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Design and Analysis of Progressive Die for an Industrial Component

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Abstract: Dies had been used in industries from years, especially for sheet metal and other forming operations. Progressive dies are forming tool comprises of two or more stations performing different operations. The raw material travels from first station to last to be formed into the finished product. In sheet metal manufacturing, the process of design and development of different components is a highly intricate. It leads to various uncertainties. These uncertainties can cause heavy manufacturing losses. Identification of these risks and resolving them is a tough job for the designer. So in this paper authors have discussed about development of a computer-aided progressive die design for an industrial component with an analysis. Design and analysis of progressive die for the given component leads to precise path for various operations which results into maximum use of material. Previously the component has been made using simple dies for different operations. Use of progressive die is beneficial because of the ability to build precision tooling in less time and at a lower cost which also can reduce labour cost.

Keywords: Design complexity, progressive die, computer aided design and analysis, precision tooling, increased productivity etc.

I. INTRODUCTION

Press stampings are prime preference for mass production of various mechanical parts. Die design is an important discipline in the engineering field, specifically in tool engineering. To stamp and form various parts from sheet metals stamping dies are used. Various operations are performed using dies. Also this operations are important factors in mass production. The design of good die requires input from designers, knowledge, skill and experience [2]. Use of progressive dies for stamping operations are one of the advanced technologies.

They can be used for production of parts having complex shapes without the necessity of operator. So the progressive stamping dies need a high level of engineering design and manufacturing technology in order to get precise layout of large number of stamping stations in a limited and narrow shape [6].

In this paper authors have discussed about developing such progressive die which can use low cost standardized tools for production. It is aimed to develop a die which can reduce production time along with cost and accuracy of production must be maintained. So it implies the standard design, modelling and analysis of progressive die operations required for production of final part.

II. LITERATURE REVIEW

The authors B.T. Cheok, K.Y. Foong, A.Y.C. Nee, C. H. Teng discussed about various aspects of knowledge-based approach for progressive stamping die design. They examined some critical issues associated with modelling of progressive die design in knowledge-based expert system [1].

The authors T. Nagakawa, S. Futamura, T. Murata, discussed about the new concept in tooling system and the press machine for the widely used progressive stamping tooling. In their paper the conventional progressive die setup is been standardized [2].

The authors K. Shirai, H. Murakami discussed about the development of a CAD/CAM system for progressive dies. In response to the increasing demand for press tools, a compact and practical CAD/CAM system for progressive dies is developed [3].

The authors Z.Q. Sheng, R. Taylor, M. Strazzanti discussed about FEM analysis and design of bulb shield progressive die. Draw processes of a dome shape bulb shield are modeled and analyzed in this paper [4].

The authors K. Park and S. Choi discussed about Finite element analysis for the lamination process of a precision motor core using progressive stacking dies. Motor cores have been fabricated using progressive stacking dies with lamination in order to obtain better electro-magnetic properties [5].

J. Choi and C. Kim discussed about a compact and practical CAD/CAM system for the blanking or piercing of irregular shaped-sheet metal products for progressive working. This paper describes research work into developing the computer-aided design and manufacturing of stator and rotor parts with blanking or piercing operations [6].

In this paper, the author Prakash H. Joshi ,given the design and construction of press tools in which various types dies viz. single stations dies, compound dies, combination dies, progressive dies etc. A stepwise design calculations are given for design of various dies [8].

III. PROBLEM STATEMENT

Initially, the component has been manufacturing from single station dies for different operations. The manufacturers are small scale manufacturers. The component to be develop has mass production. So they aims to develop a progressive die system for the same component with reduction in production time along with cost without affecting the accuracy.

IV. OBJECTIVES

To reduce production time along with cost.
To achieve maximum accuracy.
To reduce the labour cost.
To improve quality of the product.

V. DESIGN

A. About the Component

The component to be designed is called as tailgate striker which is assembled with nut bolt in head/back light assembly of four wheeler. The diagram below shows 2D model of the component,

