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STRESS ANALYSIS ON CHAIR FRAME

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ABSTRACT: The present paper deals with the stress analysis of a chair frame by using Finite Element Method. The study is constrained to only metal frame and is carried out in Ansys workbench.

The loads are acting on the various members of the chair frame. The average distribution of mass on the chair frame member is calculated. FEM analysis is done for the same load applied on the chair frame.

The results show that maximum stress generated at the support. The maximum tensile stress generated below the ultimate tensile stress of selected material (Mild Steel). Also the deformation of chair frame is calculated by using FEM analysis.

***Keywords*: Chair frame, Stress analysis, Total deformation, FEM.**

1. INTRODUCTION

Development of a new product in contemporary production is very expensive economic activity. The process of furniture construction in shortage of exact data which refers to the measurements of certain parts. Sometime measurement is done on the own experience and engineering practice.

It is not effective to carry out destructive test for testing of chair model to validate the design. The introduction of FEM made easy to test the furniture under various condition for its validation. In the past four decades the finite elements method has become the main method of numerical analysis with the application in solving boundary problems in mathematical physics and particularly continuum mechanics, whereas it still has not been applied in furniture industry to the fullest degree. Studies in this field undoubtedly contributed to the introduction of the finite element method into furniture industry.

The chair is the widely used product in day to day life. The improvement in design and manufacturing method is the main aim of this paper. This paper investigates the stress generated on the chair component and how to minimize the stress.

2. OVERVIEW

The frame structure of chair is shown in figure 1. The frames of metal pipe of various inside and outside diameter are considered for the analysis. The chair model is subjected various loads under different condition. The aim of paper is to find the stress generated in chair frame and modify the design as per requirement.

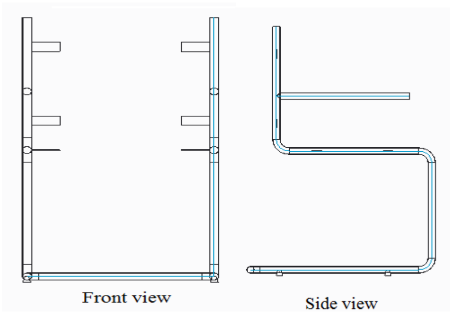

Fig.1: Orthographic views of chair

3. PROPOSED METHOD

FEM is used to analyze the model and to determine the maximum stress generated area on the frame. FEM is the best numerical tool to solve the proposed problem.

4. MODELING

The structural model of chair frame is created by using the 3D cad modeling software. The software used for designing is creo parametric 2.0. The chair model is shown below

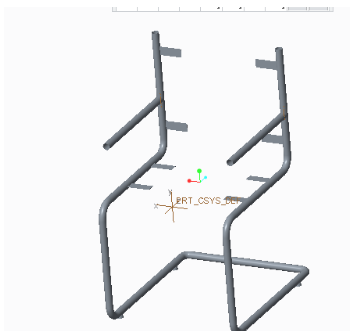

Fig.2: Chair model

4.1. MATERIAL

The properties of material used to manufacture are

Material Used	= Mild Steel
Density	= 7850 kg/m3
Tensile Strength	= 250 MPa
Ultimate Tensile Strength	= 460MPa
Isometric Thermal Conductivity	= 60.5 W/mK
Specific Heat	= 434 J/Kg K
Isotropic Resistivity	= 1.7 × 10^{-7} ohm-m

5. ANALYSIS RESULT

The analysis is carried out for various models by keeping the inner diameter of frame constant, by varying the thickness, by varying diameters. The result of the analysis shown below:

5.1. EFFECT OF STRESS ON CHAIR WHEN OD= 23 MM AND ID= 22 MM

Fig.3: Von- Misses stress for OD=23mm and ID=22mm

The chair model is tested for various loads. The stress and deformation of chair is reveals the values shown in the table and chart given below

Table 1: Result of Chair having OD=23mm and ID=22mm

LOAD	STRESS (MPa)	STRAIN (m/m)	DEFORMATION (m)
800 N	1734.3	0.013167	0.1762
900 N	1993.5	0.015136	0.19928
1000 N	2252.7	0.017104	0.22495
1100 N	2511.9	0.019073	0.25061
1200 N	2771.1	0.021041	0.27627

The analysis is carried out for number of models. The result of the analysis is shown below in tabular form. It observed from the result that, the stress increases with increase in load applied.Also comparison of various chair models is shown in the result.

