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Design, Modification and Analysis of Shaft of Concrete Mixer Machine

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Abstract-In this project Design, Modification and Analysis of shaft of concrete mixer machine has done. Shaft is an important equipment of concrete mixer machine use for concrete mixture preparation and for support a revolving drum. The main objective of this analysis is to optimize the design of concrete mixer machine. The existing shaft of concrete mixer machine gets failed after approximately 150 Hr of uses.

To analyse this shaft using FEM, firstly a proper CAD model is developed using Pro/E cad software. Then by using ANSYs software FEM analysis is done to determine the different types of stresses and deflection developed. After carried out the analysis it has been found out that the existing design of shaft of concrete mixer machine is not proper and therefor I had suggested to change the material of the shaft for efficient working and to withstand the different static and dynamic load.

Key words: shaft design, computer aided design, mixer.

I. INTRODUCTION

A concrete mixer machine is also commonly called a cement mixer, is a device that homogeneously combines cement, aggregate such as sand or gravel, and water to form concrete.

Different styles of stationary mixers have been developed each with its own inherent strengths targeting different parts of the concrete production market. A typical concrete mixer uses a revolving drum to mix the components. Today's market increasingly requires consistent homogeneity and short mixing times for the industrial production of ready-mix concrete, and more so for precast concrete. This has resulted in refinement of mixing technologies for concrete production.

To supply continuously the ready mix its necessary that the concrete mixer should be in good condition of working, but it has been observed that the shaft of mixer get failed after some uses of time.

To determine a reasonable structure and technical parameter of continuous mixers is an urgent task. So in this project I am trying to identify the different causes of shaft failure.

It was found that spun pipe manufacturing industry or industry related to manufacturing of cement or concrete product only concentrated on the geometrical properties of reinforced concrete. The geometric property of reinforced concrete is depends upon the proper ratio of input materials and also proper functioning of mixer machine.

It is observed that the shaft of mixer machine bends or it get fractured due to overloading of input mixer. This results into low quality of concrete mixture.

Mixing is a complicated process that is affected by the type of mixer, the mixing cycle as defined by the duration, the loading method, and the energy of mixing.

For most machine shafts, however, analysis should be relatively straightforward. That's because the failure typically provides strong clues to the type and magnitude of forces on the shaft and the direction they acted in, the failed parts will tell exactly what happened.

In this project FEM analyse of concrete mixer shaft has done. Shaft is an important equipment use for concrete mixture preparation. It has been observed that the existing concrete mixer shaft of Wainganga spun pipe industry get failed at after some uses of time. So it is very tedious job for the workers to work with bend or braked shaft it may dangerous to worker and complicated to overcome the failures. Also it consumes lot of time and loss of productivity.

II. DESIGN AND SPECIFICATION

Mixer has following main components:

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A. Shaft
B. Drum
C. Chassis
D. Blade
E. Gear
F. Pulley, Belt and Motor

As there is the problem with the shaft of concrete mixer shaft. Therefor only the designing of existing shaft is check.

III. SPECIFICATION OF SHAFT

A. Material of shaft: Mild steel 1030
B. Length of shaft: 630mm
C. Pedestal dia: 72mm
D. Dia of shaft: 44mm
E. Outer dia of thread: 37mm
F. Inner dia of thread: 33mm
G. Chamfer length: 155mm
H. Bottom grease hole dia: 20mm
I. Grease hole length: 360mm

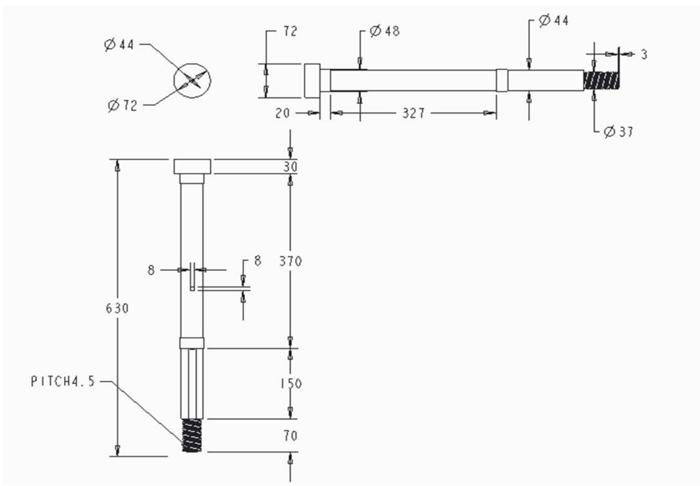

Fig:1 shaft specification

IV. SPECIFICATION FOR ASSEMBLY DRAWING

Thickness of drum=3mm
Upper rod thickness=16mm
Upper dia of drum=500mm
Middle dia=900mm
Bottom dia=600mm
Overall height=1000mmInner distance =970mm
Outer distance =1150mm
Width=100mm
Electric motor 3HP
Rpm of hopper or drum=25
Pulley dia=555mm

