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Design and Analysis of Blanking and Punching Dia

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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. The results are within 5% of allowable limit.

Keywords: Keywords: CAD, Design analysis, blanking,

1. INTRODUCTION

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.

Metal cutting is a process used for separating a piece of material of predetermined shape and size from the remaining portion of a strip or sheet of metal. It is one of the most extensively used processes throughout die and sheet-metal work. It consists of several different material-parting operations, such a piercing, perforating, shearing, notching, cutoff, and blanking. In blanking, the piece is cut off from the sheet, and it becomes a finished part. In piercing, the cutout portion is scrap which gets disposed off while the product part travels on through the remainder of the die. The terminology is different here, though both processes are basically the same and therefore belong to the same category, which is the process of metal cutting The actual task of cutting is subject to many concerns. The quality of surface of the cut, condition of the remaining part, straightness of the edge, amount of burr, dimensional stability-all these are quite complex areas of interest, well known to those involved in sheet-metal work. Most of these concerns are based upon the condition of the tooling and its geometry, material thickness per metal-cutting clearance, material composition, amount of press force, accurate locating under proper tooling, and a host of additional minor criteria. These all may affect the production of thousands and thousands of metal-stamped parts.

1.1. Types of Sheet Metal Operations

A. Punching

Punching is a forming process that uses a punch press to force a tool, called a punch, through the work piece to create a hole via shearing. Punching is applicable to a wide variety of materials that come in sheet form, including sheet metal, paper, vulcanized fibre and some forms of plastic sheet. The punch often passes through the work into a die. A scrap slug from the hole is deposited into the die in the process. Depending on the material being punched this slug may be recycled and reused or discarded.

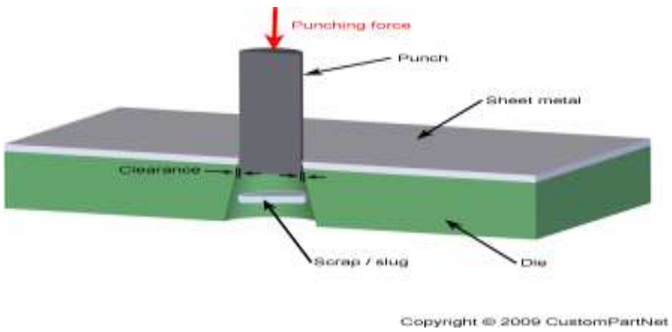

Fig. 1 - Blanking

B. Die Components

The main components for die tool sets are:

1. Die block – This is the main part that all the other parts are attached to.
2. Punch plate – This part holds and supports the different punches in place.
3. Blank punch – This part along with the blank die produces the blanked part.
4. Pierce punch – This part along with the pierce die removes parts from the blanked finished part.
5. Stripper plate – This is used to hold the material down on the blank/pierce die and strip the material off the punches.
6. Pilot – This will help to place the sheet accurately for the next stage of operation.
7. Guide, back gauge, or finger stop – These parts are all used to make sure that the material being worked on always goes in the same position, within the die, as the last one.
8. Setting (stop) block – This part is used to control the depth that the punch goes into the die.
9. Blanking dies – See blanking punch
10. Pierce die – See pierce punch.
11. Shank – used to hold in the presses. it should be aligned and situated at the center of gravity of the plate.

C. Sheet Metal Cutting (Shearing)

- Sheet thickness: 0.005-0.25 inches
- Tolerance: ±0.1 inches (±0.005 inches feasible)
- Surface finish: 250-1000 μin (125-2000 μin feasible)

D. Blanking

Blanking is a cutting process in which a piece of sheet metal is removed from a larger piece of stock by applying a great enough shearing force. In this process, the piece removed, called the blank, is not scrap but rather the desired part. Blanking can be used to cutout parts in almost any 2D shape, but is most commonly used to cut work pieces with simple geometries that will be further shaped in subsequent processes. Often times multiple sheets are blanked in a single operation. Final parts that are produced using blanking include gears, jewelry, and watch or clock components. Blanked parts typically require secondary finishing smoothing out burrs along the bottom edge. The blanking process requires a blanking press, sheet metal stock, blanking punch, and blanking die

