

Study and Analysis of Press Tool Design

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Abstract: Press tools are used to produce a particular component in large quantity, out of sheet metals where particular component achieved depends upon press tool construction and its configuration. The different types of press tool constructions leads to different operations namely blanking, bending, piercing, forming, drawing, cutting off, parting off, embossing, coining, notching, shaving, lancing, dinking, perforating, trimming, curling etc. Generally metals having thickness less than 6mm is considered as strip. Metals having thickness greater than 6mm is considered as plate. In Piercing and notching the required shape periphery is cut in the work piece material. The press tool used is for Piercing operation is called as Piercing tool .The application of press operations are widely used in many industries like food processing, packing, defense, textile, automobile, aircraft and many apart from manufacturing industry. In this connection an attempt is made on to learn the press tool design, materials, manufacturing used for press tool and calculations involved in it. In this work, a real time design of a simple piercing press tool and manufacturing of a prototype is made along with static analysis of punch where the output is a Pierce hole and notch hole. The press machine is of mechanical type of 200ton. Here the problem statement of project is two combine these two piercing and notching operation. Which is now manufacturing separately i.e. two piercing by one punch and two notching operation with another punch.

Keywords: :-Compound Die, Material Selection, Die Design, Modeling, Cost Estimation, Analysis of Punch

I. INTRODUCTION

Metal forming is one of the manufacturing processes which are almost chip less. These operations are mainly carried out by the help of presses and press tools. These operations include deformation of metal work pieces to the desired size and shape by applying pressure or force. Presses and press tools facilitate mass production work. These are considered fastest and most efficient way to form a sheet metal into finished products. Here the problem statement of project is two combine these two piercing and notching operation. Which is now manufacturing separately i.e. two piercing by one punch and two notching operation with another punch



Fig 1. Nothing Punch



Fig 3. Piercing Punch



Fig 3. Nothing Punch

II. LITERATURE REVIEW

Vishwanath M.C - The selection of any multi-operation tool, such as progressive die or combination Die , is justified by the principle that the number of operations achieved with one handling of the stock and produced part is more economical than production by a series of single operation dies and a number of handling for each single die
The tool wear curve obtained by Högman shows the relationship between tool wear and punch- die clearance. Fig4. shows that there is an optimal cutting clearance that gives the least tool wear for a given sheet material and thickness.

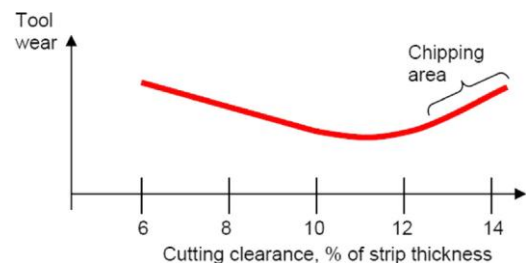


Fig. 4. Relationship between tool wear and punch die clearance obtained experimentally when blanking Docol 1400DP, 1mm thick by Högman

T. Z. Quazi explains Back Pressure Plates are required if the pressure on punch exceeds $245N/mm^2$ and also used if the punch diameter is less than four times the stock thickness. The casting simulation technology has sufficiently matured and h Subramanyam Pavuluri Stress analysis enables the designer to efficiently validate quality, safety, performance of the designed product. By using the SOLID WORKS software the analysis is performed. In this software itself gets own parameters if we input the pressure value, selection of material. The result is:

Sr.no	Description of Item	Material Selected
1	Punch & Die Block	D2 steel
2	Stripper	Cold rolled mild steel
3	Die Back Plate	Oil hardened steel
4	Punch Back Plate	Oil hardened steel
5	Guide Pillars & Bushes	Carbon Steel & Hardened ground steel
6	Punch Holder	Mild Steel
7	Top & Bottom Plate	Mild Steel
8	Allen Key Bolts	Mild Steel

Table Shows Material properties for different plates

The part deforms in displacements
 The product is static and constant over time
 The constant stress strain relationship in material.