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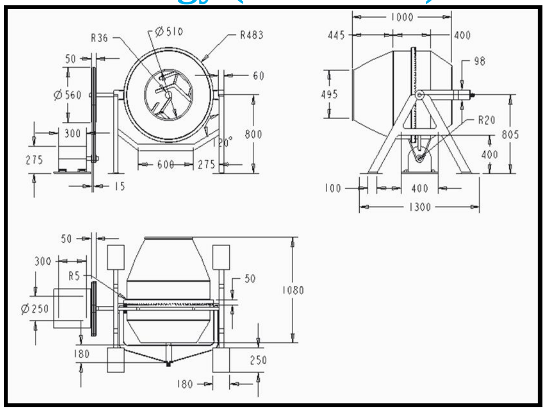

Fig2: assembly drawing

V. FORCE CALCULATION

To calculate the different type of forces acting on shaft of concrete mixer machine, I had developed free body diagram of concrete mixer machine.

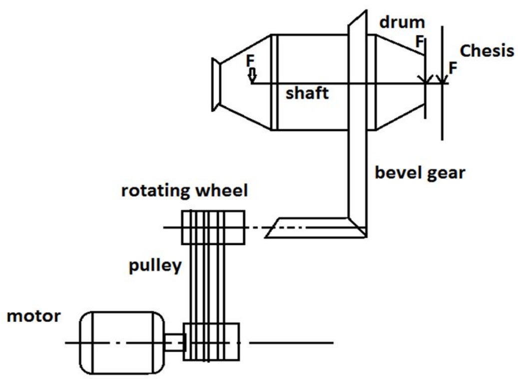

Figure:3 F.B.D. of concrete mixer machine

A. Calculation of Force of Impact

As the mixture impacts on front end of shaft, thus I calculated the impact force acted on shaft due to the mixture. But it is observed that only 30% of total mixture is impacted on front end of shaft with reference to company owner and information available on websites. Thus, calculating impact force for 30% of mixture.

Mixture proportions:
Cement – 140kg
Sand – 80kg
Water – 30kg
Aggregates – 50kg
Thus, Total mixture mass is 300kg
Thus calculating impact force for 90 kg of mass that is for 90*9.81= 882.9N

$(W/Y_{max}) = 384EI/5L^3$

$(W/Y_{max}) = K$

$I = \prod/64*44^4$

$= 183.58*10^3$

$= 384*204*10^3*183.93*10^3/5*620^3$

$= 12.09*10^3$ N/mm

Impact force = $(2*K*W*H)^{1/2}$

$= (2*12.09*10^3*882.9*300)^{1/2}$

= 80.03 KN

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B. For UDL Weight Calculation

On shaft of concrete mixer different types of loads are acting

1) Because of drum self-weight
2) Because of mixture weight

a) Drum self-weight

F1= m*g
=30*9.81
=294.3 N

b) Mixture weight

F2 = m*g
=300*9.81
=2943 N

c) Drum mean dia.

= 500+900+600/3
= 666.67 mm

d) UDL weight =F1+F2/Mean dia of drum

= 294.3+2943/ 666.67
= 4.86 N/mm

*e) Rate of UDL acted on circumference of shaft per mm = shaft dia. * UDL weight*

=44*4.86
= 0.241 KN/mm

VI. TORQUE ON SHAFT EXERTED BY ELECTRIC MOTOR

T=60P/2∏N
=60*2238/2 ∏*25
=854.85 N-m
=$854.85*10^3$ N-mm

A. Stresses in shaft

1) Shear stress due to transmission of torque

Ʈ=16*T/ ∏d^3
=16*854.85*10^3/ ∏*44^3
=51.109 N/mm^2

B. For bending stress calculation

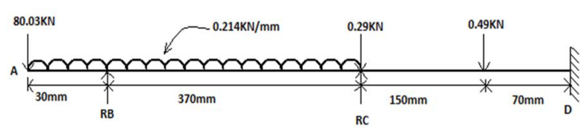

Figure 4: load diagram of shaf

C. By slope deflection method

1) Fixed end moment

Span BC

M'BC= -WL^2/12
= -0.214*370^2/12

$= -2.44*10^3$ KN/mm

$M'CB= WL^2/12$

$=0.214*370^2/12$

$=2.44*10^3$ KN/mm

Span CD

$M'CD= -Wab^2/l^2$

$= -(0.49*150*70^2/220^2)$

$= -7.44$ KN-mm

$M'DC= Wa^2b/l^2$

$= (0.49*150^2*70/220^2)$

$= 15.94$ KN-mm

2) *Slope deflection equations*

a) $MBC= 2EI/L\ (2\theta B+ \theta C)+M'BC$

$=2EI/370\ (2\theta B+\Theta c)\ -2.44*10^3$ ……………..1

b) $MCB= 2EI/L\ (\Theta b+ 2\theta c)+M'CB$

$= 2EI/370\ (\Theta b+ 2\theta c) + 2.44*10^3$ 2

c) $MCD= 2EI/L\ (2\theta C+\theta D)+M'CD$………($\Theta d=0$)

