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FINITE ELEMENT ANALYSIS OF DEEP DRAWING PROCESS

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ABSTRACT

The study aims to simulate the deep drawing process of a part used in the automobile industry as a coil spring bracket in the car door assembly using Altair Hyperform 11.0. Forming Limit Diagrams produced by the software as well as the thinning percentage contours will be studied to predict the quality of the deep drawn component.

1.0. INTRODUCTION

Deep drawing is one of the most commonly used sheet metal forming processes. It is defined as a manufacturing process in which a sheet metal work piece known as blank is subjected to tensile and compressive stresses by the action of a mechanical punch to press the blank into a die cavity. The process is capable of producing final work pieces that generate little scrap material with enough precision for the parts to be straightaway assembled without further operations. Deep drawing is widely used in the manufacturing industry also because of its rapid cycle times. Complex geometries, not necessarily ax symmetrical, can be produced with a few operations which are automatable and thus require a relatively non-technical workforce. Deep drawing has been developed at a fast rate, especially in the automotive and aircraft industries. Typical products are cylindrical, conical or box-shaped parts such as containers, kitchen sinks, beverage cans, pans and automotive panels. The raw material required should be ductile for the manufacturing process but tough and strong for the products to be of practical use.

2.0. LITERATURE REVIEW

Kaftanoglu developed a method to model flange wrinkling in axisymmetrical deep drawing using the energy method. In this approach, wrinkling occurs if the plastic work done for deep drawing is higher than the plastic work done for wrinkling. For this purpose, using von Mises yield criteria, a plastic analysis is done for the flange part of the blank, assuming plane stress conditions. For the calculation of work done for wrinkling, wrinkles are assumed to be a sine curve in shape. So the amplitude of the wrinkles are calculated, then using the plastic bending moment, work done for wrinkling is obtained. Using these procedures, plastic work versus reduction strain curves are obtained for both deep drawing and wrinkling. When the slope of the wrinkling curve is greater than deep drawing curve, wrinkling does not occur, since the energy required is greater than deep drawing. Considering the peaks of the wrinkles as plastic hinges, the blank-holder force needed to suppress wrinkling is found in terms of wave number. Experiments are conducted to verify the numerical results with several materials and for several initial blank diameters.

Ramaekers et al., made a research on the deep draw ability of a round cylindrical cup. The limiting drawing ratio is tried to be related with some process parameters like anisotropy factor, strain hardening exponent, etc… Upper and lower bound methods are used to obtain theoretical models. Using the theoretical model proposed for deep drawing, estimation for the limiting drawing ratio is tried to be achieved. Some experiments are conducted to verify the model developed. Comparing the results, it is seen that an agreement between the model for deep drawing and experiments. However, a precise prediction of the limiting drawing ratio could not be achieved. The friction coefficient is seen to be an important factor for the drawability of large size products. The study showed that decreasing friction coefficient, increases limiting drawing ratio.

Cao and Boyce examined wrinkling and tearing type of failures in sheet metal forming. For prediction of wrinkling, they used a method proposed by Cao and Boyce. The criterion is based on the energy conservation and minimum work to suppress the wrinkling. Total strain energy values for a perfect plate and for buckling plate are recorded. Then the force/pressure needed to suppress the wrinkling is calculated using the energy difference and wrinkling amplitude. In prediction of tearing, existing forming limit diagrams are used in correspondence with the local strain histories near possible tearing regions. They also developed a technique named variable binder force in which blank–holding load varies in controlled manner, not a constant blank–holding load was used. A control algorithm is proposed for variable binder force technology. Two examples are used: conical cup drawing and square cup drawing. Finite element models of both cases are analyzed by commercial program ABAQUS. Comparison with the experimental results shows that the method is capable of predicting wrinkling and tearing. The control algorithm for variable binder force is tried in both cases, and 16% extra cup forming height is provided for conical cup drawing.

Makinouchi et al analyzed wrinkling during deep drawing of conical cups numerically and experimentally. The experiments were conducted not only to create a reference for FEM simulation, but also to give some guidelines for a reliable benchmark test of the wrinkling prediction capability of various FEM codes. The simple component geometry enabled the easy comparison of experimental and FEM results. To make numerical results more general, two types of FEM analyses were employed: static-explicit (ITAS3D) and dynamic-explicit (ABAQUS/Explicit). The same simulation parameters used enabled the comparison of both techniques. The experiments were carried out with an anisotropic sheet with a view to investigate the shape of wrinkles on a hydraulic press because of its advantage in controlling load and ram velocity which can be adjusted according to the requirements of the deformation process.

Ferron et al developed a bifurcation analysis for predicting the occurrence of wrinkling in metal sheets with isotropic elasticity and transversely anisotropic plasticity. Based on the local conditions describing sheet geometry, loading and material anisotropy, wrinkling is predicted in the form of a limit curve defining bifurcation in principal stress space, along with the wavelength and orientation of the wrinkles. The practical relevance of this approach was checked by comparison with FE predictions of wall wrinkling in the conical cup test in the Abaqus, a FE code. The simulations are made for different materials.

