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Random Vibration Analysis of Ammonium Carbonate Pump Used In a Petrochemical Plant

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Abstract

FACT diversified into petrochemicals in 1990 with the production of Caprolactum. In mechanical or petrochemical industries have prime importance to vibration testing. Sine vibration testing is performed when we have been given with only one frequency at given time instant. Trend to perform random vibration testing has been increased in recent times. As random vibration takes into account all excited frequencies in defined spectrum at known interval of time, it gives real-time data of vibration severities. The vibration severity is expressed in terms of Power Spectral Density (PSD). The consideration in the paper is based on the fact that we will be dealing with only random vibration. The aim of paper is to perform random vibration analysis for pump motor shaft and also find its maximum vibration possible area.

Keywords: *finite element analysis, natural frequency, random vibration, vibration analysis.*

1. Introduction

The vibration is defined as cyclic or oscillating motion of a machine or machine component from its position of rest. When a machine fails or breaks down, the unscheduled downtime may cost tens of thousands of money per hour. Fortunately, modern vibration analysis equipment and software predict developing problems so that repair happens before disaster strikes. For this reason, the early detection, identification and correction of machinery problems are needed for safe and productive operation. The use of machinery vibration and the technological advances that have been developed over the years, that make it possible to not only detect when a machine is developing a problem, but to identify the specific nature of the problem for scheduled correction.

In the past, vibration analysis required dialing an instrument to measure the peaks and the operator then compared the peak frequencies with the operating speed and consulted a chart for likely causes. The latest generation of Fast Fourier Transform vibration analyzers has more capabilities and automated functions than their predecessors had.

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal–structural and thermo-electric analysis.

2. Design of Drive System

2.1 Design of motor shaft mount Bearing

For the smooth rotation of shaft with respect to the motor casing and to carry load of rotor as well as self-weight, we require a bearing at each end of motor casing. Both the two bearing at each side are same and using SKF6306 because of to restrict the motion of shaft and used as fixed bearings. The calculations were done following the books Machine Design and design Data. The specifications are given in the table 1. The 3D model was created in Solidworks 2016 and rendered in Keyshot 6.64.

Table 1: Specification of Ball Bearing

Type of bearing	SKF6306
Inside diameter	30 mm
Outside diameter	72 mm
Width of bearing	19 mm
Ball diameter	12.3 mm
Dynamic capacity	2200 kgf
Maximum permissible speed	10000 rpm

Fig 1: Ball Bearing Rendered 3D Sketch

2.2 Design of pump shaft mount Bearing-1

For the smooth rotation of shaft with respect to the pump casing and to carry load of impeller as well as self-weight, we require a bearing at each end of pump casing. The SKF7306BG is used at the coupling end to take load along radial direction. Angular Contact Bearings takes radial load along one direction only thus we are using two bearings in opposite direction. The calculations were done following the books Machine Design and design Data. The specifications are given in the table 2. The 3D model was created in Solidworks 2016 and rendered in Keyshot 6.64.

Table 2: Specification of Ball Bearing

Type of bearing	SKF7306BG
Inside diameter	30 mm
Outside diameter	72 mm
Width of bearing	19 mm
Ball diameter	13.49 mm
Dynamic capacity	2450 kgf
Maximum permissible speed	8000 rpm

Fig 2: Ball Bearing Rendered 3D Sketch

2.3 Design of pump shaft mount Bearing-2

For the smooth rotation of shaft with respect to the pump casing and to carry load of impeller as well as self-weight, we require a bearing at each end of pump casing. The SKF NU207 bearing used at impeller side to take load along axial and radial direction. The calculations were done following the books Machine Design and design Data. The specifications are given in the table 3.

Table 3: Specification of Ball Bearing

Type of bearing	SKF NU207
Inside diameter	35 mm
Outside diameter	72 mm
Width of bearing	17 mm
Roller diameter	10 mm
Dynamic capacity	5600 kgf
Maximum permissible speed	11000 rpm

Fig 3: Ball Bearing Rendered 3D Sketch

2.4 Selection of Jaw Coupling

A jaw coupling is a type of general purpose power transmission coupling that also can be used in motion control applications. It is designed to transmit torque (by connecting two shafts) while damping system vibrations and accommodating misalignment, which protects other components from damage. Jaw couplings are composed of three parts: two metallic hubs and an elastomer insert called an element, but commonly referred to as a 'spider'. This coupling is also known as Love Joy Coupling. The calculations were done following Jaw-Flex Couplings Technical Data. The specifications are given in the table 4. The 3D model was created in Solidworks 2016 and rendered in Keyshot 6.64.

