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Research Article

DESIGN AND ANALYSIS OF PUNCHING MACHINE FOR TEFLON (PTFE) WASHER

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ABSTRACT

The paper includes design, modeling, and analysis of the compound die punching press. The main aim of this proposed project is to replace the existing hand operated punching press with a new compound die punching press having automated feeding mechanism. This Machine is basically designed to manufacture Teflon (PTFE) washer which acts as an insulation in Poly-fusion device which is used for enlarging the diameter of plumbing accessories. The function of this newly designed press machine is same as previous one but the mechanism is modified for automated feeding and punching with highly efficient compound die. Compound die performs blanking and piercing operation in a single stroke but in two stages, so that power required can be reduced. The expected outcome from the newly designed machine is to overcome the limitations of the previous machine and increase production rate nearly 3 to 4 times. Basically, this project is to introduce automation in industries, due to this production rate, quality and efficiency of newly designed machine is also increased considerably

INTRODUCTION

Today's world is moving very rapidly towards automation. Every manufacturer is trying to automate each and every manual process to increase production rate as well as to overcome labor problems. Moving on the same way we are also trying to catch the speedy research in automated world. In Omega Enterprises, we found the manual operations for manufacturing a Teflon (PTFE) washer and taken the project in hand to automate the same with greater efficiency.

The research work includes, design and analysis of the compound die punching press with automated feeding mechanism. This Machine is basically designed to manufacture Teflon (PTFE) washer which acts as an insulation in Poly-fusion device which is used for enlarging the diameter of plumbing accessories. The main function of washer is to avoid transfer of heat from heater to the other plastic accessories and protect it from damage. The main aim of this project is to replace the existing hand operated punching press with a new compound die punching press having automated feeding mechanism. Expected outcome from the new designed machine is to overcome the limitations of previous machine and increase production rate nearly 5 to 6 times. Function of this new press machine is same as previous one but mechanism is modified for automated feeding and punching with highly efficient compound die. Compound die performs blanking and piercing operation in single stroke but in two stages, so that power required can be reduced. Staggering is also provided on the punch to reduce the shear force during blanking operation. Ultimately production rate, quality and efficiency of machine are also increased considerably.

Designing is a preliminary stage of any project. Design phase includes mathematical calculation of punching forces, power requirement, dimensions of the die and other parts. It also includes the CAD modeling and simulation of the model. For designing CAD model team use advance 3D modeling software CATIA v5. After designing this project turns in very important stage kwon as Analysis. This stage includes various type of analysis like kinematic, dynamic, Theoretical analysis of shaft flanges. For more accuracy and optimization team also use advance CAE software like ANSYS 12.0.

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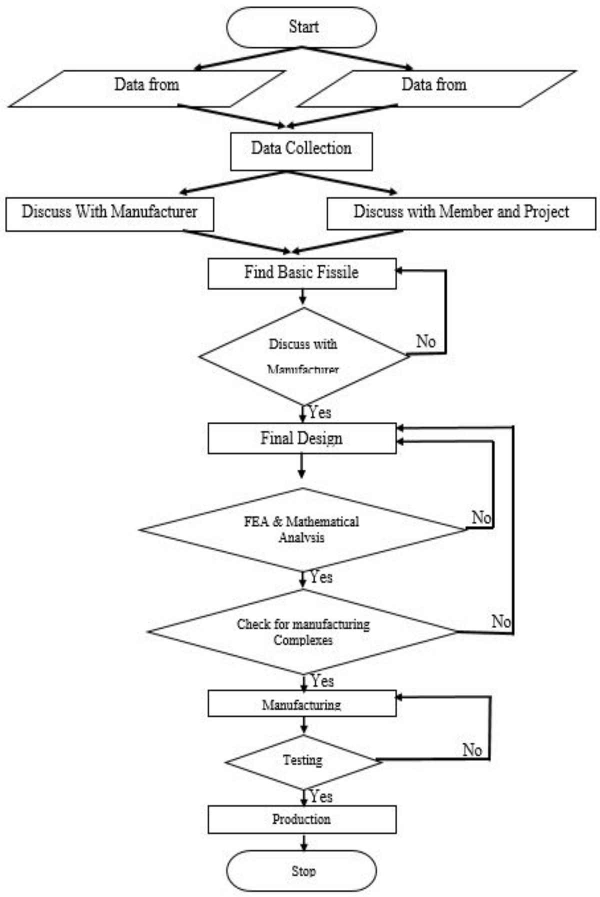
Teflon is a registered trademark of the DuPont Company for its fluoro-polymer resins. Teflon PTFE fluoro-polymer resins are part of the DuPont family of fluorine-based products that also includes Teflon FEP and Teflon PFA fluoro-polymer resins and Tefzelfluoropolymer. These materials can be used to make a variety of articles having a combination of mechanical, electrical, chemical, temperature, and friction-resisting properties unmatched by articles made of any other material. Commercial use of these and other valuable properties combined in one Material has established Teflon® resins as outstanding engineering materials for use in many industrial and Military applications. Teflon® resins may also be compounded with fillers or reinforcing agents to modify their performance in use.