Principle of metal cutting (mechanics of shearing)

The cutting of sheet metal in press work is shearing process. Punch is same shape of the die opening but the gap between the punch and die called as clearance. As punch apply pressure on metal strip then material enters into die cavity at that time material is subjected to both tensile and compressive stresses when it crosses elastic limit then after 1/3rd (one third) of material thickness then this material get fracture this only possible by providing optimum clearance between punch and die. If there is no optimum clearance then instead of fracture material will get bend. So their is need to provide optimum clearance between punch and die.

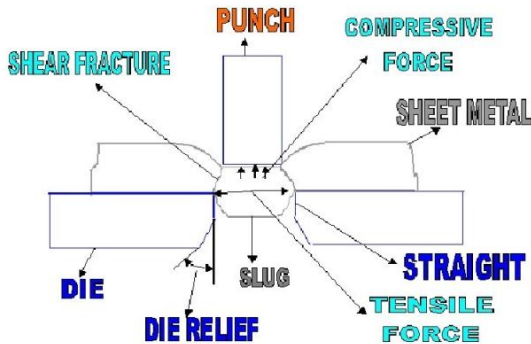


Fig 5 mechanics of shearing

III. MATERIAL SELECTION

Press tools are generally made using HCHCr, Steel alloys with high carbon. But before that based on many factors like cost, strength, hardness, strain and many parameters selection should be made. The materials used are generally selected are D2, EN31. Mild Steel is used as supporting plate. Apart from that materials like D3, high carbide materials, chromium steels and high speed steels are also used. D2 STEEL: This alloy is one of the Cold Work, high carbon, high chromium type tool steels. D2 is a deep hardening, highly wear resistant alloy. It hardens upon air cooling so as to have minimum distortion after heat treatment. Used for long run tooling applications where wear resistance is important, such as blanking or forming dies and thread rolling dies.

IV. DESIGN CALCULATION

Force Calculation:-

The plate is 10mm thickness in which two piercing hole and two notch of same profile has to be cut in one stroke of ram. The dimension of profile is shown below.

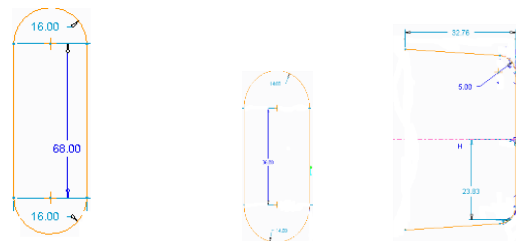


Fig: 6 Pierced hole 1, Pierced hole 2, Notches 1 & 2

Pierced hole 1:-
 perimeter = $2 \times 68 + 2\pi R = 2 \times 68 + 2\pi \times 16 = 236.53 \text{ mm}$,
 Cutting force = perimeter x thickness of raw matl. x shear strength of matl. = $236.53 \text{ (mm)} \times 10 \text{ (mm)} \times 28.28 \text{ (kg/mm}^2) = 66.89 \text{ ton}$,
 Stripping Force (50% of cutting force maximum) = 33.44 ton
 Total Cutting force for Pierced hole 1 = Cutting force + Stripping Force = $66.89 + 3.44 = 100.35 \text{ ton}$
 Pierced hole 2:-
 perimeter = $2 \times 36 + 2\pi \times 14 = 160 \text{ mm}$, Cutting force = 45.23 ton ,
 Stripping Force (50% of cutting force maximum) = 22.31 ton
 Total Cutting force for Pierced hole 2 = Cutting force + Stripping Force = $45.23 + 22.31 = 67.54 \text{ ton}$
 Notches 1 & 2:-
 Perimeter = $50 + 2 \times 32.76 = 115 \text{ mm}$, Cutting Force = 32.5 ton , Stripping Force = 16.02 ton
 Total Force = $32.5 + 16.02 = 48.52 \text{ ton}$
 So,
 The total force required = $100.33 + 67.84 + 97.52 = 265 \text{ ton}$