Table 4: Specification of Jaw-Flex Coupling

Type of Jaw Flex Coupling	L-095
Maximum Bore	28 mm
Speed of Motor	3000 rpm
Design Power @100rpm	0.22 kW
Power to be Transmitted	5.5 kW

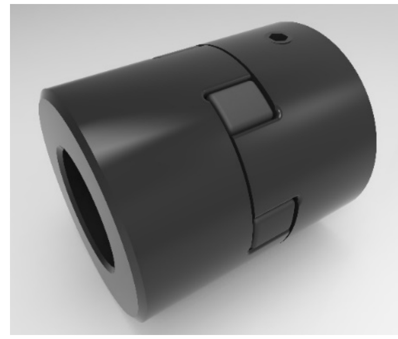

Fig 4: Jaw Flex Coupling Rendered 3D Sketch

2.5 Design of shafts

In order to transmit the power from motor to the pump the shafts are used. Both the shaft use here are stepped shafts having a nominal diameter of 28mm. The 3D model was created in Solidworks 2016 and rendered in Keyshot 6.64. In order to find what happens to the assembly during the vibration condition, we put the condition into Random Vibration analysis in ANSYS Workbench 15.

Fig 5: Shaft, Coupling and Bearing Assembly

3. Finite Element Analysis

In order to carry out a finite element analysis, the model we are using must be divided into a number of small pieces known as finite elements.

3.1 Mesh Generation

In simple terms, a mathematical net or 'mesh' is required to carry out a finite element analysis. Area elements can be triangular or quadrilateral in shape. The selection of the element shape and order is based on considerations relating to the complexity of the geometry and the nature of the problem being modeled.

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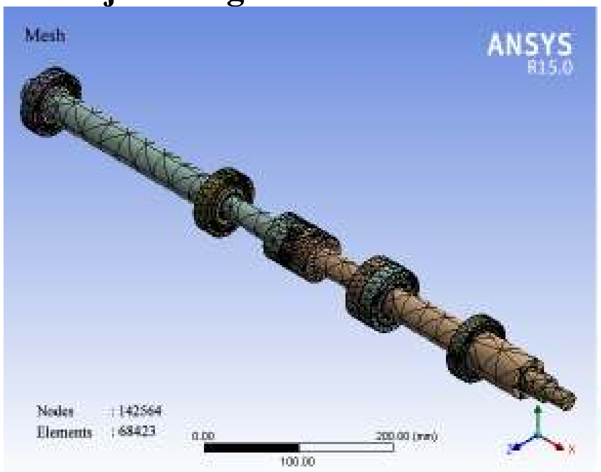

Fig 6: Mesh

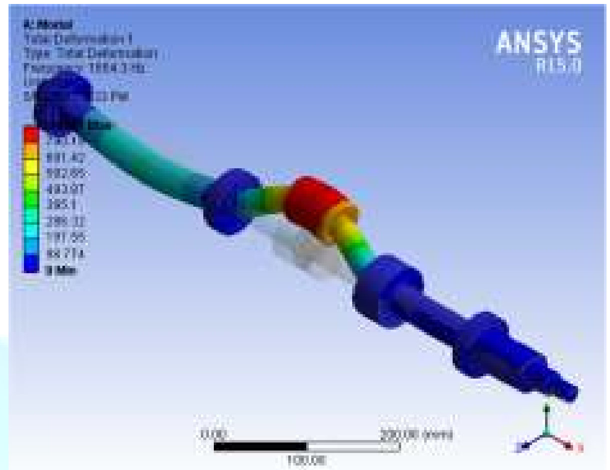

Fig7: First Natural Frequency Vibration

Finite Element Analysis (FEA) of pump motor shaft is performed using ANSYS (Workbench-16.0). Spending a sufficient time on studying imported geometry and performing auto mesh for initial trials the course meshing is done. Since motor shaft model is having solid elements the course meshing is used for FEA analysis as shown in Fig.7. There are 142564 nodes and 68423 elements in the fine meshed model.

3.2 Model Analysis

The Modal Analysis technique is used to determine the vibration characteristics of structures natural frequencies, mode shapes and mode participation factors. It is pre-requisite for random vibration analysis. Aim is to determine mode shapes and their corresponding frequencies. Here, only up to 6 modes are considered as the range of 10 Hz to 5000Hz. First 6 modal frequencies are found to be 1654.3Hz, 1668.6Hz, 1995.3Hz, 2000.9Hz, 2005Hz and 2011.5Hz respectively.