TEFLON (PTFE) Teflon is a registered trademark of the DuPont Company for its fluoropolymer resins. Teflon PTFE fluoropolymer resins are part of the DuPont family of fluorine-based products that also includes Teflon FEP and Teflon PFA fluoropolymer resins and Tefzel fluoropolymer. These materials can be used to make a variety of articles having a combination of mechanical, electrical, chemical, temperature, and friction-resisting properties unmatched by articles made of any other material. Commercial use of these and other valuable properties combined in one Material has established Teflon® resins as outstanding engineering materials for use in many industrial and Military applications. Teflon® resins may also be compounded with fillers or reinforcing agents to modify their performance in use.

Project Methodology



The project is started with collecting data from manufacturer and observation done by a team member during problem identification. Then for basic designing require data from manufacture how they want to increase production rate and what they expected from the project. After discussing this entire thing find a basic fissile solution for the problem. This fusible solution is discussed with company persons if they approve it then next is final design if they not approve the project is returned to again finding alternative design.

After designing next step is an analysis of the design. The analysis consists of mathematical calculation as well as FEA analysis. If the design is safe in the manual as well as FEA analysis then project turn in next step or project is a return to designing phase. Then next phase is checking for manufacturing complexes. Then manufacturing stage consists of complete manufacturing of machine with actual working of the model with the production of the washer. Before production stage, this is mandatory to test machine on extreme condition. After that production is taking place.

About Product

The machine is designed for manufacturing TEFLON (PTFE) washer as shown in figure 1. This washer used in poly fusion device as shown in figure 3.

Figure 1 Hand Press

Figure 2 PTFE Washer

Figure 3 Poly Fusion Device

The poly fusion device is used for plumbing application, to change the diameter of pipe for joining two ends of the pipe. The diameter is changed by heating the coil which is fitted in the front side of the poly-fusion device. When Heater is heated the heat is transfer to the Coil section. It chance to damage the electric part so for safety the Teflon washer is fitted because TEFLON restricts the heat flow.

Design Calculation

Machine design is not guided by any rigid rules; however design is not a random procedure either. There are a number of factors that can aid a machine design process. It is very important to understand the process of mechanical design and follow this process to develop machine/heavy equipment designs that deliver the best performance.

$$\textbf{Shearing force} = \frac{1.2 \times 170.66 \times 1.5 \times 18.6}{1000}$$

=5713.67 N
= 0.582 Ton
= 582.43 KG

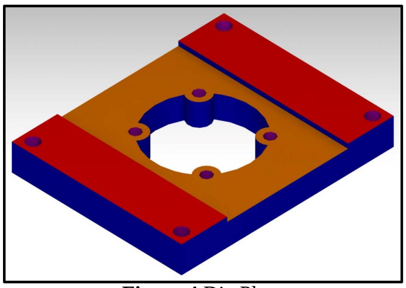
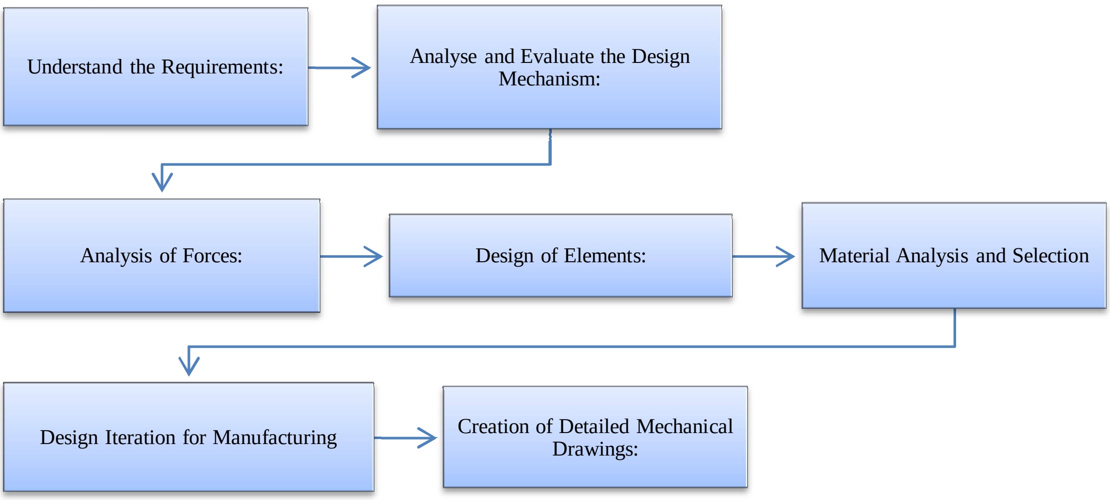


