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Design and Analysis of Blanking and Piercing Die Punch

V. G. Sreenivasulu
Department of Mechanical Engineering,
Tadipatri Engineering College,
Tadipatri, Andhra Pradesh 515411, India.

M. Ravi Prakash Babu
Department of Mechanical Engineering,
Tadipatri Engineering College,
Tadipatri, Andhra Pradesh 515411, India.

Abstract
The sheet metal working processes are widely used in almost all industries like automotive, defense, medical and mechanical industries. The major advantage for using metal working process is to improve production rate and to reduce the cost per piece. Nowadays many people are working for developing die punches with innovative ideas. This project is also based on new design for die punch. The project mainly focuses on different operations done on single setup of die punch in a single stroke, presently these operations are done on three separate setups which leading to reduce the production rate and increasing cycle time with cost as well. The theoretical calculations were done for calculating cutting force, tonnage required, Von-Mises stresses, fatigue life, buckling load and total deformation. The 3D parts are modeled in CATIA-v5 and saved in .stp file format so that it can be imported from any of the analysis software. As per the companies requirement cad drawings are drawn in AUTOCAD software. The various analyses like Von-Mises stress analysis, fatigue life, are carried out on Ansys 14.0 workbench analysis software and results are compared with theoretical results.nThe results are within 5% of allowable limit.

***Key Words:* Die punch, FEA, Ansys. Catia-V5,Autocad.**

INTRODUCTION

Processing steps involved in sheet metal industries, and increased knowledge in this process will help to improve the process and help in increase the production range of industry.

Now a day's sheet metal component are widely used in the day today life its ranging from household electrical component to big industries such as TV, camera, electrical ovens, computer as well as in automotive parts, aviation industries to reduce the cost as well as reduce the weight of the component and increase the performance of the product. Sheets with 0.2 to 20 mm thickness and higher are processed in industries depending on the requirement of customer or consumer or appl Forming processes like Piercing, Blanking, stamping and bending are very widely used in the making of sheet metal parts and it assembles different processes to manufacture sheet metal parts. Piercing and Blanking are metal shearing processes in which the input sheet material is sheared to a destination shape. In blanking, the blanked piece of material is the product and while in piercing, the material that is blanked is scrap while the remaining part of the strip is the product, as shown in the Figure. In this project, blanking and piercing are used to produce component. Blanking is one of the processes in which the sheet undergoes brutal deformation since the sheet metal is separated to have the slug and part.

Industries involved in sheet metal manufacturing shear cutting methods are widely used for high and low cost production. Shear cutting process is more advantages over the other conventional metal or sheet metal cutting operation. Sheet metal cutting operation is common in most of the
Citation.

Problem Statement

The aim of this project is to reduce cycle time of existing

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process of milling, blanking and drilling operation for component. These all operations need be combined in a single setup of die punch with a proper tool design. The monthly volume of component is 4000 to 6000 nos. Hence company needs cycle time reduction and cost reduction as well on these hinges to meet global competition. The existing cycle time of operations is approximately 4 minutes. After the implementation of this project we can expect this to 30 secs.

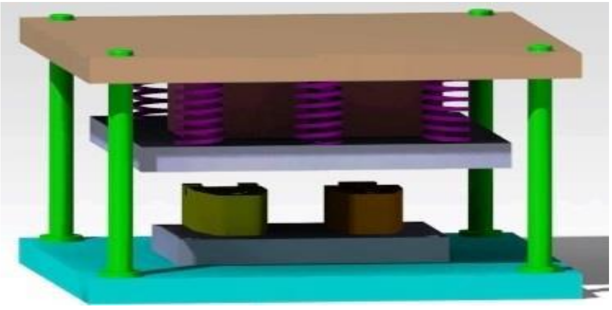

Fig -1.2 : 3D model of die punch

From Sheet Metal Forming Processes and Die Design

Blanking and punching dies are known as cutting dies. They may be simple, combination, or compound. A blanking die is generally cheaper to make and faster in operation than a trim die. A single blanking die can produce either a right or left part, while two trim dies are needed for trimming: one die for right-hand parts and another die for left-hand parts. When a sheared flat blank drops through the die block (die shoe) it piles up on top of the bolster plate. If the blank goes through the hole, it is called a drop-blank die. A die in which the sheared blank returns upward is called a return-blank die. Return-blank dies are slower in operation and cost more to build than drop-blank dies.

A punching die is a typical single-station die design for production holes made in flat stock, which may be manually or automatically fed. The stock guide keeps the stock on a straight path through the die. The amount of stock travel is controlled by the method of feeding, by stops of various designs, or by direct or indirect piloting. A combination die is a single-station die in which both cutting and non-cutting operations are accomplished at one press stroke.