$=2EI/220\ (2\theta C)\ -7.44$ ………………3

d) $MDC= 2EI/L\ (\theta C)+M'DC$

$= 2EI/220\ (\theta C)+15.94$ ……………..4

3) *Equilibrium equation*

At 'B'

$MBA= -Wl^2/2-Wl$

$= -0.214*30^2/2 – 80.03*30$

$= -2.497*10^3$ KN-mm

$MBA+MBC=0$

$-2.497*10^3+2EI/370\ (2\theta B+\theta C)-2.44*10^3=0$

$4EI\theta B/370+2EI\theta C/370=4.94*10^3$……………(A)

At 'C'

$MCB+MCD=0$

$2EI/370\ (\theta B+2\theta C)+2.44*10^3+2EI/220(2\theta C)\ -7.44=0$

$2EI\theta B/370+4EI\theta C/370+4EI\theta C/220 = -2.43*10^3$

$2EI\theta B/370+2360/81400\ EI\theta C = -2.43*10^3$………………………………………(B)

By solving equation (A) and (B)

We get,

$\theta B = 550141.59/EI$ rad

$\theta C= -186383.18/EI$ rad

4) *Final fixed end moments*

$MBA = -2.497*10^3$ KN-mm

$MBC = 2.5*10^3$ KN-mm

$MCB= 3.398*10^3$ KN-mm

$MCD= -3.396*10^3$ KN-mm

$MDC = -1.678*10^3$ KN-mm

MAXIMUM MOMENT= $3.398*10^3$ KN-mm

5) *Reactions on shaft*

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Span ABC:

$\in McF=0$

$-80.03*400-0.24*400^2/2*+RB*370-2.5*10^3+3.39*10^3=0$

RB= 130.38KN

Span CD:

$\in McF=0$

$3.39*10^3+0.49*150+1.678*10^3-RD*220=0$

RD= 23.73KN

$\in Fy=0$

RB+RC+RD= 80.03+0.214*400+0.29+0.49

130.38 +RC+23.37 = 166.41

RC= 12.66 KN

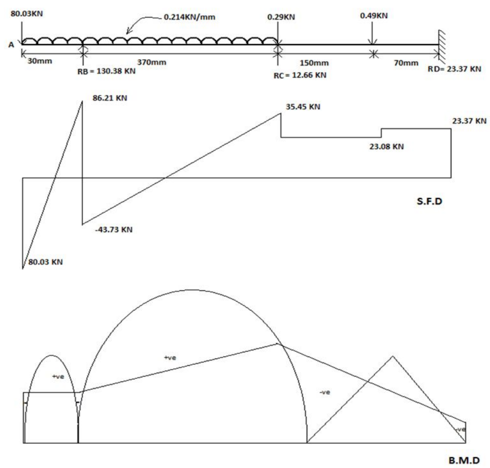

Figure 5: S.F.D. and B.M.D.

D. Shaft subjected to bending moment

$M/I= \sigma b/Y$

Where;

M = Bending moment

I = Moment of inertia & cross-section area of shaft

ó = Bending stress

Y = Distance from neutral axis to outer most shaft

$I=\prod/64*d^4$

$Y=d/2$

$M=3.398*10^3$ KN-mm

$I=\prod/64*44^4$

$=183.58*10^3$

Y=22

$\underline{\sigma b= 406.33\ N/mm^2}$

E. Maximum shear stress

$Ʈ\ max= 16/\pi d^3*(M^2+Td^2)½$

$= 16/\pi 44^3*((3.398*10^{\wedge}6)^2+(854.85*10^3)^2)½$

$Ʈ\ max = 209.49\ N/mm^2$

Ʈ allowable= yield strength of material/ safety factor

= 296/2

= 148 N/mm²

Ʈ allowable (148MPa) <Ʈmax (209.49 MPa) Hence, shaft get failed.

F. Von mises stress (according to distortion energy theory)

$\sigma eq = (\sigma b^2+3\tau^2)^{1/2}$

$= (406.33^2+3*51.109^2)^{1/2}$

$= 894.05 N/mm^2$

σeq allowable= ultimate tensile strength/ safety factor

= 527/2

= 263.5 N/mm²

σeq allowable (263.5MPa) <σeq (894.05MPa.

Thus, shaft get failed.

VII. FATIGUE ANALYSIS OF SHAFT BY ANALYTICAL APPROACH

Fatigue analysis is carried out to found out the endurance strength of shaft and factor of safety of shaft.