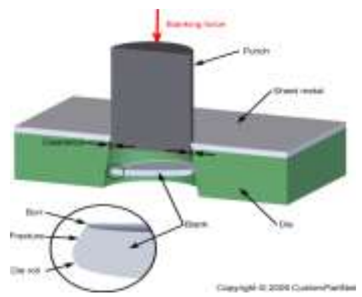

Fig. 2 – Blanking

1.2 Sheet Metal Processes

Sheet metal processes can be broken down into two major classifications and one minor classification.

A. Shearing processes: Processes which apply shearing forces to cut, fracture, or separate the material.
B. Forming processes: Processes which cause the metal to undergo desired shape changes without failure, excessive thinning, or cracking. This includes bending and stretching.
C. Finishing processes: Processes which are used to improve the final surface characteristics.

A. Shearing Processes

1. Punching: Shearing process using a die and punch where the interior portion of the sheared sheet is to be discarded.
2. Blanking: Shearing process using a die and punch where the exterior portion of the shearing operation is to be discarded
3. Perforating: Punching a number of holes in a sheet
4. Parting: Shearing the sheet into two or more pieces
5. Notching: Removing pieces from the edges
6. Lancing: Leaving a tab without removing any material

B. Forming Processes

1. Bending: Forming process causes the sheet metal to undergo the desired shape change by bending without failure.
2. Stretching: Forming process causes the sheet metal to undergo the desired shape change by stretching without failure.
3. Drawing: Forming process causes the sheet metal to undergo the desired shape change by drawing without failure.
4. Roll forming: Roll forming is a process by which a metal strip is progressively bent as it passes through a series of forming rolls.

STAGES OF SHEARING OR SHEARING THEORY

Shearing is a method of cutting sheets without forming chips. The force for shearing is applied by the shearing blades.

A. Plastic Deformation

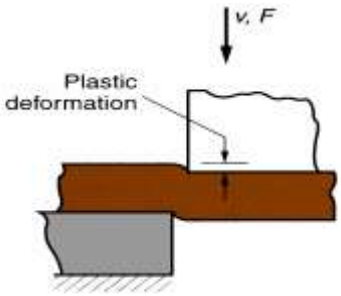

Fig. 3 – Plasting Deformation

The force applied by the punch on the stock material deforms it into the die opening. When the plastic limit of the stock material is exceeded by further application of force, the material is forced in to the die opening in the form of an embossed pad. A corresponding depression is formed on the upper face. This stage imparts a radius on the upper edge of the opening in the strip and on the lower edge of the punched out material.

B. Penetration

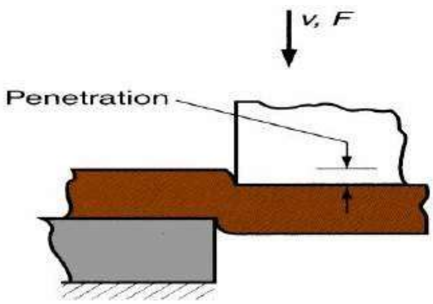

Fig. 4 – Penetration

As the load is further increased, the punch will penetrate into the material to a certain depth. An equally thick portion of the material is forced into the die. This imparts a bright polished finish (cut band) on both the strip and the blank.

C. Fracture

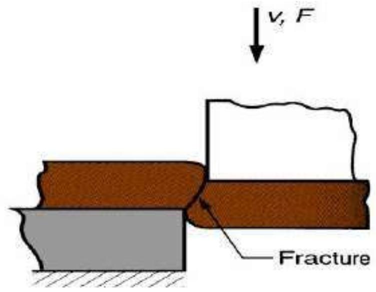

Fig. 5 – Fracture

In this stage, fracture starts from both upper and lower cutting edges. As the punch travels further, these fractures will extend towards each other and meet to cause complete separation.

