Analysis of run out problem on agitator assembly of glass lined reactor

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Abstract

Glass lined reactors are most widely used static equipment in process industries. They are required to perform reliably and for long period of time. The glass lining inside the reactor and on the agitator prevents the process media from acidic/basic corrosion of the vessel. It is important to prevent any kind of leakage from the vessel because it is only used in hazardous service. Any leakage can cause damage to the surrounding, cause fire and cause severe damage to workers. There are many reasons for damage of glass lining inside the reactor like abrasive wear, improper handling of the vessel during transportation and erection or due to failure in agitator and bearing assembly. This paper focuses on analysis of agitator assembly.

Keywords: *agitator, ANSYS, CREO, shaft, bearing.*

INTRODUCTION

On rotating machinery, runout is defined as the degree to which a shaft or coupling deviates from true circular rotation. Every shaft or coupling has a center or rotation, or centerline. Any stray from concentricity is considered runout. Due to eccentricity of centroid of agitator, it will cause a run-out from the rotational axis. Due to run-out of shaft, it generates stresses in the components. If run-out of shaft occurs beyond acceptable limits it will cause failure of agitator, shaft or bearing. In this paper we have taken a case study of glass lined reactor of capacity 4000litres. In this reactor various components are designed. In this research paper we have focused on design of shaft, bearing and agitator. By analyzing design the probability of failure at particular dimension is proved. Here, the permissible value of run-out is given 0.08mm.So, in this paper we have done the analysis for the stresses generated in the shaft and bearing at 0.07mm, 0.08mm and 0.09mm run-out of shaft to check the given permissible value. We have done analysis and the safe value of the shaft run-out is discussed.

Reactors:

Reactors are manufactured generally as per DIN standard 28136 and in accordance with ASME code of unfired pressure vessels Section VIII Div.1

1. Agitators: It is one of the main components of a reactor used for mixing and blending of process media. It is also used for heat transfer or cooling of a process fluid. Agitation is a process of producing rotary motion inside a fluid in a restricted space mainly for the purpose of mixing, chemical reaction, etc.

1.2 Principle of Agitation: The agitation can be made by making a rotary motion of the liquid phase with different types of rotor (i.e. Agitator) within the tank depending on the method of agitation.

Mechanical agitator uses impeller that rotates during operation and induces motion to achieve better contact between reactive products.

1.3 Mounting of Agitator: Mounting at top portion of agitator, such reactor used for large application.

1.4 Drive System:

Electric motor is used to rotate the agitator using a gear box to reduce rpm. And the shaft of motor and agitator shaft is connected by means of rigid-muff coupling.

1.5 Sealing system:

Such system is used for preventing leakages of liquid, gases, vapour, etc. during the process. In this system shaft seals and stuffing boxes are used.

1.6 Working of Agitator:

The agitator is rotating in a vessel, which is coupled by means of rigid muff coupling with an electric motor through a gear box usually consisting of helical gears. These gears are used for reduction of speed of shaft in ratio of (16:1). In Glassed lined reactors it has vertical orientation. As given below figure 1. This assembly is held at top part of a closed vessel with bearing housing, which is supported inside a Lantern.