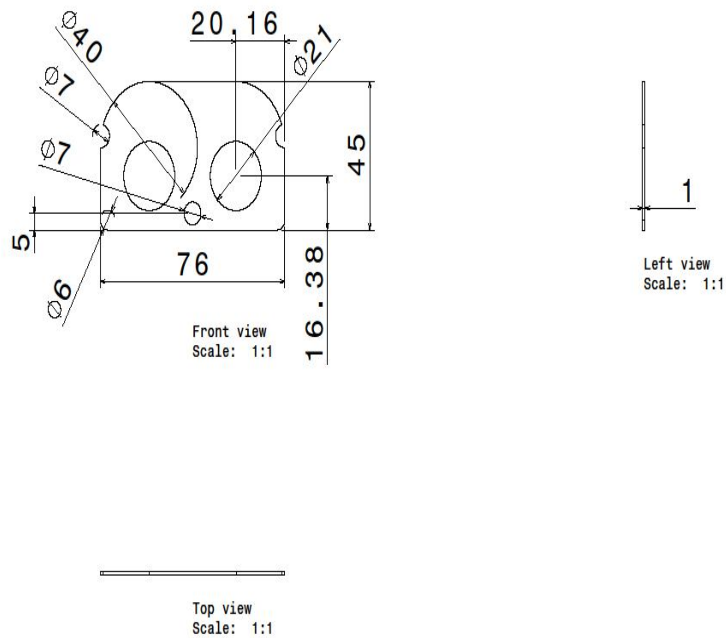

Fig. 1 2D model of component

B. Design Calculations

Operations on progressive die for development of the given component includes

- Blanking
- Piercing

According to the dimensions of the component and by using standard calculation methods for designing progressive die, we found results for required parameters. The table below shows the values obtained.
Material of the component is MS
Shear strength taken as $400 N/m^2$

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TABLE I
DESIGN PARAMETERS BY CALCULATIONS

Parameters	Value
Punch and die size for piercing holes	Ø7.12mm Ø21.12mm
Punch and die size for blanking	Same as original blank
Cutting force	15.06 ton
Actual press tonnage	20 ton
Top plate	45mm
Bottom plate	45mm
Guide pillars	4 in number
Area of the component	3000mm^2
No. of blank per sheet	24
Utilization of Sheet	70.24%
Punch holder and Stripper plate	11mm
Stripper Plate	8 to 9mm

VI. ANALYSIS

Static and modal analysis are done on progressive die assembly. The progressive Die assembly is been mesh with first order 3D Hexa-element and Second order Tetra elements in Ansys Workbench. SOLID185 is used for 3-D modeling of solid structures. It is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, hyper elasticity, stress stiffening, creep, large deflection, and large strain capabilities.
We have done modal analysis to find out frequencies so if resonance would occur or not. Also we have done static structural analysis to find out various stresses and whether are in limit or not.

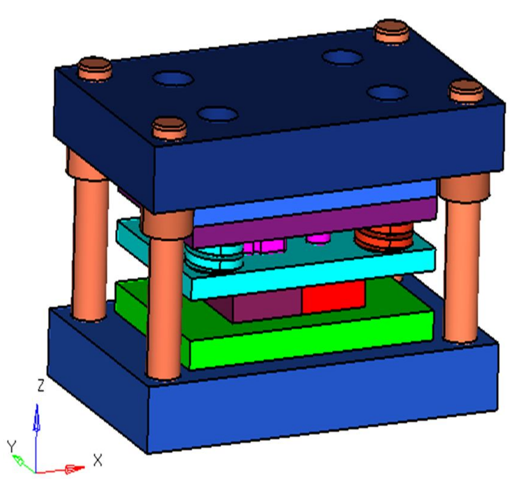

Fig. 2 Solid model of Progressive die

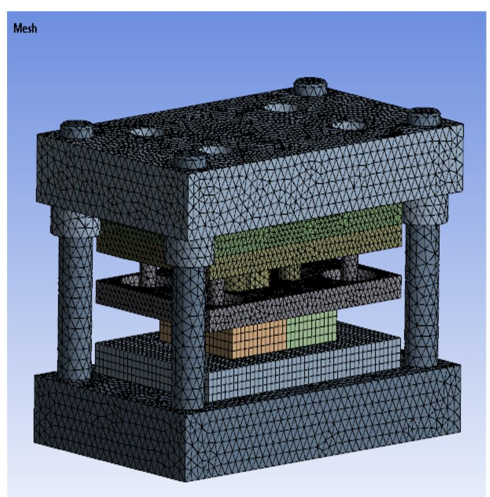

Fig. 3 Meshed model of Progressive die

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A. Modal Analysis

We obtained first five frequencies of progressive die assembly in ANSYS.

