Process of Press Tool Design and its Manufacturing for Blanking Operation

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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. Blanking is one of the sheet metal operations where we produce flat components of prerequisite shape. In Blanking the required shape periphery is cut and cut-out piece is called blank. The press tool used is for blanking operation is called as blanking tool, if piercing operation it is piercing tool and so on based on operation that we perform. The application of press operations are widely used in many industries like food processing, packing, defence, 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 blanking press tool and manufacturing of a prototype is made along with analysis. The press machine is of mechanical type.

INTRODUCTION

High rate production industries generally use press machines. Thickness can vary significantly, although extremely small thicknesses are considered as sheet and above 6mm are considered as plate. Thickness of the sheet metal fed in between is called its gauge. Sheet metal is simply fed in between the dies of press tool for any press operation to perform. The reciprocating movement of punch is caused due to the ram movement of press machine. The press machine may be of electrical type, mechanical type, pneumatic type, manual type and hydraulic type. In today's practical and cost conscious world, sheet metal parts have already replaced many expensive cast, forged and machined products. The common sheet metal forming products are metal desks, file cabinets, appliances, car bodies, aircraft fuselages, mechanical toys and beverage cans and many more. Due to its low cost and generally good strength and formability characteristics, low carbon steel is the most commonly used sheet metal because high carbon composition gives high strength to the material. The other sheet metals used are aluminium and titanium in aircraft and aerospace applications.

The purpose of this paper is to examine the causes for these seemingly contradictory results. An attempt will be made here to review the previous studies to look into future possibilities of various die designs.

The press machines may be of 1 ton, 2ton, 3ton etc. based on the amount of tonnage acting on the sheet. For general specifications and diagram of press machine see Fig: 1 and Table.1 shown below:

Fig: 1 Mechanical Press Tool Machine

SPECIFICATIONS	250 ton
Bed Size LR x FB(mm)	482x318
Bed to ram bottom(mm)	243
Bed to ram bottom(mm)	51
Adjustment of slide(mm)	25
Bloster thickness(mm)	67
Bed opening(mm)	100
Shank hole dia	32
No of strokes per min(mm)	735
No of strokes per min(S.P.M)	55
Motor power(H.p/R.P.M)	1.5/1440

Table.1 Specifications of 10 ton Press Tool Machine

PRESSES

• Mechanical Press - The ram is actuated employing a flywheel. Stroke motion isn't uniform.

• Hydraulic Press - Longer strokes than mechanical presses, and develop full force throughout the stroke. Stroke motion is of uniform speed, especially adapted to deep drawing operations.

Before design of tool it is necessary to understand the configuration of it and its components of press tool are in Fig: 2 The press tool consist of the punch , the die holder are used for fixing the die to the press machine. Die holder also used for supporting the rigidity of the die and its main function is to hold the punch. Backing plates are used at three locations in a die basically. It prevent the components to go deep inside the holder due to the force of press operation.

TOOL CONCEPT

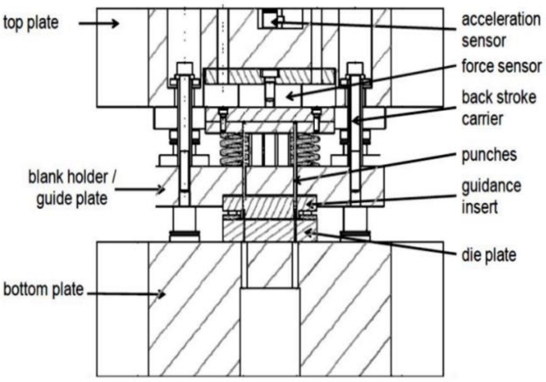
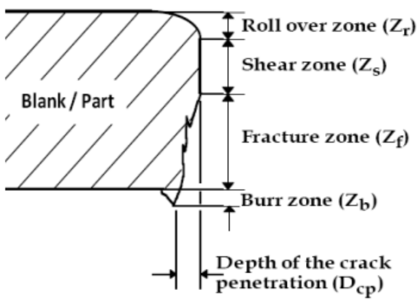
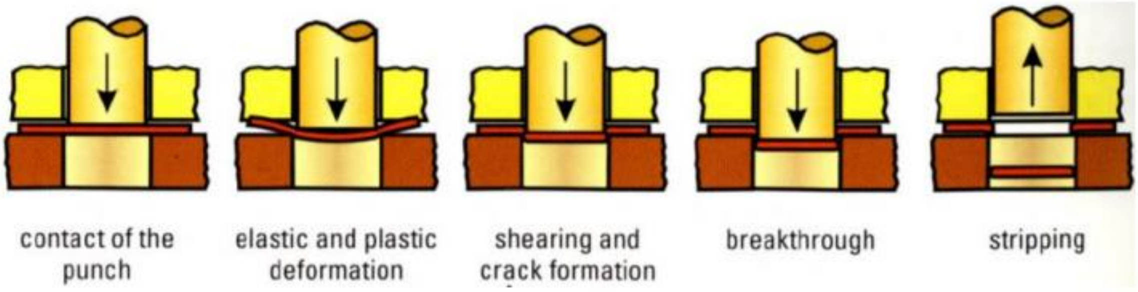


Fig: 2 Principle of Press Tool Die



Different zones of blanked part edge

Backing plates are also used for preventing the parts from getting detached and for adjusting the height of the die. A punch plate is used for the purpose of holding the punch during press operation. The main function of a stripper is to remove scrap, very frequently it is made to have important secondary functions of guiding the tip of the punch during press operation . Die plate determines the output of the press function and also the cutting is of sheet is done . For proper function clearance is left between the punch and die plate where the clearance depends on the sheet metal thickness and the type of material. The materials used for punches are powered high speed tool steel and punch dimensions determines the output of the press function. This paper is presenting the key factors and procedure involved in the manufacturing of blanking press tool and the procedure is below.



Phases of blanking process

Design of any Press Tool involves the subsequent Steps

1. Determination of force (Press Tonnage) required for the operation
2. Selection of Press for requisite force, work piece size and shape
3. Determination of shut height of the tool
4. Computing die thickness, and margins (minimum cross-section)
5. Drawing Strip Layouts and comparing Material utilization
6. Design of locating Elements
7. Selection of Locating Elements
8. Selection of Hardware
9. Drawing die plan and selection of pillar die set
10. Deciding punch length and mounting
11. Finding Centre of Pressure and Checking scrap Disposal
12. Drawing Details

PART ORIENTATION

The process begins with determining how the part are going to be run through the die. this is often governed by the features of the part and therefore the locations of the datum’s and important tolerances. Then, the trade-offs begin.

Optimizing material usage may require rotating the part within the strip, which changes the grain direction of the steel within the part and thus can affect the strength of any forms within the part. Forming with the grain can cause cracking and fatiguing of the metal and make holding consistent form angles harder . Therefore, the shape are going to be much more vulnerable to problems related to the chemical makeup of every coil that's run.