V. DIE DESIGN & MODELLING

1. Die Thickness = $\sqrt[3]{(\text{cutting force})} = \sqrt[3]{(265)} = 64 \text{ mm}$
2. Stripper thickness = $0.5 \text{ die thickness} + \text{thickness of raw matl.} = 42 \text{ mm}$
3. Die Back Plate thickness = $0.5 \text{ stripper thickness} = 21 \text{ mm}$
4. Bottom plate thickness = $1.5 \times \text{Die thickness} = 96 \text{ mm}$
5. Punch holder thickness = $\text{stripper thickness} = 42 \text{ mm}$
6. punch back plate thickness = $0.5 \text{ stripper thickness} = 21 \text{ mm}$
7. Top plate thickness = $1.25 \times \text{Die thickness} = 80 \text{ mm}$
8. No. of bolts & Sizes:-

Size of bolt=dc

Stripping force= $\pi/4 dc^2 \times n \times$ shear strength of bolt
 n= no. of bolts required
 shear strength of bolt=55 to 56 kg/mm² for mild steel & bolts are made from mild steel
 n=8

$$132.5 \times 1000 = \pi/4 dc^2 \times 8 \times 56$$

$$dc = 19.4 \text{ mm}$$

so choose the bolt of M18

$$9. \text{Minimum wall thickness} = 1.5dc + 10 = 37 \text{ mm}$$

Top Plate & Bottom Plate :- Both are thick plate which is used for supporting other die element .The bottom plate which is fixed at bottom of the press tool & it is used for clamping press tool on machine tables.

The Top Plate which is attached at of top of press tool and it is to clamp the press tool to the ram of the machine. Both plate are used for locating & supporting the die assembly

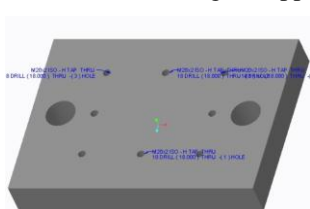


Fig: 7 Top Plate

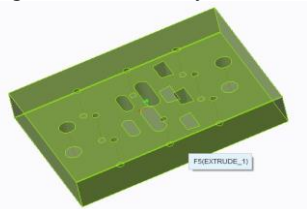


Fig: 8 Bottom Plate

Back Plate (Die & punch):-

These are also called as pressure plate .Both are placed so that the intensity of pressure does not become more on punch holder as well as die. Both plates distribute the pressure over wide area & so that the intensity of pressure on punch as well as die plate can be reduced (Reduce cutting forces).

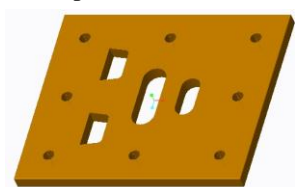


Fig: 9 Die Back Plate

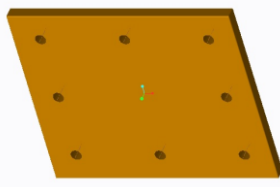


Fig: 10 Die Back Plate

Die Plate & Stripper:-

Die plate:- It is the female part of the press tool. It contains die cavity for required component.

Stripper:- It is a plate mounted over the die plate the main function of stripper as follows

- a. To guide raw material strip.
- b. It also guide sheet & punch.
- c. To remove the stock from punch after piercing or blanking etc operation.
- d. To hold proper stock in cutting or forming operations

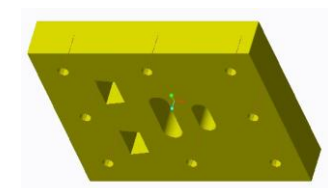


Fig: 11 Die Plate

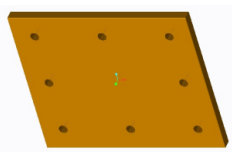


Fig: 12 Stripper

5. PUNCH&PUNCH HOLDER:-

Punch:- A punch is a male member of complete die which mates or acts in conjunction with the female die to produce a desired effect upon the material being worked.

punch holder:- For mounting punch by screw or inserting or providing a slots.

