offers excellent surface finish and closer dimensional control in the products.

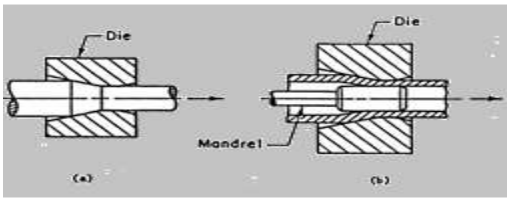

Fig. 1 (a) wire and bar drawing and (b) Tube drawing

Earlier different analytical methods like Slab method, Upper bound method or slip line theory were used for material flow and behavior analysis. In the recent years with the development in Numerical techniques and with the advancement in computers there is tremendous rise in the accuracy and pace of the solutions and information obtained in the researches. In this context, Finite Element Method is one of the most popular methods employed to resolve the forming problems. Kopp [2] presented a report that described ways for the shortening, flexibilization metal and optimization, as important tools.

The analysis on forming process show out by researchers are discussed below under different criteria

III. LUBRICATION AND FRICTION CONDITION DURING COLD DRAWING

Establishing friction conditions is crucial in bulk metal forming because of the usually high contact pressure and the influence of friction on the material flow, tool stresses and the forming force [4]. To minimum friction in forming processes is see in: increase in tool life, reduction in stagnation, increase in productivity, less energy consumption, less consumption of tools and reduction in production cost[3]. In the context of the same, Chuiko et al. [5] described the development in new forms of production lubricants and methods of oxalate application over Stainless Steel Tube. Lubricity criteria of fatty-based oils (palm, groundnut and shea butter oils), an important aspect of oil selection, were qualitatively assessed by Obi and Oyinlola [6] for friction evaluation for processes like wire forming and extrusion through open dies. Neves et al. [7] carried out experimental tests with a laboratory drawing bench with three type of different lubricants and two different lubrication conditions in order to study their effect on drawing loads and residual stresses. Similarly Byon et al. [8] .Results showed that the behaviour of drawing force varies with the lubricant-type at the initial stage of drawing.

1V. IMPROVEMENT IN TOOL DESIGN

The profile design of die and mandrel is the very important factor related to forming energy and deformation behaviour of tubular material [9]. Gunasekera and Hoshino [10] described a new method for obtaining optimal die shape to produces minimal stress in the extrusion or the drawing of non-axisymmetric sections from round bar stock. In order to find the best geometry of die and plug to reduce the drawing force. , Neves et al. [7] simulated the cold drawing of tubes with fixed plug by FEM with the commercial software MSC Superform. Kim et al. [9] The process parameters related with tool configuration. Result is tobe advanced mandrel shape, which can effectively transmit, without generating defect, drawing force to deforming tube, was designed. Wang and Argyropoulos [11] designed, modified and analyzed a plum-blossom-shape die for the direct cold drawing of hexagon/square-section rods in order to replace a series of converging dies in the traditional section drawing method. It dramatically increased the productivity, improved the product quality, and reduced the production time and cost.

A newly developed plug featuring a tiny boss club structure in the sizing zone was proposed by Xu et al.

[12]. It was found that when the plug with a tiny boss club structure is accepted, the contact quality is better and the larger plastic strain exists on the inner side of the tube, which is very crucial in improving the surface finish of the formed product part.

The traditional of effect of tools' geometries on the maximum possible tube deformation was founded by Bihamta et al. [13] on variable thickness tube drawing process with a newly developed procedure. Based on the optimum design developed by Bland et al. [14] through a finite element model, a new tool was built up which minimized the maximum stress level which induce in product to draw tubes in one pass.