2. LITERATURE REVIEW

Pranesh Krishnan [1] published paper on Design and Analysis of Punch and Die of a Micro Blanking Tool and according to their research work the problems during high production stamping are tool wear. After thousands time of stroke punch will have tool wear and more seriously punch can break apart. For micro blanking punch, the punch is small and the probability to broken also increased. The objective of this project is to design a complete micro-blanking dieset and analyse it using FEA and E fatigue to gained lifecycle value

V. G. Sreenivasulu [2] worked on Design and Analysis of Blanking and Piercing Die Punch and they conluded that 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.

Gandjar Kiswanto [3] worked on Analysis of Shear Edge Quality for Different Punch Velocities in Micro-Blanking Process and he concluded that Micro-blanking part quality was strongly influenced by the die clearance. The larger die clearance, greater irregularities of shear edge occurred. This research investigated about the influence of a punch velocity to the shear edge distribution. It is found that the proportion of shear edge in micro blanking part indicated the differences when punch velocity variation was applied.

Sk. Mastan Vali [4] published paper on Design and Analysis of Punch and Die Process by Using Ansys with Non Linear Materials and there are showing The stress and strain graph and value are obtained by using one of fea software known as Ansys. In Ansys software, the die placed as fixed one and punch is moving as distance of 7 mm. the gap between punch and die is 3 mm and clearness of hole of punch and die is 1 mm in radius of hole. Analysis was done, based on 3 different thickness of sheet like (1mm, 2mm and 3mm) with respective to material general used in industries like aluminum alloy, Mild steel (HCS) and Copper (cu).

M. Samuel[6] 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.

3. PROBLEM STATEMENT

The aim of this project is to design blanking and punching die with more efficient to reduce cycle time of existing process of milling, blanking and punching 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 5000 to 7000 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 5 minutes. After the implementation of this project we can expect this to 40secs.

4. DESIGN OF BLANKING & PUNCHING DIA

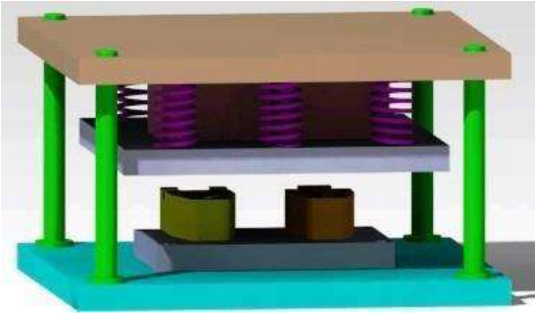

Fig. 6 – 3D model of die punch

4.1Deflection and Stress Calculation

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.

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.

4.2Buckling 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

D = 22 mm

I = 1165.68 mm^4

A = 379.94 mm²

= Radius of gyration = 20

S.R = 17.6 = Slenderness ratio

T.S.R = = Transition slenderness ratio

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

= 2166.6 N > critical load Hence the structure is safe. Load per pillar = 2166.6/4

