Design and Analysis of Rolling mill crusher shaft for weight reduction and strength enhancement.

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***Abstract :** Sugarcane roller process is the key piece of sugar industry. The primary goal of processing is to isolate the sucrose-containing juice from the stick. The extraction of juice in a factory is accomplished by pressing arranged stick between two rolls. In this technique the strong model of the segment is subdivided into littler components, imperatives and burdens are connected to the model. Geometrical show is made utilizing 3D demonstrating programming CATIA V5. The static investigation of every part are utilizing examination programming ANSYS WORKBECH. The outcomes for greatest shear weight on the best, sustain, release roller are ascertained diagnostically and contrasted. Static examination of each of the three rollers are finished utilizing extraordinary materials for examining. It is observed that shear stress in Al-Ni-Br alloy is less than existing materials.*

***Keywords**— Crushing roller, Static analysis, Max. Shear stress theory, ANSYS Workbench*

I. INTRODUCTION

Usually three roller mills are used for extraction of juice which consists of three rollers, Feed and Discharge rollers. Sugarcane is being fed into top and feed rollers which further passes through top and discharge roller along with trash plate. This trash plate is having a downside that 25% of total hydraulic load is shared by this trash plate in overcoming friction and remaining 75% only the useful one. i.e. 25% hydraulic load is shared by feed roller and 50% is shared by discharge roller. Crushing rolls are designed with high coefficient of friction and very low rotational (4–5 rpm) speed.

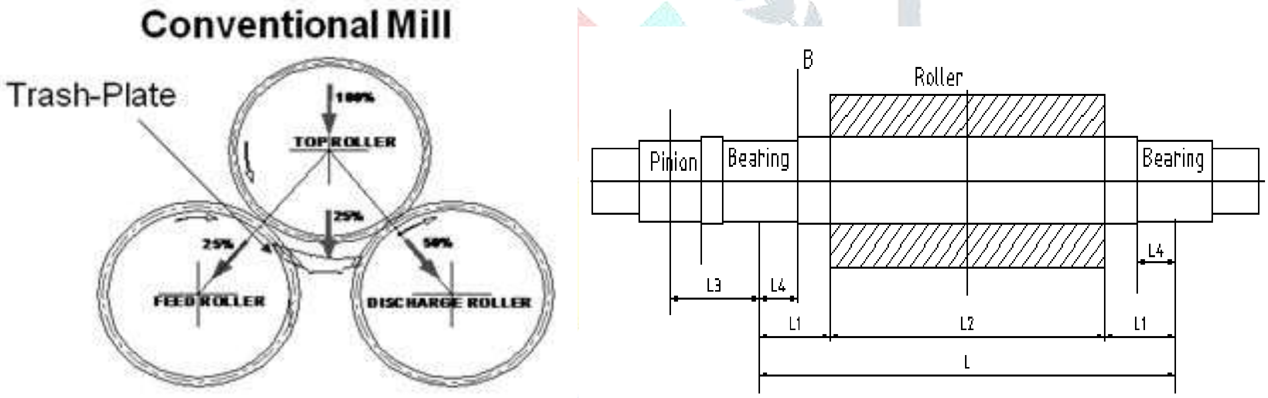


Fig 1. conventional mill and its shaft

Three rollers are used named as top, feed & discharge roller. The rollers are arranged in an isosceles triangle with a top angle of 72 degree. The feed and discharge rollers are placed at an angle of 35 & 37 respectively from the vertical below the top roller. The crushing of cane takes place first in top-feed roller and then in top-discharge roller. The shaft of roller is made up of forged steel and shell of the roller is made up of cast iron. The shell is shrink fitted on the shaft.

