Development of A Sheet-Metal Component With A Forming Die Using CAE Software Tools For Design Validation and Improvement

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Abstract:

Sheet-metal die is an inseparable constituent of the development process of any given automotive or consumer appliance. In most of the cases, this accounts for a high proportion in the tooling needs of the large size and structural member in any automotive like the chassis and the BIW. Many other brackets and gussets along with peripheral clips etc are invariably made of Sheet-metal due to the strength characteristics complimented by this material and the process of stamping.

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Introduction

A reduction in the number of trials would directly influence the cycle time for development. A shorter cycle time can be planned with due utilization of software tools that would predict the trial results without actually conducting the same! The simulation offered by the software during the process of stamping lends important insights into the modifications needed in the die and/or the component to effect a simplified and productive die. Normally, a Forming die (including Draw die) calls for refined design parameters for ensuring a smooth passage through the trial phase of the developed Die normally accompanied by crucial review inputs over the Design of the component too.

Literature Review

1) **Arash Behrouzi, Bijan Molaee Dariani, Mahmood Shakeri** had discussed **(1)** Shape error due to elastic recovery of formed part in unloading known as springback, is one of the most

important problems of tool design in sheet metal forming processes. Many researches have been performed for proposing an efficient method to decrease or compensate springback error in sheet forming processes.

2) **Juraj HUDAK, Miroslav TOMAS** had Presented **(2)** contribution deals with force parameters research (drawing and blankholding) in deep-drawing process of flat bottomed cylindrical cup. Experimental research was realised using steel sheets for enamelling KOSMALT produced by U.S.Steel Košice, Ltd. Deep drawing process of this steel is complicated due to contradictory requests from the view of steel structure: good drawability and good enameling.

3) **Hakim S. Sultan Aljibori, Abdel Magid Hamouda** had done **(3)** in the study on Minimization of response times and costs and maximization of the efficiency and quality in producing a product are imperative for survival in the competitive manufacturing industry. Sheet metal forming is a widely used and costly manufacturing process, to which these considerations apply. Aluminum sheet becomes favorable compare to steel regards to some improvement at aerodynamic designs, increased engine efficiency and fuel economy. Wide range of aluminum automotive product included doors, fenders, bumpers face bars, seat frames and roof panels have been produced. This paper was carried out to study the finite element (elastic-plastic) analysis of sheet metal forming process using the finite element software.

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4) **J. S. Colton, Y.Park** had discussed **(4)** the demand for rapid, low-cost die fabrication and modification technology is greater than ever in the sheet metal forming industry. One category of rapid tooling technology involves the use of advanced polymers and composite materials to fabricate metal forming dies. In addition because the mechanisms by which they fail are not fully understood, the dies are designed on the basis of experience and intuition. This study investigates the failure of V-bending dies fabricated from an easy-to-machine, polyurethane-based, composite board stock Based on the mechanical behavior of the die material, several failure criteria are proposed to predict die failure mode and the corresponding die life.

5) **A.Wifi. & A.Mosalam** had discussed **(5)** the complexity and interactive nature of the parameters affecting the performance of various blank-holding techniques. It has been demonstrated that certain combinations of such parameters would lead to the most favourable

working conditions leading to a successful cup drawing. Efforts should be made to develop effective optimization techniques to control these parameters and optimize the BHF schemes. Experience suggests that using the finite element method as an evaluation engine of the objective function used in optimization is very powerful, but unfortunately very time consuming. No claim is made here that the presented work is complete.

6) **Se-Ho Kim, Seung-Ho Kim, Hoon Huh** had discussed **(6)** in his journal is the tool design is carried out for a multi-stage deep drawing and ironing process of a rectangular cup with the large aspect ratio using the result of the finite element analysis. The analysis incorporates three-dimensional continuum elements for an elasto-plastic finite element method with the explicit time integration scheme using LS-DYNA3D. The analysis simulates the five-stage deep drawing and ironing process with the thickness control of the cup wall. Simulation is performed in order to investigate the failure by tearing during the forming process at the initial state of tool design.

7) **Peter Kostka,Peter Cekan** had discussed **(7)** the ability to predict different process conditions in deep drawing is essential for die face designers, tooling stamping & manufacturing engineers. These predictions in turn affect the speed, accuracy and cost of the final produced poduct.This paper briefly discusses the possibilities of controlling the blankholding pressure distribution and shows some computer simulations done in DYNAFORM, with the result being experimentally verified with tooling designed by the authors.

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Objective:

Forming involves plastic deformation (3) while material is constrained to conform to given contour or shape. This operation poses challenges for modeling using the mathematical or analytical (1) model. The size, thickness, material properties, features, direction of form and the changes in the direction for the features, depth of the forming, etc influence the complexity and affect the quality of the component.

For this dissertation work the scope can be recorded as below:

- Understanding the design intent of the component
- Die Design for the subject component
- Steel material like HCHcr (High carbon High Chromium) & OHNS (Oil Hardening non Shrinkage) grade for both punch and die block to suit the components having EDD (Extra Deep Draw) would be used for experimentation.
- Analysis to identify the defects & best methodology of processing the part & comparison would be reviewed.
- Trials and validation.
- Documentation and review.
- Recommendation with final design output.

Software Used: M.S.EXCEL/ UNIGRAPHICS NX-6/ HYPERFORM/ OPTRIX

1. Software CAD/ CAE facility is available at 'Able Technologies (I) Pvt. Ltd', Pune/ IdeaMaps, Pune. The popular software used for `forming' analysis to be used for this software would be any of the following – HyperForm / AutoForm/ MD-Marc/ D-Form/ Optrix.

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Experimentation/ Validation:

The standard or reference data available for the past design/ validation as standards or reference normally proves to be very useful while considering experimentation. The die once manufactured would be subjected to trials for checking the output (the component). The experimentation would be carried out using a Press Machine of a suitable type and tonnage. Normally, a hydraulic press is used for Form and Draw that involve stretching/ thinning of the component with a high draw ratio. The Die is set up over the machine and the component is fed manually or automatic during the trial run.

The trials are conducted in a very controlled environment with focus on the variables influencing the generation of defects. A number of trial runs are conducted to ensure consistency/ repeatability of the stamping process.

The methodology to be adopted for this development phase would include the determination of blank size, Analysis for identifying the defects and the best course of processing the part, optimized operating parameters for the hydraulic press, setting for tuning the variables on the forming die like blank-holding pressure, experimentation over varying thickness within a given range and so on.

The virtual validation of the die (simulation using software) should address the given problem during the design stage. While the die is manufactured, the trials and testing would address the phase of validation as the physical tool (die) would be tried-out for checking the nature of the physical component as an outcome of the developmental process.

The die would be considered as validated upon inspecting the physical trial components for the presence and magnitude of defects. Low occurrence and consistency in the desirable characteristics in the physical part produced would be considered as a basis for validation of the Die.

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