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DIAGNOSIS THROUGH ANALYSIS OF FAILURE OF MAINSHAFT AND WORMS OF OIL EXPELLER

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ABSTRACT

The research fruit forward the diagnosis of failure of the worms and worm shaft assembly will hereafter called as screwshaft of cotton seed oil extraction unit before prescribed life period having frequency of 1-2 times a month and suggest the solution in the same regards. The proposed works not only checks the existing dimensions through traditional method but also implies computerized techniques to evaluate various parameters. The industry at which the project work is carried out consist of eleven screw press machines of size 36 x 6.5 inches, having working principle on the rotation of a tapered screw-shaft mounted inside a grooved vessel. The screwshaft is a single square-threaded power screw having an increasing root diameter from inlet to exit. There in total clearance of nearly 0.5 inch is between the vessel and screw-shaft. As its is not economical to alter the dimension of the machine as per the present situation in the industry,the changes in the existing system will be based on the change of material; for which Static structural and Thermal analysis is done using software Ansys; by considering the four different materials and their properties, comparing the results best material is selected to replace existing low strength material.This could help the industries working in these area to improve the life and functionability of the unit which would in their term lead to higher productivity.Thus the study contributes to reduction of running cost of an industry by reducing the sudden breakdowns occuring because of failure of main shaft and worms assembly of cotton seed oil expeller machine.

Key words: Diagnosis, Screwshaft, Main shaft, Worms , Oil expeller, Failure, Material.

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INTRODUCTION

The screw type machine, which presses cotton seeds through a caged barrel-like cavity replaces, the historical method for the batch wise extraction of oil by mechanical or hydraulic pressing. Screw type Expellers use a horizontally rotating metal screw, which feeds cotton seeds into a barrel shaped outer casing with perforated walls. The cotton seeds are continuously fed to the expeller, which grinds, crushed and presses the oil out as it passes through the machine. The pressure ruptures the oil cells in the product and oil flows through the perforations in the casing and is collected in a trough underneath. The residue of the material from which oil has been expressed exits from the unit, and is known as the cake.

Expellers are power-driven, and are able to process 8 to 500 kg per hour of product or even more depending upon the type of expeller used. Bigger units processing greater quantities of oil are available for use in larger mills.The friction created by the products being expressed wears down the worm shaft and other internal parts, and also have the problem of uncertain failure of main shaft. With small machines this occurs often after expressing little, after which parts have to be replaced or repaired through resurfacing by welding. Maintenance of an oil expeller, therefore, calls for machinery and equipment rarely found in small repair shops and local manufacture of expellers would be most unlikely at the village /small town level. The profitability of the businesses, including oil processing, depends on reducing the capital and operating costs as much as possible, and at the same time maximizing the income.