II. THEOROTICAL APPROACH

Given data

Power (P) = 750 HP;
Roller speed=5 rpm;
Roller dia.= 800 mm
Shaft dia. at roller= 436mm
Load on shaft =700 Ton

Material properties

Material =**40c8**
ϱ=7850 kg/m^3
Sut=680 mpa
Syt=380 mpa
E=200000 mpa
Poisson ratio=0.3

Design of shaft

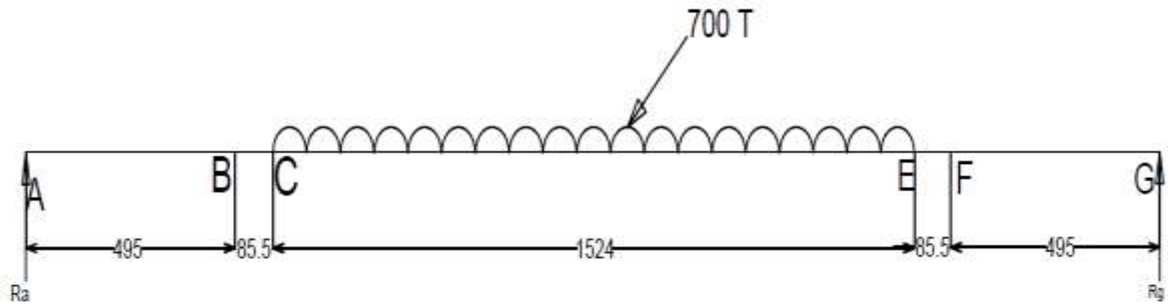


Fig 2. Loading diagram

Ra + Rg = ΣF
Rg =350 Ton
Ra =350 Ton

1)To find bending moment at Centre of shaft i.e. Md

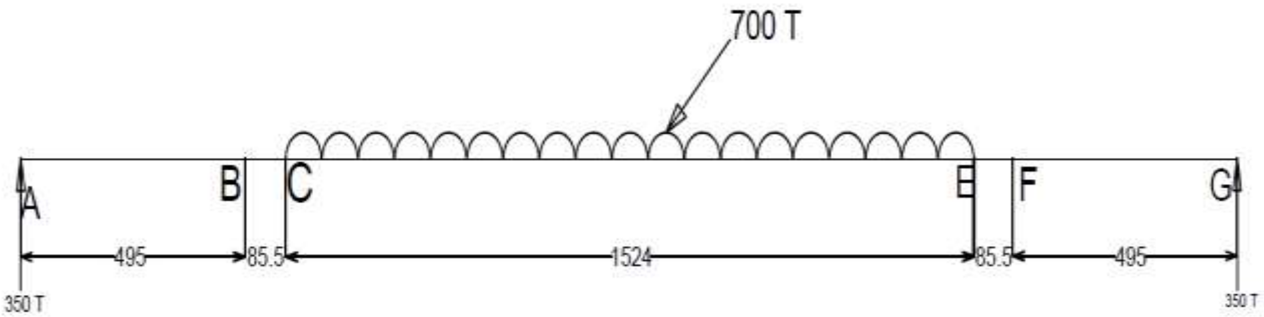


Fig 3.loading diagram for bending of shaft

$\sum Md = 335.746\times10^6$ Kgf.mm.

$\sigma b = \frac{M.Y}{I}$

$\sigma b = \frac{335.746\times10^6\times400}{2.010161\times10^{10}}$

$\sigma b = 6.67$ Kgf/mm2 at point D i.e. center of shaft

2)To find bending moment at Bearing support

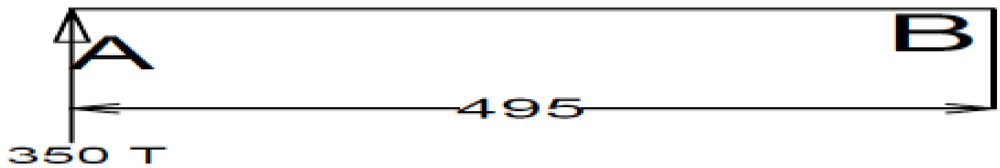


Fig 4. Loading diagram for bearing support

$Mx = 350\times10^3\times\frac{495}{2}$

$Mx = 86.625\times10^6$ Kgf.mm.

