Review of Sheet Metal Forming Analysis

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Abstract

This paper presents a review on sheet metal forming analysis which are widely used in automobile industries. Several different processing methods have been implemented in the industries to achive its repeatability and productivity. Sheet metal forming process involves nonlinearity, complex material behaviour and machining technology. As on today FEM is applied for determining stresses and further failure criterion for the formability prediction in the sheet metal forming process. Material optimization by reduction in the raw material size for sheet metal is focused. Computer Aided design model is developed by scanning the die in coordinate majoring machine is been represented. FEM, Probabilistic design, numerical analysis, forming limit stress diagram, press forming analysis, material optimization are same of the criterion being used for the sheet metal forming analysis.

Keywords –*sheet metal forming analysis, FEM, forming limit diagram, sheet metal forming process.*

I. INTRODUCTION

Sheet metal forming process have been used to manufacture required sheet metal product in many automobile, aerospace and other industries due to productivity and high strength as compared to light weight products are the strengths of sheet metals. Sheet metals are having many applications in automobile industries for manufacturing automotive parts and hence it is necessary to study the formability of these sheet metals.

The sheet metal forming processes are affected by some of the variables such as material property, blank holding pressure, press speed etc. forming limit diagrams are used to find these limitations as it represents acceptable limit of strain with two principal surface strains. Finite element methods, numerical analysis, press forming analysis are the criterion used for the sheet metal forming analysis.

II. FORMING PROCESS AND FORMING LIMIT DIAGRAMS

Metal forming has now became the important process of modern manufacturing industries, a large variety of products are made by forming processes. The primary products which are either used as raw material for other processes such as bars, beams, channels, sheets, angle sections rails, draw products such as wires and tubes, forged products such as shafts, crank shafts, gear blanks and gears, automobile components etc.

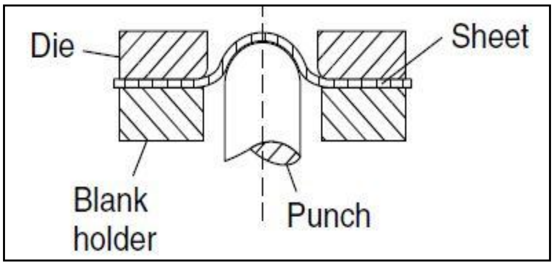


Fig. 2.1: Basic Parameters of Forming Process

Sheet metal forming process is the type of forming process which is widely used in the industries such as automobile, aerospace to manufacture required sheet metal product. Some common sheet metal forming processes used to manufacture required sheet metal product are cutting off, blanking and punching, bending, deep drawing, hydro-forming, spinning and flow turning.

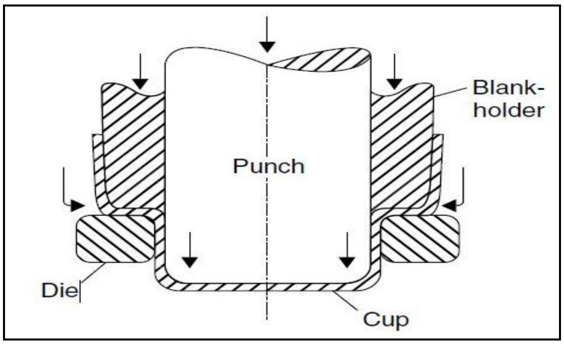


Fig. 2.2: Blanking And Punching.

A. Forming Limit Diagram

Sheet metals are used in many industries especially in automotive parts hence it is necessary to study the formability of the sheet metals. Forming limit diagram is used to study the formability of the sheet metals. Sheet metal is formed in a large variety of shapes which involve complex state of strain paths and total strains. There is no theoretical method to predict the formability of the sheet metal. The forming limit diagram predicts whether the particular material can withstand certain ratio of strains without failing.

The concept of the forming limit diagram introduced by keeler and backofen [1] and Goodwin [1] has created a significant impact in both academia and industry on how the maximum deformation that a material can withstand during sheet metal forming process can be determined.