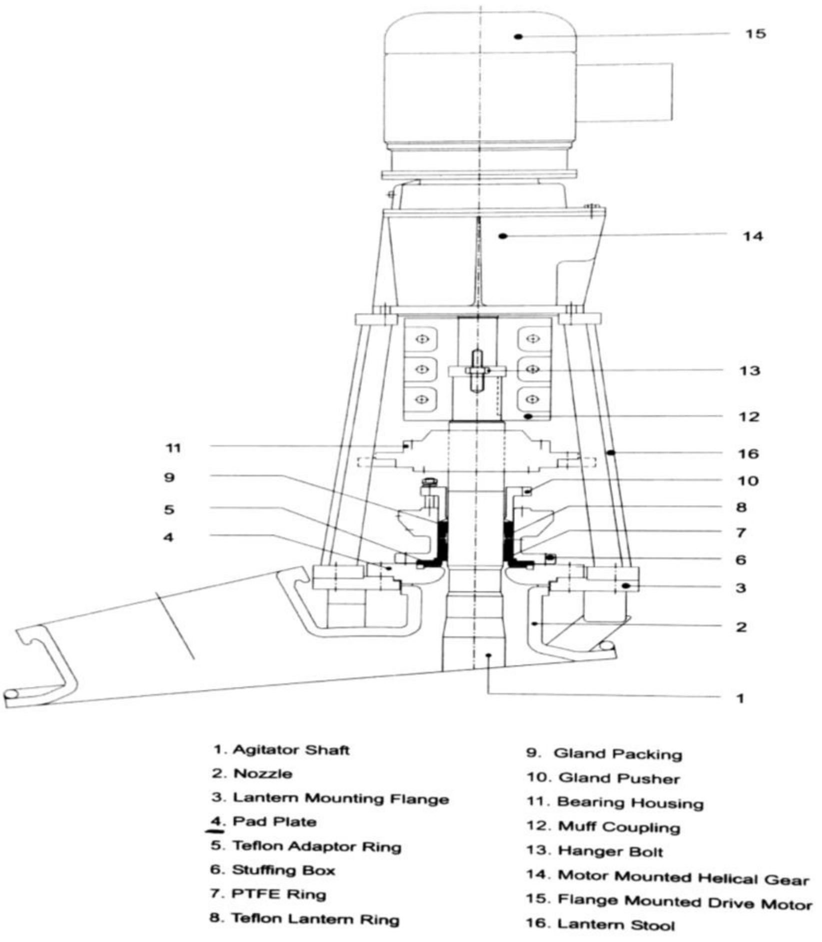


Fig 1: Agitator drive assembly

Fig 2: Lantern mounting

Above figure 2 shows, a structural element used for supporting electric motor, bearing housing, pad plat etc.

2. METHODOLOGY:

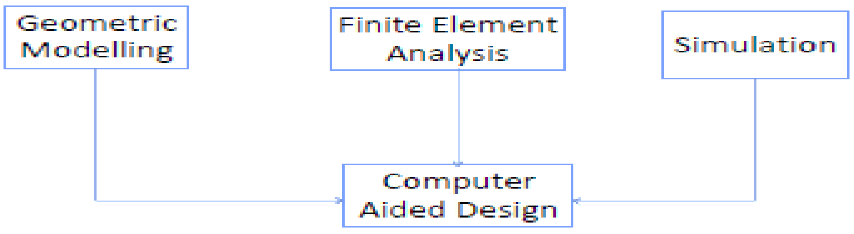


Fig 3: methodology

In this, initially geometric modelling is done for assembly of agitator. For modelling of assembly of agitator PTC CREO 4.0 is used. Then FEA is done in ANSYS R18.1.

3. BEARING FAILURE

Bearings are the most important mechanical components from the assembly of agitator having wide applications in many industries and have proven to be reliable and long-lived when properly applied. Component of bearing is bearing raceways and rolling element (i. e. ball). Higher temperature with higher rpm reduces bearing life. Ball and roller bearing failures are caused by interference of the lubricant supply to the bearing or inadequate delivery of the lubricating oil to the raceway contact.

3.1 Reasons for the failure of bearing:

- Contamination at surfaces
- Misalignment of shaft
- Corrosion
- Insufficient vibration
- Fatigue failure
- Overheating
- Excessive loads

4. SHAFT FAILURE:

Shaft is also important mechanical components in the assembly of agitator having most important application in many industries and has proven to be reliable and long lived when properly applied.

4.1Reasons for failure of shaft:

- Excessive run-out
- Misalignment
- Excessive torque
- Contamination

4.2Excessive run-out:

Excessive run-out of produces fatigue stresses in the components of assembly of agitator. Due to excessive fatigue stress there is greatly possibility of deformation of assembly components and resulting that, failure of whole assembly.

5. MODELLING OF SHAFT ASSEMBLY

A complete Agitator model is important to conduct the simulation for finding out effect of stresses and deformation at agitator shaft and double groove ball bearing in ANSYS® Workbench Academic, Release 18.1. Only Shaft and bearing assembly are used for Analysis. CAD Model for Agitator Assembly is made using PTC CREO PARAMETRIC 4.0 modelling software as per Given Dimension.