WORKING PRINCIPLE

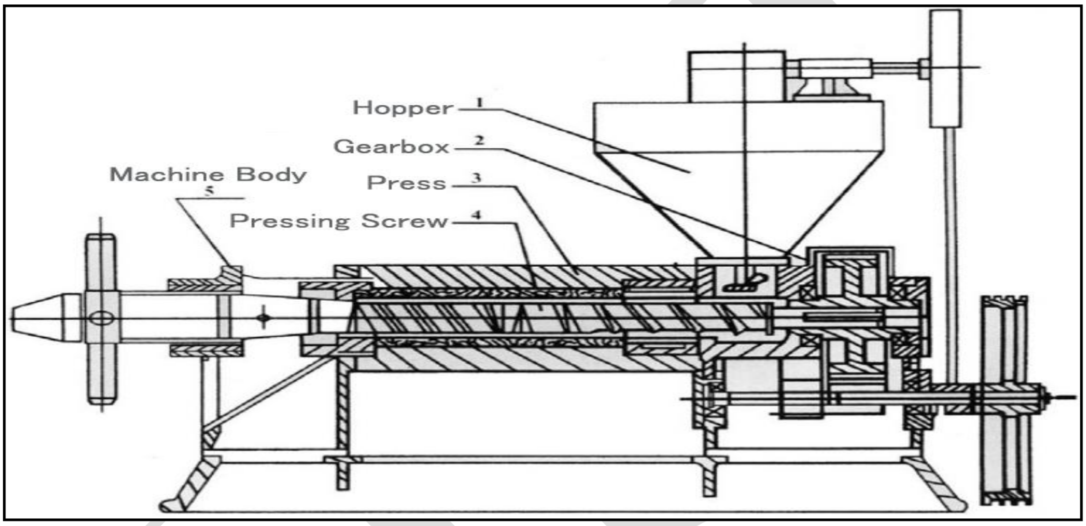

Fig 1: Working Principle of oil expeller

Raw materials enter one side of the screw shaft through the hopper and waste products exit the other side. The expeller screw shaft, rotates inside a cylindrical cage (barrel). The cotton seed to be pressed is between the screw and the barrel and propelled by the rotating screw in a direction parallel to the axis. The compression effect can be achieved, for example, by decreasing the clearance between the screw shaft and the cage (progressive or step-wise increase of the shaft diameter),the machine uses friction and continuous pressure from the screw drives to move and compress the seed material. The oil seeps through small openings that do not allow seed fiber solids to pass through. Afterward, the pressed seeds are formed into a hardened cake, which is removed from the machine. Expeller pressing (also called oil pressing) is a mechanical method for extracting oil from raw materials. The raw materials are squeezed under high pressure in a single step.

In operation, the oilseed is introduced into the machine through the feeding hopper; the machine conveys, crushes, grinds And presses the oilseed inside the cylindrical barrel (casing) with the aid of the screw shaft until oil is squeezed out of the seed. The oil extracted is drained though the oil channel into the oil tray where it is collected; the residual cake is discharged at the cake outlet and collected at the cake tray.

PROBLEM FORMULATION

In a oil industries, situated at MIDC, Yavatmal, where screw type oil expellers are used there is a common problems of wear and uncertain failure of Screw shaft which result in the breakdowns, increasing the running cost and reducing the productivity. The frequency of breakdowns due to uncertain main shaft is nearly 1-2 times in a month and the cost incurred for the repair/replacement in high which increases the running cost of the industry.

Cotton seed oil extraction unit uses the mechanical method of screw pressing for extracting oil from cotton seeds. The cotton seeds are squeezed under high pressure in a single step in a continuous feed which result in the wear among the mating parts with generation of the huge heat, which again increases the chances of failure of the parts.

OBJECTIVE

The objectives of this project were as follows:

A. Investigation of the reasons for uncertain Failure of Main shaft and Worms of cotton seed oil expeller.
B. To model all the components using modeling software Pro-E 5.0
C. To assemble the components of the Screw shaft in the software.
D. Analysis of screw of machine using Ansys 14.0 software.
E. Suggesting the best material to replace the existing low strength material necessary as per the present situation in industry.

CAUSES OF FAILURE

[1] Not use of process of "Cooking", which in the presence of moisture denaturats the proteins amd plasticizes the flakes, renders them less brittle and making them soft and thus reduces the extent of flake disintegration as a result of shear in the press.
[2] Usually caused by power failure (electricity down or circuit breakers tripped) with the hard materials jammed between the Screw and crushing chamber.
[3]Improper fitting and alignment of Shaft.
[4]Design and material of exiting mainshaft and worms to sustain the forces and stresses generated.

CALCULATION OF VARIOUS PARAMETERS THROUGH ANALYTICAL METHOD

Technical Details

These details are taken from the machine catalogue;
1.Quantity to be crushed 12 tonne per 24 hr.
2. Motor rotation N1 = 960 RPM
3. Motor Capacity = 50 HP
4. Motor Pulley Dia. D1 = 228.6 mm
5. Gear Box Pulley Dia. D2 = 762 mm
6. Input speed for Gear Box = N2
7. Main Gear Teeth = 74 ; Spur Pinion Teeth = 12 ;Bevel Gear teeth = 42 ; Bevel pinion teeth = 15
8. Shaft Torque = T

Analytical Calculations. :

Calculate Gear Ratio and Verify Screw (Main Shaft + Worms) Rotation :
a) Find input speed for Gear Box :
For belt drive D1/D2 = N2/N1
228.6/762 = N2/960
N2 = 288 Rpm
For Gear Ratio G1 = T3/T2
G1 = 74/12

$G1 = 6.166$

Similarly; $G2 = T5/T4 = 42/15$

$G2 = 2.8$

Gear Ratio = G1 x G2 = 17.2648

Main Shaft Rotation (N) :

= i/p Speed at Gearbox(N2) / Gear ratio (G)

= 288 / 17.2648

= 16.68 Rpm = Approx.18 Rpm.

