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Finite Element Analysis of Hydraulic Tire Curing Press Frame

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I. INTRODUCTION

Tire curing presses plays an vital role in tire manufacturing industries. In general tire manufacturing contains different stages of process includes. In that tire curing is the 7th stage of process. But it is main stage in tire manufacturing as it includes vulcanization of tire which gives physical strength to the Green tire to become tire. Curing is the chemical cross-linking of rubber and vulcanizing agents, resulting in an elastomer. The outcome of this reaction depends primarily on the amount and purity of the raw materials. Temperatures of up to 200 °C, pressures exceeding 30 bar and long cycles ranging from a few minutes to several hours help to create the unique properties of the final product rubber. Tire manufacturers need a fully connected enterprise to operate efficiently and compete globally. A completely connected enterprise includes the exchange of critical performance and operations information with OEMs to improve processes, increase production and reduce risks. Improving throughput and increasing machine uptime are top key performance indicators that can cut production cost for tire manufacturers. Tire manufacturers also need to manage the manufacturing process and ensure better asset utilization to maximize throughput.

Main Components Of Hydraulic Tire Press:

Fig.1.

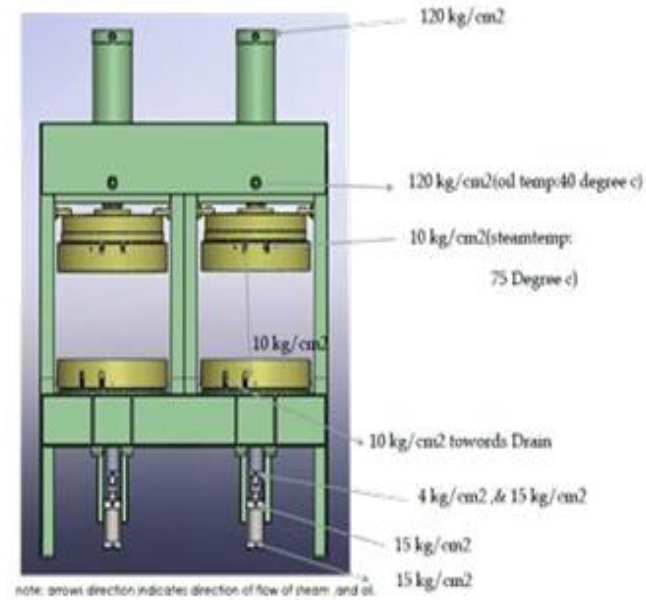

Fig.2.

Components Of Hydraulic Tire Curing Press:

- Hydraulic cylinders.
- Main frame Assembly.
- Hub Assembly.
- Top and Bottom platens with respective Tire molds.
- Center Mechanism Cylinder Assembly.
- Water Hydraulic Cylinder Assembly.
- Control panels.
- Hydraulic Power pack
- Valve battery.

A. Loads From Each Component And Other Components Loads from Each component of Tire press:

Pressure Details Obtained From Components: In Hydraulic tire press different loads from different components can be observed. In that here are the fallowing list of pressure inputs applied on each component.

Green Tire: Green tire is a readymade rubber ring which is also called uncured tire. After placing in Tire press with the help of vulcanization process, tire attains proper physical properties to with stand the radial and pressure loads of vehicles.

TABLE I: Pressures Obtain From Individual Components Other Important Components And Processes

S.no	Component Name	Pressure	Median
1.	Oil Hydraulic Cylinders Inlet	120 kg/c m2	Oil
2.	Oil Hydraulic cylinders outlet	120 kg/c m2	Oil
3	Hub assembly	10kg/cm2	Steam
4	Hose connection	10kg/cm2	Steam
5.	Bottom platen assembly	10kg/cm2	Steam
6.	C.M.C Cylinder assly	15 kg/c m2	Water
7.	Water Hydraulic Cylinder	15 kg/c m2	Water

Bladder: Bladder is made of rubber with high elastic levels. This component is fixed to C.M.C Cylinder with the help of steam it pushes the green tire at semisolid condition towards the walls of mold to attain the grooves on the surface of tire.