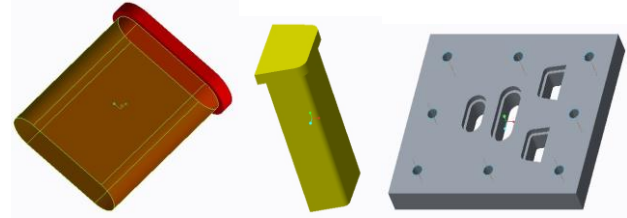


Fig: 13 Pierce punch, notch punch Punch holder

6.GUIDE PILLARS AND GUIDE BUSHES:-

These elements of die are responsible for the alignment of the lower and upper part of the die. It should withstand deflection during continuous production. Standard dimensions of these parts are used so that manufacturing would not be a problem when these are available in the market.



Fig: 14 Guide pillars , guide bushes, Allen key

7.OTHER ELEMENTS ARE:-

- I. Stopper :- To stop the strip
- II. Pilot:-Used for guiding the punch
- III. Feeder:-It is used for feed the metal strip into press tool by manually or automatic.

8.ASSEMBLY:-

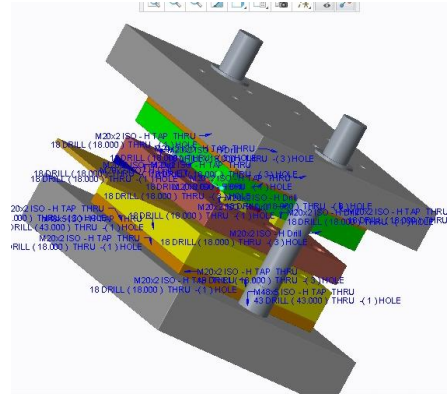


Fig: 15 Assembly

Types of Dies:-

Dies are classified by type of operation perform & by type of construction of die.

1. According to operation dies are classified as below:-

- a) Cutting Dies:-Blanking die, Piercing die, shaving dies , slitting dies, lancing dies, cropping dies, Trimming dies, notching dies etc

- b) Forming Dies:-Bending Dies, Deep draw, stamping dies , embossing dies, Press breaking dies etc

2. According to method of operation:-

- a) A simple dies to perform only one operation.
 b) Multi operation die -these dies are designed to perform more than one operation in one stroke of ram. These are further classified as below.
 I. Compound Die
 II. Combination Die
 III. Progressive Die
 IV. Transfer Die

1. Compound Dies:-

It is the die in which two or more than two operations may be completed at one station (cutting operation).This die is considered as cutting dies in which different operations like piercing & blanking will take place at one station. This die is more accurate & economically in mass production .Normally for this type of die & its operation carried out on mechanical press. e.g. Clutch plates, Washer etc

2. Combination Die:-

It is combination die in which more than two operation may be completed at one station i.e. cutting operations and forming operation. e.g. Any cup shaped product (water glass).This die is not too much accurate & economical in mass production.

3. Progressive Die:-

Progressive die has series of station at each station one operation on work piece within one stroke of press machine & each time metal strip is transfer to next station. e.g. Washer (piercing operation at one station and blanking operation at next station).

4. Transfer Die:-

Unlike progressive die the metal strip is feed progressively from one station to another. In transfer die the already cut blanks are feed mechanically from one station to next station. e.g. Bicycle chains , Carburettors hole etc.