Shaft Torque Calculation (T) :

As 1HP = 0.754699 KW

Therefore Motor Power = 50HP =37.73 KW

We know ; Power = (2x 3.14 xN / 60) T

P = 1.8849 x T

T = 20016.38 N-m

T = 20016.38 x10^3 N-mm

Angular velocity of Screwshaft = 1.8849 rad/sec

Shaft force Calculation (F) :

Considering d=75mm;

T= F.r ; 20016.38 x10^3 = F.(75/2)

F_1=533.77 x 10^3N

Considering d=80mm;

T= F.r ; 20016.38 x10^3 = F.(80/2)

F_2= 500.40 x 10^3N

Considering d=85mm;

T= F.r ; 20016.38 x10^3 = F.(85/2)

F_3= 470.97 x 10^3N

Stress Calculations :

Considering smallest diameter for calculations

- Normal stress developed (σ_n) = Force/Area = 533.77 x 10^3/4417.864

  σ_n = 120.82 N/mm^2

- Shear Stress developed. (τ) :

  Working Stress Developed = 16T/3.14xd3

  Working Stress (τ) = 241.64 N/mm^2

- Maximum Shear stress developed (τ_{max}) = Kt. 16T/3.14xd3

  = 1.61 x 16(20016.38x10^3)/3.14x75^3

$$\tau_{max} = 389.02 \text{ N/mm}^2$$

MATERIAL SELECTION

Material selection will be done considering following factors;

1. Availability
2. The cost of material
3. Suitability of material for the application.
4. Considering Chemical, Physical and mechanical properties of material suitable for the application.
5. Result obtain through Static and Thermal Analysis of each material considered.

MODEL CREATION BY USING THE MODELING SOFTWARE "PRO-E"

The existing Mainshaft and Worm assembly consist of Mainshaft and Worms having dimension following;

Total Length of shaft = 2569.4 mm,
Diameter of steps on shaft = 95mm ,85mm,80mm,75mm
Shaft Keyway = 1600.2 mm x 20mm x 8mm
Worm Lengths = 254mm, 203.2mm, 139.7mm,
95.25mm ,76.2mm,63.5mm
Worm Inner hub Diameter = 80mm - 85 mm
Worm Outer hub Diameter = 130mm
Worm Thread thickness = 10mm
Worm outer diameter = 165.1mm

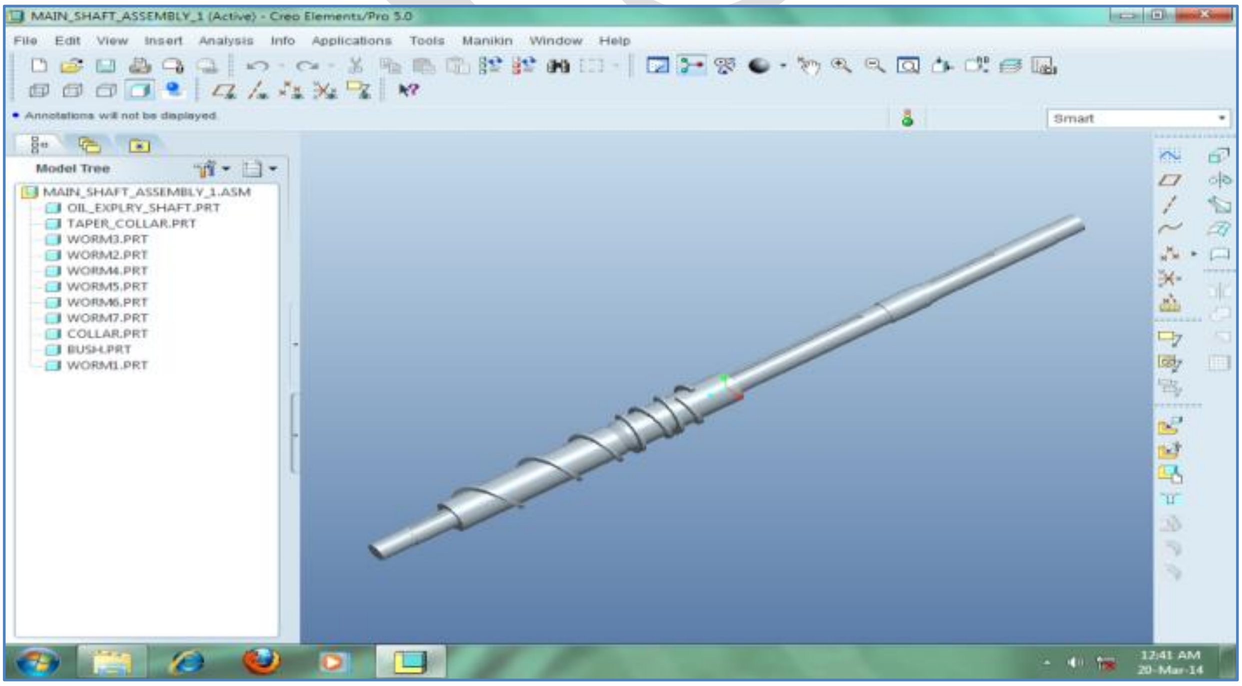

Fig 2: Mainshaft Assembly model

To create above Screw-Shaft we have used several part module commands in Pro-E software. Some of them are Extrude, Revolve extrude, Remove material, Chamfer, Fillet etc