= 541.65 N / pillar

4.3Punch

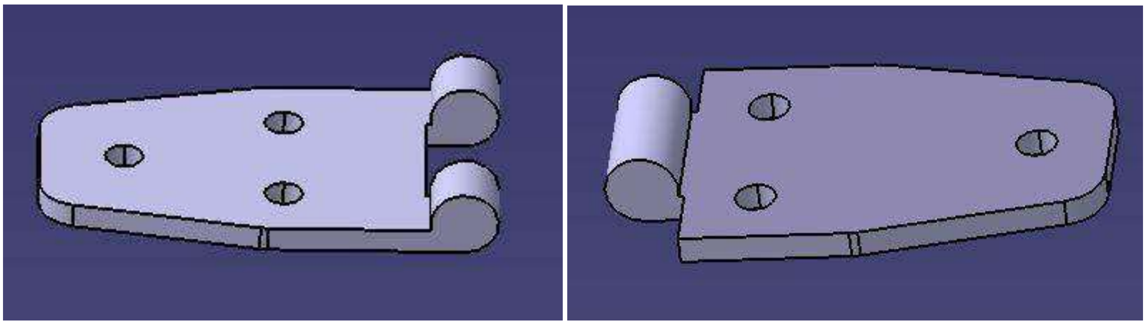

Fig. 7 Component Model (Male and Female part)

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 becomes 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 the length of the punches are calculated by-

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

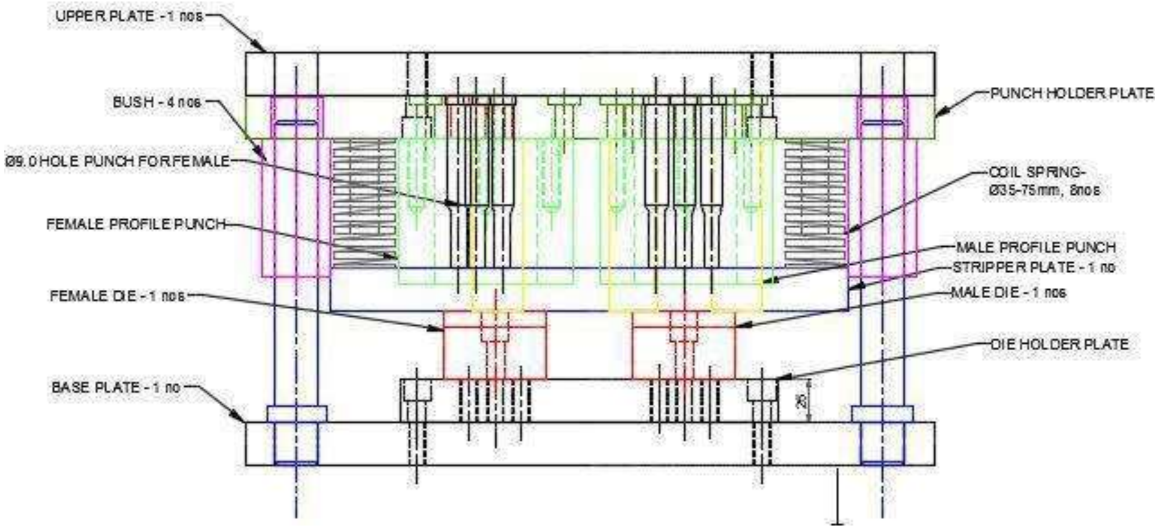

Fig. 8 -2D drawing of die punch assembly

Table 1 - Material Properties of component

Details	Specifications
Material	St-37
Thickness	7mm
Shear strength	315-345N/mm2
Tensile strength	370-450N/mm2

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

Property	Value
Young's Modulus	210000 N/mm^2
Poisson's Ratio	0.3
Shear Modulus	7800N/mm^2
Mass density	7800Kg/m^3
Tensile strength	1736N/mm^2
Compressive Yeild Strength Yield strength	2200N/mm^2
Thermal Expansion Coefficient	1.04e.005 1/K
Thermal Conductivity	20 W/(m-K)
Specific Heat	460 J/(Kg-K)

5. ANALYSIS OF BLANKING & PUNCHING DIA

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 provides 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. 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.

5.1 Analysis of Profile Blanking Punch

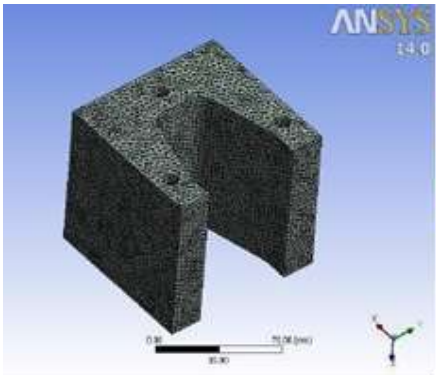

Fig.9 Meshed model of profile cutting punch.