$\sigma bx = \frac{M.Y}{I}$ $\sigma bx = \frac{86.625\times10^6\times190}{1.0235\times10^9}$

$\sigma bx = 16.080$ Kgf/mm2

[B] To Calculate shear stress
(1)shear stress at centre of shaft:-
$\tau d = Kt\times(\sigma b)D$

=141.33 N/mm2

(2)shear stress at Bearing of shaft:-

τd = Kt×(σb)A

=34.732 Kgf/mm2
=34.732×9.81 = 340.72 N/mm2

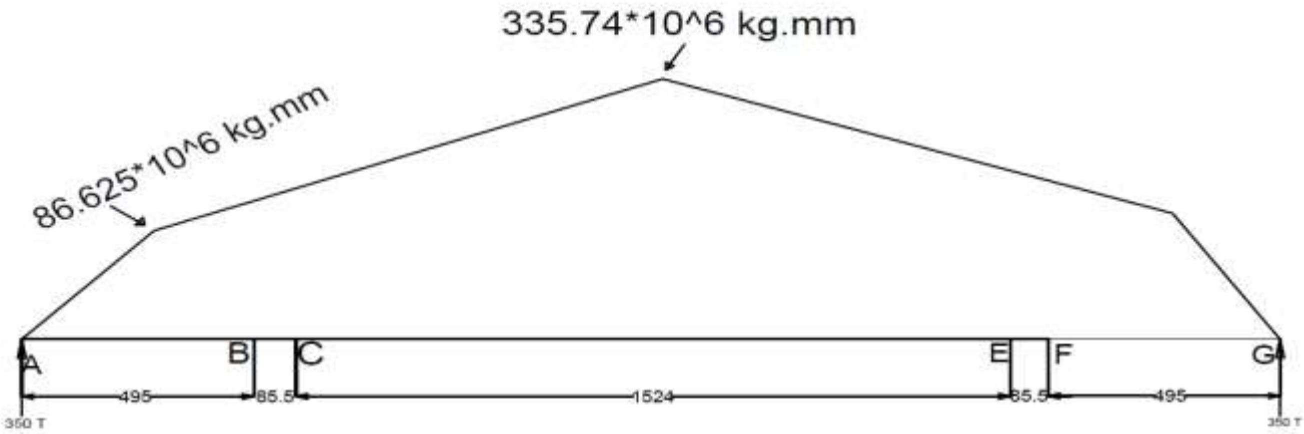


Fig 5. Bending moment diagram

III. Structural analysis

a)Three Dimensional Cad Model

A three dimensional model of crushing roller is made by using modeling software CATIA V5. CATIA is the most powerful and widely used CAD software of its kind in the world.