Components used in modelling are:

Shaft (i. e. Agitator)
Bearing housing (Bottom plat)
Bearing housing (Bearing house)
Bearing housing (Top cover)

Shaft (Agitator):

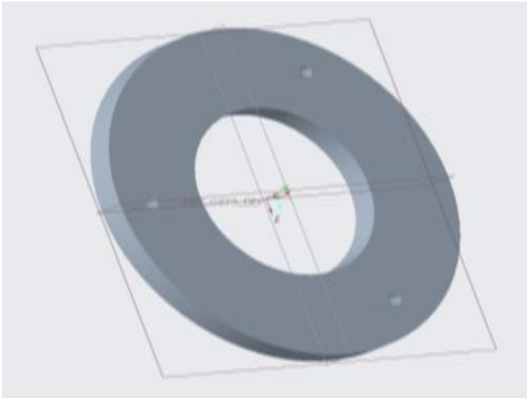


Fig 4: shaft used as an agitator

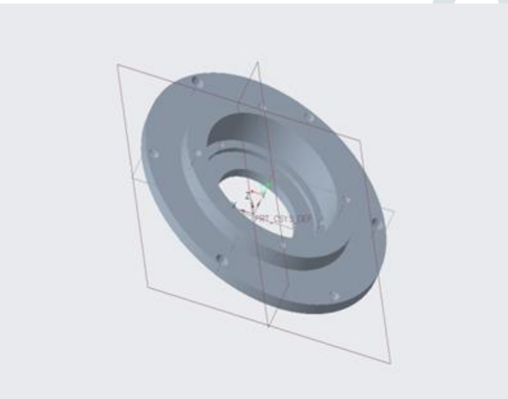
Fig 5: Bottom plate

Shaft is main component of assembly which is hanged on hanger bolt and connected with shaft of motor by means of rigid muff coupling. Material used for this shaft is SA 106 Gr.B.

5.1 Bearing housing (Bottom plat):

Bottom plat is a part of bearing housing, which is held at the bottom surface of bearing house by means of M8 bolt. Material used for this plat is IS 210 Gr.150.

5.2 Bearing housing (Bearing house):



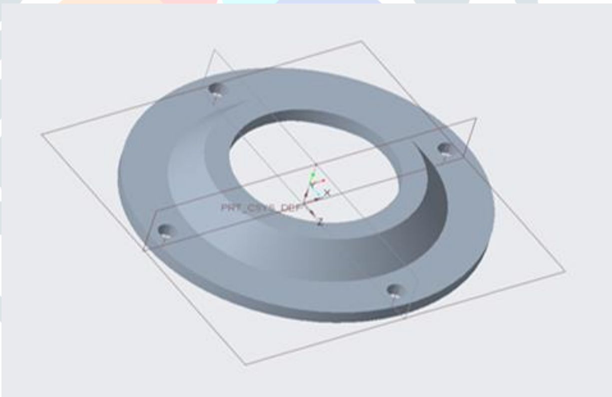


Fig 6: Bearing house

Fig 7: Top cover bearing housing

Bearing house is used as supporting element of bearing which is connected with the shaft. It is held at the middle plat of lantern housing by means of M16 bolt. Material used for this bearing house is IS-210 Gr.150.

Bearing housing (Top cover): This top cover used for covering bearing form top portion and it is held at the top surface of bearing house by means of M12 bolt. Top cover is made up of IS 210 Gr.150.

5.3 Assembly of Agitator

Fig 8: Assembly of agitator shaft

Fig 9: Assembly of agitator shaft with bearing

In above Figs. 4, 5, 6 and 7 the basic model of components of reactor are made in PTC CREO PARAMETRIC 4.0

Fig 10: Assembly of agitator shaft and bearing housing

In Fig 9 and 10 the bearing plate and bearing housing is connected with shaft and assembly model is prepared in CREO PARAMETRIC 4.0.