VI. COST ESTIMATION

Sr.no	Material	Cost per Kg (Rs)
1	D2 steel	250
2	Cold rolled mild steel	120
3	Oil hardened steel	180
4	Oil hardened steel	180
5	Carbon Steel & Hardened ground steel	150
6	Mild Steel	55
7	Mild Steel	55
8	Mild Steel	160

Die Block:-

Material Cost=Mass x material cost/kg in Rs
 =volume x density x 200
 =(0.3745x0.320x0.064x7810) x 200
 =60kgx 200
 =Rs.1200

Wire cutting cost =Surface area of cutting x wire cutting 20 paise /sq.m
 =47713.92 x 0.20
 =Rs.9543

Grinding Cost=Rs.4000

Drilling Cost=Rs.2000

Hardening Cost=Mass of Material(kg) x Cost of Hardening
 100 Rs./kg =60 x 100
 =Rs. 6000

Total cost for Die Block=Material Cost +Wire cutting cost + Grinding Cost+ Drilling Cost + Hardening Cost
 =1200+9543+4000+2000 +6000=Rs.22743

Die Back Plate:-

Cost for Die Back Plate =Material Cost + Wire cutting cost + Grinding Cost + Drilling Cost + Hardening Cost
 =(20x180)+(16737x0.2)+4000+2000 +2000=Rs.14947

Bottom Plate:-

Cost for Bottom Plate =Material Cost +Wire cutting cost +Grinding Cost+ Drilling Cost + Hardening Cost
 =(182x55)+ (797x96x0.2) + 4000 + 3000+(182x100)
 =Rs.50513

Stripper Plate:-

Cost for Stripper Plate =Material Cost +Wire cutting cost + Grinding Cost+ Drilling Cost + Hardening Cost
 = (20x180)+(745.53x0.2)+4000+2000+2000=Rs.11750

Stock Guide:-

Cost for Stock Guide=Material Cost + Drilling Cost + Hardening Cost
 = (5.66x55) + 1000=Rs.1622

Punches:-

Cost for Punches =Material Cost + Wire cutting cost +Grinding Cost +Hardening Cost
 =(10.5x200)+(80128x0.2)+8000+1050
 =Rs.25286

Punch Holder:-

Cost for Punches =Material Cost + Wire cutting cost+ Grinding Cost+ Drilling Cost + Hardening Cost
 =(20x55)+(14217x0.2)+4000+2000+2000 =Rs.11944

Punch Back Plate:-

Cost for Punch Back Plate =Material Cost +Grinding Cost + Drilling Cost=(20x180)+4000+2000=Rs.9600

Top Plate:-

Cost for Top Plate =Material Cost +Grinding Cost + Drilling Cost=(152x55)+4000+3000=Rs.15360

Guide Pillars:-

Cost for Guide Pillars =Material Cost + Grinding Cost
 =(30x180)+2000=Rs.7400

Allen Key Type Bolt:-

Cost of Allen Key Type Bolt=Material Cost
 =Rs.3621

So, The Total Cost Required for Press tool Design(approximately) =Rs.1,74,786/-

VII. ANALYSIS OF PUNCH

Press tool efficiency is lost through defects accumulating in press components. As the die significantly impact the overall efficiency of the press, defects the efficiency of the press tool. When defects arise, such as punch cracking and die corrosion leads to inefficient interactions between the punch and the die which increases the damage of the press tool ultimately reflects increase in the costs. Hence, to avoid, or at least diminish, elevated energy costs, the implementation of an improved press tool design with findings of this paper , should be considered. Stress analysis enables the designer to

efficiently validate quality, safety, performance of the designed product

Pierced hole1:-

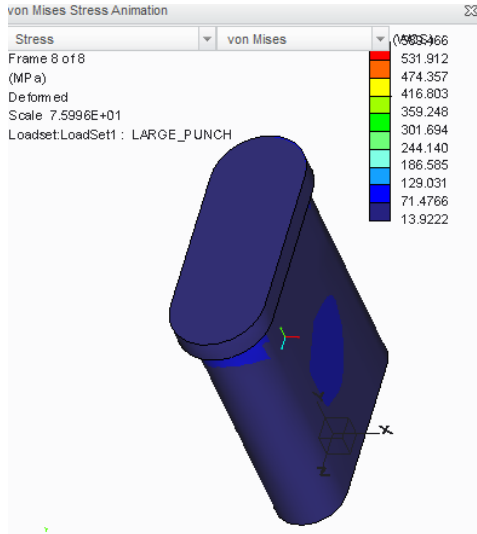


Fig 16 shows stress generated in Pierce punch1.