6. DISCUSSION

The result for OD=23 mm and ID=22 mm is given in table 1. It is observed that the maximum stress, maximum strain and total deformation increases with increase in load applied. Similarly, results obtained for varying thickness and varying diameter ranges.

Following graph shows Load applied (N) on abscissa and Von-Misses Stresses (MPa) according to the load on ordinate.

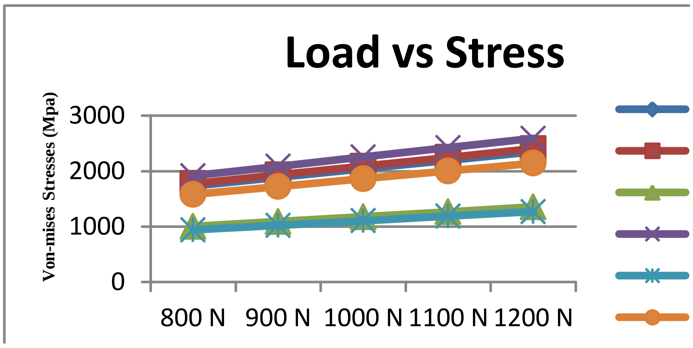

Fig.4: Load (N) VS Von -Misses stress (MPa)

The above fig. shows the stresses generated in all designed model according to gradual loading. The graph shows that, as the load increases on the chair frame stress increases. For Load of 800N,and Inner diameter of 22mm and Outer diameter of 23mm (for 0.5mm thickness) the stress observed to be 1734.3MPa as compared to Load of 1200N,it is 2347.9MPa as Load increases from 800Nto 1200N, Stresses Increases by 613.6MPa. It means for Load increase of 400N stresses increases by 35.38%

For Load of 800N,and Inner diameter of 23mm and Outer diameter of 25mmfor (1mm thickness) the stress observed to be 1001.7MPa as compared to Load of 1200N,it is 1355.1MPa as Load increases from 800N to 1200N, Stresses Increases by 353.4MPa. It means for Load increase of 400N stresses increases by 35.28%

The above graph also shows that for same load 800N stress at Outer Diameter=23mm is less as compared to Outer Diameter= 28mm, so it is clear that as Diameter increases for same load stress are also decreases.

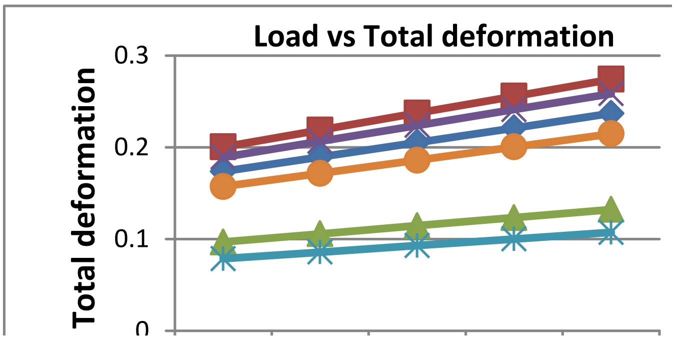

Fig.5: load (N) VS Total Deformation (M)

The above fig. shows the relation between load and deformation of chair. As the load increases on the chair, deformation of chair increases. Lesser the load, less deformation & larger load get larger deformation. As the design parameter changes the deformation also changes.

For Load of 800N,and Inner diameter of 23mm and Outer diameter of 22mmfor (0.5mm thickness) the deformation observed to be 0.17362(M) as compared to Load of 1200N,it is 0.23749(M) as Load increases from 800Nto 1200N, deformation Increases by 0.06387(M). It means for Load increase of 400N stresses increases by 36.78%

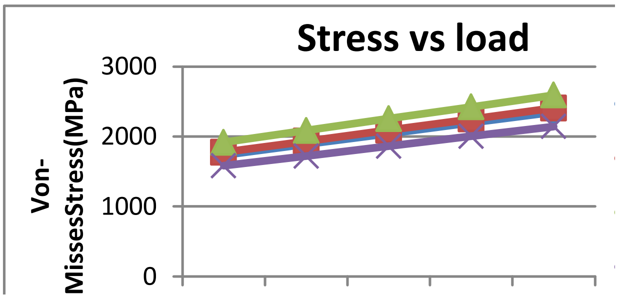

Fig.6: Stress VS Load for 0.5mm thick frame

Above fig.6 shows comparison between stresses vs. load (for 0.5 mm thick pipe frame). It is seen that as the load increases stress increased proportionally. Also as the dimension increases stress induced deceases.