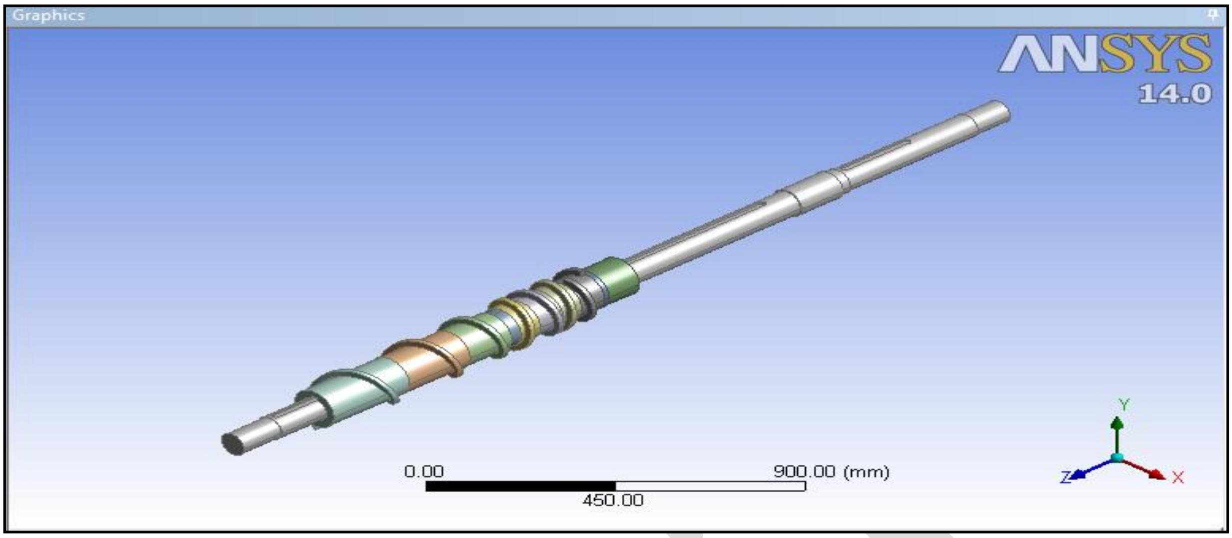

Fig 3: IGES format converted Screwshaft

STRUCTURAL ANALYSIS OF SCREWSHAFT

We have performed structural analysis of oil expeller screwshaft with the help of ANSYS 14.0 software which is FEM tool.The existing material of screwshaft is Mild Steel, other materials considered are En8,En19 and En24.The basic steps are as follows.