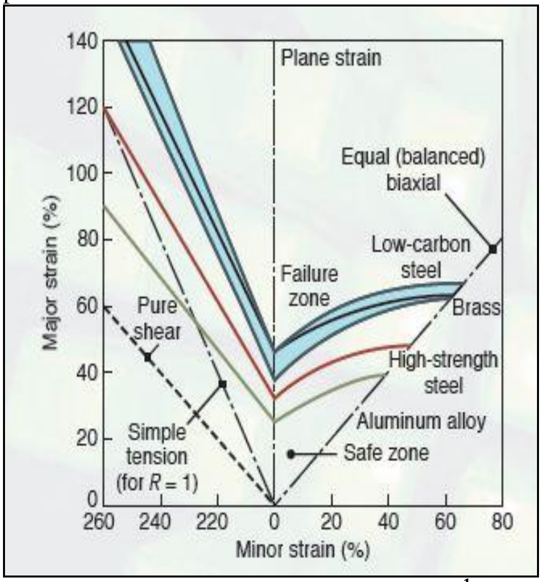


Fig. 2.1.1: Forming Limit Diagram[1].

In the experimental method, a certain diameter of circle in the form grid pattern ate printed on the surface of the sheet metal. The sheet metal gets deformed in stages. The grid pattern is examined during the each stage of deformation. Printing circular grids on the surface of sheet metal gives the advantage that during the deformations the circles will get deformed into ellipses with their major or minor axes directed along principal directions of strain.

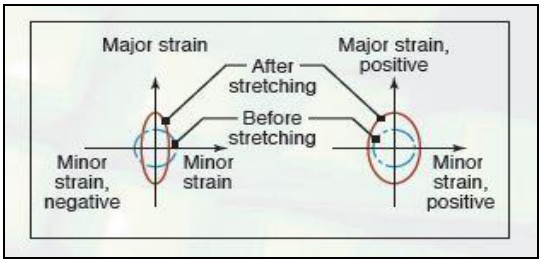


Fig. 2.1.2: Illustration of the Positive and Negative Minor Strains[1].

Principal strains and their directions can be determined by the measurement of the axes and the measurement of diameter of the circles. As the forming progresses, at some region neck may occur. The ratio of strains is determined at that region. This is a point on finite limit diagram or curve which separates the safe and the unsafe regions. The region above the lines is the failure zone and below is safe. The state of strain in forming must be such that it falls below the curve for a particular material.

The Factors Affecting FLD

- Material properties, strain hardening and strain rate exponent.
- Thickness of sheet, finite limit diagram for thicker sheet is placed higher than for a thinner sheet with little or no change in diagram.
- The forming limit curve of softened sheet of same alloy and same thickness is positioned higher to that of hard sheet.
- Anisotropy in the sheet.
- Type of coating on the sheet.
- Type of pre-straining prior to testing. The finite limit diagram may be modified by altering strain path. It can be positioned higher by selecting proper strain path.
- The orientation of test specimen with respect to rolling direction.

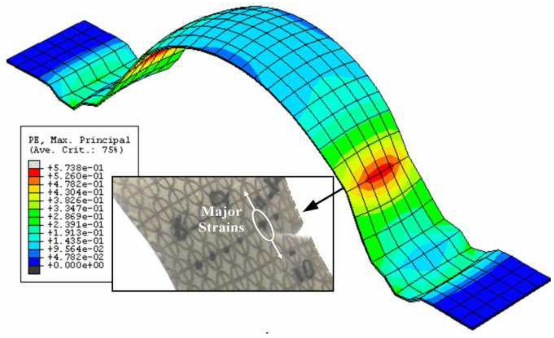
III. METHODOLOGIES

Different kinds of methodologies used for sheet metal forming process are described as follows:

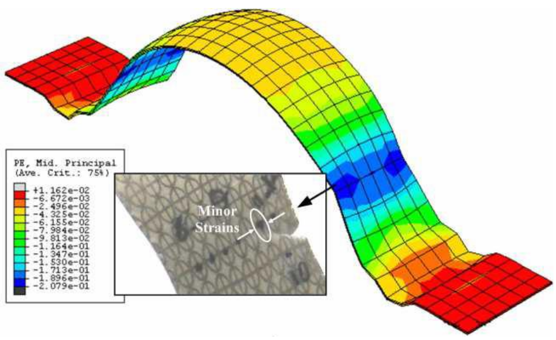
A sheet metal stamping process of mild steel for a wheelhouse used in automobile industry is examined by using an explicit nonlinear finite element code and incorporating failure analysis and design under uncertainty. Margins of tearing and wrinkling are quantitatively defined via stress based criteria for system level design. A robust design model is created to conduct a probabilistic design, which is made possible for this complex engineering process via an efficient uncertainty propagation technique. The weighted three-point-based method which estimates the statistical characteristics of the responses of interest, and provide a systematic approach in designing a sheet metal forming process under the framework of design under uncertainty.