We know,

Max bending moment and min bending moment are:

(Mb)max =3.398*10^6 N-mm

(Mb)min =2.5*10^6 N-mm

To find mean and alternating stress;

(Mb) mean =1/2 (Mb)max+(Mb)min

=1/2 3.398*10^6+2.5*10^6

=2.95*10^6 N-mm

(Mb)alt = 1/2 (Mb)max-(Mb)min

= 1/2 3.398*10^6-2.5*10^6

= 0.45*10^6 N-mm

Thus, mean and alternating bending stress are:

$(\sigma x)mean=32(Mb)m/\pi d^3$

$=32*2.95*10^6/\pi(44)^3$

$=352.75 N/mm^2$

$(\sigma x)alt =32(Mb)a/\pi d^3$

$=32*0.45*10^6/\pi(44)^3$

$= 53.81 N/mm^2$

We have, Max torque:

Tmax= 854.85*10³ N-mm

For Tmin I measured a current required to rotatea empty mixer :

Power = current * voltage *cosØ

= 5amp*440v*0.8

= 1760w

Tmin = 672.27*10³ N-mm

Thus, mean and alternating torque are:

Tmean = ½*(Tmax+Tmin)

= 763.56*10³ N-mm

Talt = ½*(Tmax-Tmin)

= 91.29 N-mm

Thus, mean and alternating shear stress are:

Ʈ mean= 16*Tm/ ∏d³

= 16*763.56*10³/ ∏*44³

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$= 45.62\ N/mm^2$

$\tau alt = 16*Ta/\prod d^3$

$= 16*91.29*10^3/\prod*44^3$

$= 5.45\ N/mm^2$

A. Fatigue stress concentration factor for bending

Kf = (K-1)*q+1

= (2.28-1)*0.22+1

= 1.282

B. Fatigue stress concentration factor for torsion

Kfs= (Ks-1)*q+1

= (1.82-1)*0.22+1

= 1.180

Where,

K= stress concentration factor for bending

Ks=stress concentration factor for torsion

q =Notch sensitivity factor

For D/d=1.6 & r/d= 0.045

C. Thus, equivalent or von mises stresses calculation

$\sigma m = ((\sigma xm * kf)^2+3(\tau m * kfs)^2)^{1/2}$

$= ((352.75*1.282)^2+3*(45.65*1.180)^2)^{1/2}$

$= 461.75\ N/mm^2$

$\sigma a = ((\sigma xa * kf)^2+3(\tau a * kfs)^2)^{1/2}$

$= ((53.81*1.282)^2+3*(5.45*1.180)^2)^{1/2}$

$= 69.88\ N/mm^2$

Stress at mean condition is max thus, consider

$\sigma m=\sigma eqi= 461.75\ N/mm^2$

Tanθ= $\sigma a/\sigma m$ & also Tanθ= Sa/Sm

= 0.80 ………………………………..……(A)

D. Endurance strength

To find endurance strength 'Se'

Se= A*K size*K surface finish*K temp*K reliability*se'/kf

But se'= 0.5 *sut

= 0.5*527

$= 263.5\ N/mm^2$

A=1 (for bending)

A=load factor

Ksize= 1-(d-12.5/75-12.5*1-Kz')-------(Kz'=0.84 for M.S.)

= 0.92

Ksurf = 0.92 (for ground finish)

Kreli = 90% = 0.897

Assume Ktemp= 1

Kf = 1.282

<u>Se= 127.22 N/mm²</u>

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E. Goodman's equation

Sa/Se + Sm/Syt=1

0.8*Sm/127.22 + Sm/ 296=1

By solving we get,

Sm=103.45N/mm²

Sa=82.76 N/mm²

Where;

Sa = amp. Normal stress

Sm = mean normal sress

Syt = yield tensile strength

F.O.S= Sa/σa

= 82.76/69.88

= 1.18

VIII. FINITE ELEMENT METHOD

Finite Element Method is the micro mechanical analysis which is now days used as a powerful and an efficient tool for understanding the stress strain behavior of the structure. The basic idea in the Finite Element Method is to find the solution of complicated problem replacing it by the number of smaller regions. Thus, the solution of each region is considered as built up of many small interconnected sub regions called Finite Elements.

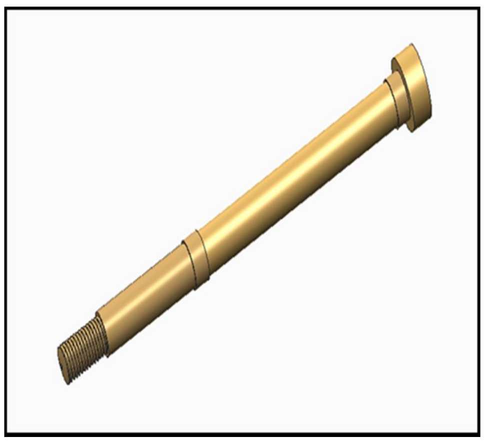

Figure6.3D model of shaft

A. Moment applied on the shaft

Figure shows the moment which is applied on the shaft.