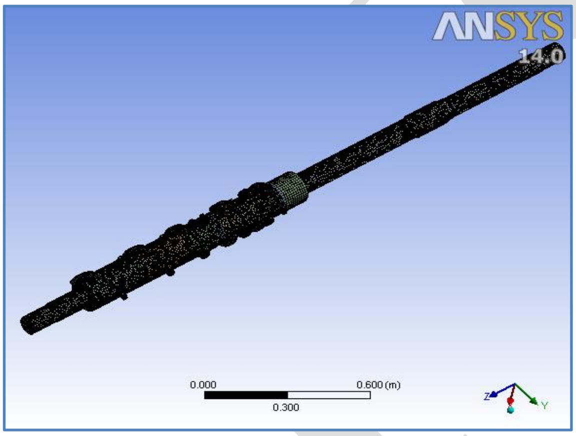

Fig.4: Meshed view of screwshaft

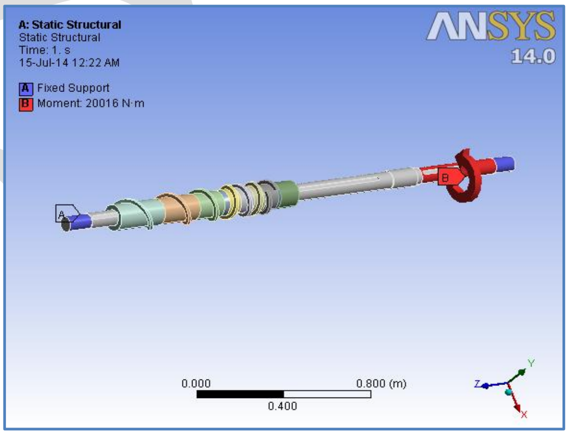

Fig 5: Loads Applied on screwshaft

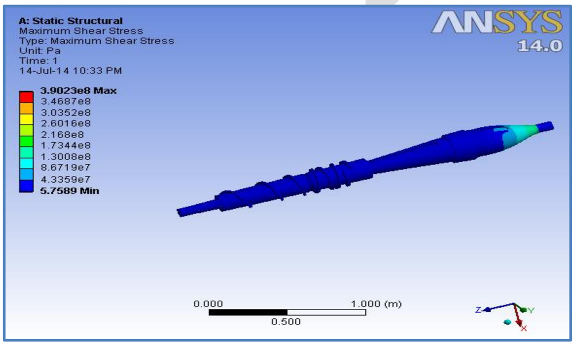

Fig 6:. M.S screwshaft Stress Intensity

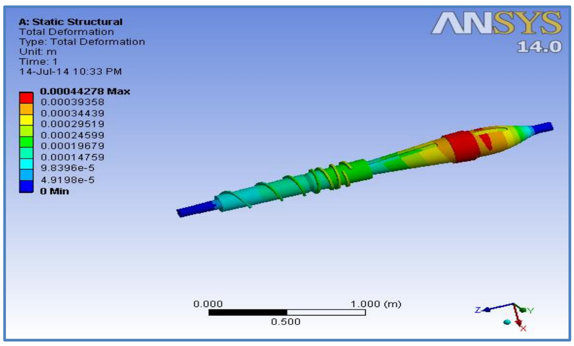

Fig 7 : M.S screwshaft maximum deformation

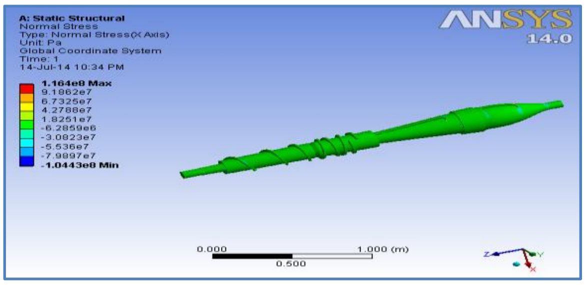

Fig 8 : M.S screwshaft normal stress

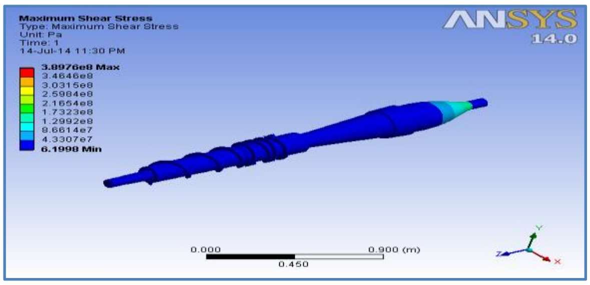

Fig 9: En8 screwshaft Stress Intensity

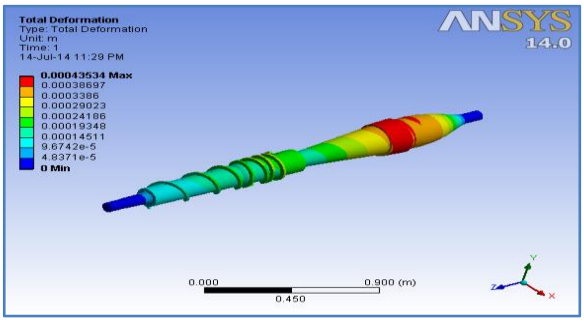

Fig 10 : En8 screwshaft maximum deformation

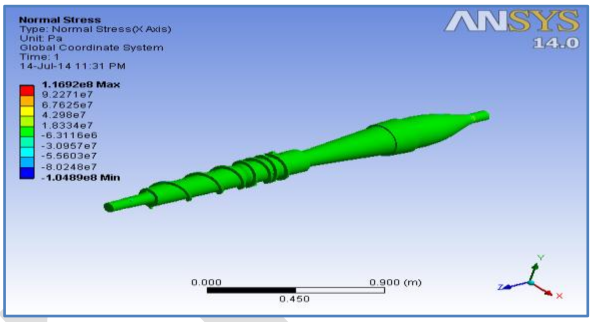

Fig 11 : En8 screwshaft normal stress

