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Design of a Punch and Die System in a Trimming Machine for Fettling of Casting

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***Abstract*: A die is a specialized tool used in manufacturing industries to cut or shape material mostly using a press. Like molds, dies are generally customized to the item they are used to create. Products made with dies range from simple paper clips to complex pieces used in advanced technology. Trimming is basically a process in which the unwanted, excess or irregular features are removed from a part. Usually trimming is the last operation carried on the part after which a finished part is formed. The main aim of this paper is Design and analysis of a punch and die system in a trimming machine for fettling of differential bearing cap manufactured by casting. The component considered here is a bearing cap.**

***Keywords*: Die, Casting, Trimming, differential bearing cap**

1. Introduction

A differential is located between the front and rear axles of an automobile. It is responsible for transmitting appropriate amount of power to the drive wheels during cornering. The differential is supported by a bearing system. Casting is the process of manufacturing metal or alloy parts. The parts of the desired shape are produced by pouring the molten metal into a prepared mould. Raw castings often contain irregularities caused by seams & imperfections in moulds, as well as access ports for pouring material into the moulds. Further, machining of the raw castings is required which involves cutting, grinding, shaving, or trimming away these unwanted bits this process is known as Fettling. The part i.e. Differential bearing cap is manufactured by casting process. After the castings, have been removed from the mold, the runners, & gates are removed. But even after shot blasting some unwanted thin fin of about 1.5 to 2.0mm thickness along its perimeter is observed. So, it is required to cut-off these extended fins from the component in the finishing process.

A. *Scope*

- Within the front or rear axle system of an automobile lies a differential which transmits the appropriate amount of power to the right or left drive wheels during cornering.
- The differential is free to rotate on a bearing system. Differential Bearing Caps are used as clamps to retain the bearings and attach the differential to the axle housing.
- These Differential bearing caps are mass produced by casting process.
- After the castings have been removed from the mould, the runners, & gates are removed. But even after shot blasting some extended projections or fins are observed on the finished product.

2. Design

Following are the main components required to be designed for trimming of the differential bearing cap

- Working Components
- Dies
- Punches
- Structural Components
- Punch holder
- Die holder
- Guiding Components
- Guide posts
- Bushings

3. Design of die

A. *Parameters to be considered in designing of die*

- Centre of Pressure
- Cutting Force
- Die Block Thickness
- Power in Press work
- Energy in Press work
- Die Holder Thickness

B. *Procedure to calculate center of pressure*

- Draw the outline of the part.
- Place X & Y axes in a convenient position.
- The outline of the part is divided into convenient line elements and numbered as 1, 2, 3 & so on.
- The length L1, L2, L3, etc. of these lines elements are calculated.
- The centroid of these line elements is also calculated.
- The distance of centroid from the X & Y axes is determined. Let x1, x2, x3 & y1, y2, y3 be the distance of centroid of the line elements from the Y & X axes respectively.
- The distance of center of pressure from each axis is

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determined by using following formula

$$X = \frac{x1*L1 + x2*L2 + x3*L3 + \ldots}{L1 + L2 + L3 + \ldots}, \quad Y = \frac{y1*L1 + y2*L2 + y3*L3 + \ldots}{L1 + L2 + L3 + \ldots}$$

Table 1
Calculation of center of pressure

No.	L (mm)	y(mm)	L*y
1	28	0	0
2	131.946	26.738	3527.972
3	28	0	0
4	45	22.5	1012.5
5	28.5	45	1282.5
6	6.94	48.47	336.3818
7	92.059	47.777	4398.303
8	6.94	48.47	336.3818
9	28.5	45	1282.5
10	45	22.5	1012.5
Total perimeter = 440.885 mm			13189.04

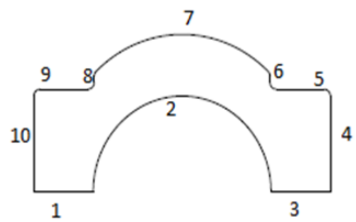

Fig. 1. Numbering of line elements in calculation of center of pressure

4. Design of punch

- The punch must be perfect mate to the die block opening the size of the working Surface of the punch is obtained by subtracting the total clearance from the desired size of the blank.
- Shear is provided on the die surface for the blanking operation.
- The punch is usually provided with a wide flange or shoulder to facilitate mounting and prevent its deflection under load.
- The minimum length of punch should be such that it extends far enough in the die block opening to ensure complete shearing of the blank.
- The Punch length must also provide for anticipated number of regrinds.
- Punches are generally made of good grade tool steel, Hardened and ground. The hardness recommended is C60 to C62.
- Punches with unguided length of more than 100 mm are avoided.