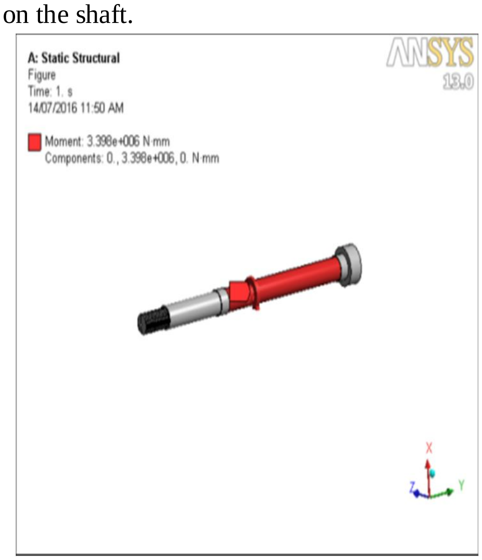

Fig:7. Moment applied on shaft

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B. Force applied on the shaft

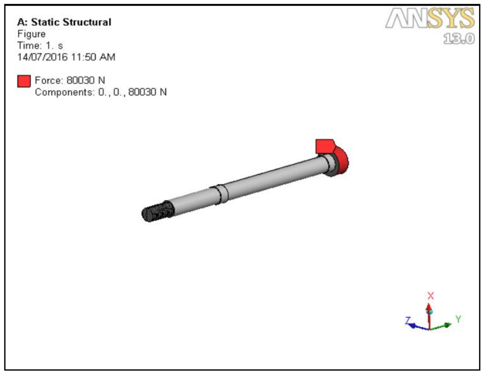

Fig:8. Force applied on the shaft

C. Equivalent stress results

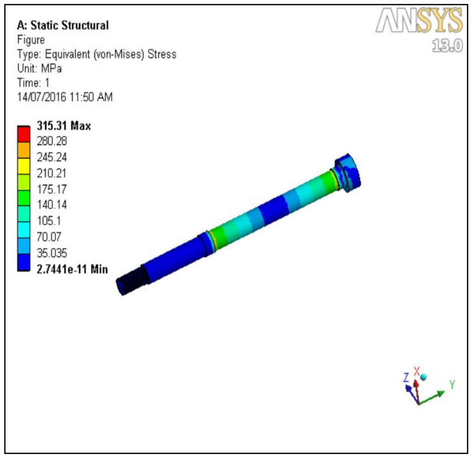

Figure 9 Equivalent stress

Equivalent stress of shaft is 315.31MPa which is greater than allowable stress of 263.5 MPa.

D. Maximum shear stress results

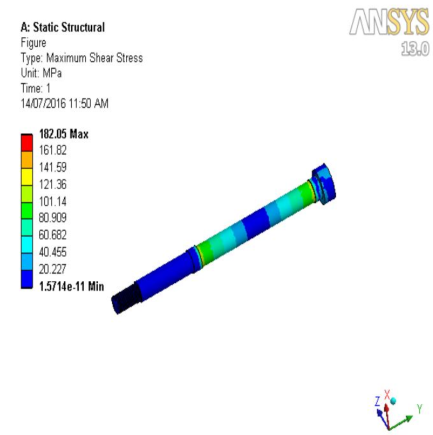

Figure 10 Maximum shear stress

Max. shear stress of shaft is 182.5 MPa which is greater than allowable stress of 148 MPa

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E. Life cycle results

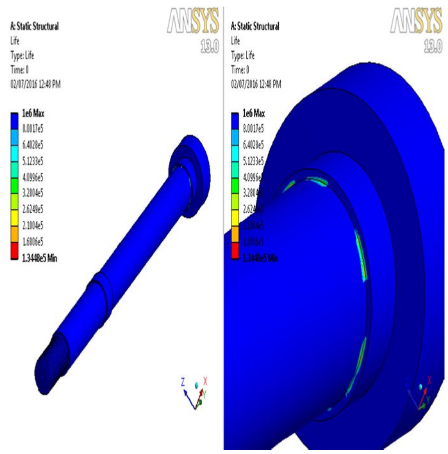

Figure 11life cycle of shaft

F. Safety factor results

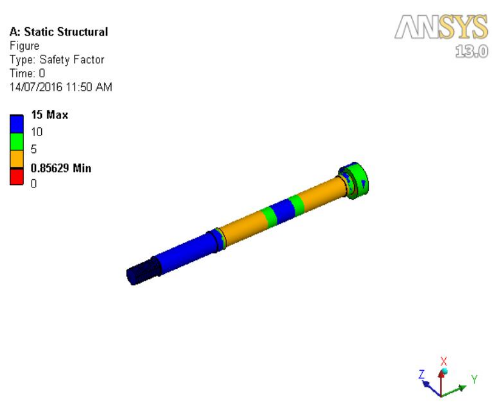

Figure 12.Safety cycle

Safety factor of shaft is 0.856 which is less than 1. Thus, design is failure.
SOLUTION 1:

Table 1 Comparison of Allowable stresses and Ansys result:

STRESSES	ANSYS RESULTS	ALLOWABLE STRESSES
Equivalent stress	315.31 MPa	263.5 MPa
Max. shear stress	182.05 MPa	148 MPa
	F.O.S=0.856	F.O.S>= 1

1) It has been observed from above table 22 which is obtained by FEM analysis of shaft of concrete mixer machine that maximum shear stress and equivalent stress both are greater than allowable shear and equivalent stresses of existing shaft material
2) Thus, failure occurs in the shaft of concrete mixer machine.
3) Thus, its need to change the parameter of shaft it may be either dimensions or by changing the material of shaft.
4) Due to the design limitations set by manufacturer of concrete mixer machine, I made a modification of shaft by changing the material of shaft.

IX. MODIFIED DESIGN

Redesign of shaft by using different material:
•SAE 4140 (Chromium Molybdenum Steel)
•SAE 4140 alloy Steel is chromium, molybdenum alloy steel. It has high fatigue strength, abrasion and impact resistance, toughness

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and torsion strength etc. It is used extensively in most industry sectors for a wide range of application such as axle shaft, bolts, crankshaft and part lathe, spindle, motor shaft, nut, pinions, pump shaft, worm, etc.

•Ultimate Strength (Sut) = 815 MPa

•Yield Strength (Syt) = 680 MPa

A. *Equivalent stress*

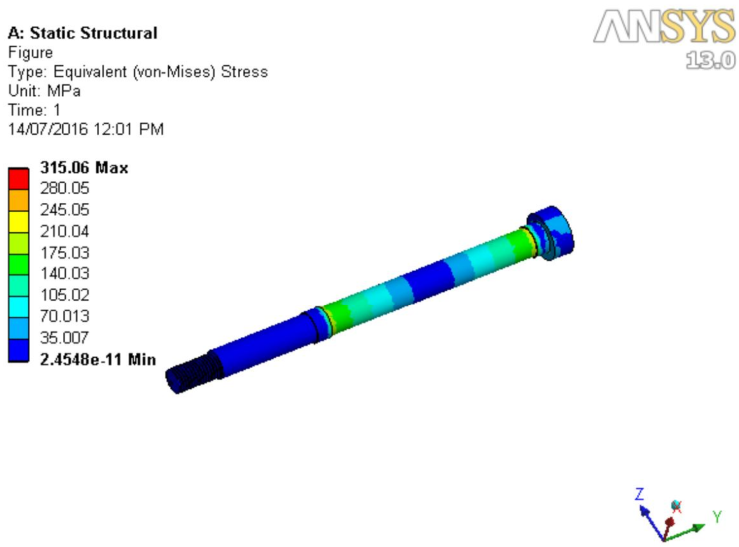


Figure: 11.Equivalent stress developed on modified shaft

Equivalent stress developed on shaft is 315.06 which is less than Allowable stress of material of modified shaft.

B. *Maximum Shear stress*

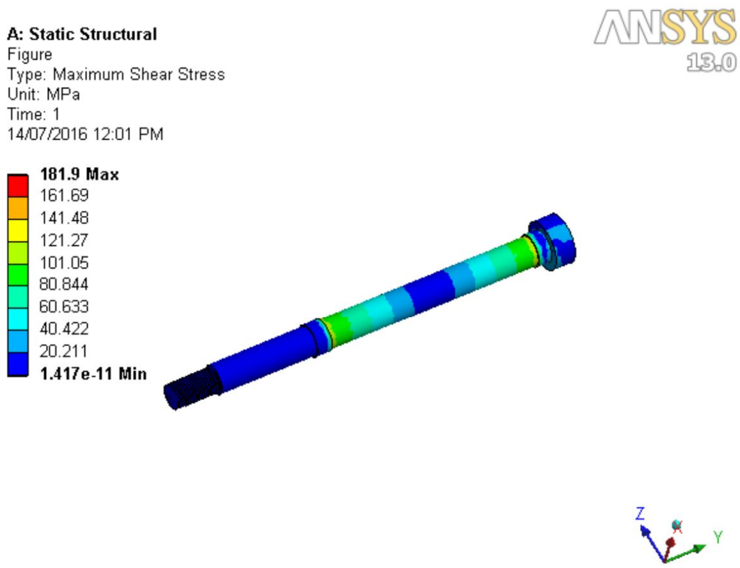


Figure: 12.Maximum Shear stress developed on modified shaft

Maximum shear stress developed on shaft 181.9 is less than Allowable shear stress of material of modified shaft.