For Load of 800N,and Inner diameter of 27mm and Outer diameter of 28mmfor (0.5mm thickness) the stresses observed to be 1581as compared to Load of 1200N,it is 2143.5as Load increases from 800Nto 1200N, stresses Increases by 562.5. It means for Load increase of 400N stresses increases by 35.57%

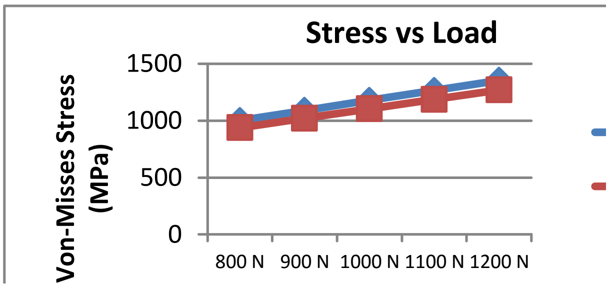

Fig.7: Von-Mises Stress VS load for 1mm thick pipe frame

Above chart shows the comparison between Von-Misses stresses VS Load for 1mm thick pipe frame. It shows that as the load increases, stress increases. Also as the dimensions increases on higher side stress decreases.

For Load of 800N, and Inner diameter of 27mm and Outer diameter of 28mmfor (1mm thickness) the stresses observed to be 938.1(MPa) as compared to Load of 1200N, it is 1270(MPa) as Load increases from 800N to 1200N, stresses Increases by 332(MPa). It means for Load increase of 400N stresses increases by 35.39%

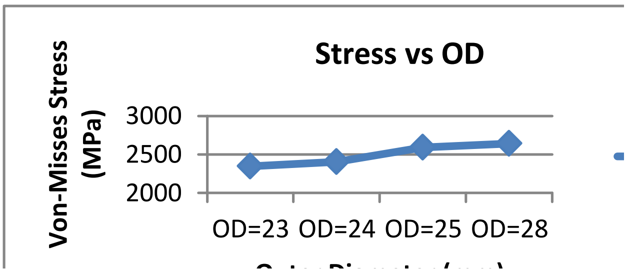

Fig.8: Stress VS OD for 0.5mm thick pipe frame at 1200N

For Load of 1200N,and Inner diameter of 23mm and Outer diameter of 22mmfor (0.5mm thickness) the stress observed to be 2347.9MPa as compared to Load of 1200N, ,and Inner diameter of 28mm and Outer diameter of 27mmfor (0.5mm thickness) it is 2643MPa as Load constant 1200N, Stresses Increases by 295.1MPa. It means stresses increases by 35.28%

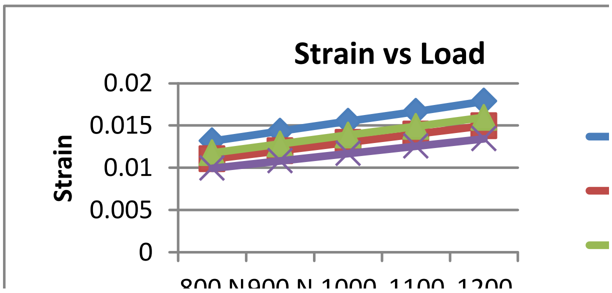

Fig.9: Strain VS Load for 1mm thick pipe frame

Above fig.9 shows comparison between strains vs. load for 0.5 mm thick pipe frame. It is seen that as the load increases, strain increased proportionally. Also as the dimension increases, strain induced deceases.

For Load of 800N,and Inner diameter of 27mm and Outer diameter of 28mmfor (0.5mm thickness) the strain observed to be 0.009943as compared to Load of 1200N,it is 0.013443as Load increases from 800Nto 1200N, Strain Increases by 0.0035. It means for Load increase of 400N strain increases by 35.20%.

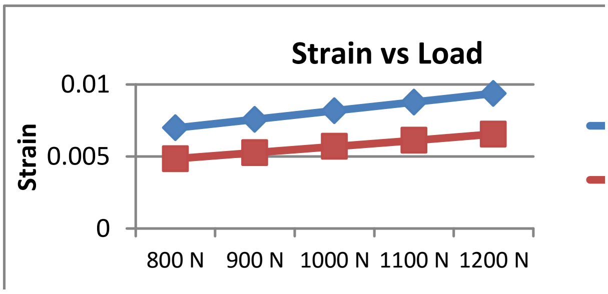

Fig. 10: Strain VS Load for 1mm thick pipe frame

Above fig.10: shows comparison between strains vs. load for 1 mm thick pipe chair frame. It is seen that as the load increases, strain increased proportionally. Also the dimension increases strain induced deceases.

