DESIGN AND ANALYSIS OF SEMI AUTOMATIC INTERMEDIATE PLATE PRESSING MACHINE

[1]Amarnath, [2]Sunil Kumar H S, [3]Giridharan V
[1]M.Tech Student, [2]Assistant professor, NMIT Bangalore, [3]Managing Partner, AES Bangalore
[1]Department of Mechanical Engineering,
[1]NMIT, Bangalore, India

ABSTRACT: Intermediate plate pressing machine is a project, design for pressing an intermediate plate to bearing shaft. In this machine two type of pneumatic cylinders are used to press the intermediate plate, one cylinder is used to resist the whole weight of the component and fixture another type of cylinder is used for pressing the plate into the bearing shaft(vertically). Here the project title is given as semi-automatic because the loading and unloading of component is manual. This project includes the concept development design, analysis and control of press machine. Various parts of pressing machine are modeled by using Solid works modeling software and controlled by PLC (Programmable Logical Control). Behavior of intermediate plate is analyzed by using analyzing software ANSYS 18.1.

Keywords: Pneumatic cylinder, PLC, solid works, ANSYS, semi-automatic

INTRODUCTION

Intermediate plate pressing machine is a project, design for intermediate plate pressing to bearing shaft will separate the first and fifth reverse gears. Intermediate plate presses vertically with the help of pneumatic cylinders. Intermediate plate is used in automobile gear box. This plate is made with medium carbon steel. Intermediate plate has two holes of different diameters of diameter 52 and diameter 75 within those hole the snap ring fitment grooves are present, in the grooves of plate snap ring has kept and these are fitted to the bearings with the help of sleeves. Here two type of pneumatic cylinders are used one is for holding the component vertically with its fixture, with the help of pilot operated pneumatic chuck valve. Another type of two cylinders are used to press the plate in to the bearing shaft. Two tapered sleeves of different dimensions are used for the extending the snap ring with respect to the vertical force. The loading and unloading of component is manual, so we called this as a semi-automatic pressing machine. This machine is controlled by PLC to three pneumatic cylinders.

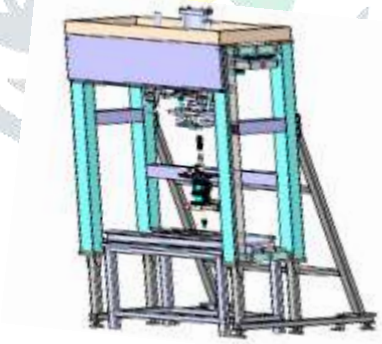

Figure1: Intermediate plate pressing machine

PROBLEM

In transmission assembly process the pressing of intermediate plate in to the bearing shaft, pressing manually there were two operators are required to press the intermediate plate by extending two snap rings with applying large force for pressing of one plate.

Component detail

An intermediate plate is used in transmission gear box assembly. The intermediate plate is made up of C-45 material weighing 3.54Kg and having 200 BHN. Figure below shows the detailed dimensions of intermediate plate.

Mechanical Properties of Intermediate plate material

Parameters	Details
Tensile strength	570-700 MPa
Hardness	170-210 BHN
Elastic modulus	200GPa
Poisons ratio	0.31