C. Life cycle

Figure: 13.Life cycle of modified shaft

D. Safety Factor:

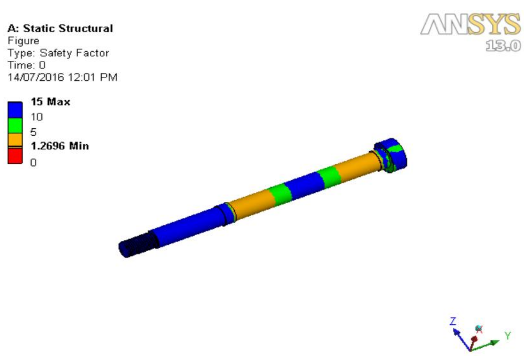


Figure: 14.Safety Factor of modified shaft

Safety factor of modified shaft is 1.2696 which is greater than 1. Hence it is conclude that modified shaft design is safe.

X. RESULT AND DISCCUSION

As decided in the objectives all the components of concrete mixer machine were modeled as per specified dimension by using Pro/E software and then assembled.

After that FEM analysis of shaft was carried out with the help of Ansys software and different stress and deformation were calculated. And following solution has been obtained

Table2 Comparison of Allowable stresses and Ansys result:

STRESSES	ANSYS RESULTS	ALLOWABLE STRESSES
Equivalent stress	315.31 MPa	263.5 MPa
Max. shear stress	182.05 MPa	148 MPa
	F.O.S=0.856	F.O.S>= 1

It has been observed from above table no. 25 which is obtained by analytical approach and FEM analysis of shaft of concrete mixer machine that maximum shear stress and equivalent stress both are greater than allowable shear and equivalent stresses of existing shaft material. Thus, failure occurs in the shaft of concrete mixer machine.

Therefore, shaft is redesigned by changing material of existing shaft.

After doing the FEM analysis on modified shaft I got the following results;

Table 3 Comparison of existing shaft and modified shaft and Result from Ansys:

SPECIFICATION	SAE 1030		SAE 4140	
Young's modulus MPa	204		206	
Poisons ratio	0.3		0.33	
Density kg/m^3	7800		7700	
RESULT FROM ANSYS				
	Result from ansys	Allowable stress	Result from ansys	Allowable stress
Max. shear stress MPa	182.05	148	181.9	340
Equivalent stress MPa	315.31	263.5	315.06	407.5
F.O.S	0.856	> 1	1.2696	> 1

Above Table No. 24 indicates that maximum shear stress developed on existing shaft is 182.05 MPa which is greater than a value of allowable shear stress of 148 MPa. Thus, shaft gets failed.

Therefore, shaft is redesigned by changing shaft material to SAE 4140. As Table No.24 indicates allowable shear stress of modified shaft is181.9 MPa which is less than a value of allowable shear stress of modified shaft of 340 MPa. Hence this design is safe.

XI. CONCLUSION

The structural static analysis of concrete mixer machine shaft is carried out to find out the different failure in the shaft due to different loading condition. By conducting FEM analysis of existing design of the shaft it has observed that maximum shear stress and equivalent stress induced in the shaft is exceeding the allowable shear stress and equivalent stress. Therefore, shaft gets failed. So it is necessary to redesigned shaft.