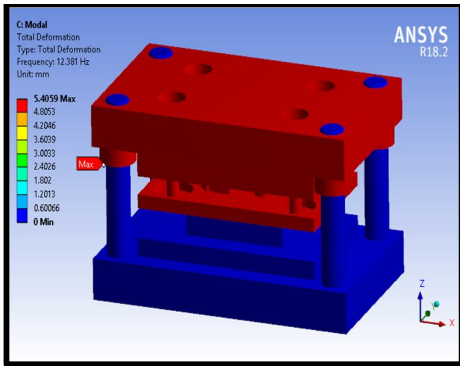

Fig. 04 1st frequency

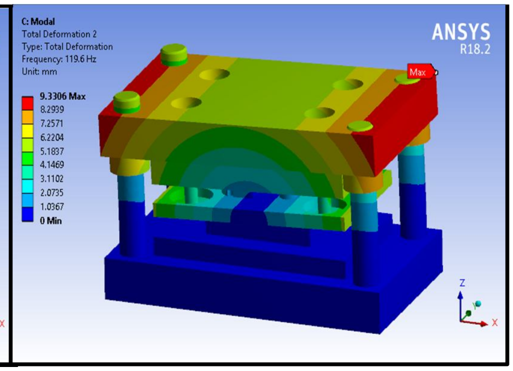

Fig. 05 2nd frequency

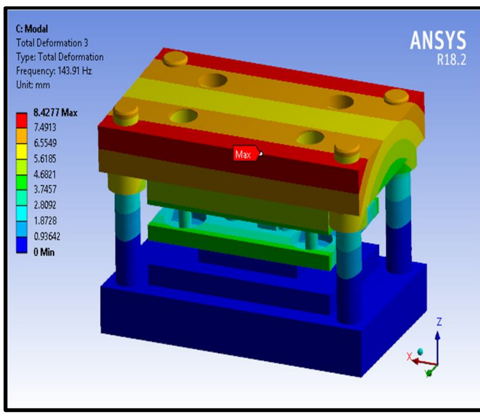

Fig. 06 3rd frequency

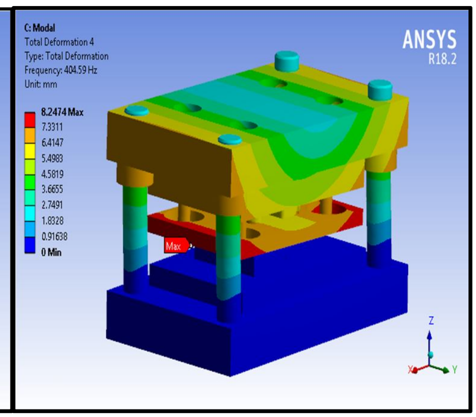

Fig. 07 4th frequency

Here the natural frequency of the progressive die assembly is 12Hz. All the five frequencies are not coincide with the natural frequency.

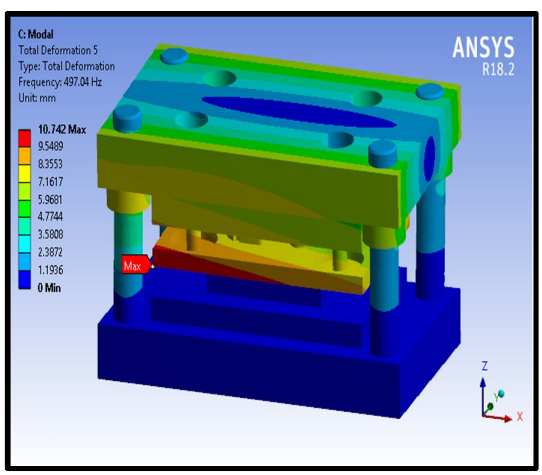

Fig. 08. 5th frequency

B. Static Structural Analysis

We have done static structural analysis to find displacements and various stresses acting on progressive die assembly

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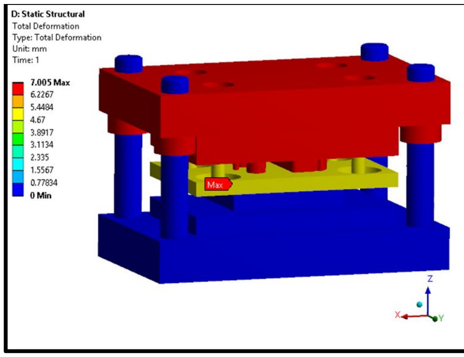

