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A REVIEW ON RESIDUAL STRESSES IN DEEP DRAWING

Dr. B.Linga Reddy[1], Dr. P.V.R.Ravindra Reddy[2], Dr.B.Chenna Kesava Rao[3]

Associate Professor, Department of Physics, CBIT, Gandipet, Hyderabad-75, India

Associate Professor, Dept.of Mechanical Engineering, CBIT, Gandipet, Hyderabad-75, India

Principal, CBIT, Gandipet, Hyderabad-75, India

Abstract: Residual stresses which are due to the inhomogeneous deformation effect the mechanical properties of the material a lot. . The residual stresses left in the cup wall after deep drawing can be very large. For a material prone to stress corrosion, premature failure can in many cases be attributed to the residual stresses. Hence the study of residual stresses is very important in the context of functional behavior and durability of the component formed. A review on the residual stresses in deep drawing is presented in this paper

Keywords: Deep drawing, Residual stress, inhomogeneous deformation.

I.INTRODUCTION

Residual stress is defined as stress in a material without the action of external forces. They are one of the most important parameters that characterize the near-surface layer of any mechanical component and control its performance [1]. They are caused by inhomogeneous deformation which could result from mechanical and thermal loadings, and phase transformation [2] and occur practically in all materials as a consequence of their manufacturing, treatment or usage. Residual stress influences the resulting properties such as toughness, fatigue life, resistance to cracking, magnetic properties and corrosion characteristics. Hence, residual stresses present in a component have a strong influence on quality of the component. They also influence the dimensions of the component and also have a strong affect on the static and dynamic strength. Residual stress represents one of the important material state characteristics together with microstructure and texture, hence a great care is given to its determination. The residual stresses left in the cup wall after deep drawing can be very large. For a material prone to stress corrosion, premature failure can in many cases be attributed to the residual stresses. For example in austenitic stainless steel the residual stresses can lead to splitting of the cup wall after the deep drawing due to stress corrosion cracking. This phenomenon is called delayed cracking or stress cracking or stress corrosion cracking.

Despite the fact, that residual stresses may have a strong influence they are rarely taken into account in the specifications of the component, and the reason for this according to Maeder et.al [3] is that it requires a lot of experiments to work out specifications taking the residual stresses into account and simple softwares for calculating the residual stresses or for predicting the components behavior don't exist. Another problem, if the residual stresses are taken into account in the specifications of the part is that it is hard to check whether the specifications with regard to the residual stresses have been met.

II.PREDICTION OF RESIDUAL STRESSES

The reliable prediction of the residual stresses is important when designing forming tools, so that springback due to the residual stresses can be taken into account in the design stage itself. Reliable prediction also enables optimization of the tool geometry with regard to the residual stresses in the formed part. The residual stresses are in equilibrium over a certain volume of material and depending on the extension of this volume, can be classified into two groups: macroscopic residual stresses and microscopic residual stresses. Microscopic residual stresses are the residual stresses when the extent of the volume is the size of the grains or even smaller and macroscopic residual stresses are those when the extent of the volume is large compared to the grain size. According to Lange.K et.al. [4] macroscopic residual stresses are the most important ones with regard to failure. The examples presented in [5] show, that minor changes in the geometry of the forming tools can have a significant effect of both the magnitude and the distribution of the residual stresses.

Even though, the importance of the residual stresses have been known for a long time, with classical plasticity methods it is virtually impossible to determine theoretically the magnitude of the residual stresses in a part formed in a complex forming process. However with the introduction of non-linear FEM cable of handling large plastic deformation, it

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has become possible to determine the residual stresses. Dancket. J et.al.[6] described a FEM analysis of conventional cylindrical deep drawing and it is shown that the residual stresses indeed can become very large and they can be reduced substantially by ironing of the cup wall.

Saito and Shimahashi [7] have analyzed the conventional cylindrical deep drawing theoretically with regard to residual stresses. They conclude that the residual stresses in the cup wall are mainly due to the unbending. Main reason to analyse the deep drawing of cylindrical cups was to investigate where and how the residual stresses are created and if possible to change the tool geometry in order to reduce the residual stresses.