Vulcanization Process: It is a process of heating the uncured tire up to semisolid sate and with the help of bladder component and molds by the application of steam it gains the physical properties. Approx. 75° C temperature maintains to make Green tire to tire.

Tire Curing Press Process Cycles Timing: Solid works is a software specially designed for mechanical automation applications, that makes the designer to make quick decisions over the model and assemblies. It is a user friendly software as it contains tools which can easily understand and apply on the specified operation. This software is Designed and developed by "Desalt Systems". Present we Made This project model with Solid works 2016.

TABLE II: The Above Table Describes The Details Of Press Closing /Opening And Cycle Process. Introduction To Solid Works:

STEPS	PARTICULARS	TIME(MIN)	P.L.C TIME
1	H.P Flushing	0	10 sec
2	H.P Dead end	0.17	480 sec
3	Cold water dead	8.17	15 sec
4	Cold water	8.42	90 sec
5	H.p Flushing	9.92	0 sec
6	Bladder /drain	9.92	10 sec
7	Bladder drain+Vaccum	10.08	10 sec
8	Open press Vaccum to continue	10.25	-
	Total cycle	10.25	615 sec

II. INTRODUCTION TO THE F.E.A AND ANSYS

A. Basics Of Finite Element Method:

Introduction to F.E.A: The name finite element is of recent origin, through the concept has been used for centuries. The basic philosophy is to replace the actual problem into a simpler model, which will closely approximate the solution of the problem at hand. A continuum is divided into a much; two adjacent regions placed side by side will have a common edge. It is assumed that the elements are connected at nodal points and it is only there that the continuity requirements are to be satisfied. Once the discrimination is made, the analysis follows a rather set procedure. The stiffness matrix of the individual element is formulated. The forces are distributed in the real structure are transformed to actually distribute in the real structure are transformed to act at the nodal lines. Assembly of individual elements is carried out to obtain stiffness matrix of the whole structure. In the finite element analysis, therefore the continuum is divided into a finite numbers of elements, having finite dimensions and reducing the continuum from infinite degree of freedom to finite degrees of unknowns. The problem to be solved by the finite element method is done in two stages:

- The element formulation
- The system formulation

The first stage involves the derivation of the element stiffness matrix. The next stage is the formulation of stiffness and load of the entire structure.

B. Structural Analysis

Structural analysis is one of the process of Analyzing the static, dynamic, buckling load condition object with the application of Finite element method processes. Some of the application areas are machine parts, civil constructions, ship buildings, aircraft bodies etc.

C. Modal Analysis

Modal analysis helps to calculate vibrations developed in the structure. It can also deal with dynamic analysis, harmonic response of the components.

Import Geometry: First of all importing the required geometry of the component.

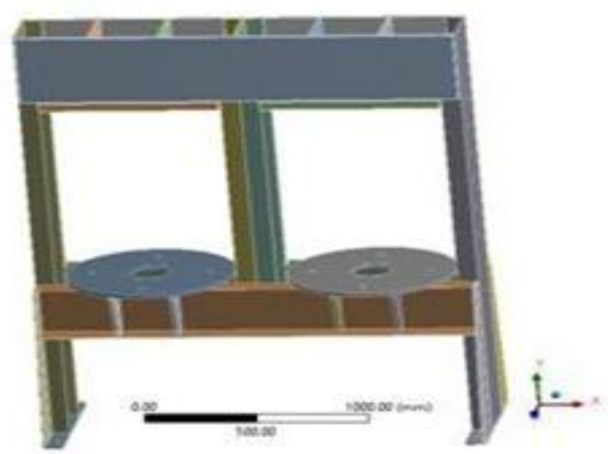

Fig.3. Tire press frame model.