METHODOLOGY

(a) SELECTION OF MATERIALS

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. The properties of the materials used in the experimentation are tabulated below:

(i) En31: EN31 is a high carbon Alloy steel which achieves a high degree of hardness with compressive strength and abrasion resistance that are acceptable for many automobile applications such as heavy duty gear, shaft, pinion, cam shafts. It is neither externally brittle nor ductile due to its lower carbon content and lower hardness. For properties of En31 shown in Table No.2, 3 and 4

(ii) Table.2 Properties of En31

Chemical Composition (%)				
Carbon	Silicon	Manganese	phosphorous	sulphur
0.18	0.35	1	0.05	0.05

Table.3 Physical properties

Melting point	**Density**
1421^0C	7.7 x 1000 kg/m^3

Table.4 Mechanical Properties and Thermal properties

Elastic modulus	**Rockwell hardness**	**Izod impact**	**Thermal properties**
190- 210 GPa.	62	77.0 J	Thermal expansion 10.4 x10^{-6} / ºC

(ii) 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. For properties of D2 steel as shown in Table.5 and 6

Table.5 Chemical composition

Chemical Composition (%)							
Carbon	Silicon	Manganese	Chromium	Sulphur	Phosphorus	Vanadium	Molybdenum
1.6	0.6	0.6	13	0.03	0.033	1.1	1.2

Table.6 Physical properties and Mechanical properties

Density	Rockwell hardness	Elastic modulus	Yield stress	Tensile strength	Melting point
7810 kg/m^3	65	215000N/ mm^2	450N/ mm^2	750N/ mm^2	1540^0C

MODELLING

The materials used for making above blocks are mild steel and HCHCr. The material for the punch and the die block is HCHCr (EN31 and P20) whereas for base plate and guide block it is mild steel (H13 and EN8) . Punch and Die block should have high strength compared to base plate and Guide block. So high strength materials are used for punch and base. By comparison on many factors like strength ability, Machinability, thermal properties, load factor and cost factor EN31 and EN8 suits best. So EN31 selected for punch and base, EN31 for die and guide block.

DESIGN CALCULATIONS

The strip layout is presented in Fig:8. The calculation is done on strip to find out the following steps, using normal SPCC material for strip.

% of strip used =(Area of component x 4)/Length of strip x width of strip

Shear force = (KxLxTxS)/1000tons)= (1.2x2x3.141x10x0.5x420)/1000 =1.97 tons

Where, K =1.1 to 1.5 (constant based on clearance), L= length of cut in mm, T= thickness of cut in mm , S= Shear strength of material in kg/mm^2

- Stripping force = 10%of shear force = 0.2 ton
- Net force = Shear force+ Stripping force = 1.97+0.2 =2.2 ton

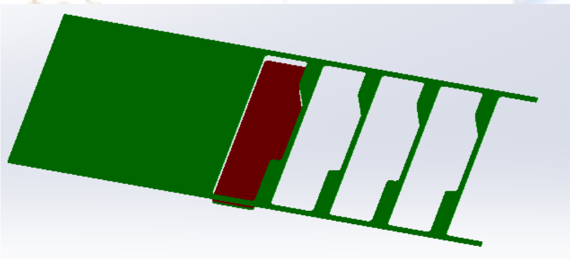


Fig: 8 Strips

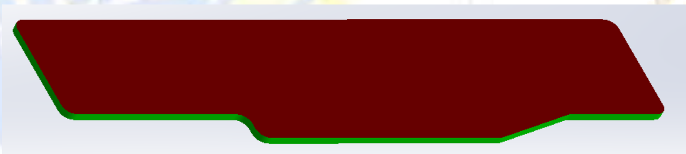


Fig: 9 Blank

The shear force, stripping force, net force and their respected values are as follows 1.97, 0.2, 2.2tons The blank is shown in Fig: 9 and the calculations for it is done as follows

Press tonnage = 1.2 x Total force = 1.2 x 2.2 = 2.64 tons

Cutting clearance = 4% of sheet thickness

Black punch size = Size of Blank die-2c

C=6% of thickness of wall

Cutting force = π x D x t x F_s =3.14x0.5x20x2.2= 69 N

Based on the output product required the calculations are made and proceeded to manufacture. Before we perform machining operations the material is already heat treated in order to achieve soft material. For D2 material to become soft material Annealing should be done. In annealing process (1550-1600^{0}F) is heated and slowly cooled to about 1000^{0}F. Now machining operations should be performed except finishing process. After machining

Quenching (150^{0}F cooled), Tempering(950^{0}F), Hardened to (1800-1850^{0}F) to obtain hardened material. Then only finishing operations are to be done to achieve the tool. Machining operations include lathe operation and milling operation on CNC (Computer Numerical Control). The operations done on lathe are facing and turning. Apart from that we also used drilling machine

Bill of Materials:

SI.NO	PART NAME	MATRIAL	QUANTITY	THICKNESS	WIDTH	LENGTH	HRC
101	BASE PLATE	MS	1	30	400	450	-
102	PARALLEL BLOCK 1	MS	2	40	60	400	-
103	PARALLEL BLOCK 2	MS	2	30	60	400	-
104	BOTTOM PLAE	MS	1	45	400	400	-
105	SETTING BLOCK	MS	4	45	45	58.1	-
106	STRIP GUIDE BASE	MS	1	20	30	163	-
107	STRIP SUPPORTER	MS	1	15	74	163	-
108	STRIP GUIDE FRONT	EN31	1	15	25	75	48-50
109	STRIP GUIDE REAR	EN31	1	15	25	75	48-50
110	DIE HOLDER	MS	1	35	195	245	-
111	DIE BACKPLATE	EN31	1	15	195	245	48-50
201	DIE	D2	1	35	65	95	58-60
301	TOP PLATE	MS	1	45	400	400	-
302	PUNCH BACKPLATE	EN31	1	15	195	245	48-50
303	PUNCH HOLDER	MS	1	25	195	245	-
304	STRIPPER PLATE	EN31	1	25	195	245	48-50
305	STRIPPER BALANCER	EN31	4	15	25	25	48-50
306	BUSH LOCK	MS	8	3	15	15	-
307	EJECTOR PIN	EN31	3	6	6	18	48-50
401	PUNCH	D2	1	25	60	110	58-60

SI. NO	PART NAME	QUANTITY	MISUMI STANDARD CODE
1	GUIDE POST	4	MYKP25-140
2	LIFTING HOOK	8	CHN16
3	SPOOL RETAINER	6	CSR13-60
4	SPRING	6	SWH30-45
5	SUPPORT PILLER	4	SGPH16-90
6	SUPPORT BUSH	4	SGBH16-20

a) Punch and Die Block

The main function of the punch is to strike the sheet metal, which is attached to the hub of the power press machine. The striking power is dependent on tons capacity of machine. The punch is fitted by means of tapering at its top locked by a nut. The dimensions of punch are and its drawing in AUTOCAD 2014 as shown in below drawings. The shape and dimensions of the product to be achieved depends on design of Die block. The product is of coin type shape with 20mm dia. Clearance should be there between punch and Die block, otherwise we cannot perform the operation. Clearance is given based on the thickness of sheet and it is about 10% of sheet thickness. If we consider sheet thickness as 2mm then positive tolerance should be given as 0.2mm for die block.