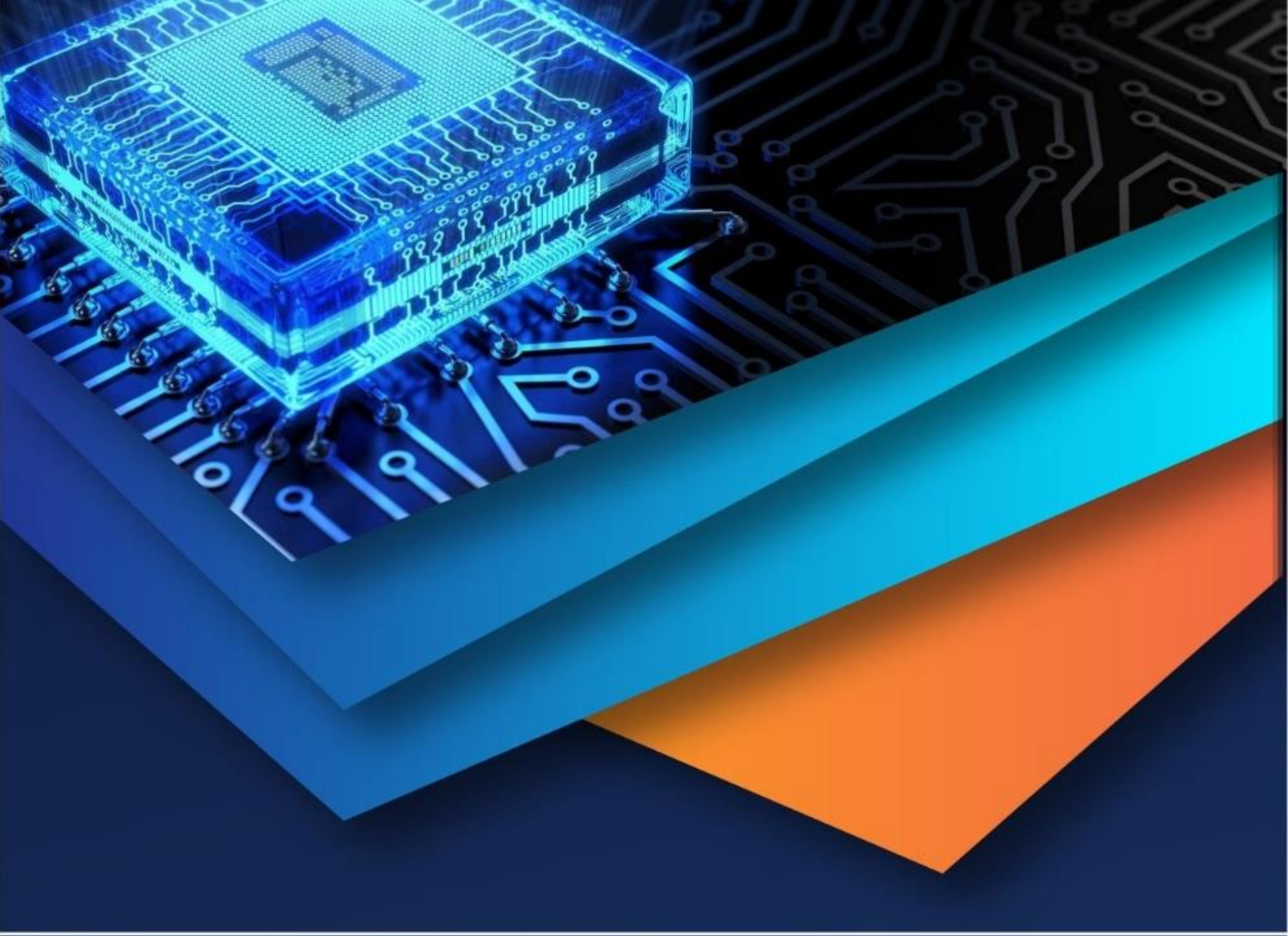
The property of shaft can be improved either by changing its dimension or by changing material. But due to machine space constant it is not possible to increase the diameter of shaft. Therefore, the shaft is redesigned by taking new material and after conducting again the FEM analysis of shaft with change material. The maximum shear stress and equivalent stress are within limits or less than allowable limits. Therefore, design is safe. Life cycle of shaft and safety factor is also calculated by analytical method and later it is validated by using Ansys software.

XII. FUTURE SCOPE

A. In this project design of shaft is analyzed by changing the material.
B. In future the design of shaft can be analyzed by changing its diameter.
C. Design of different components of the mixer can also be optimized.
D. In this project, shaft is only analyzed by using static condition, it is possible to analyze shaft by using dynamic condition as the load continuously varying inside the drum.

REFERENCES

[1] NsikanIdung, and Thompson Aguheva (2012), “Design and Fabrication of an Industrial Poultry Feed Tumble Mixer”, Leonardo Electronic Journal of Practices and Technologies. Vol 20, Issue 1, pp. 49-60, ISSN 1583-1078.
[2] SukhadipChougule and K. M. Narkar (2015), “Analysis of Double Shaft Paddle”, International Engineering Research Journal (IERJ). Vol 2, Issue 2, pp. 4415-4417, ISSN 2395-1621.
[3] HakkıGokhanElustun (2008), “Creation of mixture shaft and its stress analysis”.
[4] S.S Rattan, Strength of material, second edition, (Tata McGraw-Hill Publication, 2008).
[5] R.S. Khurmi, (2005): Strength of material, (Mechanics of solids), (S. Chand & company PVT. LTD).
[6] Dr. R. K. Bansal, Strength of material, sixth edition, Laxmi Publication, 2010.
[7] V.B. Bhandari, Design of Machine Element, (Tata McGraw-Hill Publication. New Delhi.2004).
[8] Budynas −Nisbet, Shigley’s Mechanical Engineering Design, (McGraw−Hill Publication, Eighth Edition, New Delhi, 2008).
[9] Shigley, J. E. and Mitchell, L.D., Mechanical Engineering Design, Fourth Edition, McGraw-Hill, New York, 1983
[10] R. S. Khurmi and J. K. Gupta, (2005): “A textbook of Machine Design”, Euroasia Publication House Pvt Ltd, 5th Edition, Delhi.
[11] B. D. Shiwalkar, Machine design data book, Denett& Co. Publication, 2011 Edition.
[12] Wainganga Spun Pipe Industry PVT. LTD. Sewagram.



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