D. Material Data

Structural Steel

Structural Steel > Constants

TABLE III: Material Properties: Properties:

Density	7.85e-006 kg mm^-3
Coefficient of Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002Wmm^-1 C^-1
Resistivity	1.7e-004 ohm mm

In the first step incorporating the properties of the component takes place as bellow.

TABLE IV: Material Properties 2

Sl. no	Property Name	Value
01	Material	Structural steel(mildsteel)
02	Density	7.85 g/cm2
03	Mass	124.34 kg
04	Volume	1.5840+0.007 mm3

Mild steel is a very famous metalwith in cheapest types of steels available. It can be found in almost every metal product. This type of steel contains less than 2 percent of carbon, which gives magnetic power well. Since it’s relatively inexpensive, mild steel is useful for most projects requiring huge amounts of steel. Mild steel does not have great structural strength, making it unsuitable for building girders or structural beams.

Meshing: After incorporating all input information for the component in to the ansys software. The next step includes meshing. Meshing is a process of desecrating the object in to several number of pieces. In the same way the above component includes free mixed type meshing.i.e., It may discretize in rectangles, triangles, quadrilateral shapes.

TABLE V: Meshing Details

Sl no	Name	Qty
01	Nodes	551
02	Elements	64

Frequencies Observed Causes Total Deformation: During the running conditions of the components over the main frame assembly, at different times the following are the level of frequencies observed on the site with the full load condition.

a. Frequency 1:

TABLE VI: Frequencies At Different Times

Mode	Frequency [Hz]
1.	19.276
2.	27.216
3.	53.871
4.	55.861
5.	99.098
6.	137.26
7.	201.42

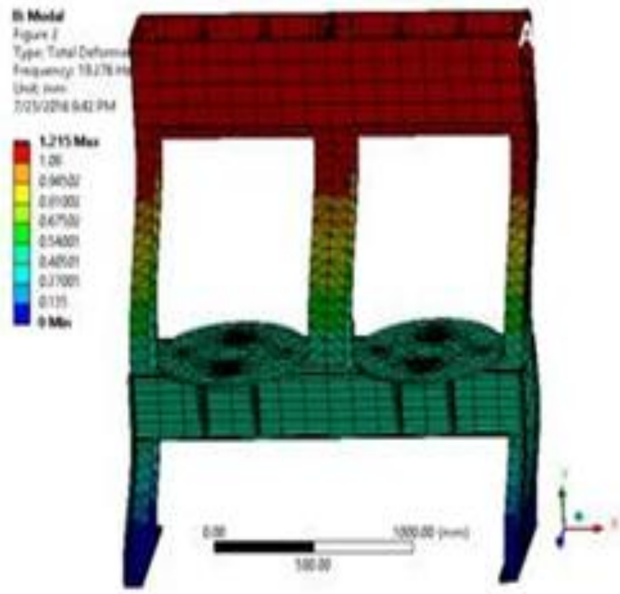

Fig.4.

Meshing and Total Deformation By Frequency: The above table indicates the frequencies obtained on the frame. In that maximum level of frequency observed is 201.42 Hz. As this level of Frequency not disturbing the quality of the product. This Frequency of vibration is acceptable for the machine frame to with stand with the loads and also satisfied the quality of the product through vulcanization process.

b. Frequency 2:

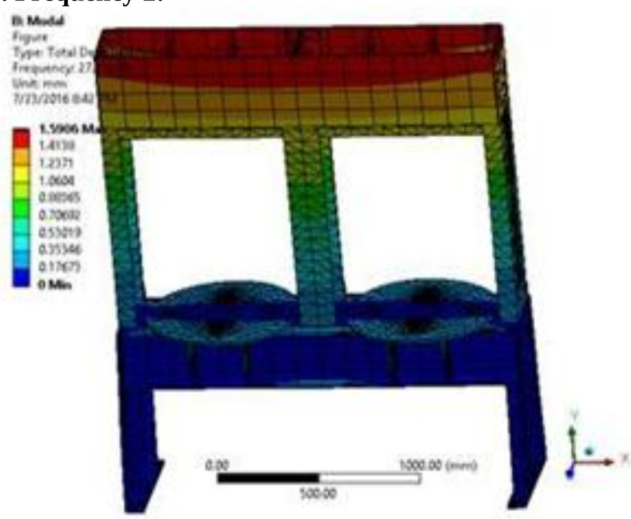

Fig.5.