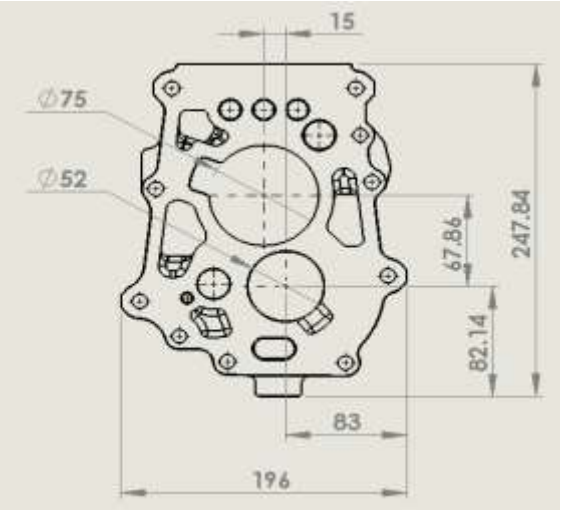

Figure2: Intermediate plate

Machine Specifications

1. Station	: IM Plate and Gear train assembly
2. Component	: Gear Train Assembly for NALT IM plate press
3. Component as presented	: Before pressing, individual parts, after Pressing assembled
4. Load and Unload	: Manual
5. Operation performed	: Pressing with respect to axis
6. Component loading height	: 850mm ±25mm
7. Overall size(W x D x H)	: 1100mm x 800mm x 1900mm
8. Electrical power	: 3phase / 415V / 2.5KVA / 50Hz
9. Pneumatic power supply	: 06bar (max)

DESIGN CALCULATIONS

1. Press fit force calculation

We have,

$F_p = P x \eta x d x \pi x L$ ——————— (1)

Where, F_p= Press Fit force in N

P = Pressure of contact in N/mm^2

η = Friction between hub and shaft

d =Nominal diameter of joint in mm

L = Length of joint between hub and shaft in mm

a) **For Dia. 52mm**

d_i	D	d_o	L	I	η	E_i	E_0	v_i	v_0	P
42mm	52mm	64mm	20mm	0.0155mm	0.12	190GPa	180GPa	0.28	0.28	$5.69N/mm^2$

From Equation ①

$F_p = P x \eta x d x \pi x L$

F_p = 2.23KN

b) For Dia. 75mm

d_i	D	d_o	L	I	η	E_i	E_0	v_i	v_0	P
65mm	75mm	85mm	20mm	0.0155mm	0.12	190GPa	180GPa	0.28	0.29	$2.76N/mm^2$

From Equation ①

$F_p = P x \eta x d x \pi x L$

F_p = 1.56KN

Press fit force required

1. For dia 52 ⟶ 2.23KN = F_1
2. For dia 75 ⟶ 1.56KN = F_2

Therefore Total force required to press the intermediate plate for shaft bearing.

$F = F_1 + F_2$

F = 3.79KN

2. Design of base plate

As per the machine specifications, length = 400mm and width = 304mm of base plate is required for easy mounting of all components.

To find thickness of base plate
Total load acting on base plate = cylinder + guide rod + LM Rail guide + Guide block + structure cross rail + side structure + sliding plate + force by cylinder
Therefore total load acting on base plate is 6242.963 N

W = total load acting on plate / length of plate = 15.6 N/mm

Max moment = $WL^2/8$ = 312000N-mm

Moment of Inertia (I) = $bt^3/12 = 25.333t^3 mm^4$

Using bending formula, $\frac{M}{I} = \frac{\text{bending stress}}{y}$

$312000/25.333t^3$ = bending stress/ y

For C45, Syt = $465N/mm^2$

Allowable bending stress = Syt/FOS, (assume FOS =1.5) = $310N/mm^2$

Deflection y= l\2 = 400\2 = 200mm

Therefore, $12317.41/t^3 = 310/200$

Thickness of plate, t =19.955mm

Hence 20mm plate thickness is selected for safe design.