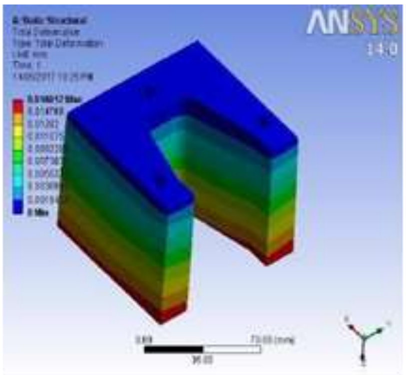

Fig.10 Total deformation of profile blanking punch.

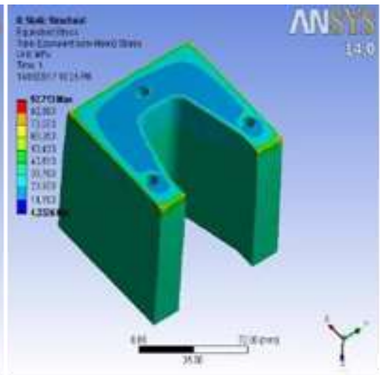

Fig.11 Von-Mises stresses on profile blanking punch.

As shown in fig 10 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. As shown in fig 11 the analysis results, the minimum Von-Mises stress is 4.33 Mpa and Maximum Von-Mises stress is 92.71Mpa. As shown in fig 12 the analysis results, the minimum life is 65000 cycles and Maximum life is 100000 cycles.

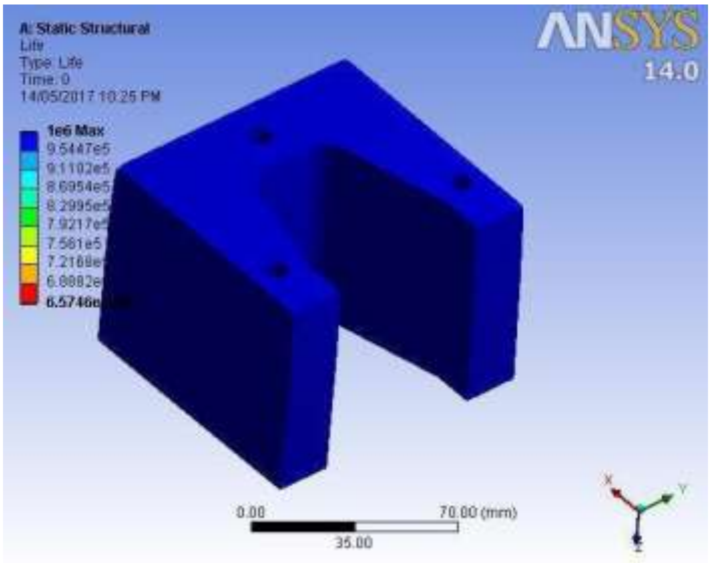

Fig. 12 Fatigue life of profile blanking punch

5.2Analysis of Piercing punch

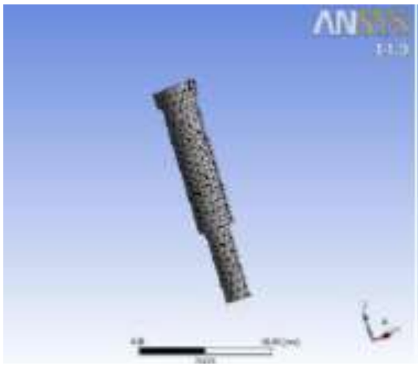

Fig.13 Meshed model of Piercing punch.