For Load of 800N,and Inner diameter of 25mm and Outer diameter of 23mmfor (1mm thickness) the strain observed to be 0.0069838 as compared to Load of 1200N,it is 0.0093732 as Load increases from 800Nto 1200N, Strain Increases by 0.0023894. It means for Load increase of 400N strain increases by 34.21%

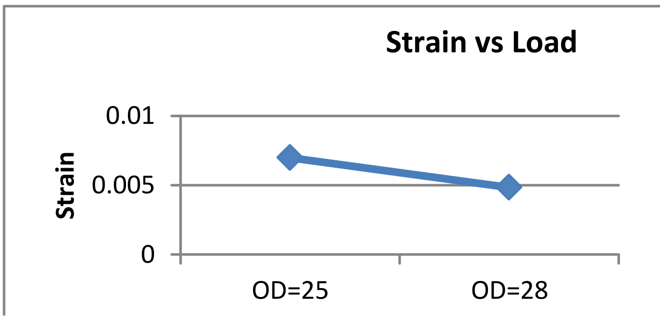

Fig. 11: Strain VS OD for 2mm thick pipe frame at 800N

Above Fig.11: shows the comparison between strains vs. outer diameter of 1mm thick pipe frame at a load of 800N. It shows, for constant load as the diameter increases, the strain induced in the tube decreases.

THEORETICAL CALCULATION

The Validate the results obtained by ANSIS 14.0, Theoretical calculation is done. The procedure adopted is given as below.

ANALYTICAL DESIGN OF CHAIR

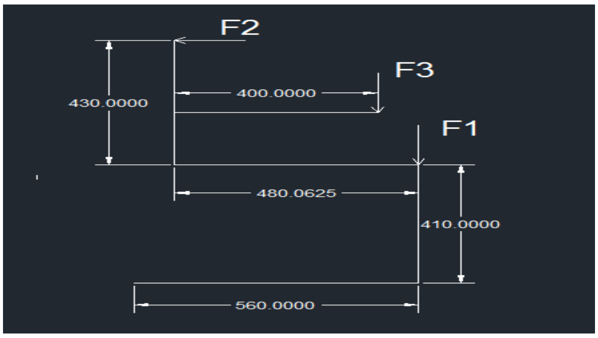

Fig.12: Design of Chair

Where,

F1 = 800N
F2 =- 150 N
F3 = 50 N

The outer diameter of chair is 23 mm and thickness of chair is 0.5 mm. The designed chair should be validating by comparing the bending stress generated with standard bending stress.

Reaction at A

(-150 x 430) + (50 x 400) + (800 x 480) = 339500 N-mm
339500 = R_A x 480
$\mathbf{R_A}$ = 339500/480 = 707.291 N
$\mathbf{M_B}$ = 707.291 x 410
= 289989.31 N-mm

Now,

$\mathbf{Z} = \prod/32\ [23^3 - 22^3]$
$= 149.12\ mm^3$

$\boldsymbol{\sigma_b} = \frac{289989.31}{149.12}$
$= 820\ N/mm^2$

SAE 1095

$\mathbf{S_{ut}} = 840\ N/mm^2$

Hence,

$\boldsymbol{\sigma_b < S_{ut}}$

Therefore, the design is safe are selected material of chair (M.S) Mild Steel standard value of mild Steel is SAE 1095 $\mathbf{S_{ut}} = 840\ N/mm^2$ (from Data Book).

CONCLUSION

The stress analysis of the steel frame chair was studied using ANSIS 14.0 and results are discussed in below. From the results is obtained it is conclude that

- Comparison between Von-Misses stress VS load for 0.5 mm thick pipe frames shows that as the load increases stress increased proportionally. Also as the dimension increases the stress induced deceases.
- Comparison between strains vs. load for 0.5 mm thick pipe frame shows that as the load increases, strain increased proportionally. Also as the dimension increases the strain induced deceases.
- Comparison between deformation VS load for 0.5 mm thick frame shows that as the load increases deformation increased proportionally. Also as the dimension increases the deformation take place deceases.

4. The design is safe for selected material of chair made by Mild Steel, their property SAE 1095 $\mathbf{S}_{ut}$ = 840 N/mm^2 (from Data Book) the above analytical results obtain theoretically, it is observed that the theoretical result are well in agree-met with the result obtain from FE

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