Figure 4 Die Plate



Die Clearances

Die clearance depends on the part material property. If the material is ductile in nature then the clearance is small and for brittle material, it is large clearance. If the clearance is given in reverse then there for ductile material it passes through die means here it draws from die instead of cutting. And in the ductile material, it damages the cutting edges of punch and dies. The die clearance for mild steel is 2.5% or 5% of thickness per side.

C = 2.5 % of thickness
= (2.5/100) x 1.5 = 0.225 mm
Or
C = 5% of thickness
= (5/100) x 1.5 = 0.075 mm

Large clearance increases the tool life but also increase bur size for good finishing here take 2.5 % of thickness per side.

Force Analysis

Shear Force

Shear force $F = \frac{(K \times L \times T \times S)}{1000}$ TONS

K =1.2 for normal clearance
L = perimeter of the blank = 170.66 mm
T =thickness of the stock strip = 1.5 mm
S =shearing strength of PTFE = 18.6Mpa

Die Block

The bottom assembly is the female part of the punch tool. The most important part of bottom assembly is die block. The cutting edge is given to the die block. The land is also provided on the die block. This land is provided for the proper cutting. The land for the die is given by the 1.5t.

Thickness of the die plate T = $\sqrt[3]{\text{Shear Force}}$
Thickness of the die plate T = $\sqrt[3]{0.58243}$
= 8.35
= 9 mm

Thickness of punch holder plate

It is necessary to find out the size of punch holder plate because applied force which is come from the shaft is transmitted through this plate. When blanking and piercing operation is happening back force is applied on it.

Thickness of the punch holder plate = 0.75 T
= 0.75 (9)
= 6.75 mm
= 9 mm

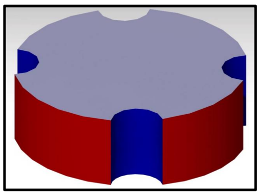


Figure 5 Punch

Thickness of the top bolsters plate

Thickness of the top bolster plate = 1.25T
= 1.25(9)
= 11.25 mm
= 15 mm

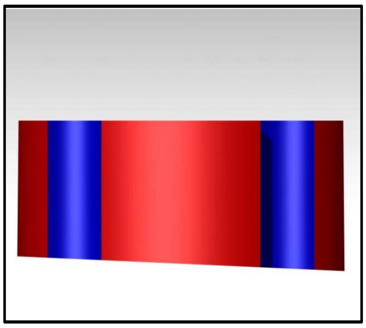


Figure 6 2^0 of Punch

Thickness of the bottom bolster plate

Thickness of the bottom bolster plate = 1.75T
= 1.75(9)
= 15.75 mm
= 20mm

Punch

Punch is made part of the press tool. The cutting operation is carried out here. So the material required for manufacturing the punch is harder than the part material

The travel of punch is given by the following formula,

Travel = Entry in Stripper plate + Entry in die + Part Thickness.
= 10+10+5
= 25 mm

For reduce, punching force punch is applied gradually because it has 2° tappers as shown in the figure. Due to that cutting action is tack place gradually ultimately it reduce power consumption, increase the quality of punching and life of punch.

Design of Shaft

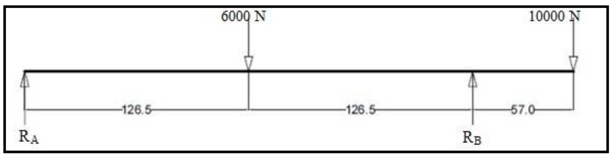


Figure 7 Force Acting on Shaft

Shaft material-EN8

Ultimate Tensile strength-621Mpa
Yield strength- 465Mpa
Young's modulus-207Gpa
Allowable shear stress (τ) - 66 MPa

$$P = \frac{2\pi NT}{60}$$

$$373 = \frac{2\times\pi\times 20\times T}{60}$$

T = 178.09 N-m

Centre distance between pulleys (X) - 350mm
Size of pulley
1) 40mm 2) 96mm

Angle of contact (θ),

$$\text{Sin}\alpha = \frac{R2-R1}{X}$$

$$\alpha = \sin^{-1}\frac{48-20}{350}$$

α = 4.58
Angle of contact θ =180-2α
= 180 - 2 × 4.58
= 170.84°
= 2.98 *rad*

We know that,

$$\frac{T1}{T2} = e^{\mu\times\theta}$$

$$= e^{0.3\times 2.98}$$

= 2.17

Now,
T = (T1 - T2) × R
178.09 = (2.17 T_2 - T_2) × 48
T_2 = 3171.11 N
T_1 = 9881.3087 N
W_c = 6877.83 + 3169.51
= 10047.34 N