III.EXPERIMENTAL TECHNIQUES FOR RESIDUAL STRESSES

Experimental techniques play the main role in residual stress determination. Several destructive or nondestructive experimental methods based on different physical principles are developed [8]. Frequently used ones include diffraction (x-ray, neutron) techniques, ultrasonic techniques, bending methods or destructive techniques based on residual stress relieving measurement. The hole-drilling residual stress measurement method [9-12] is a destructive technique based on the original residual stress relieving by drilling a small hole into the material surface. The method is labeled as semi-destructive, as the material damage is very small and often removable. Traditionally, the method has been used for measuring uniform residual stresses, that is, stresses that do not vary significantly with depth from the specimen surface. Strain gauge or optical [13] methods are most often used for strain measurement. The standard ASTM E837 [14] has been adopted as the basic concept of the method, however, many modifications and improvements have been developed. Much attention has also been given to the use of the holedrilling method to measure residual stresses that vary with depth from the surface [15-16]. This type of measurement is called “stress profiling.” It requires that the strains relieved by the hole drilling be measured after each of a sequence of steps in hole depth. The solution to the corresponding stresses within each of the hole depth steps is an “inverse problem,” and is typically carried out using the integral method. This calculation method involves solving a set of linear equations, where the matrices contain geometrical factors that depend on hole depth and diameter.

In addition to leaving the part examined unfit for service, these techniques require substantial expertise and are fairly costly to perform. In order to overcome this, a range of nondestructive techniques for stress evaluation have also been developed. One major technique involves diffraction of X-ray or neutron beams as a method of determining the strain on a particular lattice plane of the material. The physics of these processes is well understood and both diffraction techniques are capable of good spatial resolution, although the X-ray technique is limited to measuring the stresses near the surface. Neutrons are more deeply penetrating, but require the presence of a high flux reactor. Thus, there are relatively few facilities that can perform stress evaluation from neutron diffraction measurements. An alternate nondestructive technique, acoustoelasticity, involves the measurement of the variation of speeds of ultrasonic waves caused by the presence of the stress field. Within the broad heading of acoustoelasticity, there is a range of different methods that have been considered, all of which are limited to the evaluation of plane states of stress.. The most common acoustoelastic technique is called the birefringence technique [17-18]. This technique is based on the fact that the difference in the speeds at which two shear waves propagating normal to the plane of stress, but polarized in the principal stress directions, is proportional to the difference in the principal stresses. The constant of proportionality is a material constant (called the acoustoelastic constant for birefringence). Another technique, which is receiving considerable attention, involves the difference in the speeds of two shear waves propagating in one principal direction and polarized in the other [19, 20]. In this case, the difference in the square of the shear wave speeds is equal to the difference in principal stresses divided by the material's mass density. The acoustoelastic constant need not be found out for the shear wave technique. A third technique, called the longitudinal wave technique, involves the change in the speed of a longitudinal wave traveling in the direction normal to the plane of the stress [21]. This technique, like the birefringence technique, requires that the acoustoelastic constant be known in advance. Each of the three acoustoelastic techniques discussed has certain advantages and disadvantages. A clear advantage of the Shear wave technique is the absence of an acoustoelastic constant whose uncertainty affects the precision of the resulting stresses. The birefringence technique has an advantage in that there is a relatively larger velocity variation per unit stress than in either of the other techniques. The advantage of the longitudinal wave technique is the ease with which measurements can be made over a large region of a sample, and the spatial resolution which can be achieved. All of the techniques use relative measurements (as opposed to absolute measurements) of velocity variation. An analytical development has made it possible to estimate the complete residual stress state everywhere in a planar structure [21]. Neither of the other acoustoelastic techniques have yet to be demonstrated as having the capability for such whole-field stress determination. J.J Dike et.al [22] applied this technique to extremely anisotropic material also.

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IV.CONCLUSION

In this work a brief review is presented regarding the residual stresses in deep drawing process. the methods for prediction of residual stresses and the experimental techiniques have been presented.

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