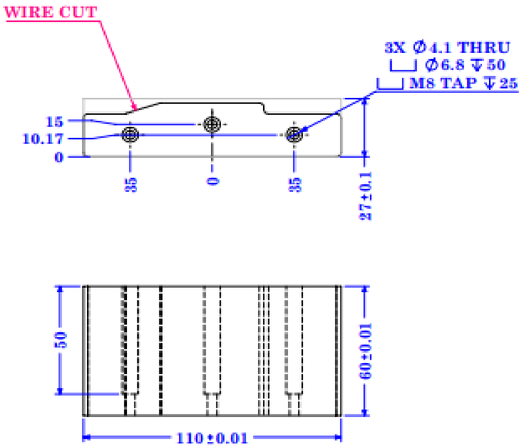


Fig: 3 Punch

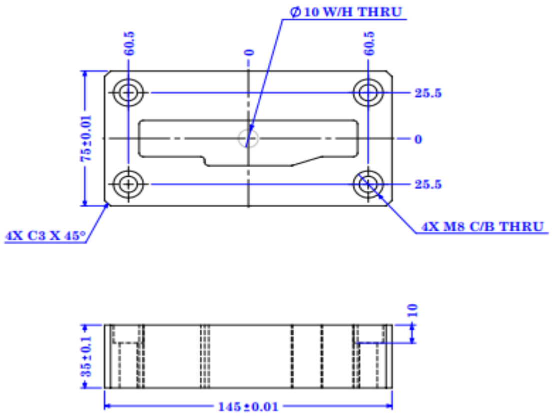
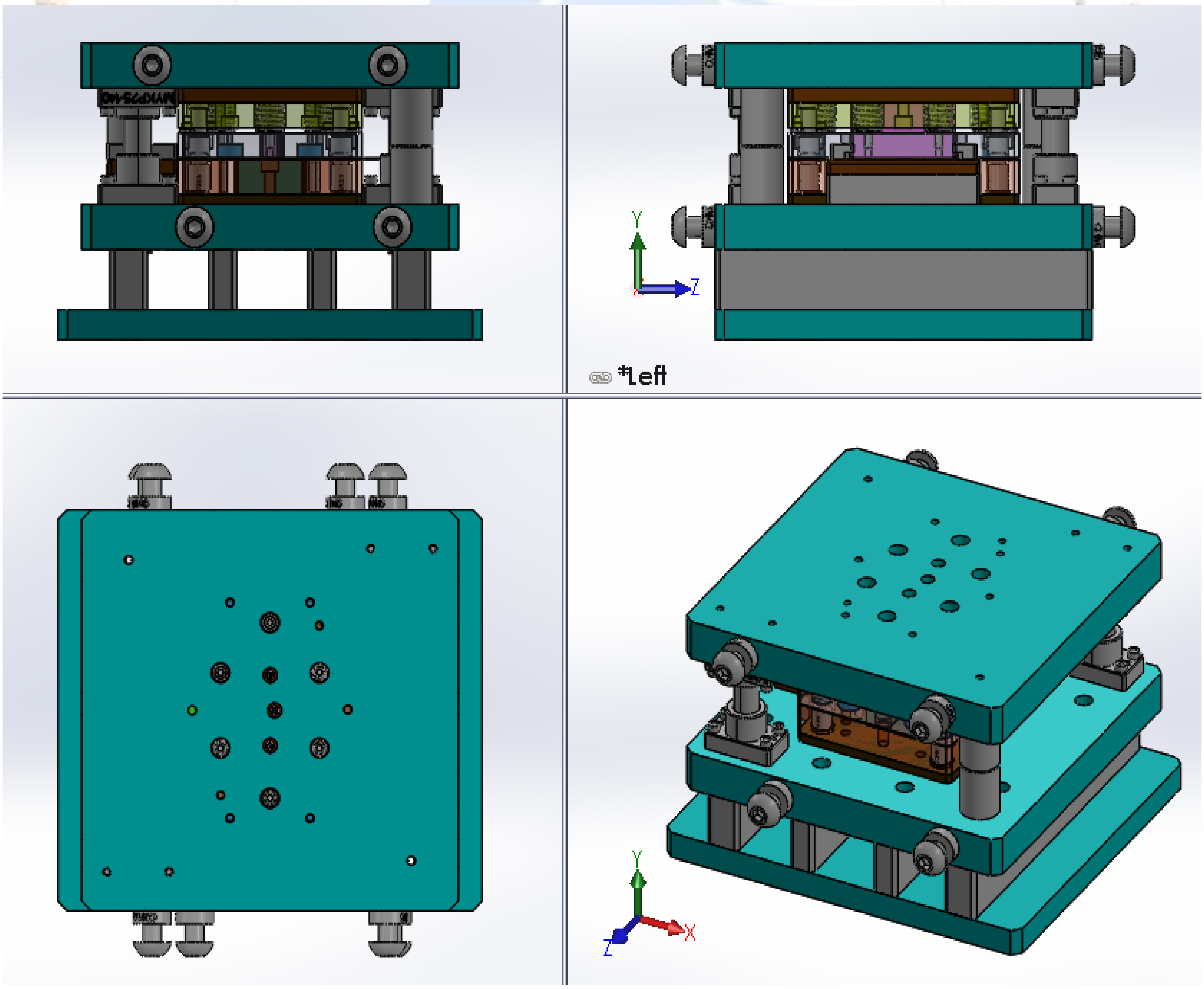


Fig: 4 Die Block

b) Guide Block and Base Plate

The Guide block is just a supportive block that acts as intermediate between the punch and the Die block. The main function is to oppose the Shear force and perform sheet metal operation. The drawing and dimensions is shown in Fig:5 for the guide block. The Base plate or bottom plate is placed at the end of the configuration where the work piece or scrap goes down. Here the punch moves down with high force, so in order to prevent the breakage of Die high strength material is used and placed as bottom plate. So base plate and punch are made of same material. The diagram and dimension for Base plate is shown in Fig: 6 below:

ASSEMBLY



ASSEMBLY

The assembly of all four parts including the screwing is shown below with front and top view:

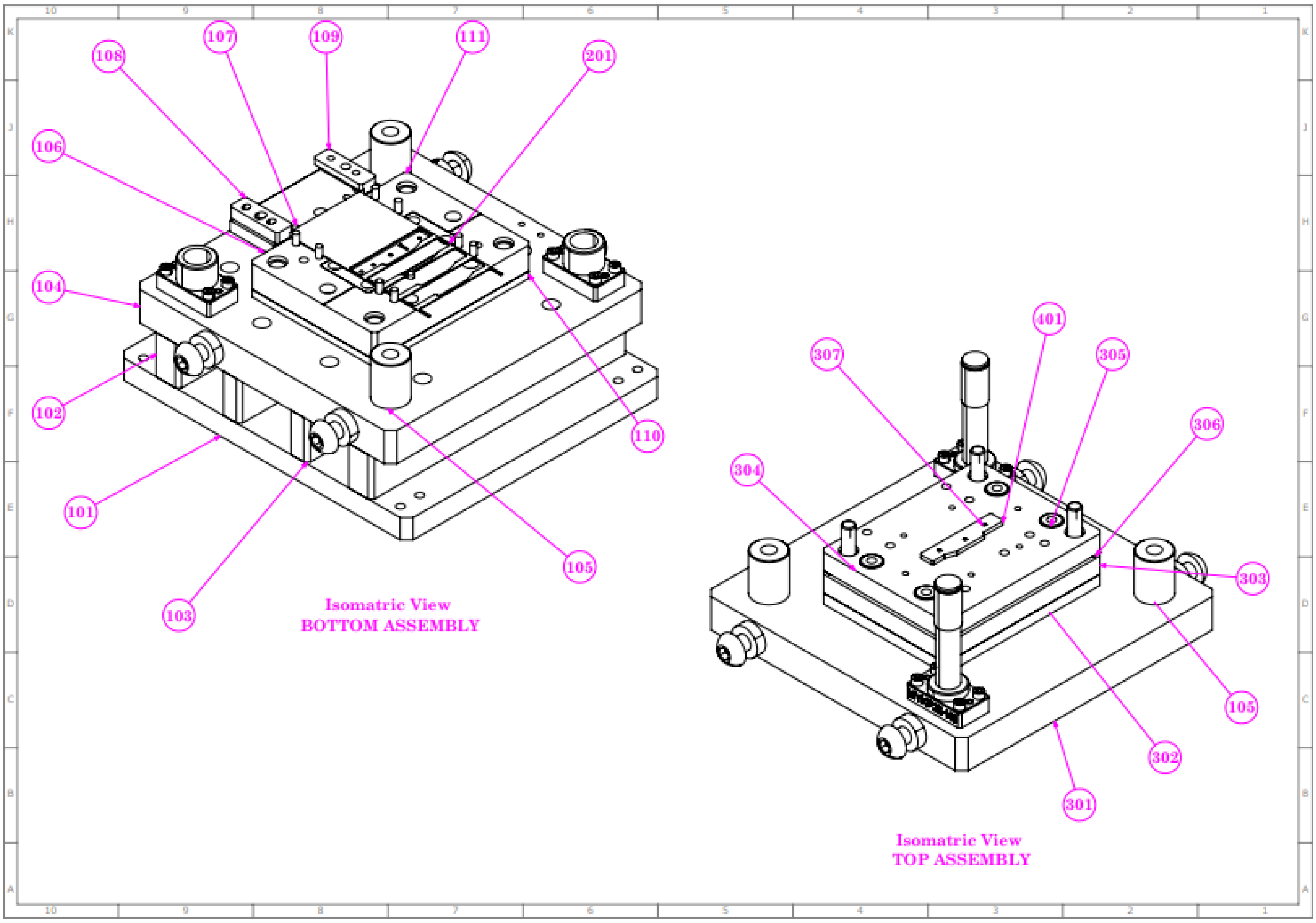


Fig: 7 Assembly Diagram

ANALYSIS FOR PUNCH - Press Tool Efficiency

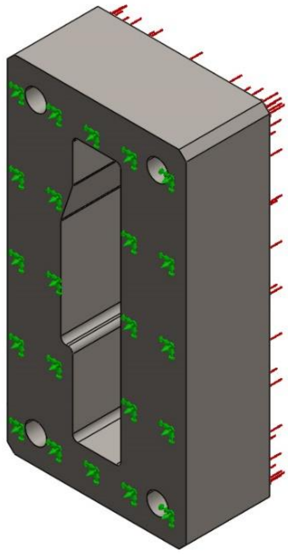
Press tool efficiency is lost through defects accumulating in press components. As the die significantly impact the overall efficiency of the press, defects the efficiency of the press tool. When defects arise, such as punch cracking and die corrosion leads to inefficient interactions between the punch 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, consistent with the findings of this paper, should be considered. Meshing is shown below. 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:

The part deforms in displacements

The product is static and constant over time

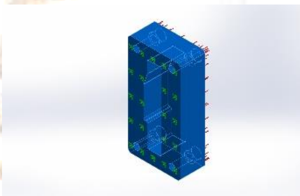
The constant stress strain relationship in material.

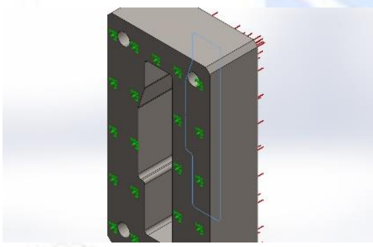
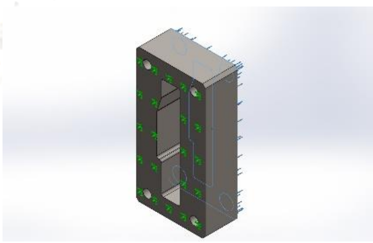
Model Information

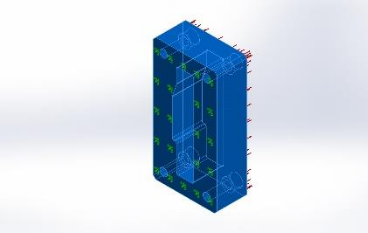


Model name: BLANKING DIE
Current Configuration: Default

Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude1 	Solid Body	Mass:2.19919 kg Volume:0.000279796 m^3 Density:7,860 kg/m^3 Weight:21.5521 N	D:\ME-ED\Mini project\BLANKING DIE.sldprt

Load name	Load Image	Load Details
Force-2		**Entities:** 1 face(s) **Type:** Apply normal force **Value:** 20,000 N
Pressure-1		**Entities:** 1 face(s) **Type:** Normal to selected face **Value:** 2.45166e+06 **Units:** N/m^2