We know that the equivalent twisting moment,

$$T_e = \sqrt{(km \times M)^2 + (Kt \times T)^2}$$

$$= \sqrt{(1.5 \times 570000)^2 + (1.5 \times 178000)^2}$$

= 855416.7931 N-mm

We also know that the equivalent twisting moment (T_e),

$$895719.822 = \frac{\pi}{16} \times \tau \times D^3$$

D = 41. 03 mm

Again we know that the equivalent bending moment,

$$Me = 0.5\,[Km \times M + \sqrt{(km \times M)^2 + (Kt \times T)^2}]$$

$$= 0.5\,[1.5\times 570000 + \sqrt{(1.5 \times 57000)^2 + (1.5 \times 178000)^2}\,]$$

= 1750719.822 N-mm

We also know that the equivalent bending moment (*Me*),

$$Me = \frac{\pi}{32} \times \sigma_b \times D^3$$

$$1750719.822 = \frac{\pi}{32} \times 175 \times D^3$$

D = 44.37 mm
Taking the larger of the two values, we have
D = 44.37
D = 45 mm (According to standard)

Computer Aided Engineering (CAE)

Computer-aided design (CAD) is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. Each stage requires specific knowledge and skills and often requires the use of specific software.

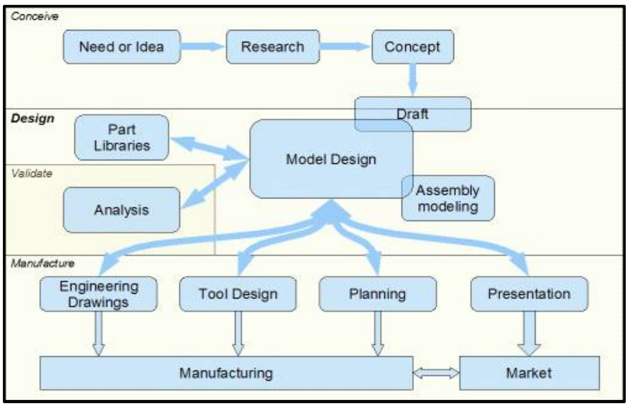


Figure 8 Computer Aided Manufacturing Procedure

Cad Model of Sub-Assemblies

Analysis of Critical parts

For analysis consider that machine is working for 5 years and in each 10000 washers is produce per month

Shearing Force = 5713 N
With FOS = 5713 × 4 ……………………… (FOS = 4)
= 22852 N

For Design Cycle

Consider that 10000 washer produce/month
M/C Working for 5 year
So,
Total cycle = 10000 × 5 × 12 = 600000 cycle
Consider FOS 4
So,
Total Cycle = 600000 × 4
= 2400000

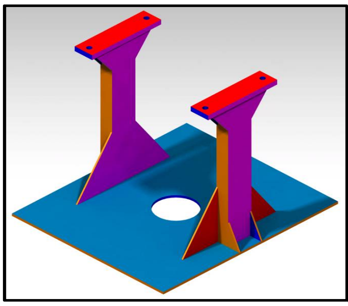


Figure 9 Frame

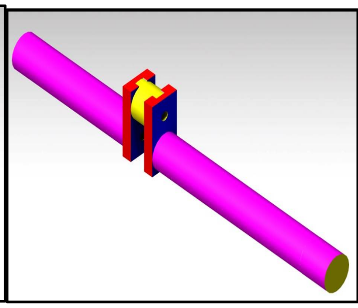


Figure 10 Shaft

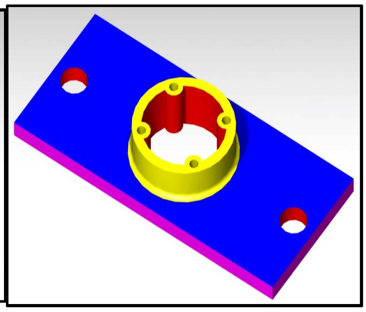


Figure 11 Guide Plate

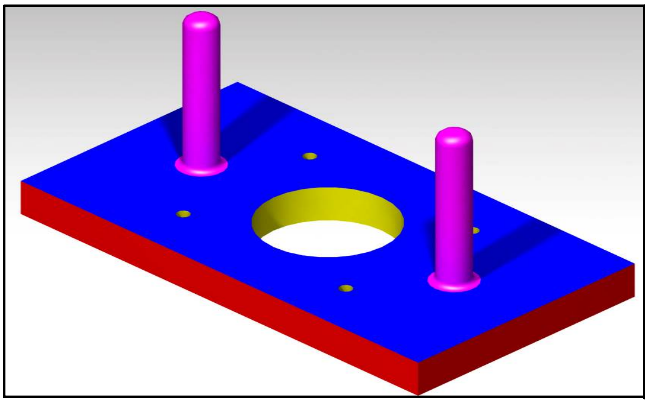


Figure 12 Guide pillar with Bottom bloster Plate.