Total Deformation Due To Frequency 2: At this stage in the total deformation, at the frequency range of 27.216 Hz obtained at this condition is about 0 min to 1.5906 mm Max.In theiradding’sobserved, maximum deformation of the object is 1.5906 mm. As it is little deviation as comparison with loads applied on it. Thisreading is acceptable and it satisfies the production needs. As it would not effect the product quality.

c. Frequency 3:

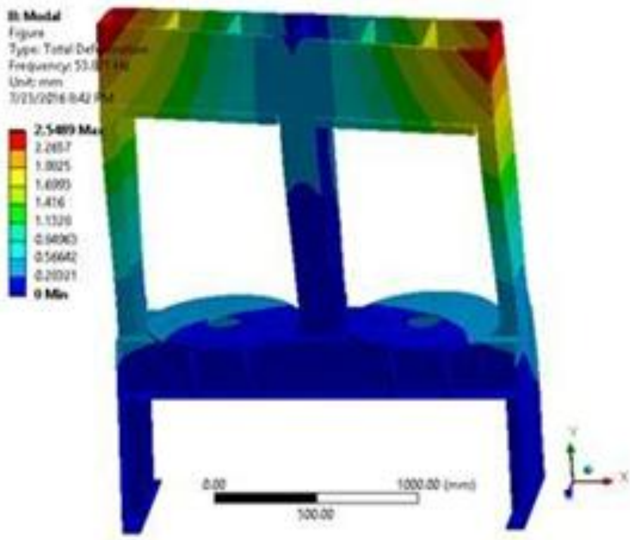

Fig.6.

Total Deformation Due To Frequency 3: In this stage the total deformation, at the frequency range of 53.871 Hz obtained at this condition is about 0 min to 2.5489 mm Max.In the above readings observed, maximum deformation of the object is 2.5489 mm. As it is little deviation as comparison with loads applied on it. This reading is acceptable and it satisfies the production needs. As it would not effect the product quality.

d. Frequency 4:

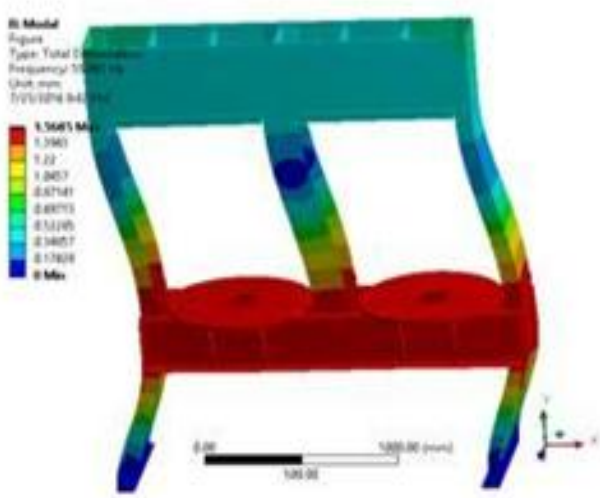

Fig.7.

Total Deformation Due To Frequency 4: In this stage the total deformation, at the frequency range of 55.861 Hz obtained at this condition is about 0 min to 1.5685 mm Max.In the above readings observed, maximum deformation of the object is 1.5685 mm. As it is little deviation as comparison with loads applied on it. This reading is acceptable and it satisfies the production needs. As it would not effect the product quality.