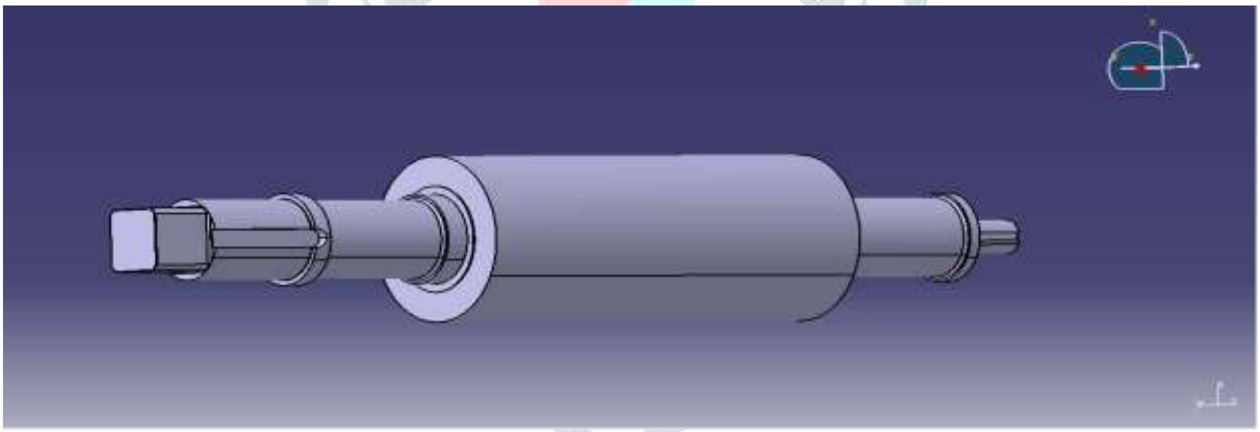


Fig.6.CATIA 3D model of crusher shaft

***b)* Static Analysis of Top Roller**

1) Mesh Generation

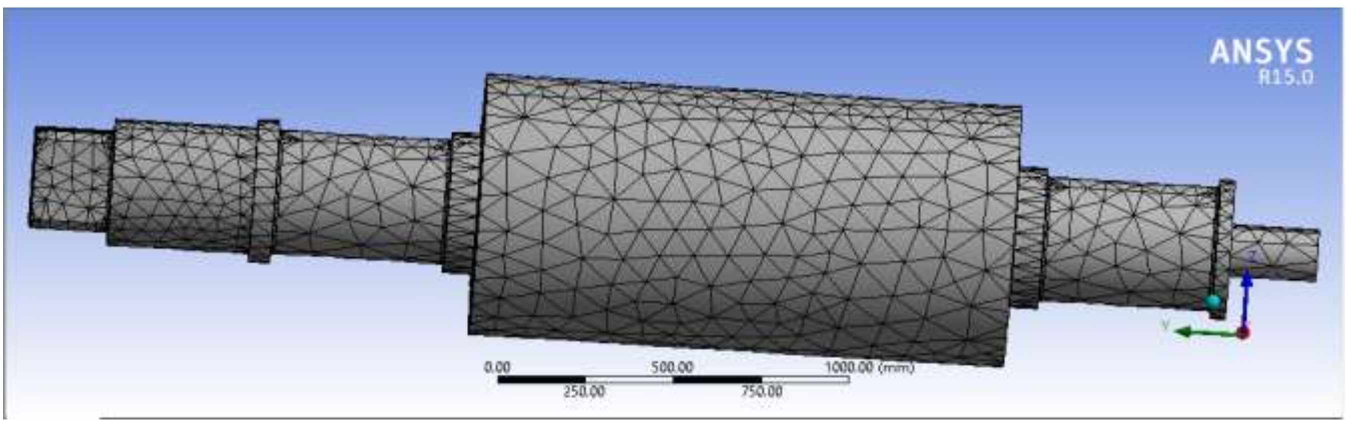
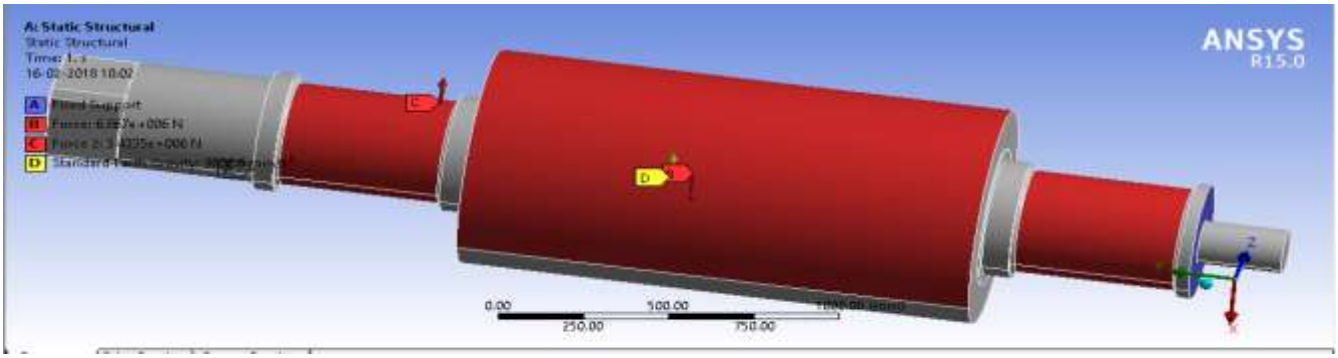


