Integrated Process Simulation and Die-Design in Sheet Metal Forming

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***Abstract*— The design of new forming tools gets more problematic as the geometries get more complicated and the materials less formable. The idea with this project is to evaluate if an implementation of simulation software in the designing process, to simulate the forming process before actually building the tools, could help avoid expensive mistakes.**

In order to see the effect of die deformation on the forming of sheet metals, the draw-ins, strains, and spring backs of an automotive fender panels are numerically simulated considering the die deformation, which is found by the simultaneous structural analysis of press and dies. By coupling the forming analysis and the structural analysis, the die deformation is simultaneously taken into account in the forming process.

***Index Terms*: CATIA, Die Design, FEM Integration, Process Simulation, Sheet Metal Forming**

I. INTRODUCTION

In the recent years, the role and importance of metal forming processes in manufacturing industry have been continuously increasing primarily due to its material and cost effective nature. It is further emphasized by the recent advances in tools, materials and design, which in turn provide significant improvements in the mechanical properties and tolerances of the products. Moreover, in the recent years metal forming develops in the direction of net-shape or near-net-shape manufacturing to reduce the need for subsequent machining operations and to minimize the total manufacturing cost. Consequently, in metal forming both the process planning and the tool design represent very important and complex tasks.

The global competition also requires that manufacturing industry besides the skill and the experience accumulated in the shop practice should increasingly utilize proven techniques of Computer Aided Engineering for rapid and cost effective process design and tool manufacturing. The application of various methods of Computer Aided Engineering has become one of the most important topics in manufacturing industries and particularly in the automotive industry.

To illustrate the metal forming process, there must be a model of the real process. This is calculated in the software using the finite element method based on implicit or explicit incremental techniques. The parameters of the model must describe the real process as accurately as possible so that the results of the simulation are realistic.

In metal forming simulation, the forming of sheet metal is simulated on the computer with the help of special software. Simulation makes it possible to detect errors and problems, such as wrinkles or splits in parts, on the computer at an early stage in forming. In this way, it is not necessary to produce real tools to run practical tests. Forming simulation has become established in the automotive industry since it is used to develop and optimize every sheet metal part.

II. PROBLEM DEFINATION

- The design for die and punch are less efficient.
- Limited die and punch for complex shape.
- Deformation of the blank is typically limited by buckling, wrinkling, tearing, and other negative characteristics which makes it impossible to meet quality requirements or makes it necessary to run at a slower than desirable rate.
- Spring back is a particularly critical aspect of sheet metal forming. Even relatively small amounts of springbuck in structures that are formed to a significant depth may cause the blank to distort to the point that tolerances cannot be held.

III. OBJECTIVES

The main part of this project lies in simulating the different stages of the stamping process and together with a design engineer decide how the forming tools should be designed. This will, hopefully, make the design process smoother and also spare the company expensive trial and error time.

IV. LITERATURE REVIEW

Miklós Tisza,et al [1] stated that Computer aided engineering has a vital and central role in the recent developments in sheet metal forming concerning the whole product development cycle. The application of various methods and techniques of CAE activities resulted in significant developments.

In their research an integrated approach for the application of knowledge based systems and finite element simulation is introduced. Applying this knowledge and simulation based concept for the whole product development cycle – from the conceptual design through the process planning and die design as an integrated CAE tool – provides significant advantages both in the design and in the manufacturing phase.

Y.T.Keum, et al [2] carried out the forming and the spring-back analyses of an automotive fender panel by coupling the forming analysis and the structural analysis for considering die deformation. The distributions of stress and deformation of the dies are obtained by introducing the simultaneous dies-press analysis. By adopting deformed tools found by the structural analysis in the forming analysis, the drawins, strains, and spring-backs in the draw panel were accurately predicted.

T. Dutton, E. Pask [3] stated that, a combination of implicit and explicit time integration finite element calculations can successfully simulate the displacements associated with surface defects. The visual impact of such simulated defects can be examined using photo chromatically correct ray-tracing techniques. The combination of these methods will allow the designer and manufacturing engineer to identify areas of concern earlier in the design process and examine the benefit of design or tool modifications.

Andersson [4] carried out an experiment to find out Comparison of Sheet Metal Forming Simulation and Try-out Tools in Design of Forming Tools. And as a result he said that the use of sheet-metal-forming simulation leads to a significant reduction in both cost and time compared with the use of try-out tools. The requirement is that the respective parameter for study demonstrates good correspondence between simulation and actual production processes. Sheet metal-forming simulation is also superior to try-out tools with regard to predicting and verifying the forming process.

V. PROCESS PLANNING AND DIE-DESIGN IN SHEET METAL FORMING

One of the main drawbacks in industrial practice hindering the even more wide application of simulation techniques that the output results of simulation packages are not usually directly and easily usable for computer aided die design. Obviously, there are tremendous efforts to successfully link CAD and FEM systems, however; still there are a lot to do in this field [4].