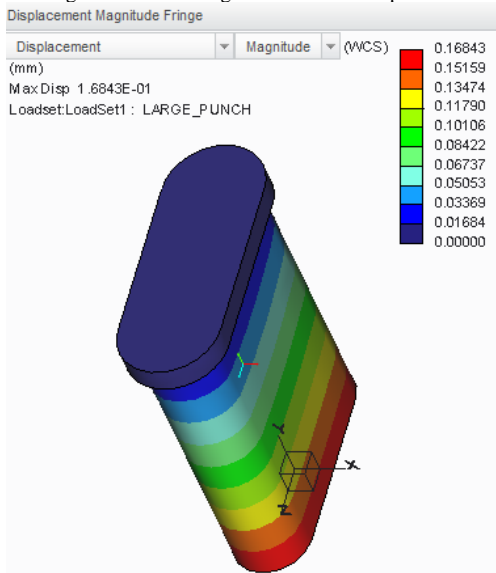


Fig 17 shows displacement generated in Pierce punch1.

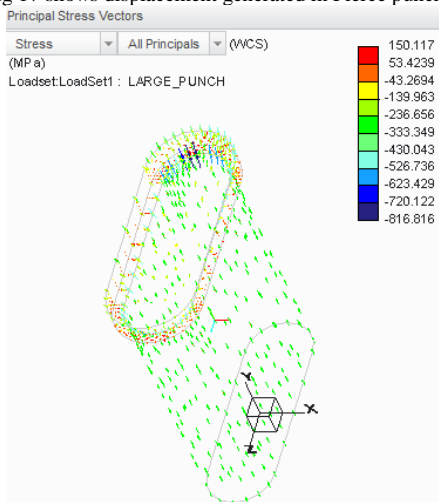


Fig 18 shows principal stress vector generated in Pierce punch1.

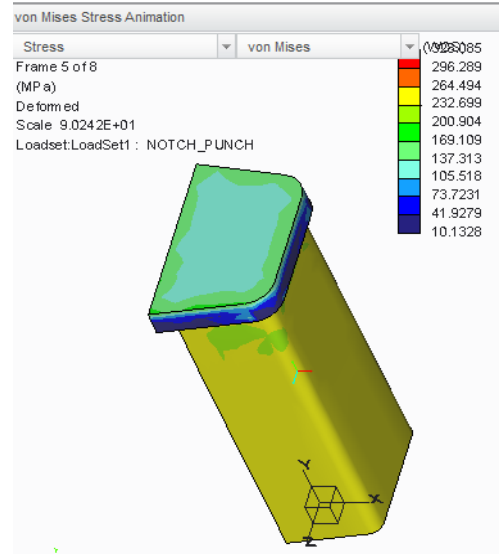


Fig 19 shows stress generated in notch punch 1&2.

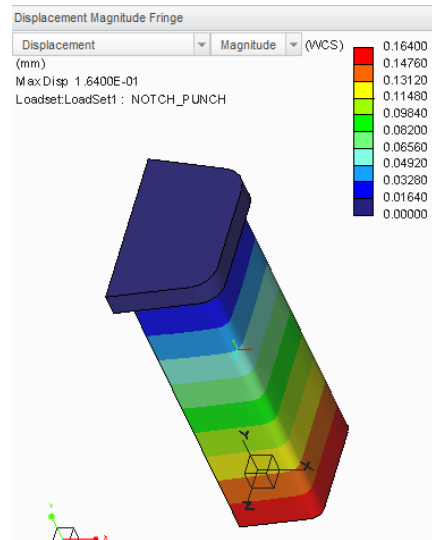


Fig 20 shows displacement generated in notch punch 1&2.