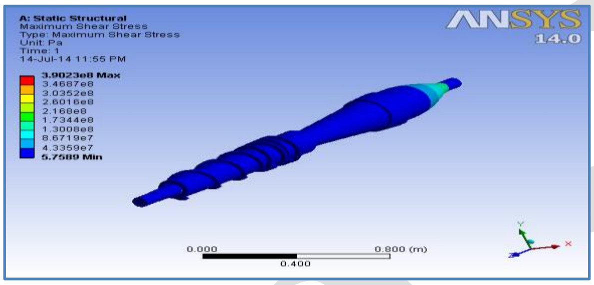

Fig 12: En19 screwshaft Stress Intensity

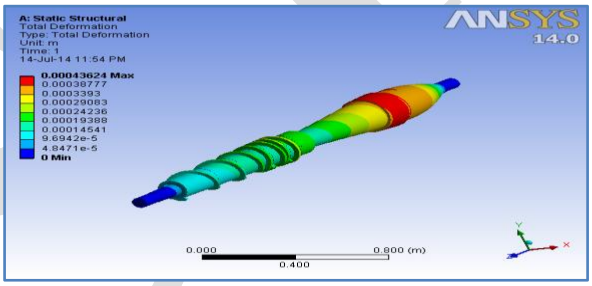

Fig 13 : En19 screwshaft maximum deformation

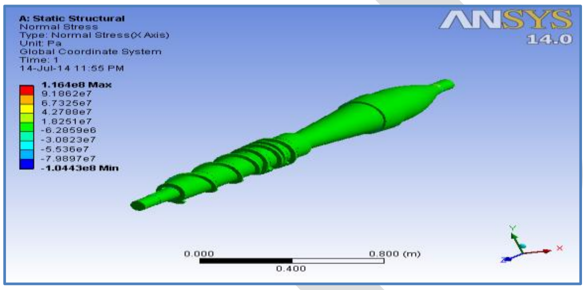

Fig 14 : En19 screwshaft normal stress

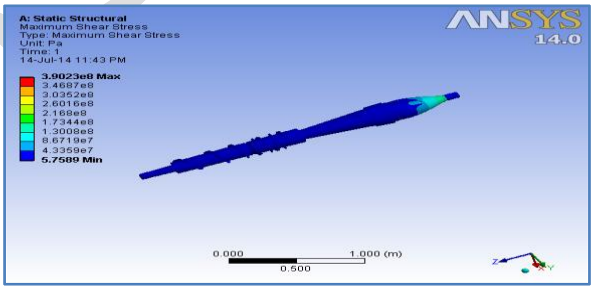

Fig 15: En24 screwshaft Stress Intensity

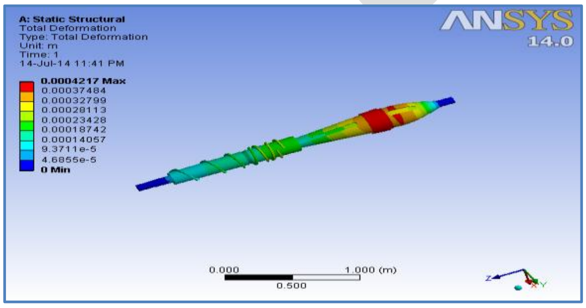

Fig 16 : En24 screwshaft maximum deformation

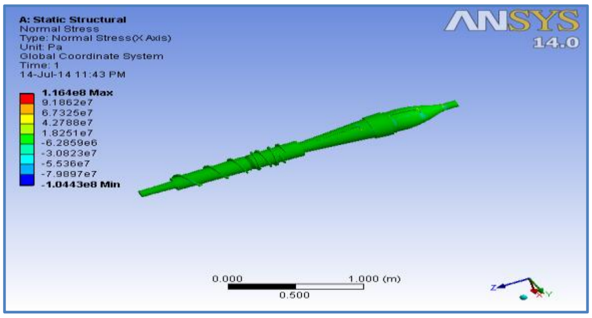

Fig 17 : En24 screwshaft normal stress

THERMAL ANALYSIS OF SCREWSHAFT

We carry out thermal analysis for the temperature range 35 ^{0}C To 105^{0}C.