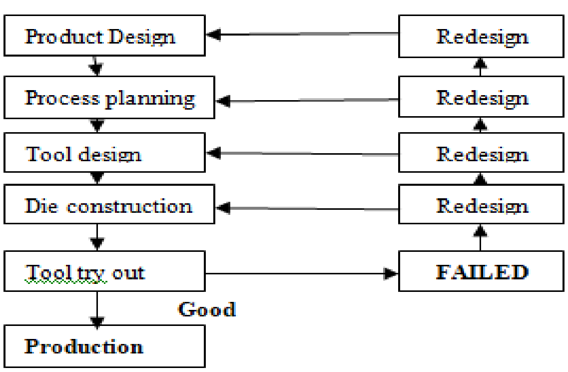


Figure 1 : Flow chart of process planning and die design in traditional CAD environment

his solution requires a fully integrated approach of computer aided product design, process planning and die design, as well as the finite element simulation of the forming processes. It means that simulation tools should be efficiently used throughout the whole product development cycle [5].

If the try-out is successful, i.e. the die produces parts with no stamping defects, it will be sent to the stamping plant for production. On the other hand, if splitting or wrinkling occur during the tryout, the die set needs to be reworked.

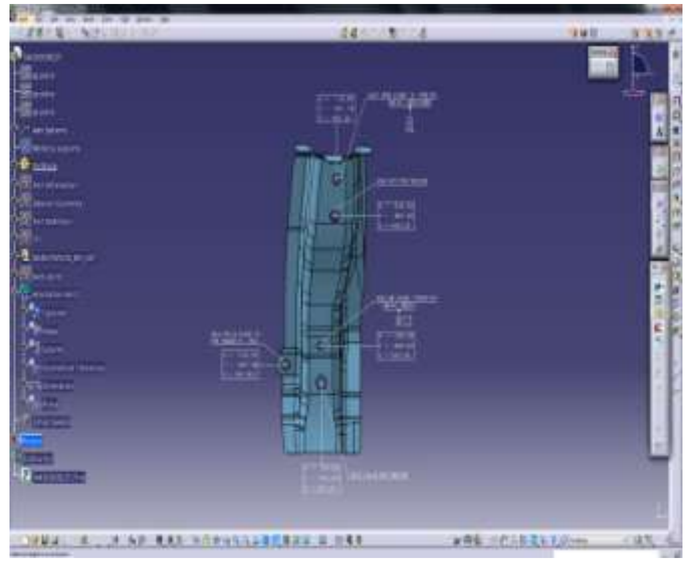


Figure 2 CAD Model of the component 1

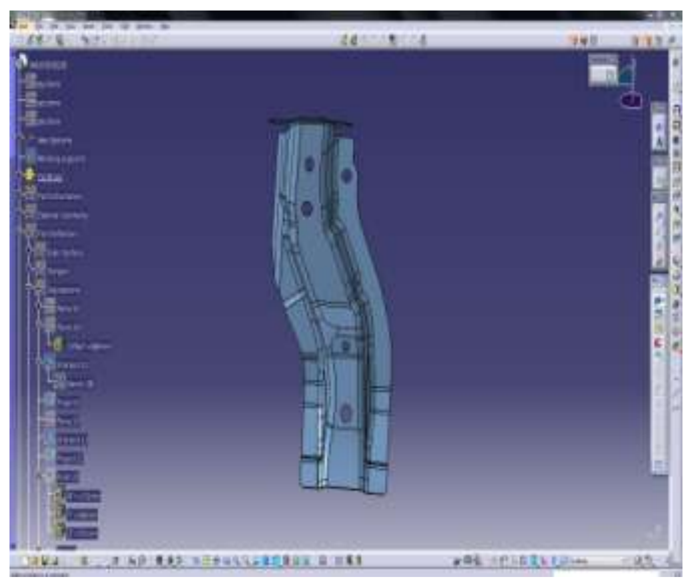


Figure 3: CAD Model of the component 2

A piercing die has to be design for the following above CAD model. Each component has 3 holes of different diameter. To design the punch and die button for the holes a standard dimension chart is used.

HOLE CHART (WITH FINISH PUNCH & DIE SIZES) *AS PER PE GUIDE LINE

COMP. THK	1	MATERIAL STRENGTH	[illegible]					CUTTING CLEARANCE %	10
			FOR ROUND HOLES	FOR OBLONG & SQUARE HOLES		ONLY FOR SPECIAL TOLERANCE CASES			
HOLE NO	FEATURE TYPE	CLASS	HOLE DIA	SLOT WIDTH	SLOT LENGTH	SPL TOL (LOWER VALUE) FOR SPECIFIC REQUIREMENT	SPL TOL (UPPER VALUE) FOR SPECIFIC REQUIREMENT	PUNCH SIZE	DIE SIZE
1	ROUND	ACLASS	10.5					Ø 10.6	Ø 10.84
2	ROUND	ACLASS	8					Ø 8.1	Ø 8.34
3	OBLONG	ACLASS		12	8			12.1 X 8.1	12.34 X 8.34

Figure 4: Standard Hole Chart

A piercing die comprises of two parts, i.e. Lower Die & Upper Die.