Fig. 09 Displacement of assembly

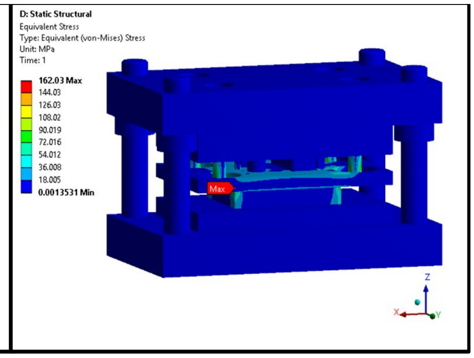

Fig. 10 Von Misses Stresses generated on assembly

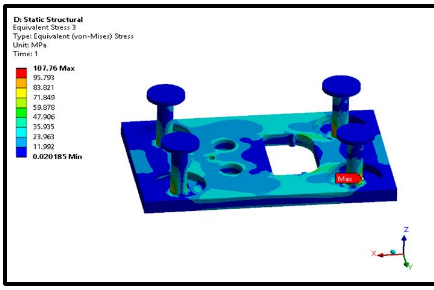

Fig. 11 Von Misses Stresses on stripper

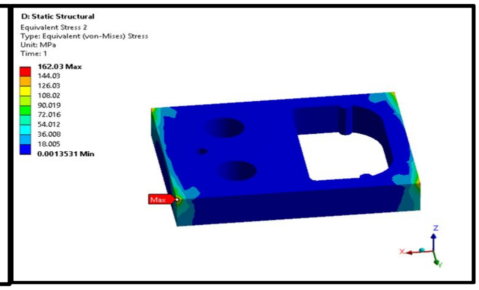

Fig.12 Von Misses Stresses on die

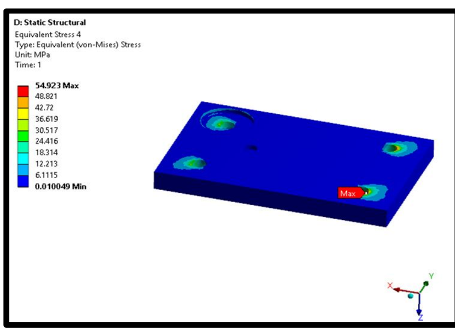

Fig. 13 Von Misses Stresses on bottom plate

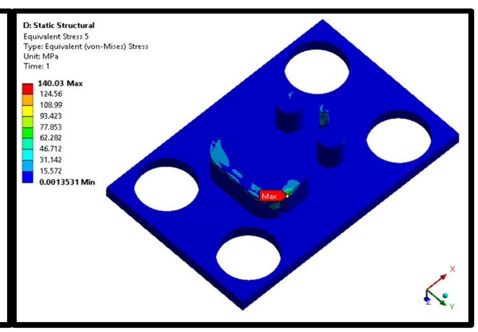

Fig. 14 Von Misses Stresses on punch and punch holder

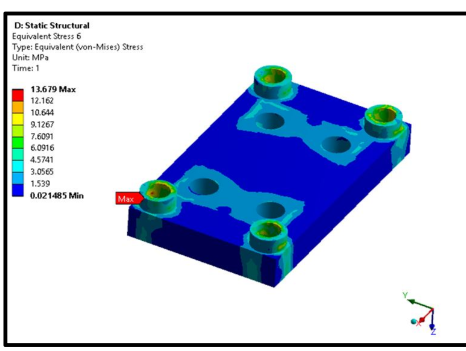

Fig. 15 Von Misses Stresses on bottom plate

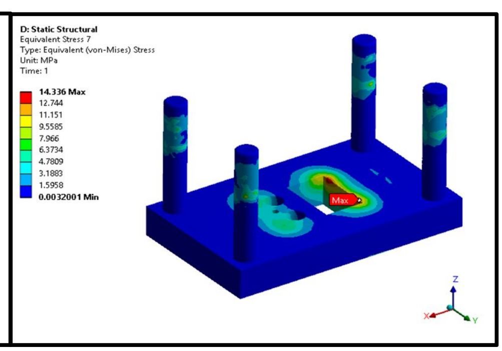

Fig. 16 Von Misses Stresses on guide pillars

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The max in the figures shows maximum displacement takes place during operations.

VII. OBSERVATIONS AND RESULTS

Following are the results obtained from modal and static analysis of progressive die assembly

Table II Observations From Modal Analysis

Modes	Frequency
1	12.38
2	119.6
3	143.91
4	404.59
5	497.07

From the above modal analysis it is been observed that First natural frequency on the progressive die assembly is 12 Hz. The operating frequencies or external excitation frequencies should not coincide with the said above natural frequencies in order to avoid resonances.