Blanking Services Information

Show all Blanking Services ProvidersBlanking is a manufacturing process where a punch and die are used to remove blanks in preparation for processing and finishing. This cutting process is done by applying a shearing force to a material sheet. In blanking, the removed piece is the desired workpiece and is referred to as a blank. The process can be used to cut out almost any 2D shape and is commonly used for simple workpieces with simple geometry. Due to the shearing force, the pieces often need a finishing to smooth out burrs.

LITERATURE REVIEW

Identification of tool wear influence on process parameters of sheet metal blanking includes an exhaustive literature review of various authors. For literature review research papers are collected from various research journals.

RidhaHambaliet. al [4] studied the influence of the tool wear on the punching force and on the evolution of the sheared profile was accounted for by changing the values of the edge radii of punch and die set by simulation and experimentation. The comparison between the result obtained by simulation and experimentation shows that for various states of punch wear, there is no difference between maximum blanking loads.

M. Samuel [5], have done experimental analysis by using punches and dies with different radii for sheet metal materials Al-killed cold rolled and annealed under different conditions. The experimental result shows that maximum blanking force and the punch penetration at crack initiation and load required to separate the blank from the sheet stock are sensitive to tool geometry, clearance and conditions of material such as cold rolled and annealed. A.M. Goijaerts et al [6], shows a change in cutting radii of the tools, which shows a drastic change in punch displacement at fracture whereas a change in clearance which does not exhibit a drastic change in punch displacement.

DESIGN OF DIE PARTS

Deflection and stress calculation

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Let us assumed to be a SSB beam which are mounted through four corners in the punch plate. It is loaded in the centre of the plate and their deflection should be.

δ = ----------------------------------- (13)

Where, F = 80% of the cutting and forming forces = 2666.752 N

L is the beam frame distance = 150 mm

Young's modulus (E) = 72 x 10^3 N/mm²

where, b = 200 mm (width of the plate)

h = 32 mm (height of the plate)

I = 860160 mm^4

δ = 0.0004 mm < 0.025 mm

σ = F/A

= 0.4166 N/mm²

The stress applied to the punch plate is 0.4166 N/mm² which is much less than 160 N/mm². Hence, the design is safe.

3.5 Guide Pins and Bushes

Guide pins and bushes are made up of aluminium silicon alloy (LM6) which is used to align the punches and the die block. It attached between the top plate and stripper plate.

Buckling for guide pins

The guide pins materials are made up of LM6 alloy having a tensile strength of 160 N/mm² and their young's modulus is 72x10^3 N/mm².

= 2l for one side is fixed and other side is set free.

l = 146 mm

I = -(14)

D = 22 mm

I = 1165.68 mm^4

A = 379.94 mm²

S.R = / --(15)

= = Radius of gyration -(16)

= 20

S.R = 17.6 = Slenderness ratio

T.S.R = = Transition slenderness ratio -(17)

T.S.R = 94.2 mm

Here, the Johnson equation should be applied for critical buckling load. Since, the S.R ratio is lesser than that of T.S.R [7].-(18)

= 2166.6 N > critical load

Hence the structure is safe.

Load per pillar = 2166.6/4

= 541.65 N / pillar

Punch

The punches are mounted in the punch plate which is made up of plain carbon steel 14C6. The lengths of the punches are properly quoted for the die performance. If the punches are having too much length, the compressive stress become excessive which results in tip breakage. The lengths of the punches are calculated from the Euler's formula.

The critical force is calculated through one is fixed and other end set as free [7].- (19)

The length of the punches are calculated by- (20)

D = dia. of the punch = 7.5 mm

This shows that the length of the punch which is safe and it can perform without failure

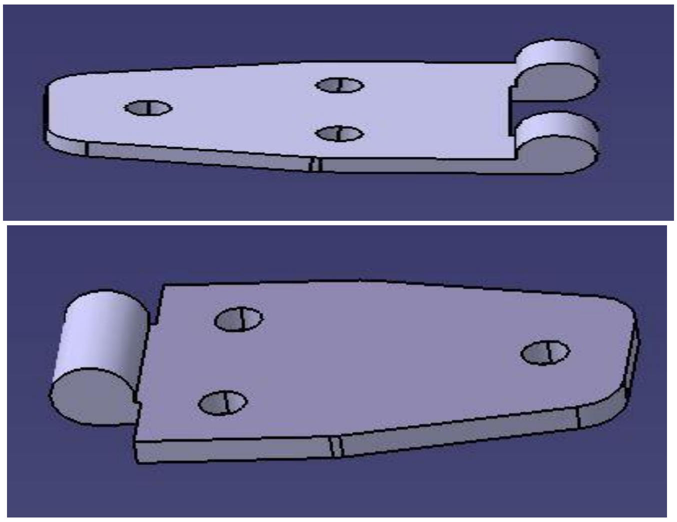

Fig -3.1: Component Model (Male and Female part)