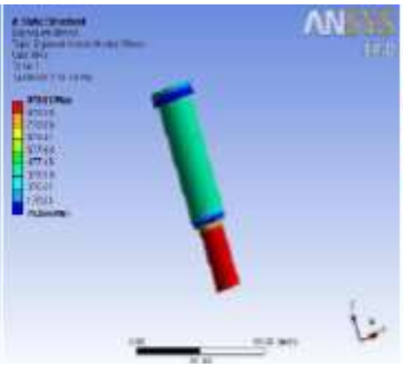

Fig. 14 Von-Mises stresses on piercing punch.

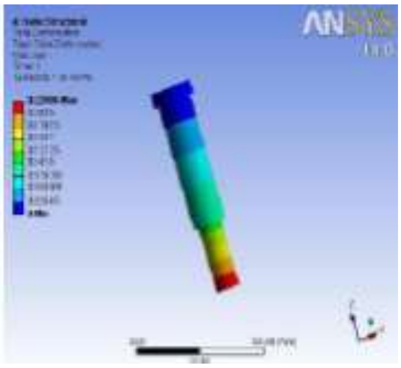

Fig.15 Total deformation of piercing punch.

As shown in fig the minimum Von-Mises stress is 75.566 Mpa and Maximum Von-Mises stress is 979 Mpa. In fig 15 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 And as shown in fig 16 the analysis results the minimum life is 250 cycles and Maximum life is 100000 cycles

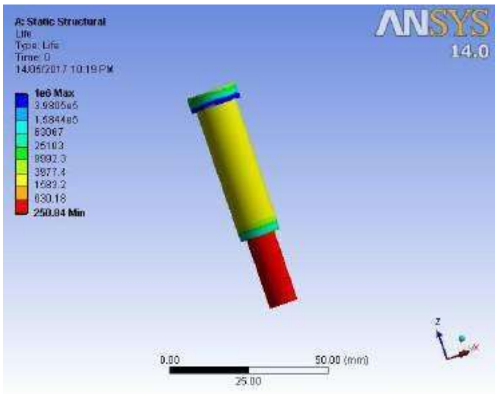

Fig. 16 Fatigue life of piercing punch.

5.3 Analysis of slotting punch

As shown in 18 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 19 shows the analysis results, the minimum Von-Mises stress is 87.749 Mpa and Maximum Von-Mises stress is 1503Mpa. And fig 20 shows the analysis results, the minimum life is 1108 cycles and Maximum life is 1.15e7 cycles.

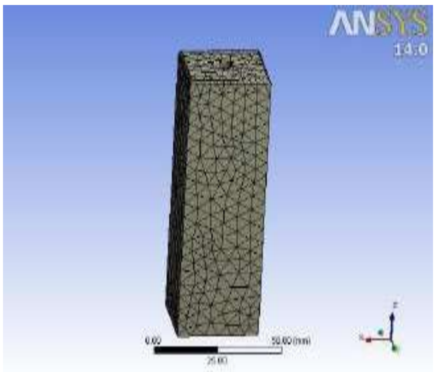

Fig.17 Meshed model of slotting punch.

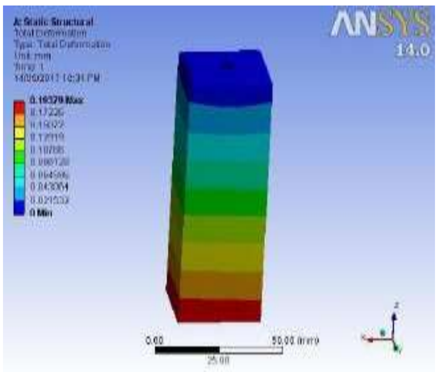

Fig.18 Total deformation of piercing punch.