DESIGN MODEL

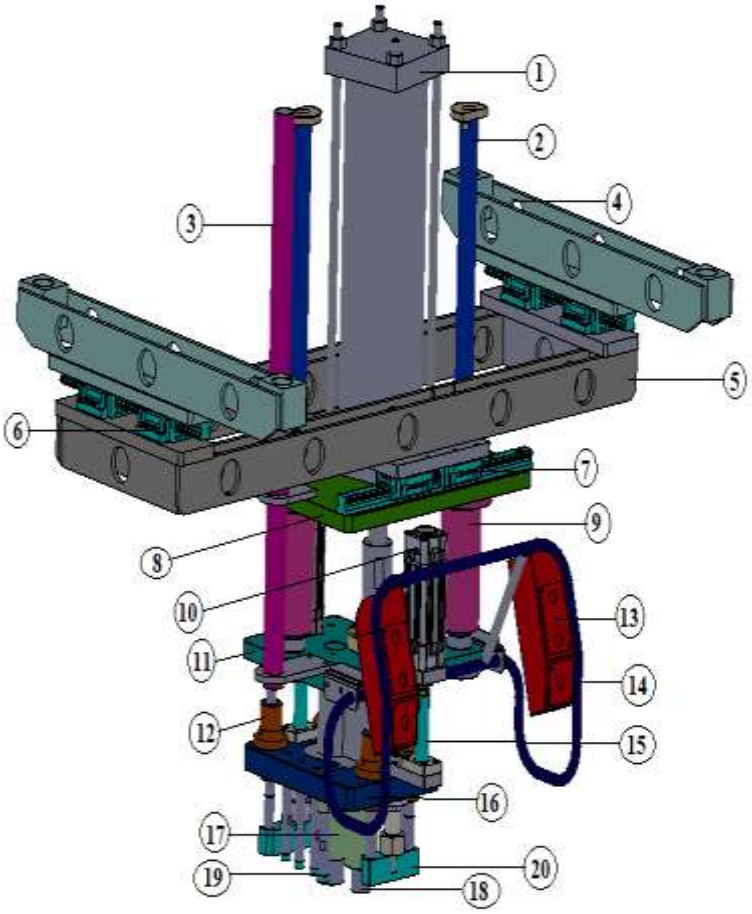

Figure 3: Design model

Sl.No	Parts	Quantity
1	Cylinder 125 of bore	1
2	Guide Rod	2
3	Holding Pipe	1
4	Side Structure	2
5	Structure Cross Rail	1
6	Guide Block	8
7	LM Rail Guide ways	4
8	Base Plate	1
9	Shaft	2
10	Cylinder 32 of bore	2
11	Plate 2	1
12	Bush Holder	4
13	Push Button box	2
14	Handle tube	1
15	Press Rod	12
16	Plate 1	1
17	Guide Holder	2
18	Guide Sleeve Holder	2
19	Nylon	14
20	Magnet Holder	2