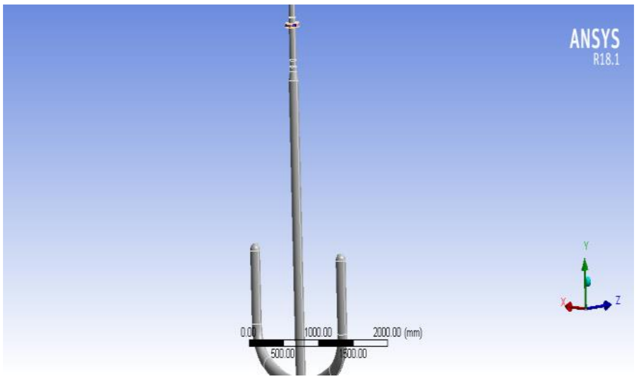


Fig 11: Meshing of model

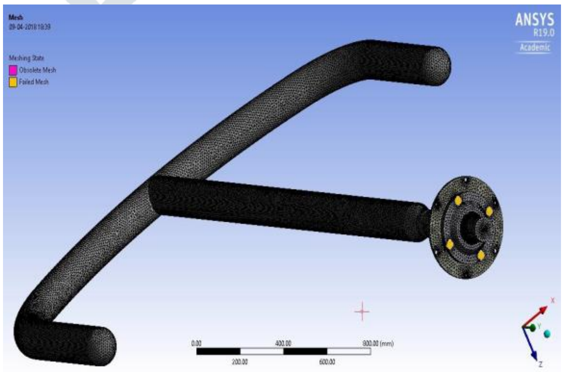


Fig 12: Meshing of model

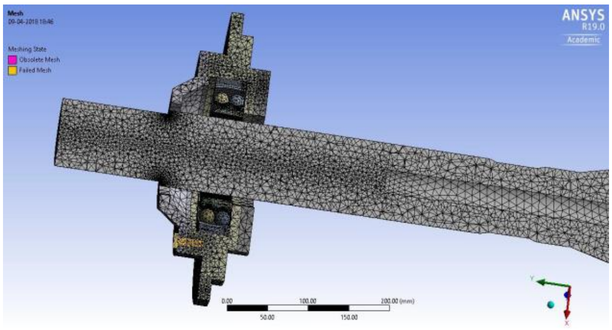


Fig 13: Meshing of model

Above Fig 11, 12 and 13 shows meshing of shaft and bearing as per mesh conditions given in table 1. Elements are taken 15021 and nodes are 31010 to prepare this meshing model.

Table 1: Material property

Mesh Condition	
Span Angle Center Coarse	**Coarse**
Minimum Edge Length	8.7054e-002 mm
Nodes	31010
Elements	15021

In Table 1 various mesh conditions are given.

5.4 Material Property:

Shaft material properties are given in Table 2 and for bearing material properties is given in Table 3.

Table 2 Material property (Shaft)

ASTM/ASME A 106 GRADE B (Shaft material)	
Density	7.85e-006 kg mm^3
Specific Heat	4.34e+005 mJ kg^{-1} C^{-1}
Strength of material	138 MPa
Allowable Strength	47.59 MPa
Factor of Safety	2.8

Table 3 Material property (Bearing)

Chrome Steel (Bearing material)	
Density	7.81e-006 kg mm^3
Specific Heat	4.34e+005 mJ kg^{-1} C^{-1}
Strength of material	2033 MPa
Allowable Strength	677.67 MPa
Factor of Safety	3