Frequency 5:

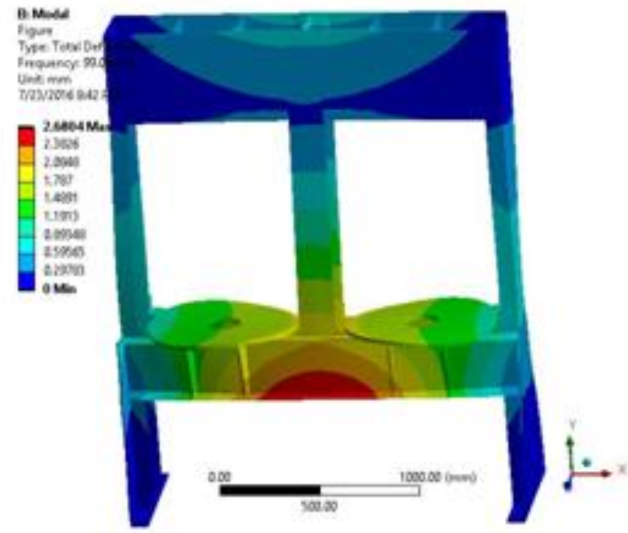

Fig.8. Total deformation due to frequency 5

In this stage the total deformation, at the frequency range of 99.098 Hz obtained at this condition is about 0 min to 2.6804 mm Max. In the above readings observed, maximum deformation of the object is 2.6804 mm. As it is little deviation as comparison with loads applied on it. This reading is acceptable and it satisfies the production needs. As it would not effect the product quality.

f. Frequency 6:

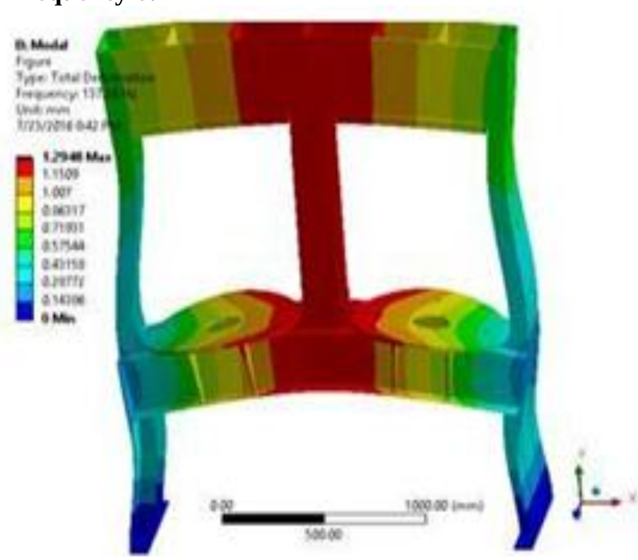

Fig.9.

Total Deformation Due To Frequency 6: In this stage the total deformation, at the frequency range of 99.098 Hz obtained at this condition is about 0 min to 2.6804 mm Max.In the above readings observed, maximum deformation of the object is 2.6804 mm. As this deviation as comparison with loads applied on it is satisfactory. This reading is acceptable and it satisfies the production needs. As it would not effect the product quality.

E. Static Analysis

Import Geometry:

Material Data: Structural Steel general image of main frame model Boundary conditions:

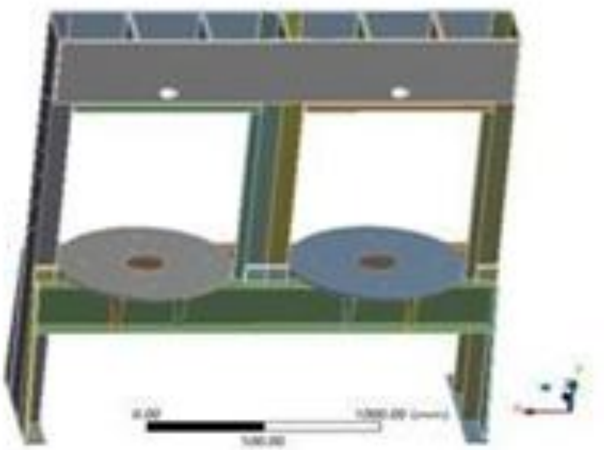

Fig.10.