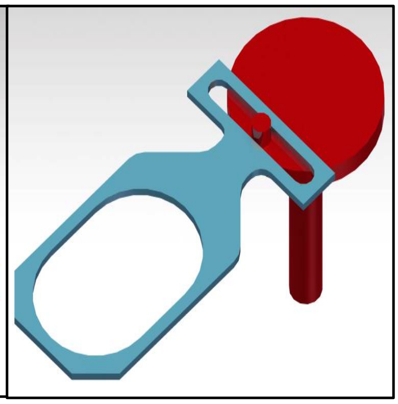


Figure 13 Feeding Mechanism

Finite Element Analysis (FEA)

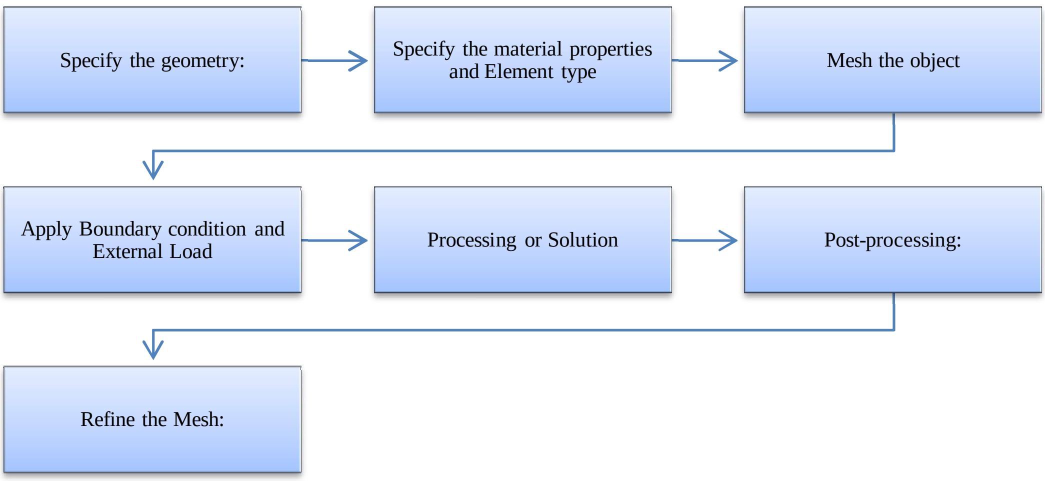


Figure 14 FEA Procedure

Analysis of frame is carried out for 2400000 cycles.
Mechanical Properties for input for FE analysis

Table 1 Mechanical Properties of Component

Sr. no.	Part Name	Young's Modulus GPa	Ultimate Tensile Strength (MPa)	Yield Tensile Strength (MPa)
1	Die Block	210	550	280
2	Shaft	210	550	280
3	Frame	210	370	230

Table 4 FEA Result of Punch

Parameter	Load	Element	Node	Displacement	Von Meshes Stresses	FOS
Value	22854 N	13805	2569	0.003 mm	123.25 MPa	1.81

RESULT AND DISCUSSION

Analysis of machine component is carried out FE method in ANSYS 12.0 result of analysis is shown in the following table-