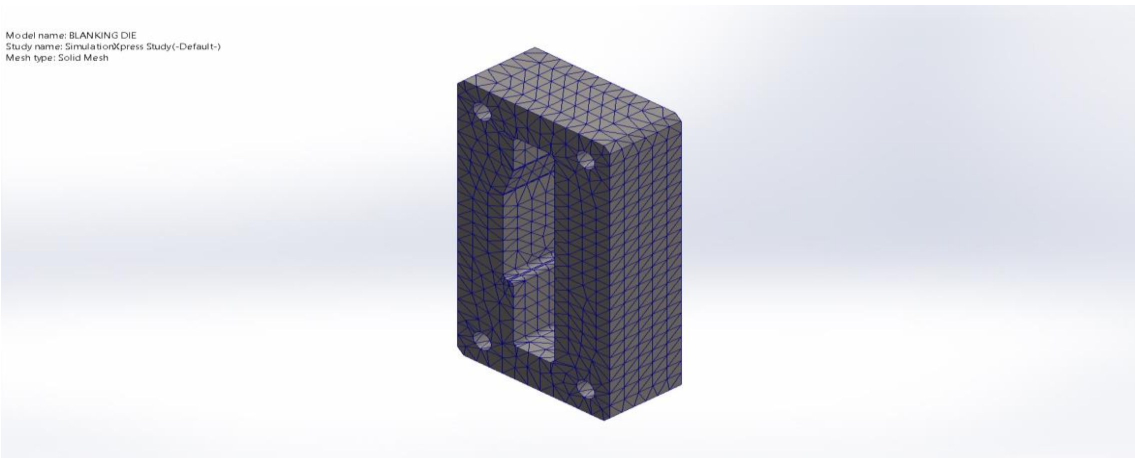
Model Reference	Properties	Components
	Name: **AISI Type A2 Tool Steel** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress**	**SolidBody-1(Cut-Extrude1)(BLANKING DIE)**

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points for High quality mesh	16 Points
Element Size	6.54232 mm
Tolerance	0.327116 mm
Mesh Quality	High

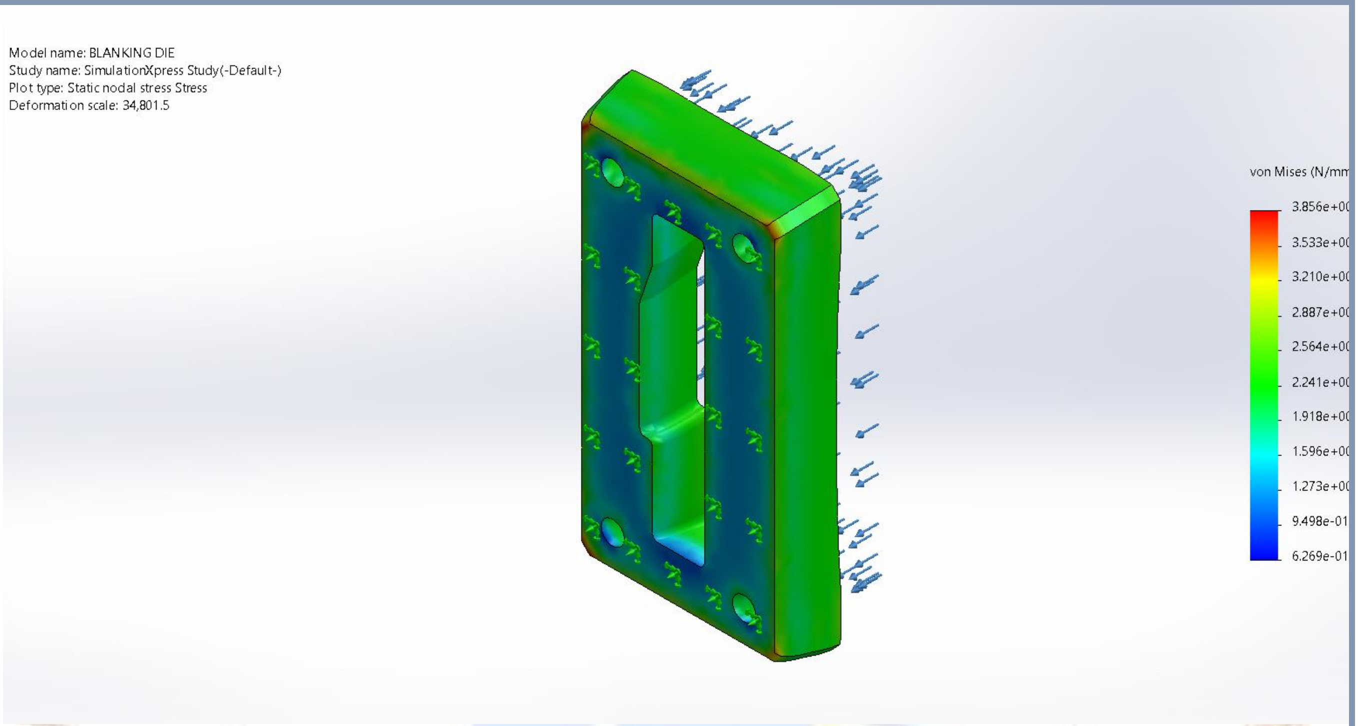
Mesh information – Details

Total Nodes	13868
Total Elements	8525
Maximum Aspect Ratio	20.633
% of elements with Aspect Ratio < 3	97.3
Percentage of elements with Aspect Ratio > 10	0.106
Percentage of distorted elements	0
Time to complete mesh(hh;mm;ss):	00:00:02
Computer name:	