V. MODIFICATION -TOOL GEOMETRY

Modification in conventional tube geometry like development of the Rifled Tubes etc., as per the application requirement has also been a part of several researches. Rifled Tubes have high heat-transfer efficiency and therefore are used for the furnace wall tube in the large power plant boilers. Assurance of high dimensional accuracy in the rifle tubes was given by Yoshizawa et al. [15] with the help of a manufacturing technique developed through experiments. Bayoumi [16] gave an analytical solution for the problem of cold drawing through flat idle rolls of regular polygonal metal tubular sections from round tube. The forming tool load in plastic shaping of a round tube into a square tubular section was determined by Bayoumi and Attia [17] both analytically and numerically by applying finite element simulation. Parshin [18] utilized the obtained equations in the standard finite-element program to analyse the variation in the shape of the eight-beam star like tubes in the course of multipass drawing. Xu et al. [12] developed an aluminium tube with rectangular cross-section with high dimensional accuracy and surface finish. High quality micro copper tube with straight grooves (MCTSG) with an outer diameter of 6 mm was obtained by Yong et al. [19].The influence of drawing parameters on the forming of micro straight grooves was investigated based on the forming mechanism. Bihamta et al. [20] modified the classical tube drawing process. The sinking and fixed-mandrel tube drawing methods were mixed together to produce tubes with variable thickness in the axial direction.

V. RESIDUAL STRESSE EFFECT

Residual stress and its measurement is very important aspect of cold drawing process as it has a significant impact on the material performance in the field. Minimisation of the induced tensil residual stresses was investigated by Karnezis et al. [21]. Elices [22] showed that how stress-relaxation losses, environmental assisted cracking and fatigue life of cold-drawn pearlitic wires are influenced by residual stresses. Elices [22] further discussed that residual stresses due to cold-drawing are known to be detrimental to the mechanical performance-particularly as regards to creep, fatigue and ductility .A numerical model using the code ABAQUS was developed by Atienza et al. to study the residual macro stress state generated by drawing. Phelippeau [24] identified and discussed the mechanisms controlling the elongation to failure of cold drawn steel wires and examined, in particular, the role of residual stresses. Nakashima et al. [25] patented a method to produce seamless tubes in such a way that the residual stress generated during the stage of correction after cold working is limited to 30 MPa and scattering thereof is 30 MPa or less, when measured by Crampton method. In the similar context, Ripoll et al. [26] proposed two methods for reducing the residual stresses during wire drawing, namely applying an advanced die geometry and performing an inexpensive post- drawing treatment based on targeted bending operations. Kuboki et al.[27] examined the effect of a plug on residual stress in tube drawing by both numerical analysis and laboratory experiment. The typical variation in residual stresses from tensile to compressive was seen across the drawn gold wire cross section in the experiment carried out by Narayanan et al. [28]. Results of residual stress measurements and simulation were also presented by Pirling et al. [29] .A three dimensional finite element model was developed to calculate the change in wall thickness, eccentricity, ovality and residual macro-stress (RS) state for cold drawn tubes. A prediction model for the maximum axial residual stress was proposed by Béland et al. [14] through a finite element method that considers the inhomogeneous deformation and heat generation in a high-carbon (0.82-wt% C) drawn wire .

VII. DRAWING DEFECT

The misapplication of the manufacturing process or lack of control at any stage may introduce defects and residual stresses that can affect the performance of structure in service, making it susceptible to failure. The surface flaw of a drawn wire has a significant influence on the quality of product [30]. The defects of cold drawn wire inherited from the wire rod may be divided into two groups: those due to metallurgical processes; and those due to rolling. The first group is formed in steel smelting and casting; the second is formed in heating and deformation in the course of rolling [31]. Same is true for drawn tubes. In this context considerable amount of research has been carried out, some of which is reviewed below. Rajan and Narasimhan presented experimental process and observations of defects developed during flow forming of high strength SAE 4130 steel tubes. The major defects observed were fish scaling, premature burst, diametric growth, micro cracks, and macro cracks. When we consider the micromechanical point of view, it is a known fact that the drawing process influences the microstructure of the material in the form of progressive trend towards a closer packing and a more oriented arrangement [33].