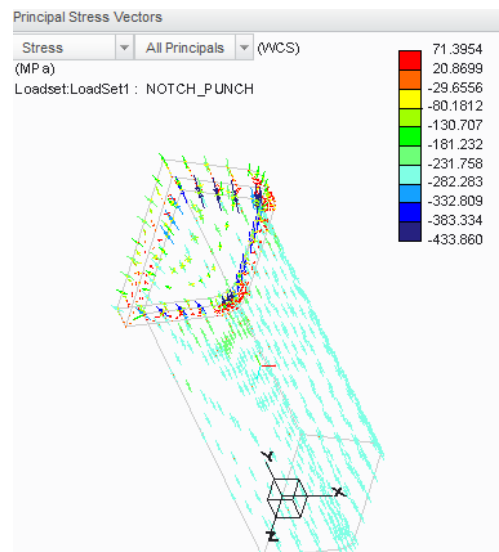


Fig 21 shows principal stress vector generated in notch punch 1&2.

Pierced hole2:-

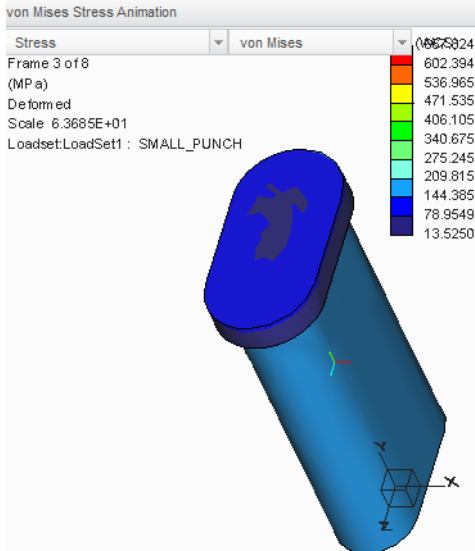


Fig 22 shows stress generated in Pierce punch2.

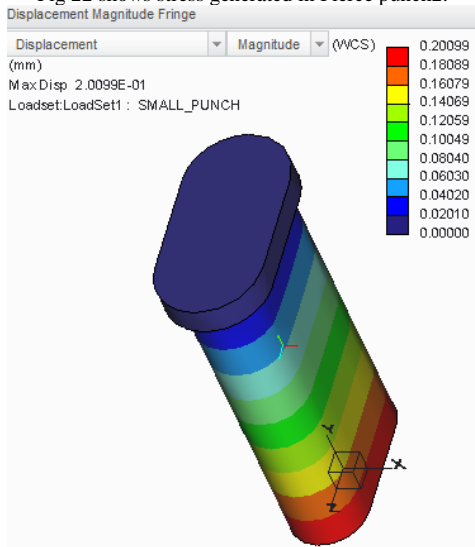


Fig 23 shows displacement generated in Pierce punch2.

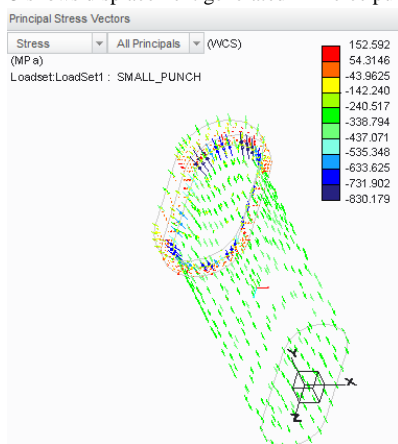


Fig 24 shows principal stress vector generated in Pierce punch2.

By using the Creo Parametric software analysis is performed. In this software it we put the input force value, selection of material. The result is:
Von Mises stresses.
Displacement magnitude fringe.
Principle stress vector.

VIII. CONCLUSION

Design of press tool for Piercing and notching made for sheet metal component (plate) has been developed by following the fundamental die design principles. The press tonnage required for the operation is above the capacity of the machine which exists. So it is required to use some force reduction method so that it is suitable for its existing press ton machine. Moreover the geometrical compatibility of the mechanical press and the designed combined press tool is excellent.

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 posses more strength. They are mainly used for making of tools.

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