Boundary conditions are those which are used to fix the component with types of loads on it and also to constrain the object.

Types of Loads:

- point load
- Uniformily distributing load
- unifromly varying load

Fixed Supports:

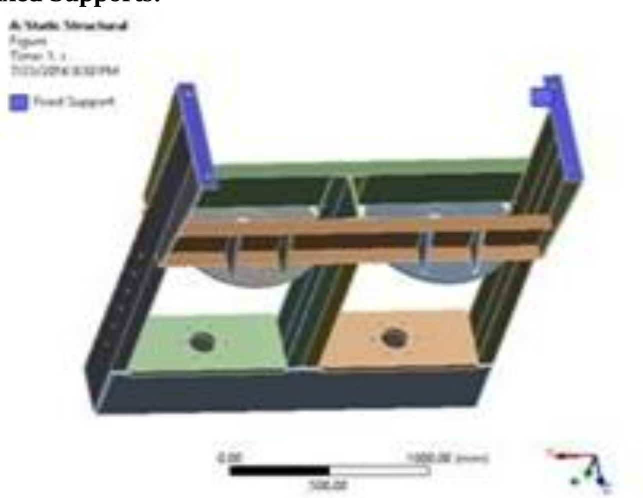

Fig.11.

Fixed Support Location: In this the applying of fixed supports are shown. In the main frame assembly generally the fixed supports are its bottom support plates. These Bottom support plates are bolted with the anchor bolts, which are sufficiently grouted under the pit with reinforced concrete. Bottom support fixed plate is mounted with M16 Bolts in the working site. And hence while analyzing bottom plates are taken as fixed supports.

Forces Applied:

Load on L.H.S Plate:

Model (A4) > Static Structural (A5) > Force >

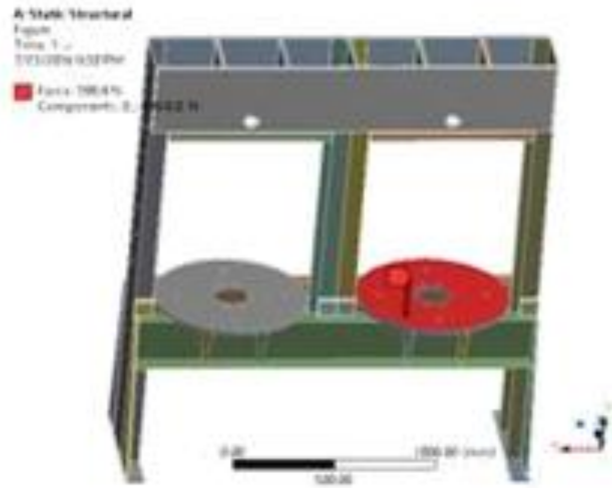

Fig.12.

Force Application On R.H.S Of Support Plate: In this the applying of forces on the required supports are shown. In the main frame assembly generally the forces arise from the components. As from the above the Hydraulic cylinder applies the load of around 188N and also with the help of self-load the load varies to 588.4 Generally this load is obtained with the applied pressure of 120 kg/cm2.Hence the hydraulic cylinder load comes over the support plate and also as bottom support plate is fixed initially all theloads comes over support plate.

