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COMPUTER AIDED ENGINEERING (CAE) EXPERIMENTAL APPLICATION FOR DEEP DRAWING PROCESSES OF A SHEET METAL

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ABSTRACT

Deep drawing is a manufacturing process for forming flat sheets into geometrical cup-shaped metal stock, called blanks, without failure or excessive localized thinning. The formability limits of the deep drawing process are investigated for the effects of fixed blank holder forces on the wall thickness distribution and wrinkles. Furthermore, wall thickness distributions obtained experimentally have been compared with theoretical modeling of the part which was obtained by using ANSYS program. The paper presents Computer Aided Engineering (CAE) tool (ANSYS LS-DYNA) for simulation realized with taking the contact model, material specifications into consideration by using non-linear explicit finite elements method.

Keywords: CAE, The deep drawing process, Finite Element Method (FEM).

1. INTRODUCTION

The sheet metal forming process of AL 1050 alloy sheet has been widely used for mass production of various components in the fields of automobile and aerospace industries. However, the forming technology should be developed to increase the prediction of formability of the certain material under the right conditions such as suitable stress rate, low pressure without wrinkles or creases, and the failure to design the process and die that are the most important research topics in deep drawing area [1].

As a result of the experimental works on plastic forming, some tables have been prepared on how much the extraction mold would be thinned in different depths [2]. Since these tables are formed with empirical methods, they only work for the applications where experimental material is used and are formed with the assumption that the material flows in two dimensions. These experimental data are insufficient for cold formation of parts having complex geometries. The wrinkles on the sheet metal are tried to be prevented with the locking areas open towards pressure plate [3]. Also the locations and amount of the locks are determined with experiments. Besides, the welding works made on molds form permanent internal stresses on the mold, which shortens the usage life. All of these processes have high costs. Thus, deep drawing with using the material values by simulation technique will lead to acceleration of the processes and lowering the production costs [4]. A new scheme for the blank holding force is introduced in order to apply more realistic blank holding forces in simulation. The wrinkling in the flange region of the blank turns larger with the increase of the blank holder gap [5].

2. THE METHOD DEVELOPED IN DEEP DRAWING RESEARCH

The deep drawing process consists of various forming processes such as bending, twisting, pressing. Simply, a conventional deep drawing unit is composed of a punch whose tip corners are radius, a mold whose sides are with radius and the blank holder which is used to press the sheet material as shown in Figure 1. With the movement of the punch, the sheet material is pushed radially into mold that provides the formation. The specifications of the sheet metal, punch and mold used in the study are given in Figure 1.

Deep drawing experiments for sheet plates have performed, using the analysis results that had obtained by the finite elements method. To investigate the effects of the blank holder forces on differences in the wall thickness, which were extracted under constant pressure, deep drawing process is carried out and examined while the blank holder pressing pressure is incremented by 0.5 Mpa steps.