Fig.7. Meshing of crusher shaft

2) Loading And Boundary conditions



.**Fig.8**.loading of crusher shaft

3) Results of static analysis for top roller

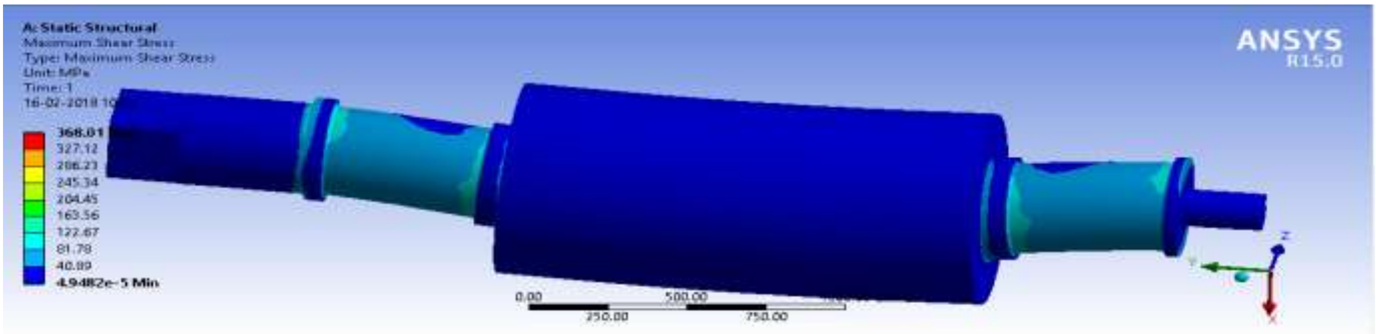


Fig.9.Shear stress on top roller

IV. Results of Static Analysis of Rollers With Different Materials
Aluminium Alloy

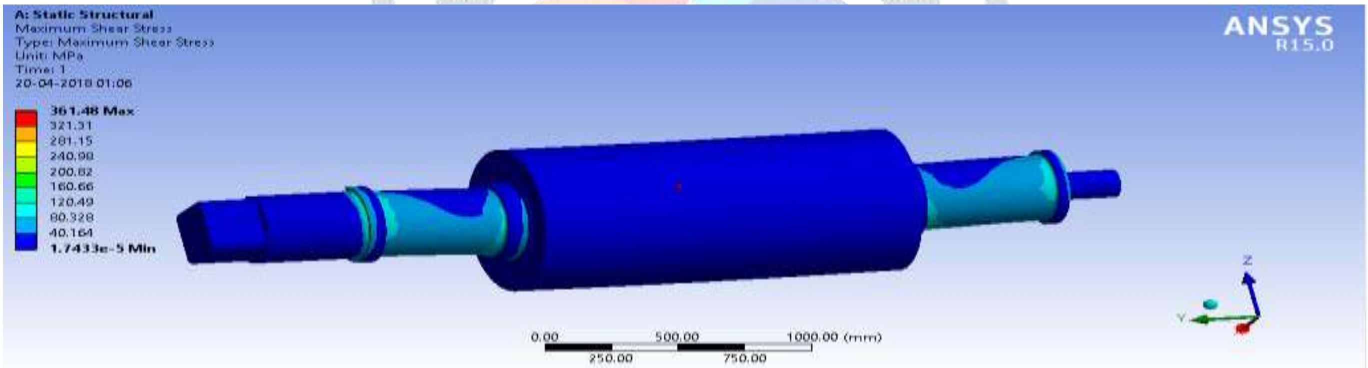


Fig.10. Shear stress on Aluminium alloy

Aluminium Nickel Bronze Alloy

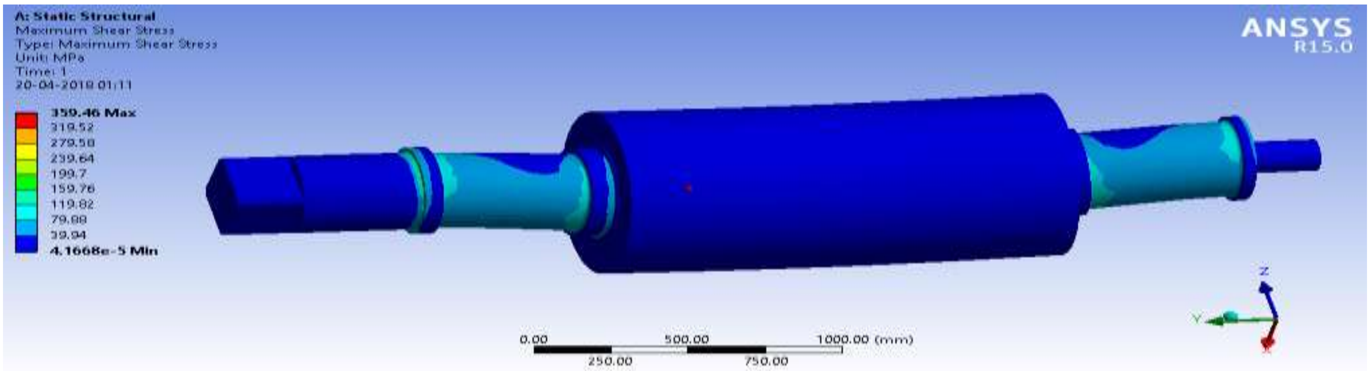


Fig.11. Shear stress on Aluminium Nickel Bronze alloy

Copper Alloy

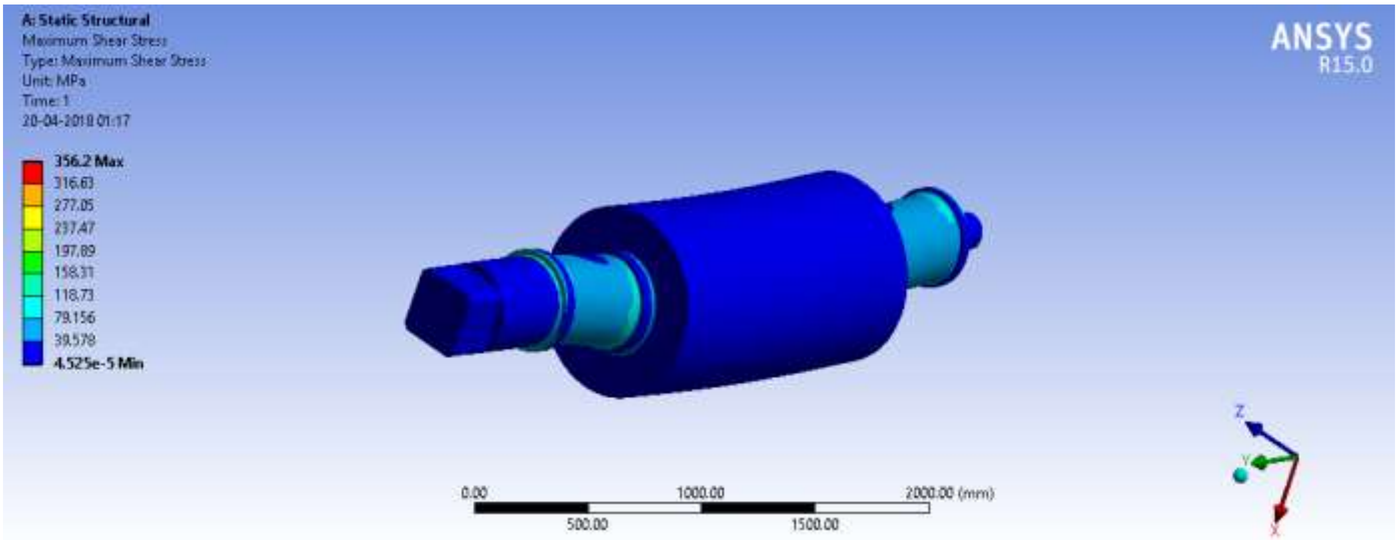


Fig.12. Shear stress on copper alloy