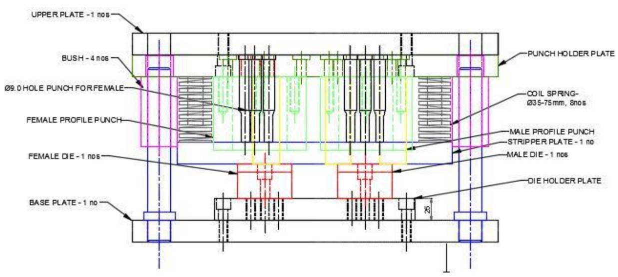

Fig 3 .3: 2D Drawing of die punch assembly

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Details	Specifications
Material	St-37
Thickness	6mm
Shear strength	320-350N/mm2
Tensile strength	370-450N/mm2

Table -1: Material Properties of component

Property	Value	Units
Young's Modulus	210000	N/mm²
Poisson's Ratio	0.3	-
Shear modulus	7900	N/mm²
Mass density	7700	Kg/m³
Tensile strength	1736	N/mm²
Compressive Yield strength	2150	N/mm²
Yield strength	2150	N/mm²
Thermal Expansion Coefficient	1.04e.005	1/K
Thermal Conductivity	20	W/(m-K)
Specific Heat	460	J/(Kg-K)

Table -2: Material Properties of Die Punch material (D2 steel)

ANALYSIS IN ANSYS

In this project the analysis is carried out in Ansys 14.0 work bench. The punch is critical element in die punch, hence analysis is carried out on punches and the results are compared with theoretical calculations for validation. The material used for punches is D2 steel/HCHCr.

It provide the stress result with the design cycle. It helps to predict the part to perform under load. Whenever the problem arise related to analysis, need a comprehensive analysis of the product is required [8]. 4.1 Analysis of Punches The analysis of punches are analyzed by the simulation express tool in which each punch is made fixture at the top of the punch and the load is applied at the tip of punch. The maximum shear load is occurred in the edges of the punch and deformed to maximum deflection which is calculated. The following figures show that the punches are deformed only at the tip.

Analysis of Piercing punch

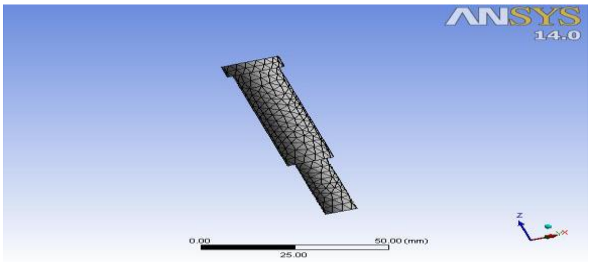

Fig- 4.1: Meshed model of Piercing punch.

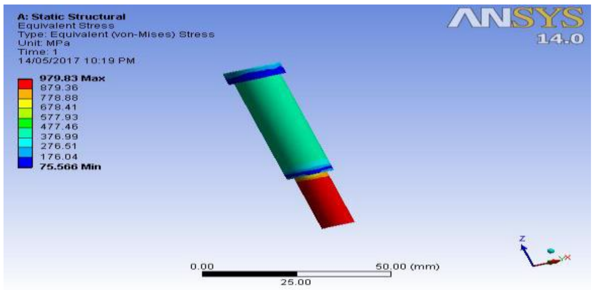

Fig- 4.2: Von-Mises stresses on piercing punch.

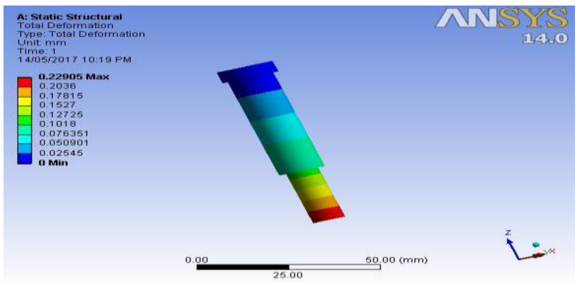

Fig- 4.4: Total deformation of piercing punch.