Working Flow chart of IM Plate Pressing Machine

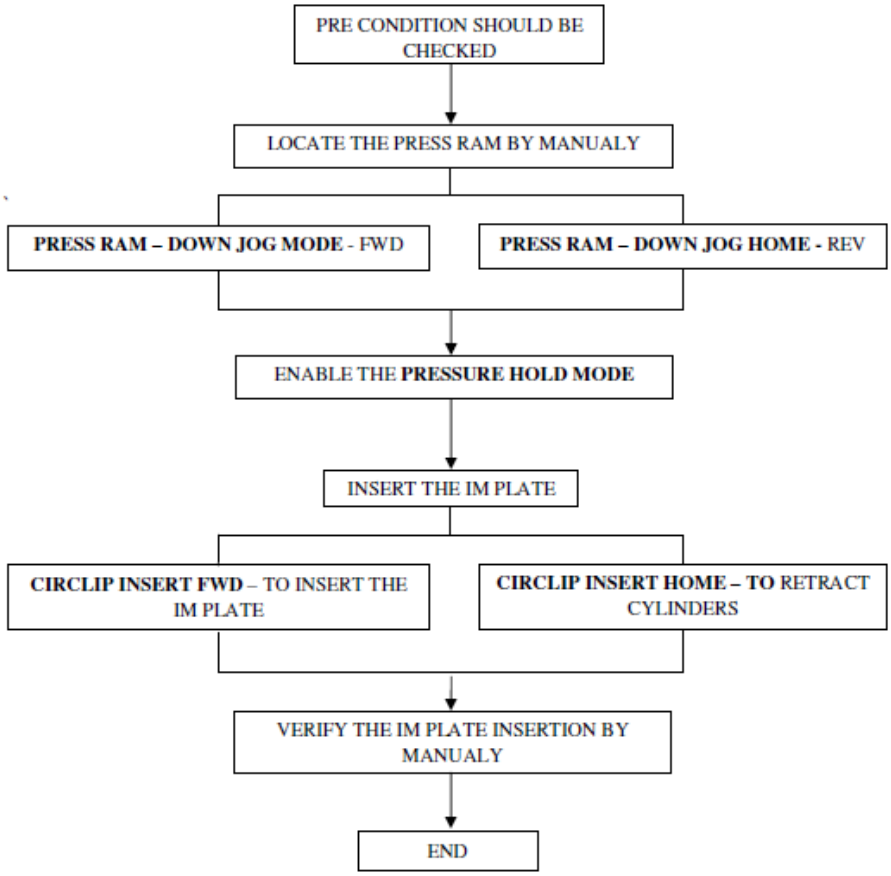

Figure4: The working flow chart of IM plate pressing machine

In the gear box assembly line after top gear shaft (TGS) and cluster gear shaft (CGS) assembly, at station 3 intermediate plate pressing machine is installed to press the intermediate plate.

Working processes of IM plate pressing machine are as follows:

- Preconditions should be checked

  Preconditions are the conditions given before execution of the process. In other words preconditions are the predications that indicate what must be true before any function or task is called. In the intermediate plate pressing machine the following preconditions should be checked.

i. Air compressor pressure
ii. Air hose connections are checked properly before starting the process.

- Press ram

  Press ram should be located manually on the component, before starting the process, with the large cylinder of 400 strokes. Which is consists of double acting cylinders, press rods, housing assembly, base plate, nylon rods, magnet holders and handling tube assembly. With the help of handling tool press ram should be adjusted manually and the press ram movement is on LM rail guides. Press ram should be set on the component before starting the process. Press ram get down by jog mode which means the mode that allows for the manual operation of the tool movement via the jog buttons for pressing the intermediate plate.

- Enable the pressure hold mode

  After locating the press ram manually on the component, enable the pressure hold mode on the component with the help of pneumatic cylinder of 400 strokes. It holds the whole component and fixture that contains intermediate plate placed on the main shaft of the gear box. The pressure hold mode enables at the time of cylinder actuation. The pressure hold mode helps in holding the component and fixture constantly without vibration and to overcome the upward movement of component.

- Locating of sleeves and IM plate

  After enable of the pressure hold mode to hold the component and the fixture, locate the sleeves of diameter 75 and diameter 52 on the main shaft manually with the help of manpower. After locating the sleeves on shaft put the intermediate plate (with snap ring inside) on sleeves.

- Circlip insertion

  Circlip is a type of fastener or retaining ring consisting of a semi flexible metal ring with open ends which can be snapped into place, into a machined groove on a dowel pin or other part to permit rotation but to prevent lateral movement. After locating the sleeves and intermediate plate on the shaft, go for the Circlip insertion to the intermediate

plate. There are two types of circlips are present, they are internal circlip and external circlip. In this project internal circlip is used to hold the plate with shaft.

- Inspection

  An inspection is, most generally, an organized examination or formal evaluation exercise. In engineering activities inspection involves the measurements, tests and gauges applied to certain characteristics in regards to an object or activity. The results are usually compared to specified requirements and standards for determining whether the activity is in line. Verify the intermediate plate insertion by manually.