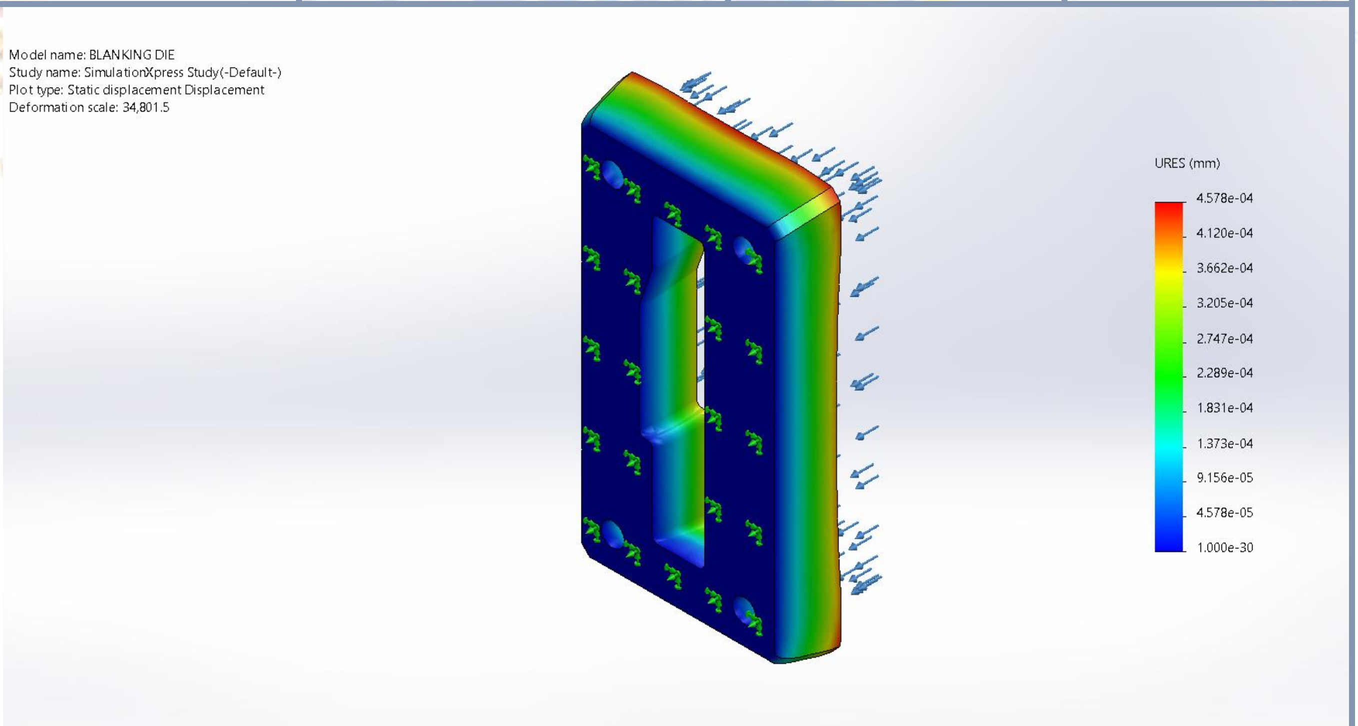
Study Results

Name	Type	Min	Max
Stress	VON: von Mises Stress	6.269e-01N/mm^2 (MPa) Node: 13271	3.856e+00N/mm^2 (MPa) Node: 545



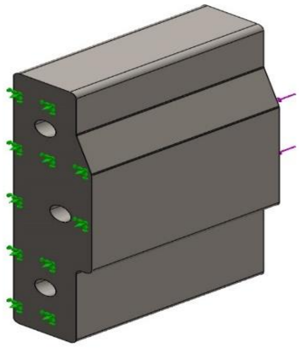
BLANKING DIE-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.000e+00mm Node: 20	4.578e-04mm Node: 749

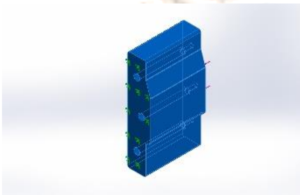


BLANKING DIE-SimulationXpress Study-Displacement-Displacement

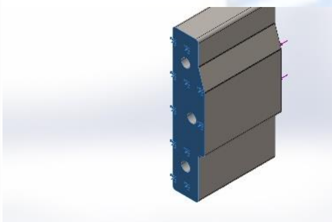
Model Information

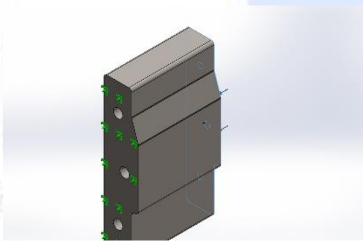


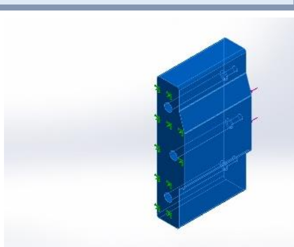
Model name: BLANKING PUNCH
Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Imported1 	Solid Body	Mass:1.11141 kg Volume:0.0001414 m^3 Density:7,860 kg/m^3 Weight:10.8918 N	D:\ME-ED\Mini project\BLANKING PUNCH.sldprt

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** **1 face(s)** **Type:** **Fixed Geometry**

Load name	Load Image	Load Details
Force-1		**Entities:** **1 face(s)** **Type:** **Apply normal force** **Value:** **20,000 N**

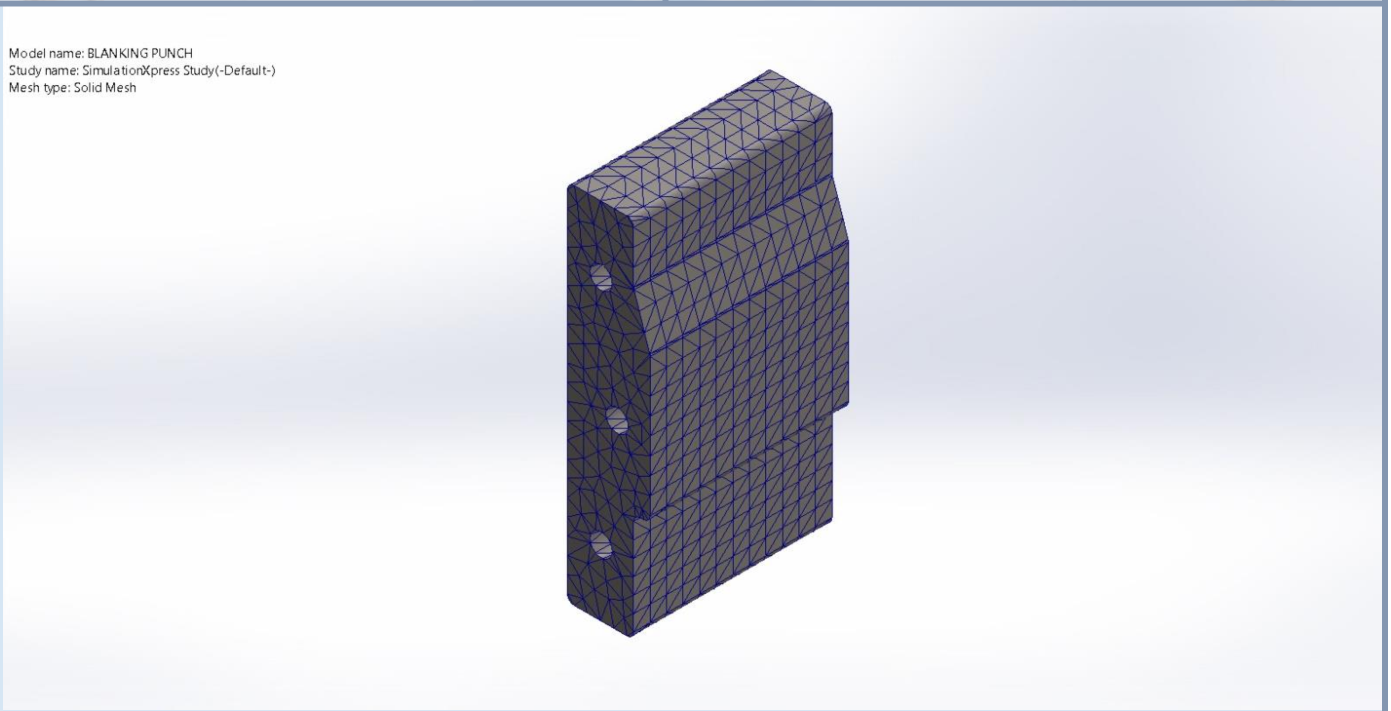
	Material Properties	
Model Reference	**Properties**	**Components**
	Name: **AISI Type A2 Tool Steel** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress**	**SolidBody 1(Imported1)(BLANKING PUNCH)**