Load on R.H.S Plate:

Force Application On L.H.S Of Support Plate:

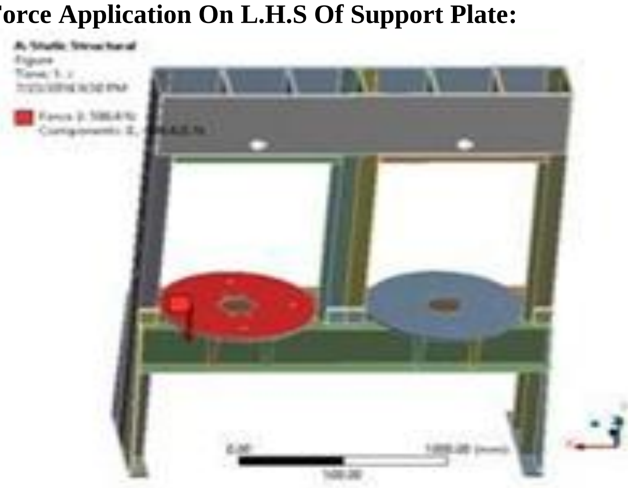

Fig.13.

As from the above the Hydraulic cylinder applies the load of around 188N and also with the help of self-load the load varies to 588.4 Generally this load is obtained with the applied pressure of 120 kg/cm2.Hence the hydraulic cylinder load comes over the support plate and also as bottom support plate is fixed initially all the loads comes over support plate.

TABLE VII:

S. No	Forces area	Applied force valve
1	L.H.S SUPPORT PLATE	588.4 N
2	R.H.S SUPPORT PLATE	588.4 N

Forces Applied On Support Plates:
Results:
Total Deformation:

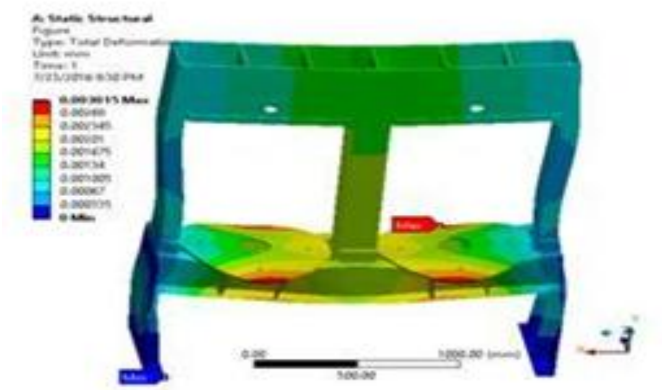

Fig.14.

Total Deformation Due To Loads: With the loads applied as per the above mentioned as of 588.4 N on Right side support plate of main frame. And also load of 588.4 N on left side support plate of main frame, deformation of the material takes place with respective to the above loads. In main frame with the application of 588.4 N load on the top face of the support plate it gone some deformation around 0 to 0.003015 mm max. Until unless as the deformation would not effect the process of making of making tires, Deformation is acceptable. Practically these deviations in the structure is not effecting much on the vulcanization process with which rubber tires are manufacturing using tire curing presses.

TABLE VIII: Total Deformation Range

Sl.No	Deformation TYPE	Maximum	Minimum
1.	Total Deformation	0.003015 mm	0.00

Equivalent Elastic Strain:

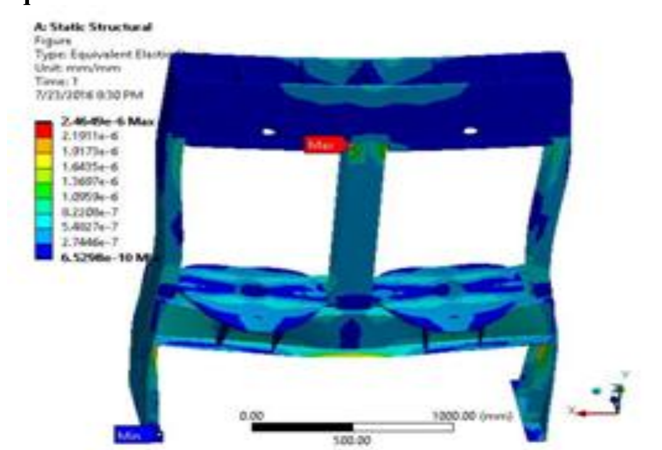

Fig.15.