Table III Observations from static structural analysis

Sr.No.	Parameters	Von Misses Stress(Mpa)	Yield Stress(Mpa)
1	DIE	162	827
2		107	370
3		55	370
4	PUNCH	140	827
5		13	370
6		14	370

Table IV Experimental Results

Parameters	Before	After
Total Time required	33 secs	12 secs
Utilization of sheet	61.33%	70.24%

From the above static structural analysis it is been observed that maximum von misses stresses are well below the yield stress. Also from experimental results we can clearly see that the difference in time and utilization of sheet.

VIII. CONCLUSION

Progressive die is economical way to form metal components, it keeps the strength, durability of metals. Also FEM analysis done for progressive die components. The calculations and FEM results are within limits. All results of stresses and frequencies obtained from analysis shows that they are in acceptable range. So the designed progressive die is safe for the production of given components under loading conditions.

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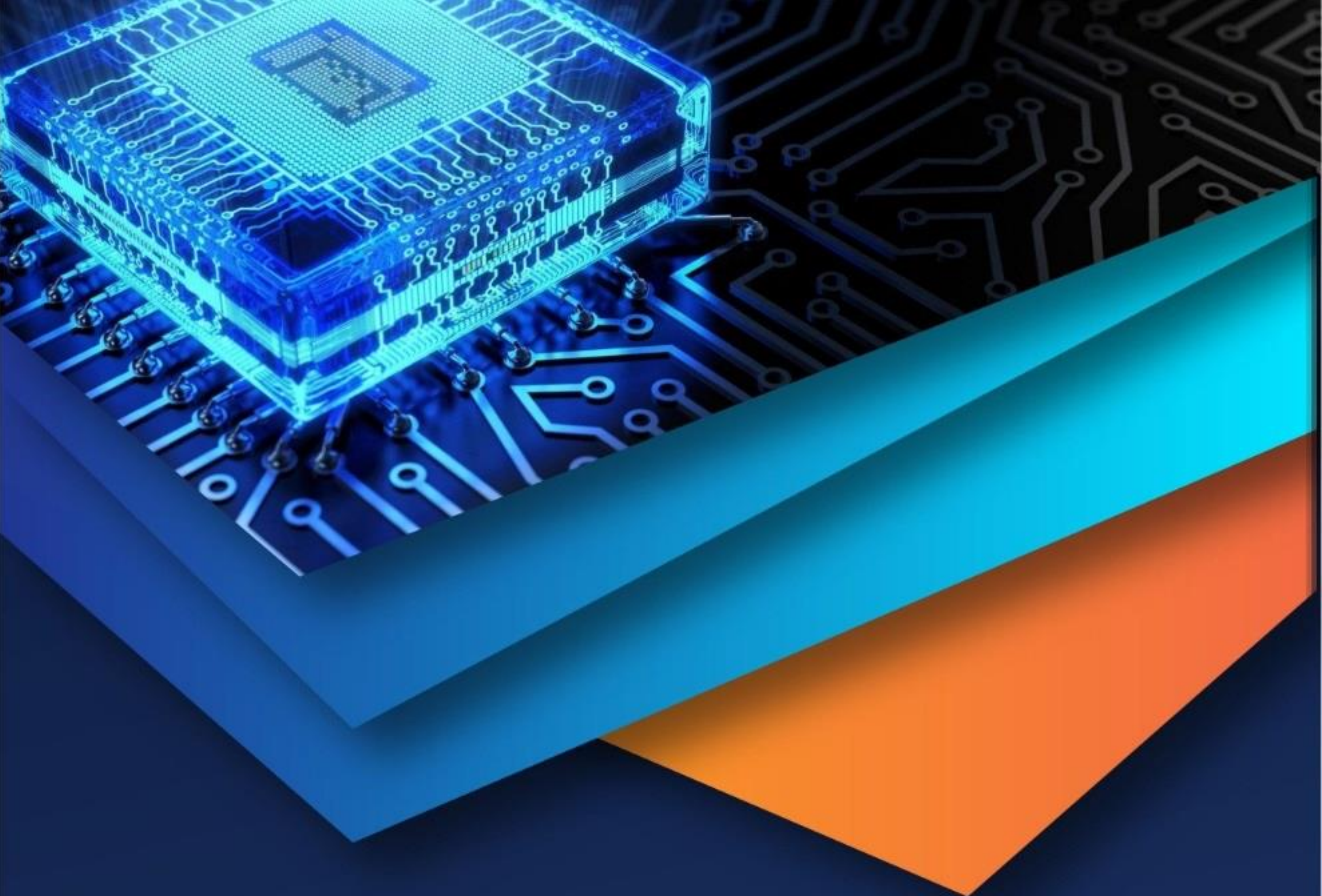

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