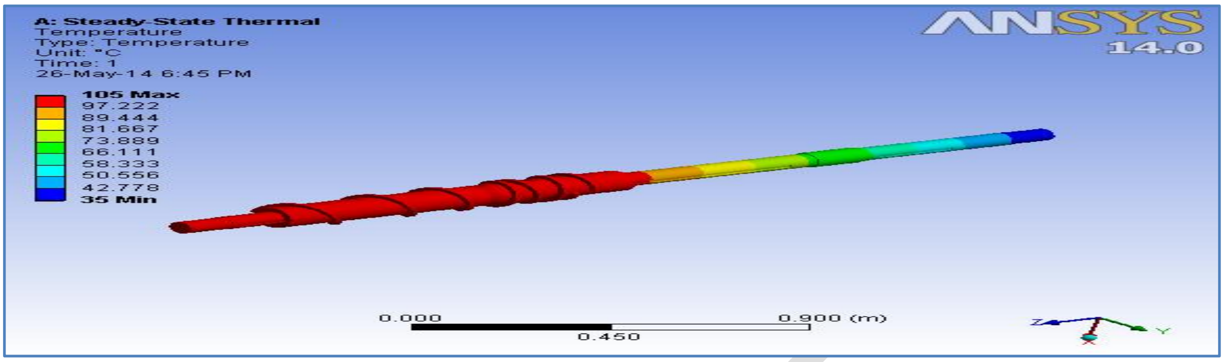

Fig 18.: Applied temperature on Screwshaft

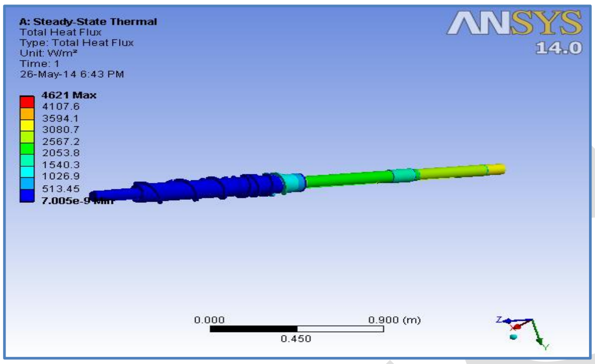

Fig 19: M.S screwshaft Total Heat Flux

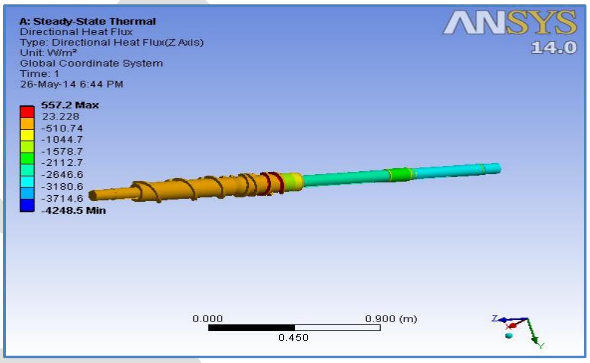

Fig 20: M.S screwshaft Directional Heat Flux

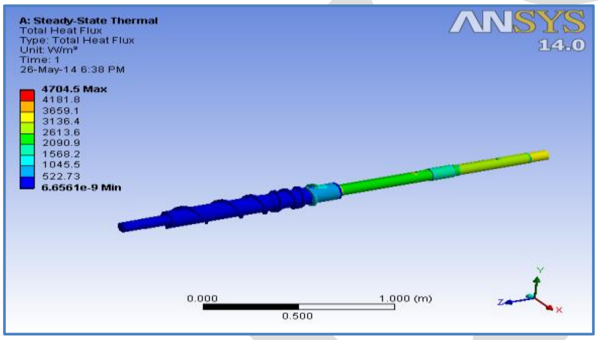

Fig 21 :En8 screwshaft Total Heat Flux

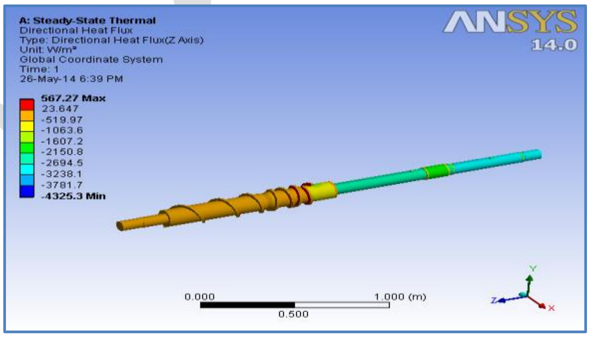

Fig 22:En8 screwshaft Directional Heat Flux

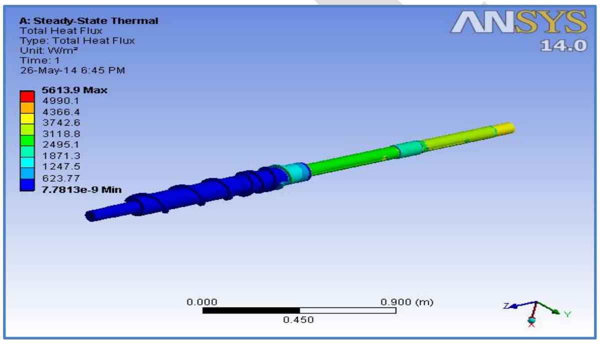

Fig.23: En19 screwshaft Total Heat Flux

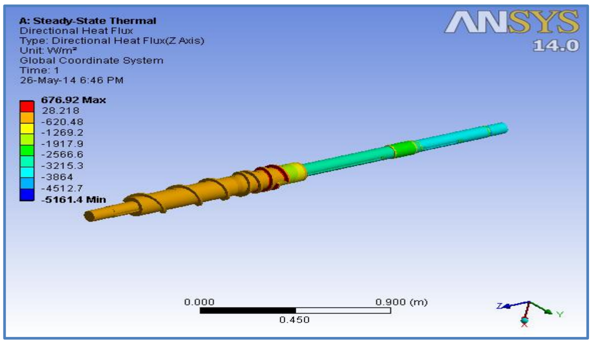

Fig.24:En19 screwshaft Directional Heat Flux

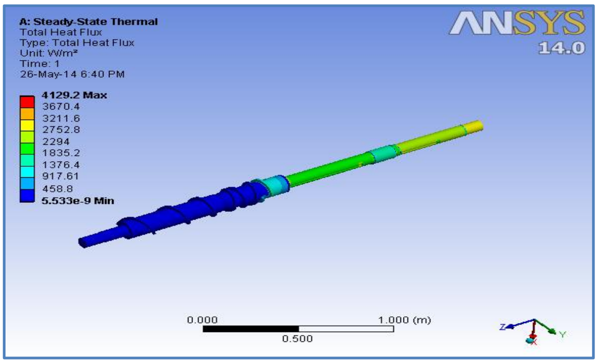

Fig.25:En24 screwshaft Total Heat Flux

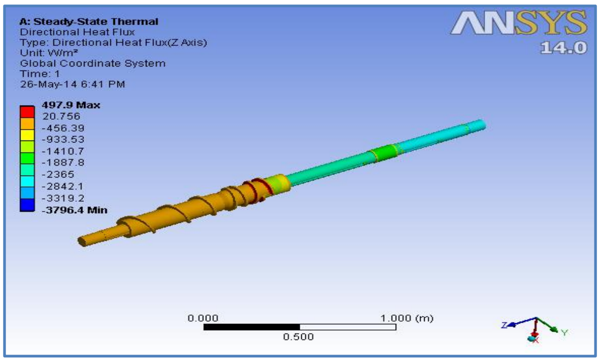

Fig.26: En24 screwshaft Directional Heat Flux

RESULT COMPARISION AND DISCUSSION

Table.1 Comparison of Results

Parameters – Materials	STRUCTURAL ANALYSIS RESULTS			THERMAL ANALYSIS RESULTS	
	Deformation (m)	Max^m Shear Stress (N/m^2)	Max^m Normal stress (N/m^2)	Heat Flux	Directional Heat Flux Along Z-axis
M S	0.000442	3.902×10^8	1.16×10^8	4621.0	557.2 max
En8	0.000435	3.897×10^8	1.16×10^8	4704.27	567.27 max
En19	0.000436	3.902×10^8	1.16×10^8	5613.92	676.92 max
En24	0.000421	3.902×10^8	1.16×10^8	4129.90	497.9max

1.By studying above results we can conclude that the total deformation in En24 and En8 screwshaft is lesser than all other materials screwshafts for structural analysis.The Maximum shear stress is also reduced in EN8 screwshaft as compared to existing mild steel screwshaft,.
.EN8 screwshaft can be a better alternative for existing material shaft.
2 By studying above results we come to know that, we are getting better results of heat flow through the En19 and En8 material as compared to other materials, but among the En19 and En8 material, En8 material is more economical and has properties and result suitable for the application, therefore we can suggest En8 material to be the best material for Screwshaft.

CONCLUSION