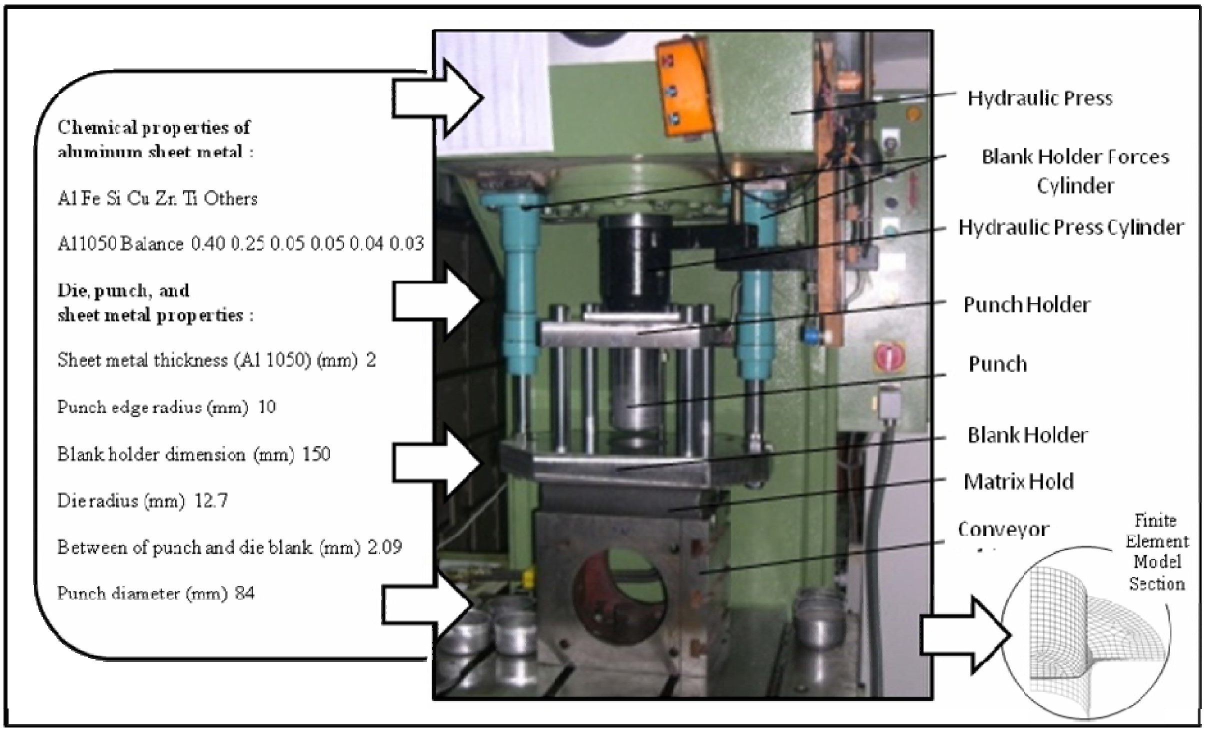


Figure 1. Deep drawing operation machine (hydraulic press and its elements)

3. STUDY OF THE DEEP DRAWING FOR ALUMINIUM SHEET MATERIAL

In the study, explicit ANSYS/LS-DYNA module is used for the theoretical model [6]. When placing the parts in the system, the direction and the values of wall thickness were taking into consideration. The molding system is composed of the press, the blank holder circle, sheet metal and the female mold from top to the bottom.

The simulation [7] is realized by designing the exact sizes which were used in the experimental system. A free network is netted for the punch, mold, and pressure plate by using the S.R. C Rotation thin-shell number 163 element as shown in Figure 2. Using the same element on sheet plate, in order to get better and faster results a more dense meshing was applied on the areas which were deformed, it was cut into larger elements in the areas where the deformation is less and 4090 elements are formed.

The solutions and viewing the solutions were made in the ANSYS/LS-DYNA and the extraction diagram is made in the LSPREPOST program [7] .

In this research, different blank holder circle presses were used by taking the meshing amounts of the model, the anisotropic characteristic of the material into consideration. The product which is formed as a result of each blank holder press is examined in a discipline. Therefore different results are obtained with different blank holder presses.

To search the tearing limits of the extracted blank holder, the constant blank holder force was raised up to 15 MPa, considering the results obtained from finite element method (FEM) analysis. As a result of the extraction process, the examples exerted with more than 10 MPa force, were torn before it could slip under the sheet metal blank holder circle, after it takes the tip radius form of the punch. The upper limit is determined by adjusting this press limit up and down. The experimental results of the sheet metals for 0.4 MPa and 2 MPa blank holder forces results of the formation with finite elements are given in Figure 3.