3.0. OBJECTIVES

Sheet metal processes, especially deep drawing is an important manufacturing process as many parts with complex geometries used in automotive and aircraft applications are being manufactured by these sheet metal processes. Deep drawing is a complex process and the end product depends on many variables, which need to be studied. Without extensive knowledge of all these variables, achieving a defect free deep drawn product is difficult. This study aims to simulate the deep drawing process of a part used in the automobile industry as a coil spring bracket in the car door assembly using Altair Hyperform 11.0. Forming Limit Diagrams produced by the software as well as the thinning percentage contours will be studied to predict the quality of the deep drawn component.

4.0. METHODOLOGY

The Following steps has been followed.

1. Introduction to Deep Driving Process: Steps Involved;
    a. Stages in Deep Drawing
    b. Stresses in Deep Drawing
    c. Deformations in Deep Drawing
    d. Draw ability of Sheet Metals
    e. Formability of Sheet Metals
    f. Parameters affecting Deep Drawing
    g. Defects in Deep Drawing
2. Modeling and Simulation
    a. Modeling – Stage – One – Two – Three
    b. Simulation
        i. Radioss One-Step Analysis
        ii. Incremental Radioss Analysis
3. Result and Analysis

5.0. CONCLUSIONS

This dissertation work has been attempted to understand the deep drawing process through simulation only. Experimental work has not been done as the Altair Hyperform gives us the Forming Limit Diagrams, which are widely used to predict failure in drawn components. Radioss One-Step optimised the initial blank diameter to be 128 mm but a blank diameter of 125 mm was taken as the 128 mm blank was showing highly wrinkled products. Deep drawing was carried out in three stages using Radioss Incremental. The first stage product was defect free, but the second and third stage products showed a slight possibility of tear due to thinning. To ascertain the reason behind this extra thinning, alternative simulations were carried out for second stage, varying blank holder pressure and the depth to be drawn, but no positive effects were observed. Hence, the product with a little extra thinning was considered to be the final product.

6.0. FUTURE SCOPE

The present analysis doesn’t take spring back into account, which can be analysed in the future. Also, constant blank holder pressure was used, but a number of studies nowadays are pointing towards varying blank holder pressure, which should certainly be applied to this model. The use of taper in the product has given high drawing ratios and this fact should be well exploited in the future.

REFERENCES

i. Schey, *"Introduction to Manufacturing Processes"*, Third Edition ed.: McGraw-Hill, 2000.

[2.] Cao, Jian, and M. C. Boyce. "A predictive tool for delaying wrinkling and tearing failures in sheet metal forming." *Journal of Engineering Materials and Technology* 119.4 (1997): 354-365.

[3.] De MagalhãesCorreia, João Pedro, and Gérard Ferron. "Wrinkling predictions in the deep-drawing process of anisotropic metal sheets." *Journal of materials processing technology* 128.1 (2002): 178- 190.

[4.] El Sherbiny, M., H. Zein, and M. Abd-Rabou. "Thinning and residual stresses of sheet metal in the deep drawing process." *Materials & Design* 55 (2014): 869-879. 61

[5.] Kaftanoglu, B. "Plastic analysis of flange wrinkling in axisymmetrical deep-drawing." *Proceedings of the Twenty-First International Machine Tool Design and Research Conference*. Macmillan Education UK, 1981.

[6.] Karl-Heinrich Grote and Erik K. Antonsson, "*Springer Handbook on Mechanical Engineering*": Springer Science and Business Media, LLC New York, 2008.

[7.] Kawka, M., Olejnik, L., Rosochowski, A., Sunaga, H., &Makinouchi, A. (2001). Simulation of wrinkling in sheet metal forming. *Journal of Materials Processing Technology*, *109*(3), 283-289.

[8.] Ramaekers, J. A. H., A. de Winter, and M. W. H. Kessels. "” Deepdrawability of a Round Cylindrical Cup." *IDDRG*. Vol. 94. 1994.

[9.] Rees, D. W. A. "Factors influencing the FLD of automotive sheet metal."*Journal of materials processing technology* 118.1 (2001): 1-8.

[10.] SeropeKalpakjian and Steven R. Schmid, *"Manufacturing Processes for Engineering Materials"*, Fourth Edition ed.: Prentice Hall, London, 2003.

[11.] SeropeKalpakjian, Stephen Schmid, “*Manufacturing, Engineering and Technology*”, SI 6th Edition, 2009

[12.] Z. Marciniak, J.L. Duncan and S.J. Hu, "*"Mechanics of Sheet Metal Forming""*, Second Edition ed.: Butterworth-Heinemann, 2002.