The result shows that the study for robust design in the sheet metal stamping is used to consistently quantify the margin of safety or failure and to efficiently take uncertainties into account to create a system level robust design model. The robust design for a wheelhouse stamping process is conducted to maximize the total mean value of margins and to minimize the total variance of margins. The feasibility of the implementation of design and optimization under uncertainty in sheet metal forming processes constrained with failure analysis is presented in the paper by Thaweepat Buranathiti, Jian Cao, Z. Cedric Xia and Wei Chen [3].

A theoretical failure model is designated for the numerical predictions of the forming limit strains of automotive sheets which are used in the automobile industries. For the computational prediction of forming limit diagrams under plane stress deformation conditions, a numerical model is demonstrated. The numerical model procedures the Hill's orthotropic yield criterion which is the description of the directional variation of yield stress and Swift's diffusive necking and Hill's localized failure criteria are employed in the deformation induced failure prediction of the sheet metal. Using an additive back stress form of the nonlinear kinematic hardening rule The Bauschinger effect is involved correctly in the deformation modeling. A set of algebraic equations are generated by transforming the failure conditions and plasticity model. These algebraic equations that might be resolved incrementally for both proportional and non-proportional deformation paths.



a)



b)

Fig. 3.1: (a) Major Strain of the SM of 30 mm Width (b) Minor Strain of the SM of 30 mm WIDTH[4].

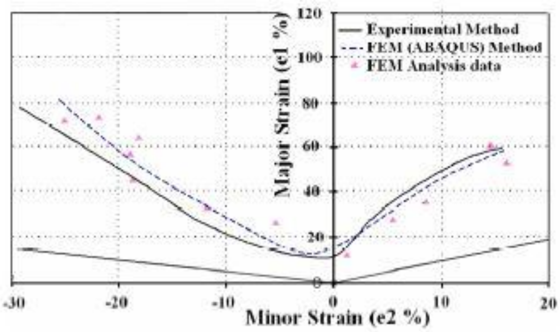


Fig.3.2: Comparison of the FLD Curves Obtained by FEM and Experimental Method[4].

It is predicted that finite limit curves for steels are sufficiently accurate and conservative in each sides of finite limit diagrams which is presented in the paper by Mehmet Firat [4].

The formability of the sheet metals which is a critical to the success of sheet metal forming processes. The finite limit diagrams have been determined in this paper experimentally for some grades by conducting punch stretching, an appropriately designed and fabricated tools. The Formability detected from finite limit diagrams has been related with mechanical properties and formability parameters like type of punch used, diameter of punch, resistance takes place between punch and sheet, work hardening exponent (n) and plane anisotropy (r) of the sheets. Influence of sheet metals thickness, influence of lubricant such as mineral oil, influence of work hardening exponent and plane anisotropy values on the finite limit diagrams are also discussed in the paper.

The results shows that with the increasing the thickness of the sheet metals, the forming limit strain is increased. Dry test is much more sensitive to the small variations in the mechanical properties than that of the lubricated tests. The material properties such as r and n values affect the finite limit diagrams. The limiting strains increases with the increasing the n and r value for the sheets which is presented in the paper by S. A. Jenabali Jahromi, A. Nazarboland, E. Mansouri, S.Abbasi [5].

The numerical finite element method is used for determining forming limit stress diagrams of the sheet metal. The conventional forming limit diagrams is well accepted tool for predicting the formability and safety limit of the material in sheet metal forming processes. The finite limit diagram is a strain based criterion by which principal strains at failure are evaluated. The forming limit diagram is dependent on forming history and strain path, but stress based criterion does not confirm this dependency. This criterion is more robust against any changes in strain path occurring in the forming process. A determination method of the stress based failure criterion for sheet metal forming was introduced in the paper by Sansot Panich, Vitoon Uthaisangsuk, Jittichai Juntaratin and Surasak Suranuntchai [6].

IV. CONCLUSION

As on today, most of the research work has been carried out on sheet metal determining the finite limit diagram by finite element method, experimental method, numerical analysis, material optimization on sheet metals. An attempt is to be carried out on forming analysis of an automobile air filter mounting bracket based on above criteria.

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