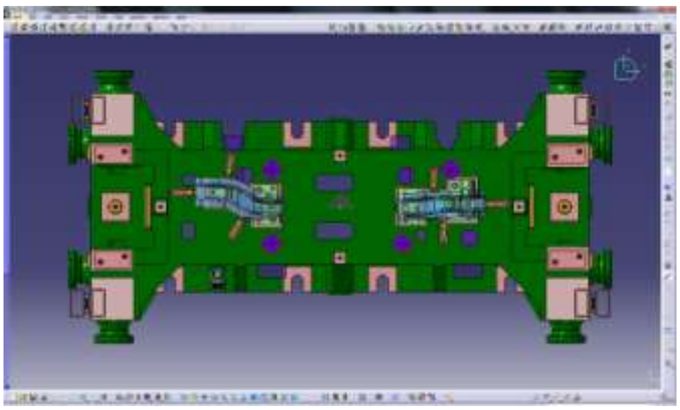


Figure 5 : Lower Die with component

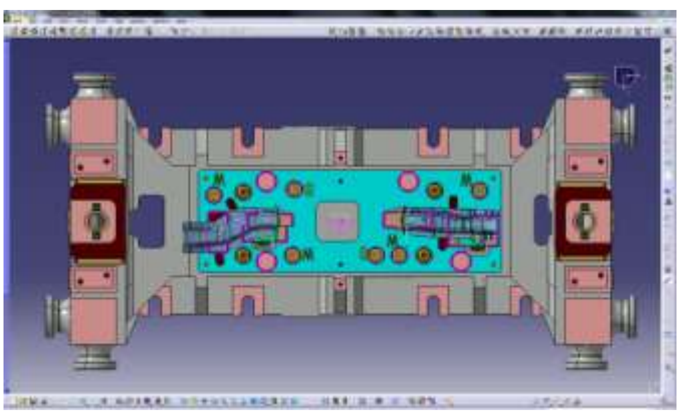


Figure 6 : Upper Die with component

- Die material: cast iron
- Component material: DP590
- Sheet thickness = 1.2 mm

Calculation:

- Cutting load [F] = L * t * τ_b

  Where, F = cutting load

  L = cutting parameter

  t = sheet thickness

  τ_b = sheet shear strength

  F = 220.780*1.2*590

  F = 156312.24 N

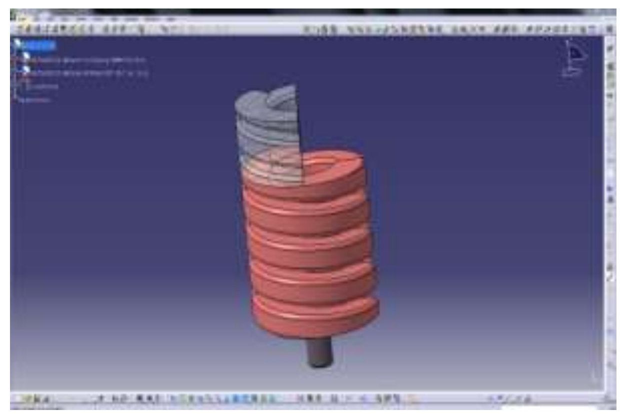
  F = 15631 Kg
- Stripping load = 10% of cutting load

  15631/10 = 1563.1 Kg = 1.5 tonne
- Clearance = 0.095 mm (from table)
- Entrance = 6mm
- Stripper stroke = 10mm + Sheet thickness + entrance

  = 10mm + 1.2mm + 6mm = 17.2mm ≈ 15mm

  Coil spring is used to balance the exerting force.

  Selection of coil spring is done by using the MiSUMi standard part handbook.



SWM 30.50 coil spring is used (from handbook) which exert the force of 168.75 Kgf.

- Stripper force = stripping load / spring force

  = 1563/168.75 = 9.27 ≈ 10

Therefore, 10 springs are used to balance the force.

- Weight calculation ;

  Total weight = Die Volume * weight factor * specific gravity of steel

  Die volume = 1950mm*800mm*380mm

  $=592.8*10^6 mm^3$

  Weight factor = 0.4

  Specific gravity of steel = 8 gms/cm^3

  total weight = $(592.8*10^6)*0.4*(8*10^{-6})$

=1896.96 Kg

≈ 1..5 tonne

Combine weight of die = 3 Tonne

VI. DISCUSSION & RESULT

The following piercing die is designed as per the requirement for both, in-house try-out press and for the vendor's end press.

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