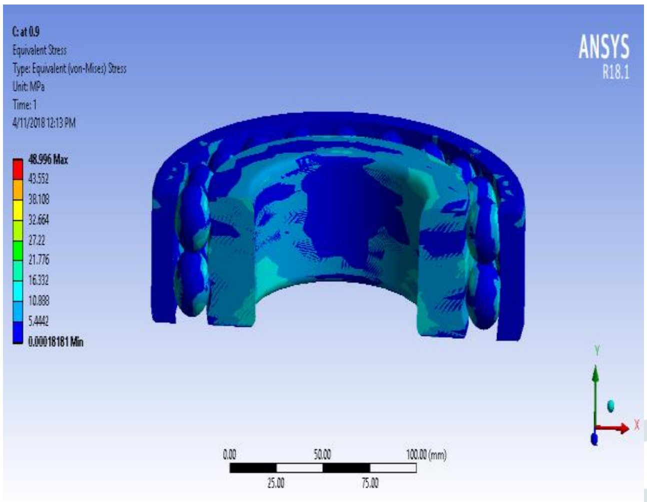
6. FEA OF AGITATOR ASSEMBLY

6.1 Finite Element Analysis of agitator shaft assembly:

The FEA was performed using ANSYS R18.1 version. The model used for analysis is showed in figure 9. The objective of this analysis was to find out at which run-out value the forces acting on agitator exceed the allowable strength. Finite element analysis was performed on 0.07 mm, 0.08mm & 0.09 mm shaft run-out.

6.2 Analysis of shaft:

6.2.1 Analysis of run-out at 0.09mm



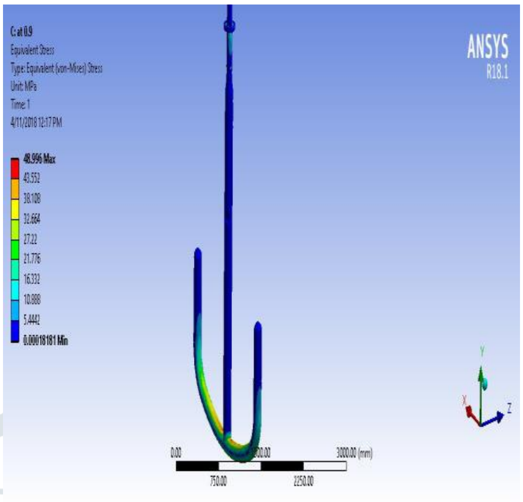


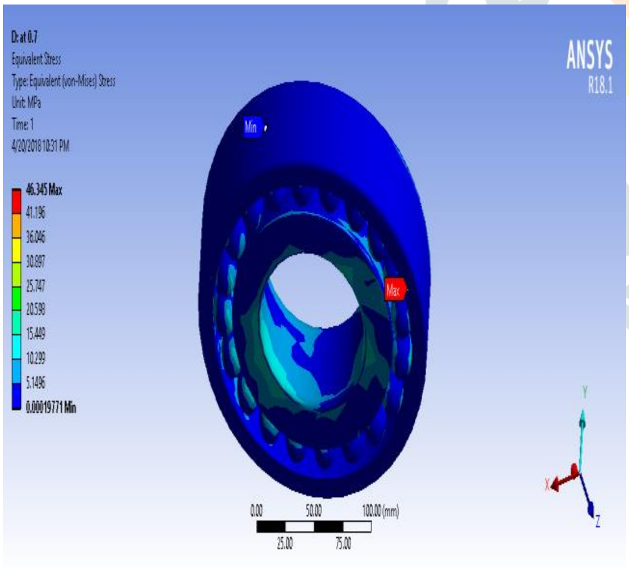
Fig 14: FEA on Bearing (Bearing section) for stress @0.09mm run-out

Fig 15: FEA on shaft for stress @0.09mm run-out

In Fig 14 and 15 analysis of shaft is done and as per figure 16, deflection occurs at the end of shaft is max. (i.e. 3.9466mm)

6.2.2 Analysis of run-out at 0.08 mm

In figure 17 and 18 FEA analysis of bearing and shaft is done at run out value 0.08mm. In figure 19, it is seen that, maximum deflection occurs at the end of agitator which is 3.8796mm