As shown in the analysis results, the minimum deformation is 0 mm at top of the punch and Maximum deformation is 0.2290 mm at the tip of punch.

As shown in the analysis results in fig 8, the minimum life is 250 cycles and Maximum life is 100000 cycles

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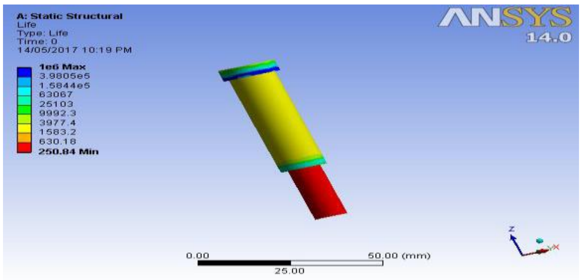

Fig- 4.5: Fatigue life of piercing punch

Analysis of slotting punch

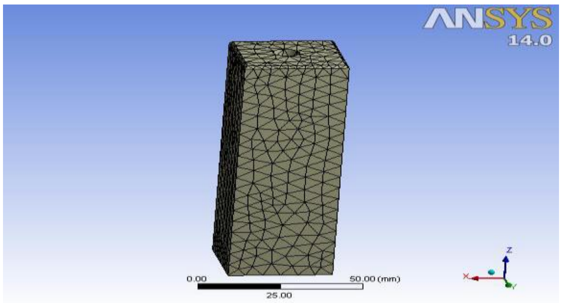

Fig- 4.6: Meshed model of Slotting punch.

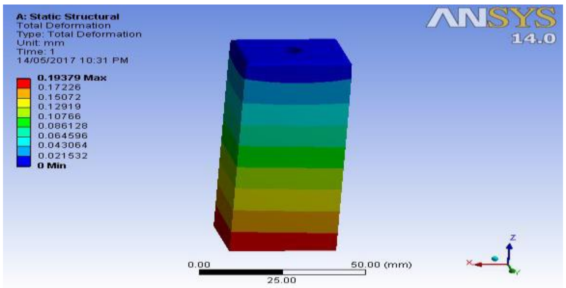

Fig- 4.7: Total deformation of piercing punch.

As shown in the analysis results, the minimum deformation is 0 mm at top of the punch and Maximum deformation is 0.1937 mm at the tip of punch.

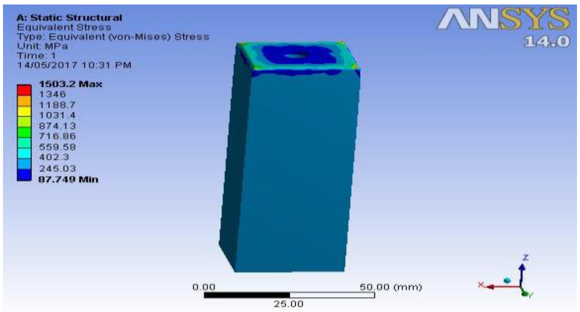

Fig-4.8: Von-Mises stresses on slotting punch.

As shown in the analysis results, the minimum Von-Mises stress is 87.749 Mpa and Maximum Von-Mises stress is 1503Mpa.

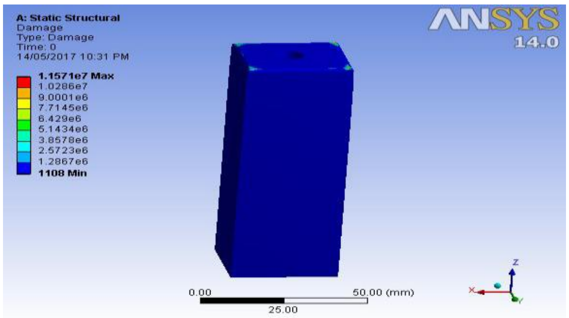

Fig- 4.9: Fatigue life of slotting punch.

As shown in the analysis results, the minimum life is 1108 cycles and Maximum life is 1.15e7 cycles.

Analysis of profile blanking punch

Fig- 13:

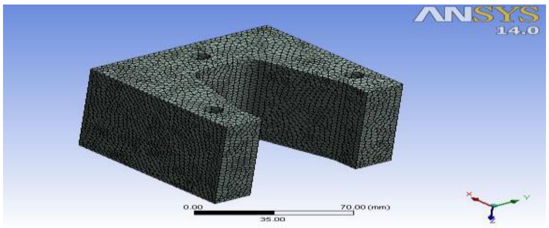

Fig- 4.10: Meshed model of profile cutting punch.