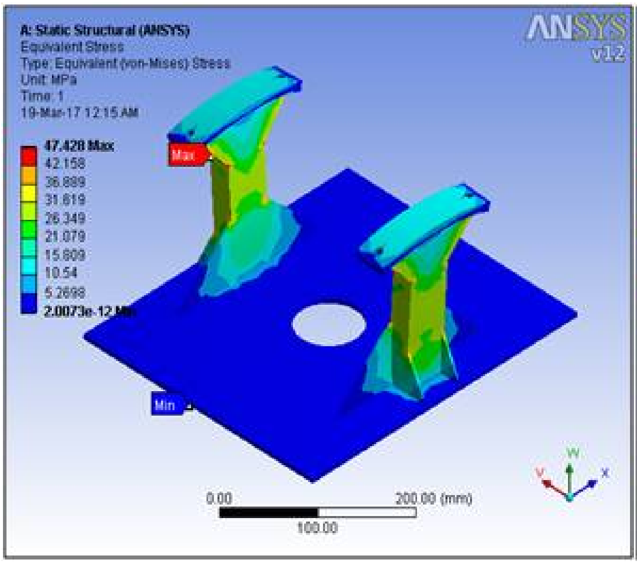


Figure 15 FEA Stress Result for Frame

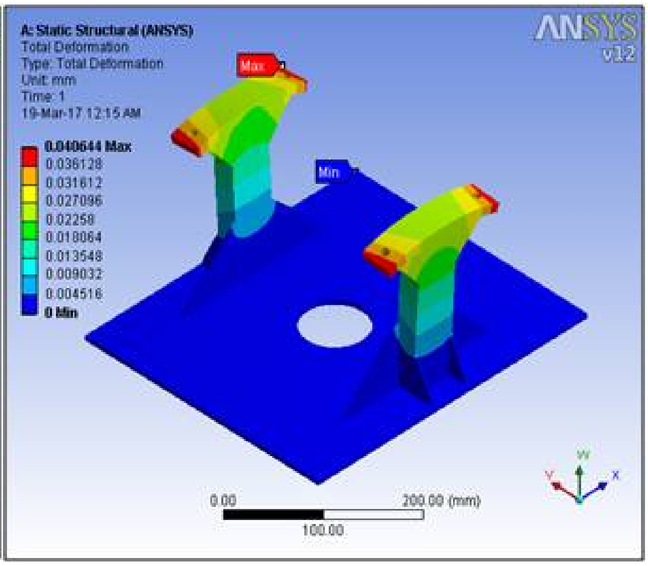


Figure 16 FEA Displacement

Table 2 FEA Result of Frame

Parameter	Load	Element	Node	Displacement	Von Meshes Stresses	FOS
Value	22854 N	10881	5279	0.040 mm	47.42 MPa	1.81

FE analysis is carried on the component with considering FOS of 4 and loading cycle of 24,00,000 By FEA analysis it is found that component of the machine is safe under extreme loading

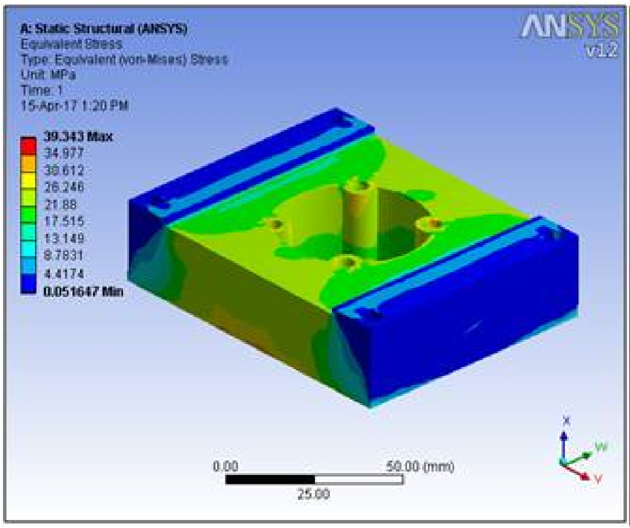


Figure 17 FEA Stress Result for Die Block

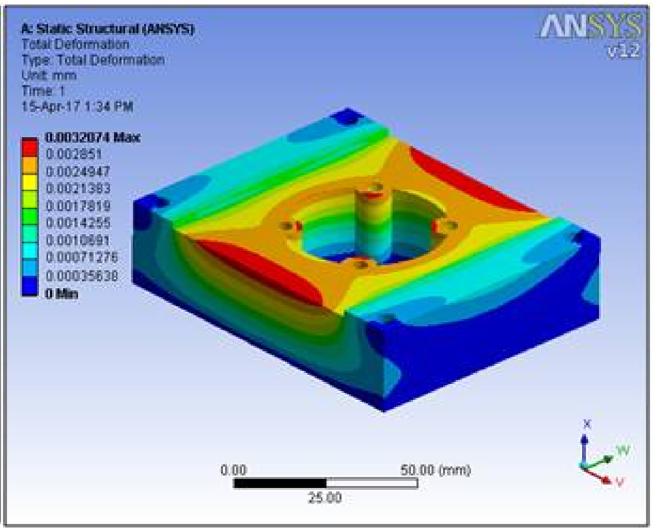


Figure 18 FEA Displacement of Die Block

Table 3 FEA Result of Die block

Parameter	Load	Element	Node	Displacement	Von Meshes Stresses	FOS
Value	22854	208693	137615	0.033 mm	39.34 MPa	6.35

conditions. By performing FE analysis found that Factor of safety, Stress generated and displacement is less than desire value.