ANALYSIS

ANSYS software of 18.1 version is used for analyze the deformation of mounting structure in ANSYS Workbench

Steps involved in analysis:

1. Type of analysis : Static structural
2. Importing model: The 3D model of the mounting structure is imported in step file.
3. Model geometry

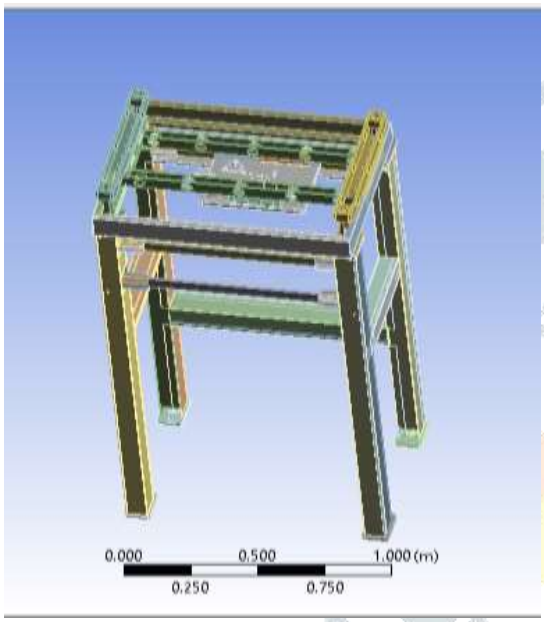

Figure5: ANSYS model geometry

Figure6: Meshing model

4. Meshing

   Number of elements : 338755

   Number of nodes : 170586

Parameters	Structure
Type of Analysis	Static structural
Type of coordinate system	Global coordinate system
Type of meshing	Tetrahedral element meshing
Type of contacts	Bonded
Support	Fixed support
Load	10000N

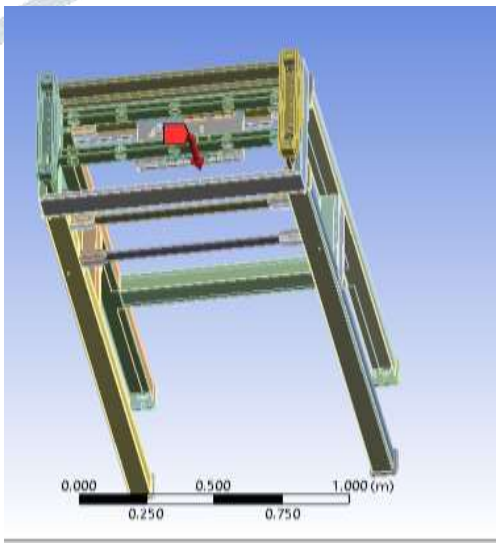

Figure7: force condition

RESULTS AND DISCUSSION

Intermediate plate pressing machine design helps in increasing the productivity and accuracy of the product. And also it will helpful in lowering the time required for the pressing of Intermediate plate.

ANALYSIS RESULTS

VON-MISES STRESS ANALYSIS:

Figure below shows the Von-mises stress for mounting structure and base plate having maximum value of 176 MPa and minimum value of 1.0966e-6 Pa.