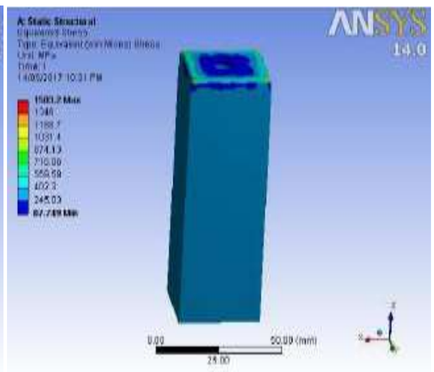

Fig.19 Von-Mises stresses on slotting punch.

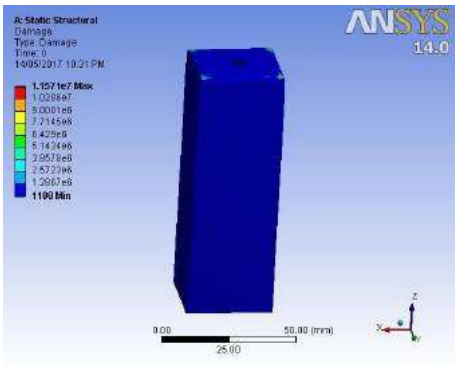

Fig.20 Fatigue life of slotting punch.

6.RESULT & 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 todecide 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.

Table 3 – Deformation Result

Description	Total Deformation (mm)		
	Theoretical	Ansys	Error (%)
Piercing Punch	0.2150	0.2210	2.9
Slotting Punch	0.1900	0.1945	2.2
Profile blanking Punch	0.01590	0.0170	4.9

Table 4 -Fatigue Life Result

Description	Total Deformation (mm)		
	Theoretical	Ansys	Error (%)
Piercing Punch	97500	100000	2.9
Slotting Punch	>1e6	>1e6	-
Profile blanking Punch	>1e6	>1e6	-

Table -5: Von - Mises stress results.

Description	Total Deformation (mm)		
	Theoretical	Ansys	Error (%)
Piercing Punch	1030	985	3.7
Slotting Punch	1490	1508	1.7
Profile blanking Punch	99	95	3.6

Maximum working stress for piercing punch is 985 N/mm², which is less than the Von-Mises stress 1030 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 1490 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.

7. 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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References

1. Pranesh Krishnan et.al, Design and Analysis of Punch and Die of a Micro Blanking Tool Conference Paper in International Journal of Recent Technology and Engineering · April 2021 DOI: 10.35940/ijrte.D7416.118419
2. V. G. Sreenivasulu et.al, Design and Analysis of Blanking and Piercing Die Punch international journal & magazine of engineering technology management and research.
3. Gandjar Kiswanto et.al, Analysis of Shear Edge Quality for Different Punch Velocities in Micro-Blanking Process International Journal of Mechanical Engineering and Robotics Research Vol. 6, No. 4, July 2017
4. Sk. Mastan Vali et.al, Design and Analysis of Punch and Die Process by Using Ansys with Non Linear Materials International Journal of Research in Engineering, Science and Management Volume-2, Issue-6, June-2019 www.ijresm.com | ISSN (Online): 2581-5792
5. J.BOOPATHI et.al, Simulation and structural analysis of a Punch and Die used in Industries Science, Technology and Development Volume VIII Issue V MAY 2019ISSN : 0950-0707
6. Optimum selection of variable punch-die clearance to improve tool life in blanking non-symmetric shapes Soumya Subramonian, Taylan Altan, Bogdan Ciocirlan, and Craig Campbell.
7. Strain-controlled fatigue properties of steels and some simple approximations by M.L. Roessle, A. Fatemi.
8. Flanging using step die for improving fatigue strength of punched high strength steel sheet by Purwo Kadarno, Ken-ichiro Mori, Yohei Abe, Tatsuro Abe.
9. Computer aided blanking die design using CATIA by H. M. A. Hussain.
10. Study of the contribution of different effects induced by the punching process on the high cycle fatigue strength of the M330-35A electrical steel by Helmi Dehmani, Charles Bruggerb, Thierry Palin-Lucb, Charles Mareauc, Samuel Koechlina.