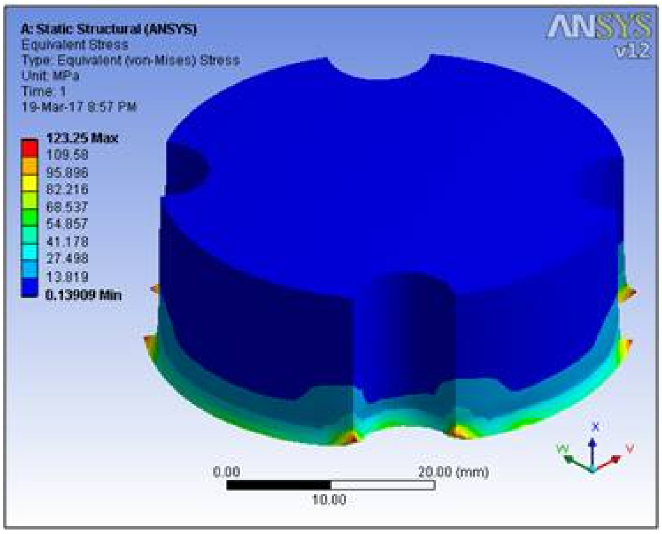


Figure 19 Stress Result for punch

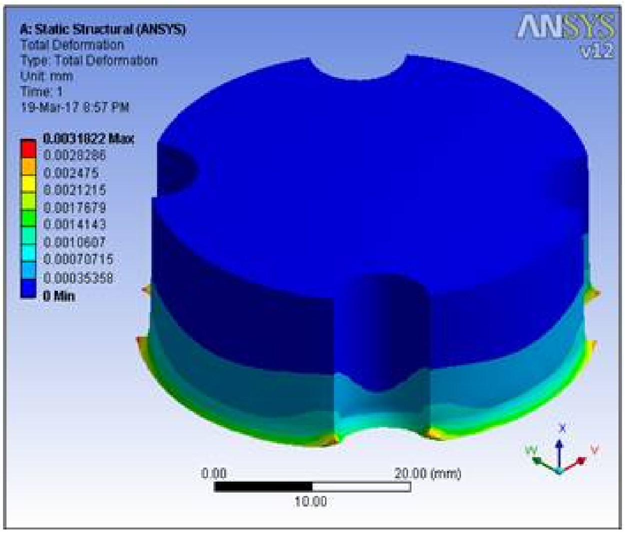


Figure 20 Displacement Result for Punch

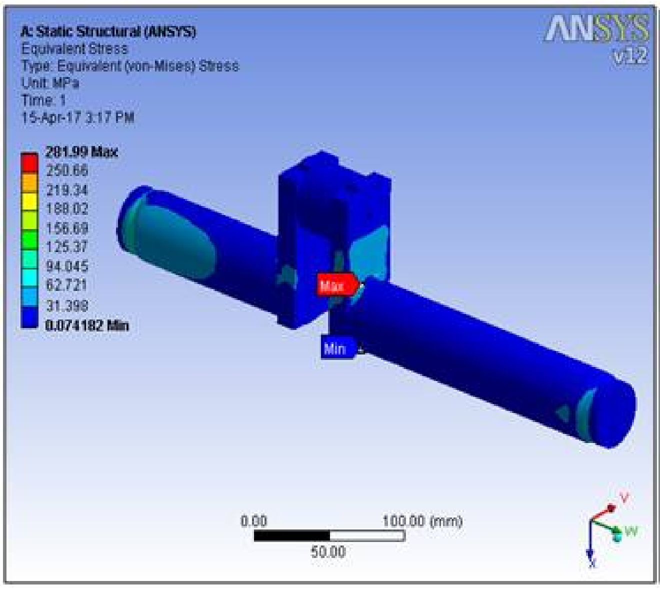


Figure 21 FEA Stress Result of Shaft

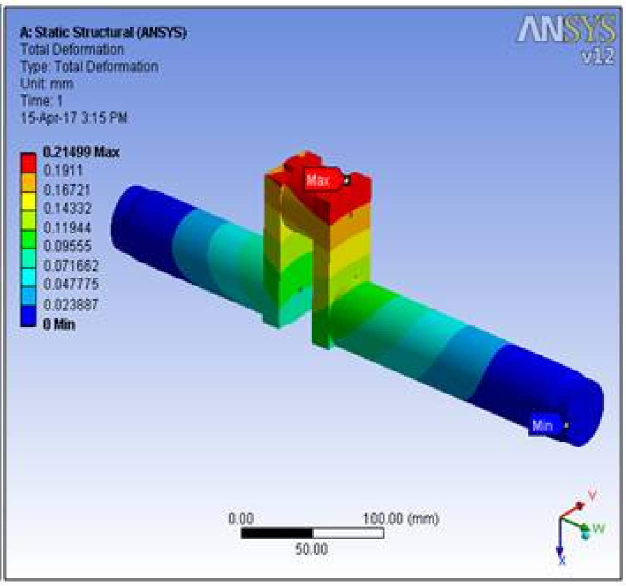


Figure 22 FEA Displacement Result of Shaft

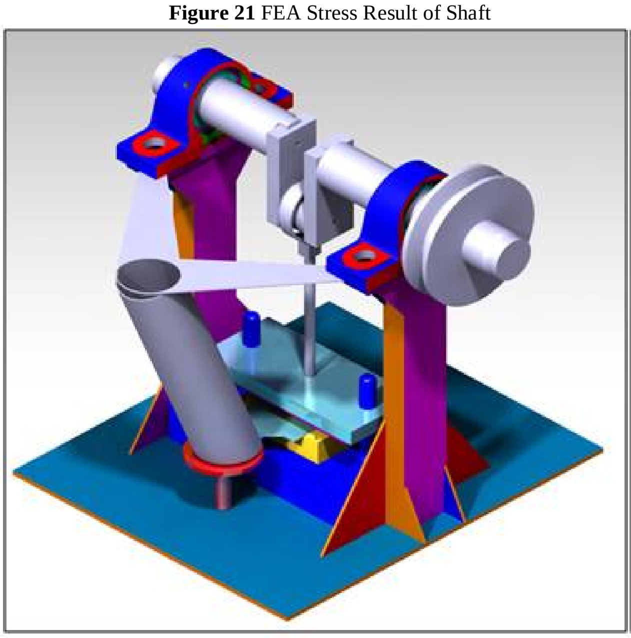


Figure 23 CAD Model of Machine

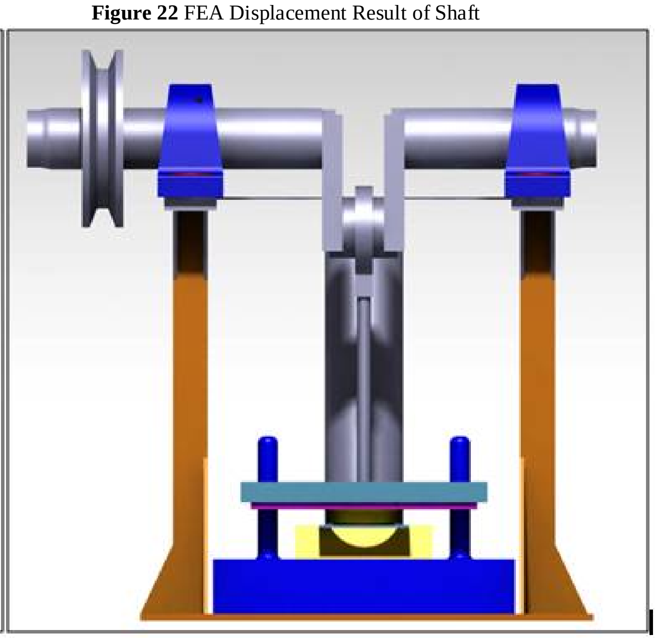


Figure 24 Front View of Machine

Table 5 FEA Result of Shaft

Parameter	Load	Element	Node	Displacement	Von Meshes Stresses	FOS
Value	22854 N	124049	80699	0.21 mm	281.99 MPa	1.3121

Table 6 Comparison of FEA Result

Parameter	Load	Element	Node	Displacement	Von Meshes Stresses	FOS
Frame	22854 N	10881	5279	0.040 mm	47.42 MPa	1.81
Die Block	22854 N	208693	137615	0.033 mm	39.34 MPa	6.35
Punch	22854 N	13805	2569	0.003 mm	123.25 MPa	1.81
Value	22854 N	124049	80699	0.21 mm	281.99 MPa	1.3121

1. For Speed, reduction calculated Gear ration is 1:72
2. This Reduction gives in 1:30 in progressive Worm and Worm wheel gear box
3. Second stage 1:2.4 by a belt drive

Conclusion and Summery

1. From present work we conclude that The proposed design of compound die machine, in which punching and piercing operation takes place simultaneously in a single stroke, is capable to increase production rate by 4 times and decrease in manufacturing cost
2. By FEA analysis found that element of proposed design of machine is safe at extreme loading condition in static and fatigue analysis. Stress and Displacement result is in an acceptable range.
    - Production rate is increases (20-30 washer/min)
    - Automatic feeding of raw material is achieved
    - Production rate constant
    - Manufacturing cost of washer per piece is Reduces

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