After studying exiting screwshaft of the oil expellers at Oil industries.The main reason for the failure diagnosis is non use of the process of cooking, heavy choking of material between the screwshaft and crushing chamber due to presence of foreign particles, wrong assembly or fitting of screwshaft, and misalignment, apart from these the most important reason is the being old machines they use of the ordinary mild steel material for Screw Shaft which is having low strength and hardness. As it is not possible to change the diameter of shaft as there is very little tapper clearance between worm threads outer diameter and crushing chamber inner diameter, so selection of the material of good mechanical and thermal properties such as high tensile strength, hardness, thermal conductivity, specific heat, density etc; to with stand the forces, shear stresses and thermal stresses is desirable, due to these static structural analysis and thermal analysis of the Screwshaft considering materials as En8, En19, En24 is done. From the comparison structural analysis and thermal analysis result obtained it is concluded that En8 material is highly recommended as ;

i) From the static Structural analysis it is observed that En8 material has lesser deformation of 0.000435 m and also has least stress value of 3.897 $x\ 10^8$ N/m^2 as compared to other materials result.

ii)From the Thermal analysis it is observed that En8 material is getting better results of heat flow through the En8 screwshaft having Heat Flux value of 4704.27 W/mm^2 max and direction heat flow of 567.27 max,which result in reduction in the thermal stress generated and reduction temperature concentration on one spot as compared to other materials.

iii) The En8 is having lowest cost among En8, En19 and En24 and also is easily available.

iv) The En8 is having much better mechanical and thermals properties as compared to the existing screwshaft material.

So, replacing the present mild Steel material with the En8 will reduce the chances failure of Screw Shaft, reducing the running cost and increase the productivity of Oil Expellers at oil Industries.

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