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points for High quality mesh	16 Points
Element Size	5.21129 mm
Tolerance	0.260564 mm
Mesh Quality	High

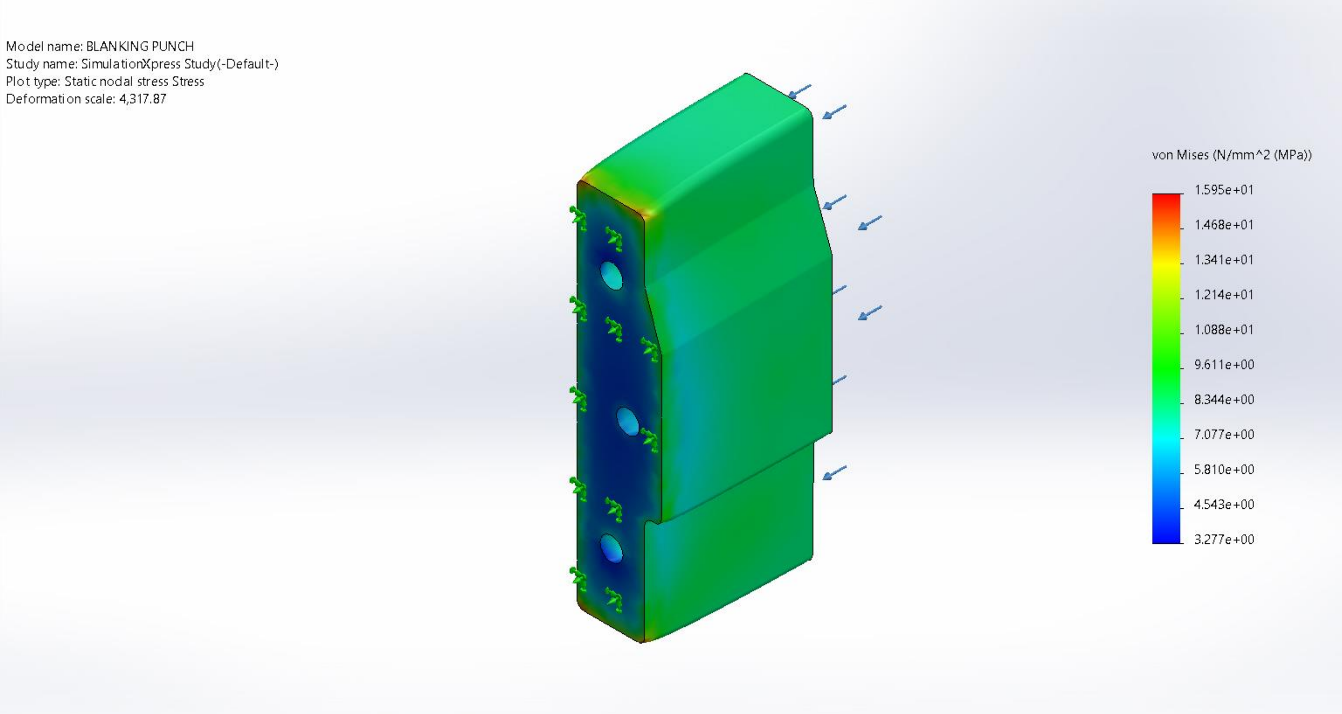
Mesh information – Details

Total Nodes	16691
Total Elements	10719
Maximum Aspect Ratio	16.642
% of elements with Aspect Ratio < 3	96.7
Percentage of elements with Aspect Ratio > 10	0.056
Percentage of distorted elements	0
Time to complete mesh(hh;mm;ss):	00:00:01
Computer name:	



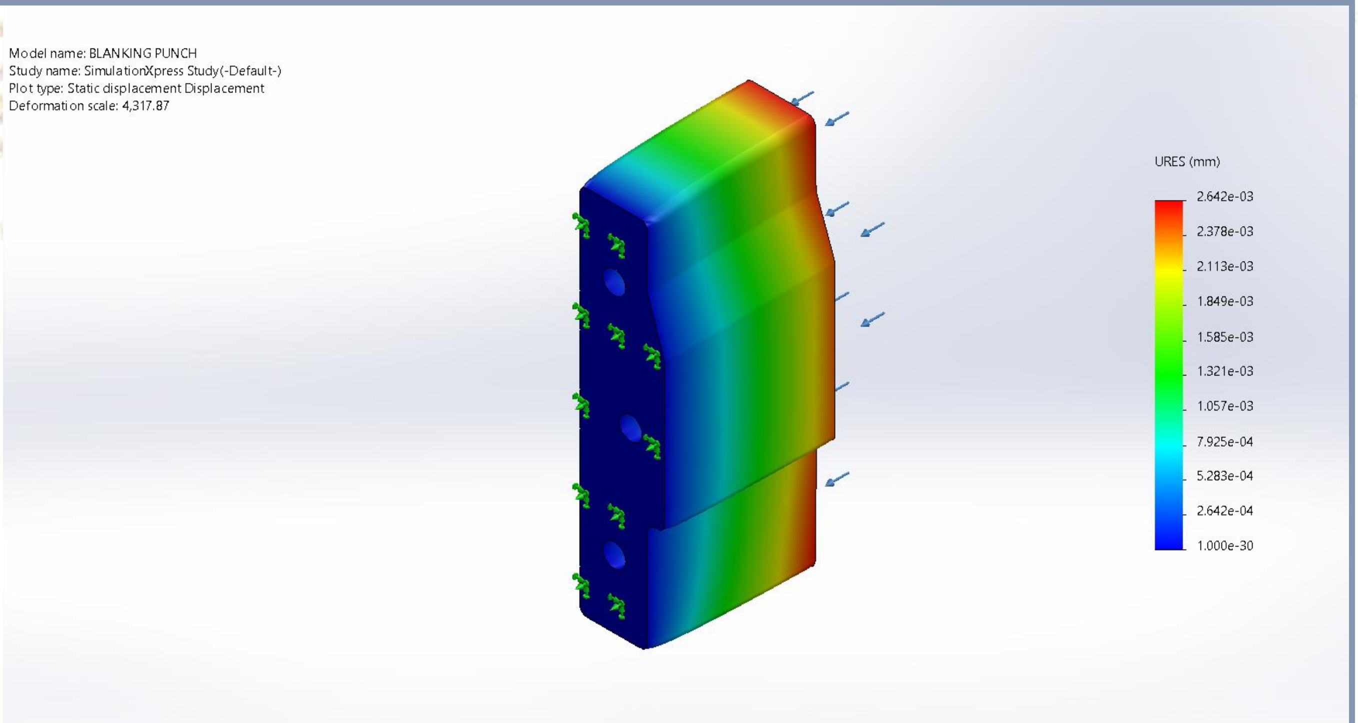
Study Results

Name	Type	Min	Max
Stress	VON: von Mises Stress	3.277e+00N/mm^2 (MPa) Node: 160	1.595e+01N/mm^2 (MPa) Node: 11776