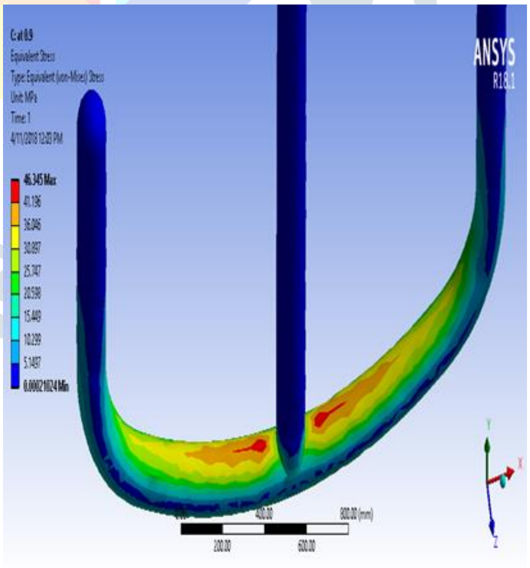
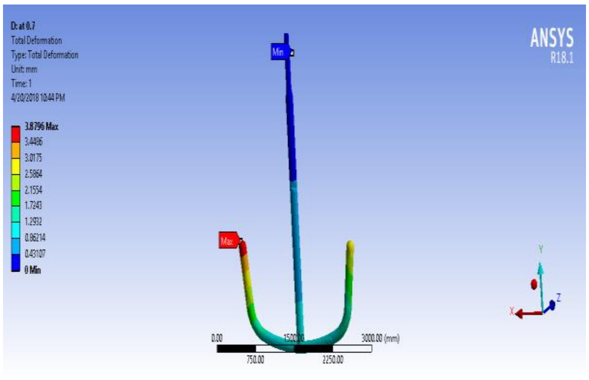


Fig 17: FEA on bearing for stress @0.08mm run-out

Fig18: FEA on shaft for stress @0.08mm run-out



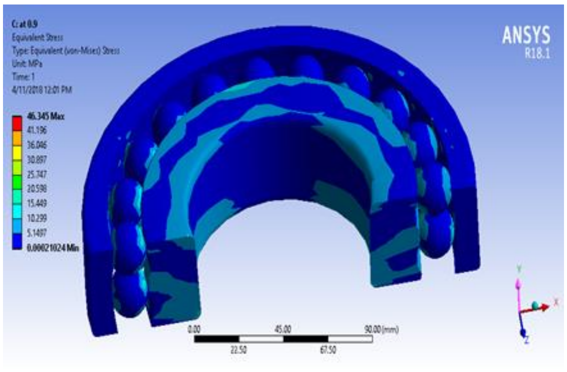


Fig19: FEA on shaft for deflection @0.08mm run-out

Fig 20: FEA on bearing (Bearing section) for stress @0.07mm run-out

6.2.3 Analysis of run-out at 0.07mm

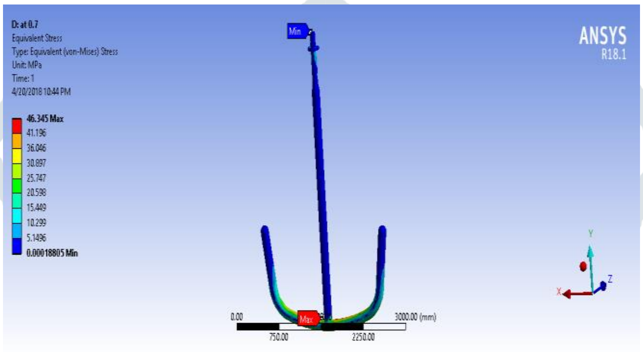


Fig 21: FEA on shaft for stress @0.07mm run-out

As per above figures 20 & 21, stress produce on bearing is 20.598MPa and same for shaft is 46.345MPa. From the above figure 22, it seen that, deflection occurs at the end of shaft is 3.8135mm.

Comparison between all three analysis:

Table 5: Comparison of shaft run-out

Stress	**0.09mm**	**0.08mm**	**0.07mm**
Stress on Bearing (MPa)	21.776	20.598	20.598
Stress on Shaft (MPa)	48.996	46.345	46.345
Deflection at end of shaft (mm)	3.9466	3.8796	3.8135

CONCLUSION

In present work, a successful attempt has been made by developing a simulation model to solve the problem of failure in reactor simultaneously using ANSYS code, which in turn used to understand the stresses formation phenomenon clearly. The initial simulation has been performed by using traditional data and a reasonable match has been found. Moreover, through developed simulation the process insights have been explored by identifying the stress distribution at the end of agitator. The observation says that the deflection was higher at the runout value 0.09mm and stress generations. The maximum deflection was recorded at the end of agitator end in case of run out value 0.09mm. The stress distribution pattern shows that it starts reducing during lower values.

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