Due to drawing process in cold working process many effect happen during process in manufacturing industry mass production should be rapid so drawing peocess is use generally so different type of drawing effect should be analyzed which is related to material also, during this process material should be suitable to withstand this process without changing its property and also prevent failure.there is also examination of strength of material which is very important facture for material during this process.Anisotropic fracture behavior is exhibited by pre-stressing steel wires (heavily drawn) in air and in aggressive environments promoting stress corrosion cracking in several forms as was reported by Toribio et al. [33] .Camacho et al. used the Finite Element Method to study the effect of drawing variables on defects they also carried out a three-dimensional finite element analysis (FEA) that investigated the growth of surface defects due to wire drawing. They stated that superior wires without flaws could be obtained by removing the flaws before drawing and by multi- pass drawing. Weygand et all analysed the drawing process with a finite element model to determine the factors that are responsible for defects called splits. The effect of residual stresses due to the cold-drawing process on the fatigue crack propagation in a metallic cracked round bar with a V-shaped circumferential notch was examined by Carpentaria et al. The crack propagation under cyclic tension combined with the residual stresses was analysed by taking into account the SIF values and the actual stress ratio. Toribio et al. numerically analysed the role of drawing-induced residual stresses and strains in the performance of cold drawn prestressing steel wires under conditions of hydrogen embrittlement (HE). The results of the study carried out by Tang et al .illustrated the damage evolution of the drawn wire in each of the eight passes and the damage distribution along axial and circular directions. Wire breakage is expected to occur in those areas of the drawn wire where fractures most possibly initiate.

Furthermore, the numerical analyses contributed a new approach for the optimization of the drawing parameters.

VIII. INFLUENCE OF THE OPERATING PARAMETERS

De Castro et al. investigated the effects of die semi-angle on the mechanical properties of round section annealed copper bars. The FEM calculations of the drawing stress and the effective strain distributions in the tube sinking process were performed by Sadok et al. [22]. The calculations were done for various process parameters, including different profiles of the working part of the die. Chen and Huang [23] employed the finite element method and the Taguchi methods to optimize the process parameters of the wire drawing process. Neural networks were used by Dwivedi et al. to model relationships between controlled and uncontrolled process parameters and the yield. In most cases emphasis is given on one process parameter at a time and its individual effect is studied on the product. Dekhtyarev et al. carried out a research to demonstrate the combined effect of these parameters on final properties of the product and production process as a whole. Rocha et al. analysed distortion for a typical manufacturing process of pre-straightened, cold drawn and induction hardened AISI 1045 cylindrical steel bars using DoE (Design of Experiments). Celentano et al. assessed the influence of specific operating conditions, such as the decrease of the number of wire reductions and the presence of back tension, on the material response during the whole process numerically. During the same period, Bourget et al.studied the effects of time, temperature, and furnace heating rate in order to identify an optimized heat treatment for tubes with different cold work levels.

The variable thickness tube drawing was parameterized by Bihamta et al. Haddi et al. studied the influence of drawing conditions on temperature rise and drawing stress in cold drawn copper wires. From the experimental results, a relationship between temperature rise, drawing stress and friction coefficient was built. Bui et al. carried out a study in which experiments were conducted to evaluate the effect of cross section reduction. Nagarkar et al. simulated drawing of round tubes while passing through the sink pass, using ANSYS software to study the effect of various parameters like die angle on the product quality. Cetinarslan determined the effects of some drawing parameters like deformation ratio and drawing speed on wire drawing. It was observed that these variables significantly affect the tensile and torsion strength of the ferrous wires. the drawing process by different methods. Thin- walled tubes drawing through conical convergent dies with fixed inner, conical or cylindrical, plug was analysed by Rubio et al.using the upper bound method. Analytical formulations were extensively used by Gur'yanov. He calculated the limiting extension per drawing pass using six different formulas in order to determine the axial- stress increment in the working cone of the die.

Similarly tension in the drawing process was determined by Gonza´ lez et al.via free body equilibrium method to solve the drawing problem for dies of axisymmetric or symmetric sections. As opposed to the classical slab method, solution of the equations obtained through this method accounted for internal material distortion.An extension of an upper bound solution developed earlier was proposed by Bui et al.to predict the drawing stress field. Rubio analysed tube drawing using analytical methods, i.e. Slab Method (SM), with and without friction effects and the Upper Bound Method (UBM).

X. CONCLUSIONS

To create demanding position in manufacturing industries and need s of customers for improving in terms of product quality, minimum product development cycle time, use of optimization resources and incorporation of modern methods,with different technologies to achieve the aforementioned goals.

This paper represents causes and benifites of cold drawing process; which is used for manufacturing high quality products that have wide variety of applications in different sectors of engineering. It helped in understanding the developments and research carried out over a period of time for different problems associated with cold drawing and different approaches involved in problem solving ranging from analytical methods to Finite Element Method.

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