Equivalent Elastic Strain: With the loads applied as per the above mentioned as of 588.4 N on Right side support plate of main frame. And also load of 588.4 N on left side support plate of main frame, some strain develops in the material that takes place with respective to the above loads. In main frame with the application of 588.4 N load on the top face of the support plate Equivalent elastic strain observed is in the range of 6.5298e-10min to 2.4649e-6 Max. Until unless as the equivalent strain would not effect the process of making of tires, Deformation is acceptable.

TABLE IX: Equivalent Elastic Strain

Sl.No	Deform ation Type	Maximum	Minimum
1.	Equi Elastic Srain -	2.4649e-6	6.5298e-10

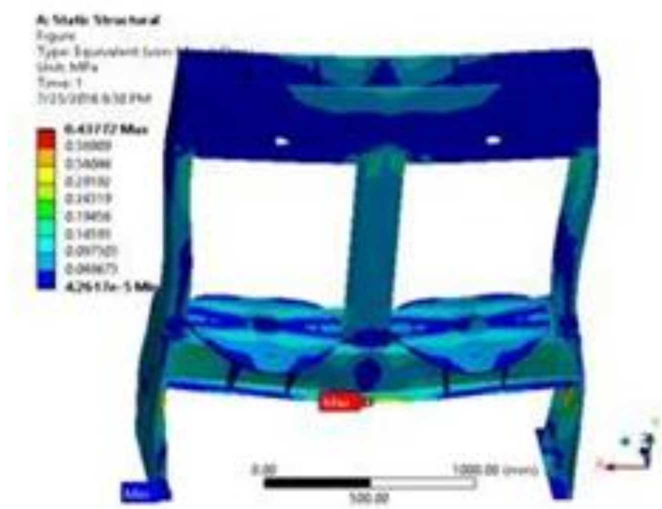

Fig.16. Equivalent (Von-Mises) Stress.

Equivalent Stress(Von-Mises): With the loads applied as per the above mentioned as of 588.4 N on Right side support plate of main frame. And also load of 588.4 N on left side support plate of main frame, stress in the material develops with respective to the above loads.In main frame with the application of 588.4 N load on the top face of the support plate Equivalent stress (von –misis) observed is in the range of 0.43775max to 4.2617e-5Min.Until unless as the equivalent stress would not effect the process of making of making tires, Deformation is acceptable.

TABLE X: Equivalent Von –Misis Stress

Sl.No	Deform ation Type	Maximum	Minimum
1.	Equi Vonmisis Stress -	0.437722	4.2617e-5

III. RESULTS

Main frame consists of steel plate and U type steel welding with high temperature treatment. After machining, release stress to improve machine life cycle. Return oil with filter and cooler to maintain stable hydraulic system. Excellent solid frame mechanism design with FEA approval to enhance body strength.

Loads Applied:

TABLE XI: Loads Applied

SL NO	NAME	MAX
1.	FORCE1	588.4N
2.	FORCE 2	588.4N

TABLE XII: Results Obtained

Sl. No	Result Name	Max	Min
1.	Total Deformation	0.003015 mm	0.00
2.	Equivalent Elastic Strain	2.4649e-6	6.5298e-10
3.	Equivalent Stress(Von-Misis)	0.437722	4.2617e-5

IV. CONCLUSION

In Hydraulic tyre curing press frame, with the application of hydraulic loads on the main frame, Different frequencies of deformation observed, while doing modal analysis. Maximum deformation observed is at frequency of 137.26 Hz of about 1.2948 mm Max. And from structural Analysis we have max strain of 2.469 e-6, max stress 0.43772 and finally total deformation observed is about 0.003015 mm maximum. As the above analysis reports brings the result that the loads are very minute when compare to the strength of the frame why because there are very small deformations. So, we can conclude that the main frame is stable, safe and suitable for mass production of tires through curing processes with the loads exerted from the components.

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