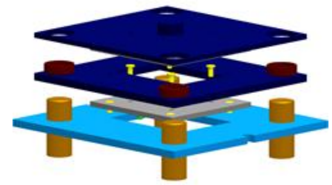

Fig. 2. Design of punch

5. CAD Design

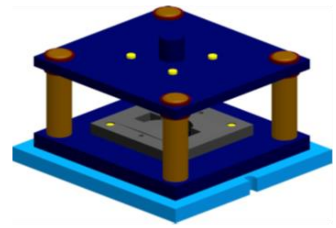

Fig. 3. Solid model of punch and die assembly

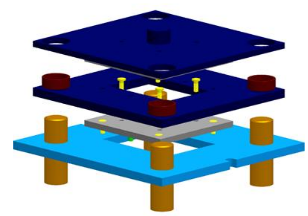

Fig. 4. Exploded view of punch and die assembly

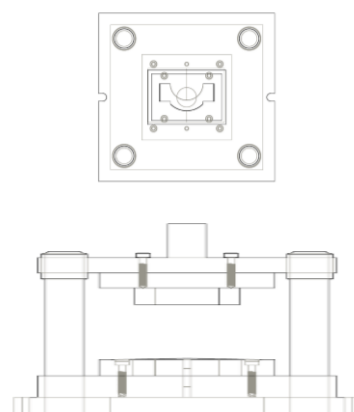

Fig. 5. Orthographic drawings of assembly of punch and die system

6. Results

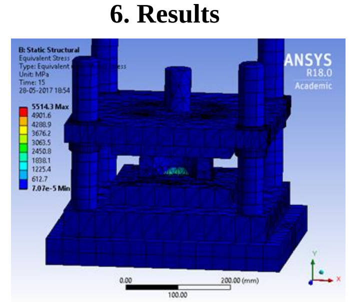

Fig. 6. Result

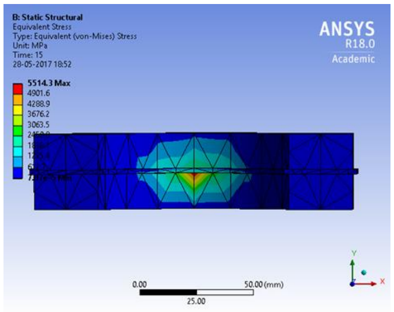

Fig. 7. Result

A. *Finite element method for design*

Numerical methods provide a general tool to analyze arbitrary geometries and loading conditions. Among the numerical methods, Finite Element Analysis (FEA) has been extensively used with success; however, this kind of analysis requires the generation of a large set of data in order to obtain reasonably accurate results and consumes large investment in engineering time and computer resources is a good choice for the analysis of sheet metal processes since it helps in eliminating the need for time-consuming experiments to optimize the process parameters The FEM simulations are increasingly used for investigating and optimizing the blanking processes. Many time-consuming experiments can be replaced by computer simulations. Therefore, highly accurate results of sheet metal forming may be obtained by using the FEM simulation. The finite element method gives an approximate solution with an accuracy that depends mainly on the type of element and the fineness of the finite element mesh. In the manufacturing area, Design of Experiments (DOE) is found to be an efficient statistical technique that can be used for various experimental investigations. The design of experiments is one of the powerful tools used to investigate deeply hidden causes of process variation. It is a systematic, rigorous approach to engineering problem solving that applies principles and techniques at the data collection stage to ensure the generation of valid, defensible, and supportable conclusions. In the blanking process, experimental design is considered a powerful approach for product and process development, and for improving the yield and stability of an ongoing process found that the design of experiments technique is an efficient and cost-effective way to model and analyze the relationships that describe process variations.

The sheet metal industry is highly interested in knowing if two identical products manufactured of two different materials, can be blanked with a reasonable quality without the need to build two separate setups. This will increase the efficiency of the production processes and reduce the level of wasted materials, time, cost, and effort involved in the production stages. In addition, the industry needs a suitable model to overcome the long cycle time in developing a particular blanking process. This can be achieved by combining the Finite Element Method and Design of Experiments techniques aiming at identifying opportunities to increase efficiency and productivity as well as eliminating waste and reducing production cost associated with the blanking process. The main objective of this paper is to construct a finite element model to predict the shape of the cut side of a blanked product, and to investigate the effect of potential parameters influencing the blanking process and their interactions using the design of experiments approach in order to choose the process leading parameters in an optimal way.

7. Conclusion

- Design of Press tool for trimming of Differential bearing cap is developed by following the fundamental die design principles. The output received is;
- Output product having perimeter 440.8 mm and the required cutting force is 29.4 tons. So it suits for above 30 ton press machines.
- It is seen from the calculations of actual cutting forces, that as the shear on the die increases the cutting fore reduces.
- Shear of 1t, 1.5t, 2t and 3t were considered for the die. And by comparing the results a shear of 1.5t is suitable for the die as the cutting force lies within the range of available press tonnage capacity.
- More parts can be trimmed simultaneously if the shear on the die is maximized, as the cutting force required is less, but increasing shear also has some limitations.
- The tools generally made from steel alloys. Based on carbon composition they are classified in P type, D type, H type of all D type is having more carbon percentage which indirectly possess more strength. They are mainly used for making of tools.

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