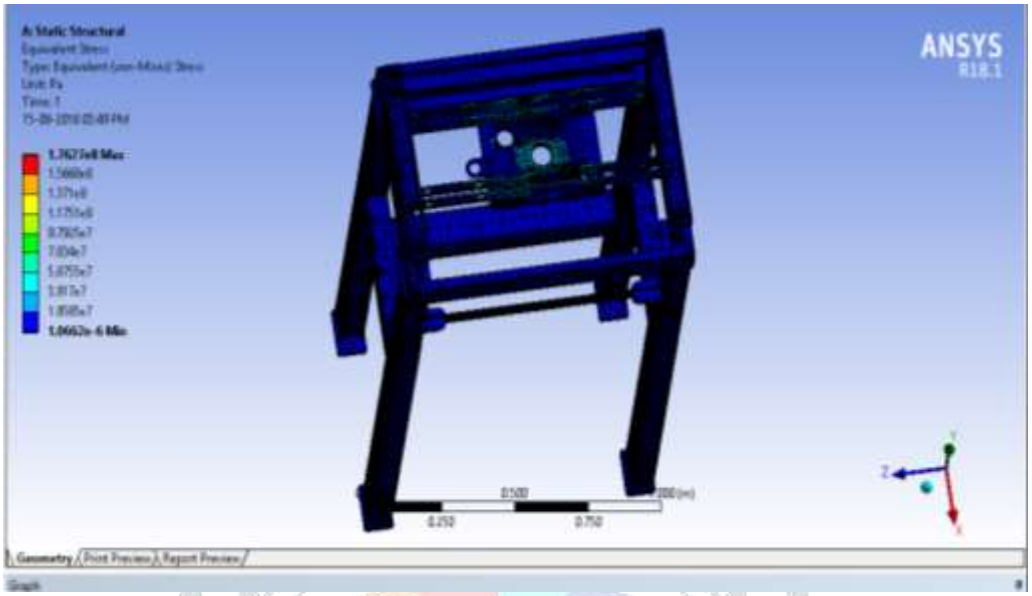

Figure Von-mises stress for mounting structure and base plate

Deformation

Figure below shows the maximum deformation of base plate having maximum value of 0.976mm.

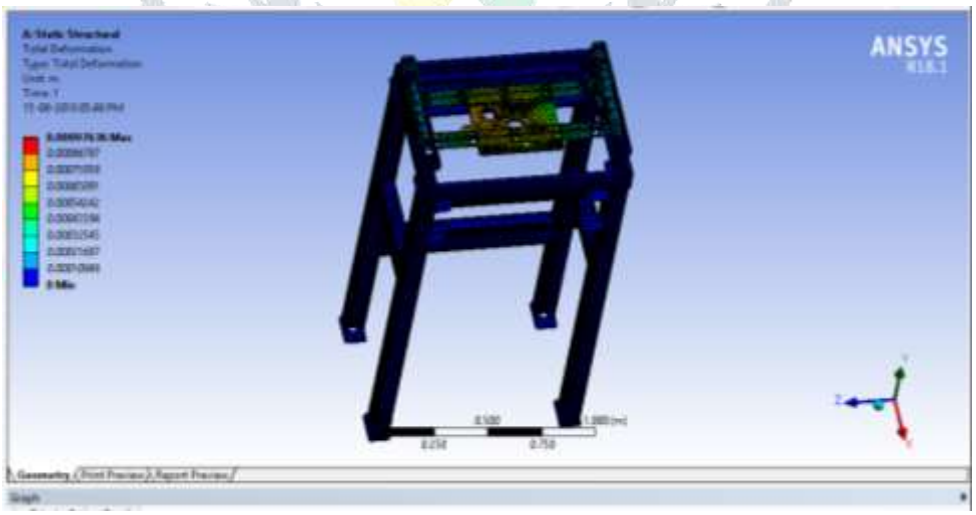

Figure8: Deformation of base plate.

Discussion

i. The above results depicts that the value of Von-mises stress is between 176 MPa and 1.0966e-6 Pa which is within the range of stress criteria said by Von mises.
ii. In the analysis of frame it is found that the maximum deformation in the plate is 0.976mm.

iii. In design of base plate, theoretical value of thickness is 19.955mm. Selected plate thickness is 20mm hence the design is safe.

CONCLUSION

Intermediate plate pressing machine is designed and analyzed using software ANSYS. It is easy to operate without skilled operator. It is intended to facilitate the process of pressing intermediate plate.

The following conclusions could be drawn from this study

i. Intermediate plate pressing machine can press intermediate plates of 100 No's averagely in every shift of 8 hours.
ii. Only one operator can operate intermediate plate pressing machine for loading and unloading of components.
iii. This technique is observed to be more efficient than the manual method, which needs more human energy.
iv. A great advantage of the proposed appliance is the fact that it be easily performed. Because its construction and controlling systems are very simple. (It is also possible to set the velocity of piston rod movement).

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