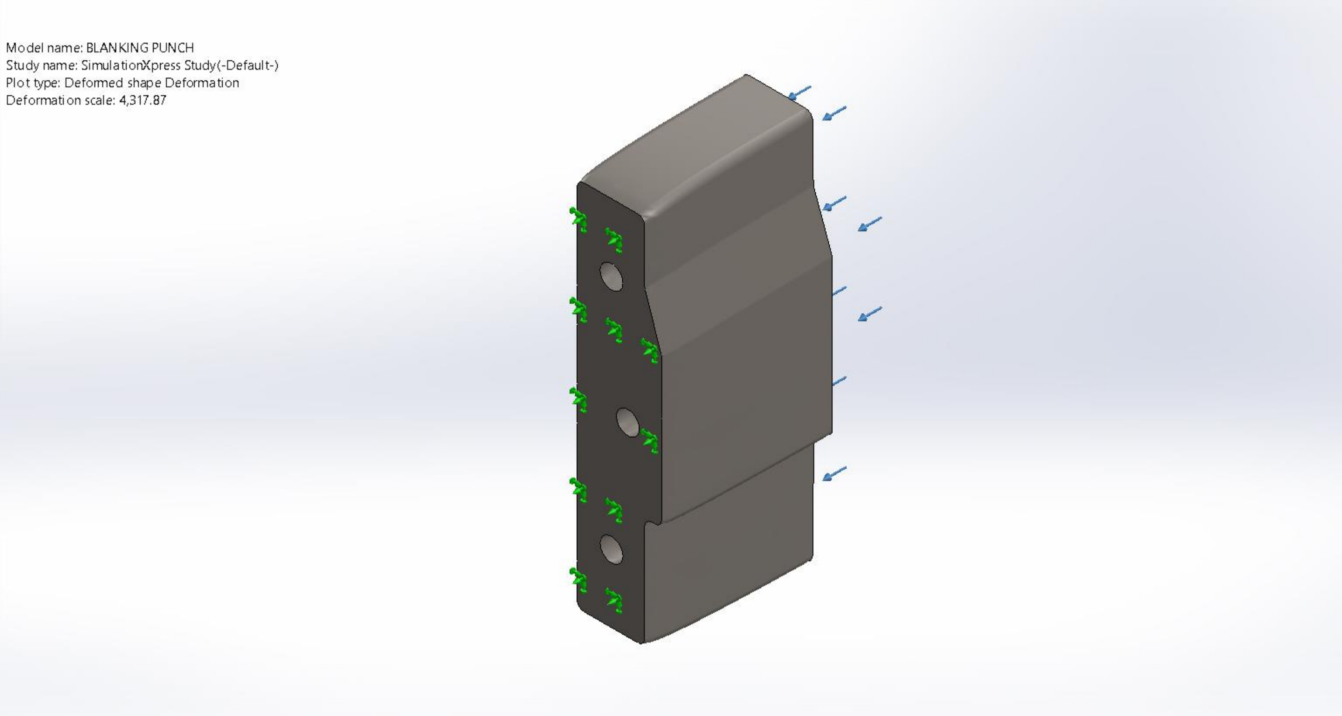
BLANKING PUNCH-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.000e+00mm Node: 14	2.642e-03mm Node: 11861



BLANKING PUNCH-SimulationXpress Study-Displacement-Displacement

Name	Type
Deformation	Deformed shape



BLANKING PUNCH-SimulationXpress Study-Displacement-Deformation

APPLICATION OF PRESS TOOLS

Press tools are extensively used for the production of sheet metal components in mass.

Examples

Most of the products namely, Television, Tape recorder, Radio, Refrigerator, Automobile Car, Scooter, Motorbike, Watch, Computer etc, consist number of components made of either plastic or sheet metal.

ADVANTAGES

1. Automated mechanical press lines ensure efficient manufacturing of medium-size and large panels in production of high volumes.
2. Depending on the number of required forming operations, the lines consist of four, five, or six automated mechanical single presses
3. Advanced mechanical presses offer a long slide stroke and thus permit the manufacture of complex part shapes.
4. Fully automated systems solutions for high - volume manufacturing
5. Fast and reliable component transport with advanced technology
6. Parts of the highest quality thanks to perfected press and bed cushion technology
7. The most advanced automation technology increases production rates
8. High levels of uptime for the lines & Process reliability
9. More parts are produced
10. Improved part dimensional accuracy
11. Greater material strength

With its blanking and forming presses in this series offers manufacturing systems that permit cost-effective blanking, drawing, coining, piercing, and calibrating for the production of ready-to-install precision parts in a single operating sequence.

A number of fields - proven modules can be assembled to form application - specific, customized manufacturing systems. Press models in these series are mechanical presses with modified knuckle-joint drive.

CONCLUSIONS

Design of press tool for blanks made for sheet metal component has been developed by following the fundamental die design principles. The press tonnage required for the operation is below the capacity of the machine which exists. So it is suitable for its preceding press ton machine. Moreover the geometrical compatibility of the mechanical press and the designed combined press tool is excellent. The output received is

- Output product having diameter 20mm and its tonnage capacity is 2.2 tons. So it only suits for above 2.5 ton press machines.

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.

- The stress region in punch and strain displacement is found.

Therefore newly developed combined press tool is recommended in order to have an improved productivity, improved efficiency, better flexibility, more economical manufacturing process with lower cost of the product.

REFERENCES

(1) N.B.Suresh, A Lerner's guide to Press Tools, published by Pannaga international academy, fourth edition [2010].

(2) G.R.Nagpal, Tool Engineering and Design, Khanna Publishers

(3) M.Rachik, J.M.Roelandt, A.Maillard, "Some Phenomenological & Computational Aspects of Sheet Metal Blanking Process", Journal of Material Processing Technology, Elsevier, Volume 128, 2012, Page 256-265

(4) TOOL DESIGN DATA BOOK, directorate of technical education government of tamilnadu.

(5) GT&TC Standard Data Hand Book

(6) Prakash H.Joshi, Press Tool: Design & Construction, Wheeler Publishing

(7) Jutz-Scharkus, Westermann Tables, Revised second edition, new age international (P) limited, publisher [2006] [1996]

(8) David A.Smith, Die Design Handbook, SME- Society of manufacturing engineers, Third Edition [1990]

(9) Emad Al-Momani, Ibrahim Rawabdeh "An Application of Finite Element Method and Design of Experiments in the Optimization of Sheet Metal Blanking Process"