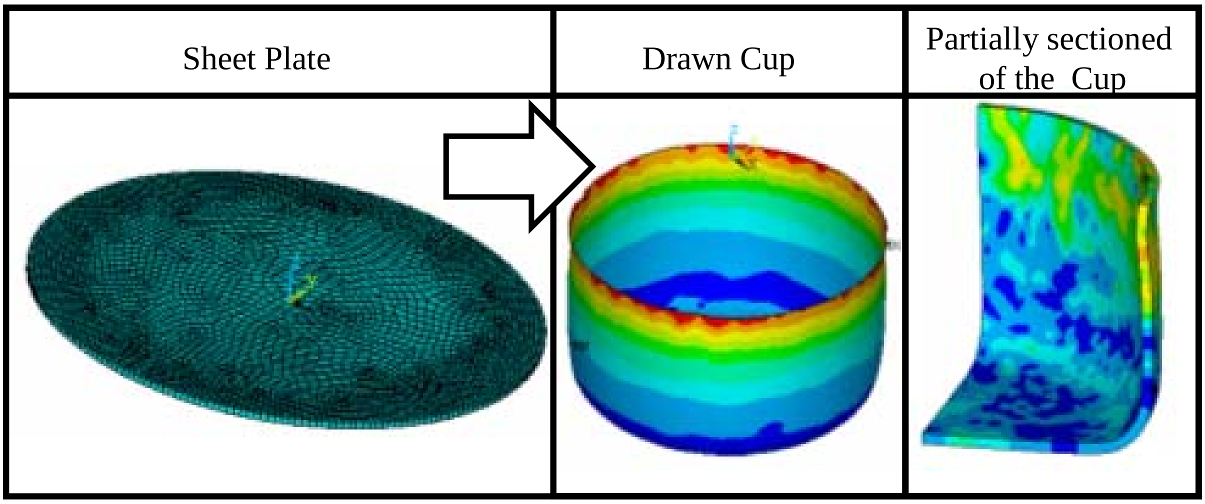


Figure 2. The state of the sheet metal before and after forming

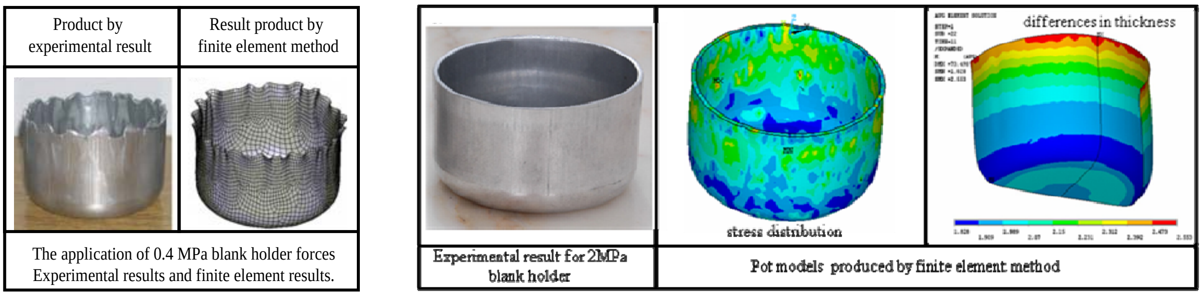
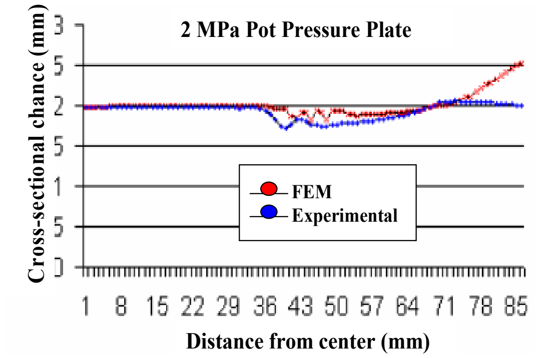


Figure 3. Sheet metal drawing experimental and FEM results for Al 1050 alloy

4. FEM ANALYSIS CONSIDERING THE WRINKLING AND TEARING LIMIT

In order to investigate the most suitable blank holder force amount to be used in the deep drawing process of the Al 1050 material, the forces between 0.4 MPa and 15 MPa are applied to analyze in the ANSYS/LS-DYNA software. In the present study, for blank holder forces of 0.65MPa and less, while wrinkles were observed as it is given in Figure 3. It is determined that the blank depth is smaller than 48 mm. For the blank holder forces more than 10 MPa tearing starts. As a result of the experiments, it is seen that extraction can be performed between 0.65 and 10MPa blank holder forces without any wrinkling and tearing as depicted in Figure 3.



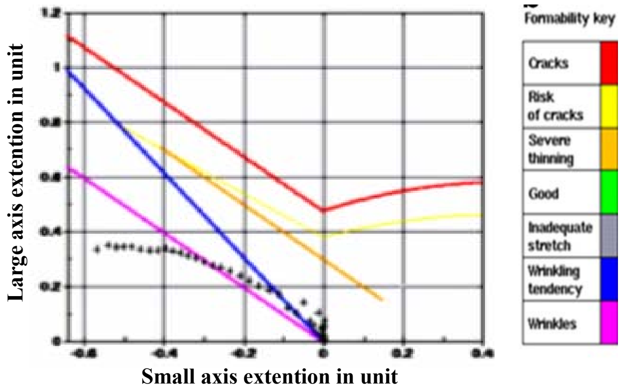


Figure 4. Thickness changes in ANSYS LS-DYNA and specimen for 2 MPa

Figure 5. Limit diagram for 2 Mpa Blank holder force

5. CONCLUSIONS

The research explained in this article focuses on the theoretical and experimental investigation of blank holder forces plate effect in the cylindirical cup deep drawing process of alloy AL 1050 material using fixed blank holder. While multi-step extraction is applied it is requested that the blank holder, which is extracted in the 1st step, has a uniform wall thickness and smooth mouth structure or if a smooth mouth structure is required without a second process, it is seen that suitable results can be obtained with the blank holder force between 2 and 4 Mpa. In this study, by forming the sheet metals with FEM formation conditions, blank holder force and forming limitation for every kind of diagrams could be determined without the mold sets experiments requirement. The simulated results showed good agreement with the experimental results. Thus, shortening of time and cost can be obtained at design and manufacturing cycle.

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