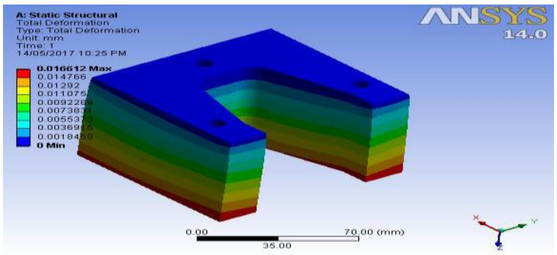

Fig- 4.11: Total deformation of profile blanking punch.

As shown in the analysis results, the minimum deformation is 0 mm at top of the punch and Maximum deformation is 0.01662 mm at the tip of punch.

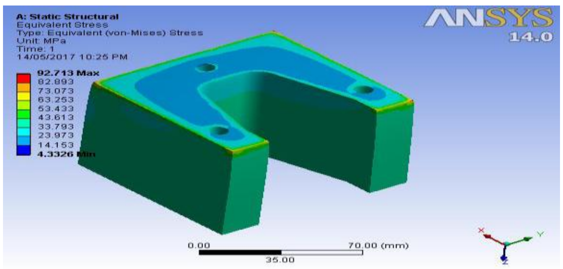

Fig- 4.12: Von-Mises stresses on profile blanking punch.

As shown in the analysis results, the minimum Von-Mises stress is 4.33 Mpa and Maximum Von-Mises stress is 92.71Mpa.

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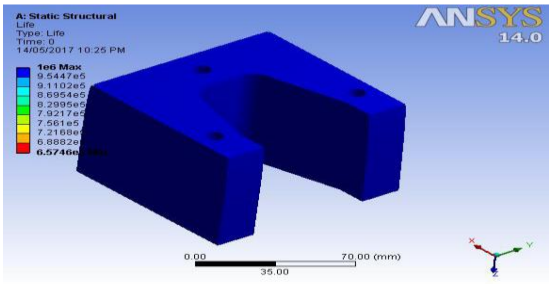

Fig- 4.13: Fatigue life of profile blanking punch

As shown in the analysis results, the minimum life is 65000 cycles and Maximum life is 100000 cycles.

Results and Discussion

First step is to decide the geometry of the Die-Punch tool, while having consideration on this; we need to take component which is selected for the optimization or alteration of manufacturing process. Here alternative method of manufacturing selected is punching; when a punching operation is selected first parameter under scanner is the amount of material required to be eliminated from the original raw material. Further in this process we need to decide the number of cycles for which this punch is been designed, here we are utilizing this punch for at least fifty thousand repeating punching operations, keeping in mind the monthly production of these parts around five thousand quantities.

Sl.No	Description	Total Deformation(mm)		
		Theoretical	Ansys	Error (%)
1.	Piercing Punch	0.2200	0.2290	3
2.	Slotting Punch	0.1896	0.1937	2.1
3.	Profile blanking Punch	0.01582	0.0166	4.8

Table -3: Fatigue life results.

Sl.No	Description	Fatigue life(cycles)		
		Theoretical	Ansys	Error (%)
1.	Piercing Punch	97000	100000	3
2.	Slotting Punch	>1e6	>1e6	-
3.	Profile blanking Punch	>1e6	>1e6	-

Sl. No	Description	Von-Mises Stress (N/mm2)		
		Theoretical	Ansys	Error (%)
1.	Piercing Punch	1020	979	3.5
2.	Slotting Punch	1480	1503	1.5
3.	Profile blanking Punch	96	93	3.5

Maximum working stress for piercing punch is 927 N/mm², which is less than the Von-Mises stress 1020 N/mm².Hence punch will not fail under applied load of 59383N.

Maximum working stress for Slotting punch is 400 N/mm², which is less than the Von-Mises stress 1480 N/mm².Hence punch will not fail under applied load of 358400N.

Maximum working stress for profile blanking punch is 37 N/mm², which is less than the Von-Mises stress 96 N/mm².Hence punch will not fail under applied load of 226800N.

Critical buckling load for piercing punch is 356029N.Actual load on piercing punch is 59383N, which is less than 356029N.Hence buckling will not occur.

CONCLUSION

In this project a die punch for blanking and piercing operation is designed and analysed for component. The theoretical calculations were done for calculating cutting force, tonnage required, fatigue life and stresses. The 3D models created in Catia-V5 and analysis is done on Ansys 14.0 workbench. The main objective of the project is to improve productivity and reduce production cost. The exiting cycle time for blanking and piercing operation is approximately four minutes which manufacturing cost is around six rupees. After implementation of this project we can expect the cycle time will be 30 to 40 secs and cost will be around 1.5 to 2 rupees.

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