Phosphorus Bronze Alloy

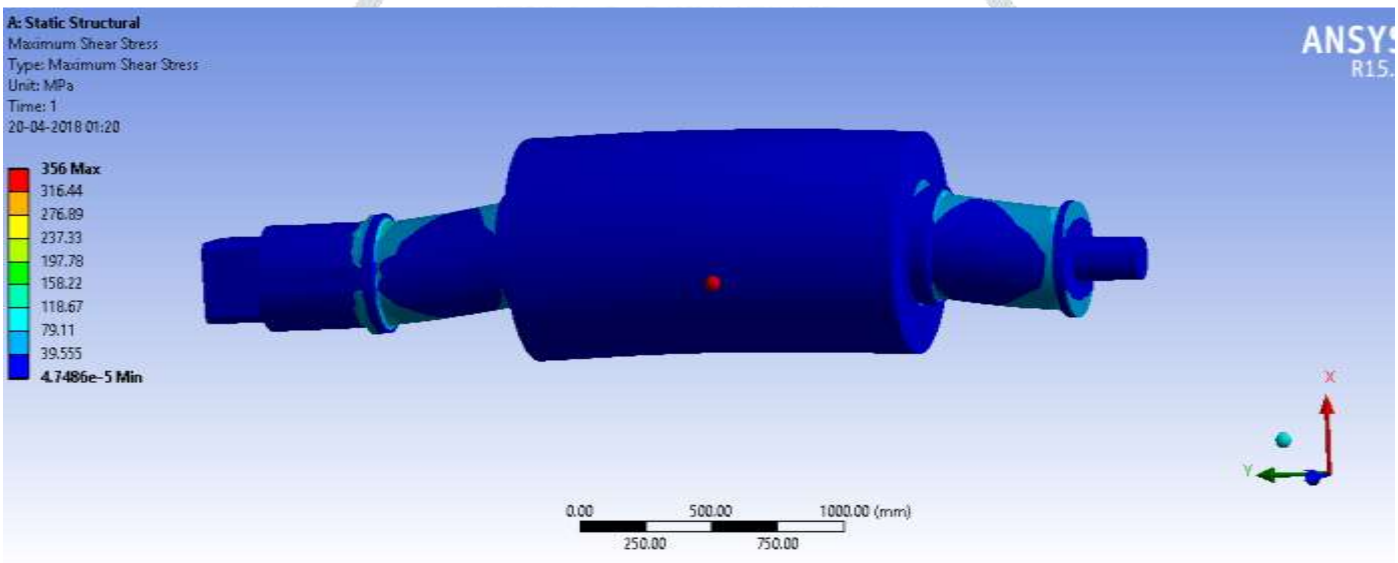


Fig.13. Shear stress on Phosphorus Bronze alloy

Table No-1.Result of static analysis of roller

Material	Shear stress (Mpa)	Total deformation (mm)	Mass (Kg)
Aluminium alloy	361.48	4.17	2745.2
Al-Ni-Br alloy	359.35	2.565	7512.2
Copper alloy	356.2	2.69	8225.8
Phosphorus Bronze alloy	356	2.69	8721
Forged Steel	368.01	1.45	7779.4

V.Conclusion

3-D modeling and analysis has been done for roller shaft and from static analysis for different material results is observed. From the results it is conclude that-

1) Maximum shear stress value for roller is less than yield strength in shear of material so,the shaft is safe.
2) As the value of max. Shear stress is very less than yield strength in shear of material, so there is scope for weight optimization.
3) Maximum shear stress values by analytical calculations and by software are nearly same, so results are validated.
4) Based on the total deformation and mass of material,Al-Ni-Br alloy is the best among given materials.
5) As material is a changed value of max. Shear stress is nearly same.
6) The shear stress in Al-Ni-Br alloy is less than Forged steel, so strength also be increases.

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