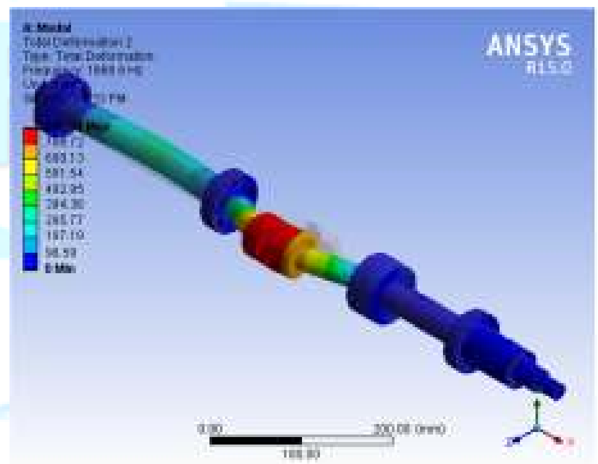

Fig 8: Second Natural Frequency Vibration

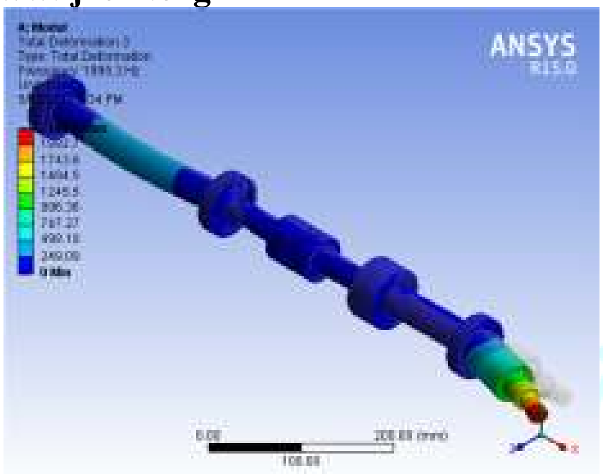

Fig 9: Third Natural Frequency Vibration

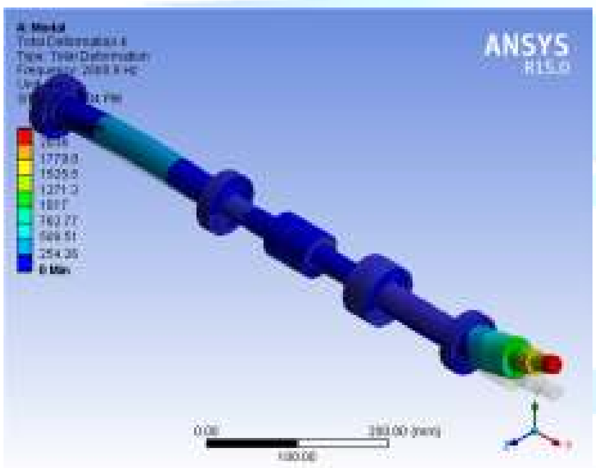

Fig 10: Fourth Natural Frequency Vibration

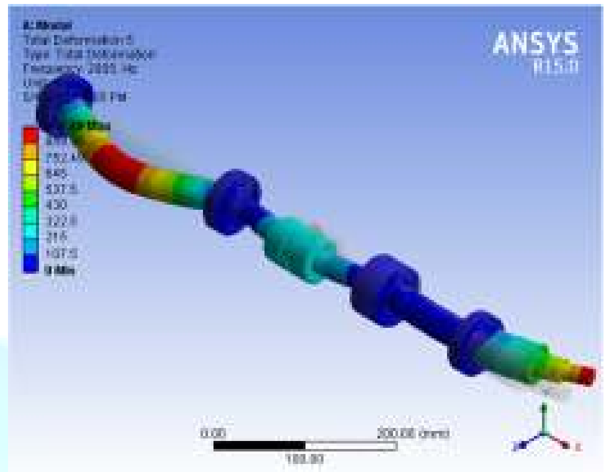

Fig 11: Fifth Natural Frequency Vibration

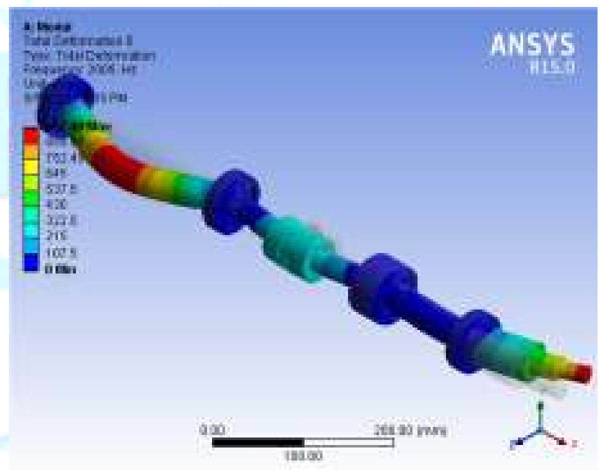

Fig 12: Sixth Natural Frequency Vibration

3.3 Random Vibration Analysis

The random vibration testing has been increased in recent times. As random vibration takes into account all excited frequencies in defined spectrum at known interval of time, it gives real-time data of vibration severities. The vibration severity is expressed in terms of Power Spectral Density (PSD). The consideration in the paper is based on the fact that we are dealing with only random vibration.

The values for input PSD are selected according to SAE Standard-J1455 (August-94) and US Military Standard (MIL-STD-810G). Multiplication factor of 9.812 should be used if we want to convert unit of PSD from [g2/Hz] to [((m/sec2)2)/Hz]. Table 4 shows the input PSD table for Y-Axis. As the component of gravitational acceleration is acting along vertical direction the maximum severity is seen here. If motor assembly sustains this vibration, it will also sustain vibrations along transverse and longitudinal axis. Therefore, PSD is applied along only vertical axis (Y Axis).

Table 5: PSD Acceleration Values

Vertical Direction (Y-Axis)	
Frequency (Hz)	PSD (g^2/Hz)
10	0.015
40	0.015
500	0.000015
Overall m/s = 1.04G	

The following diagrams are taken to analyze the Random Vibration. Here we uses Directional Deformation and Random Vibration analysis for the finite element analysis.

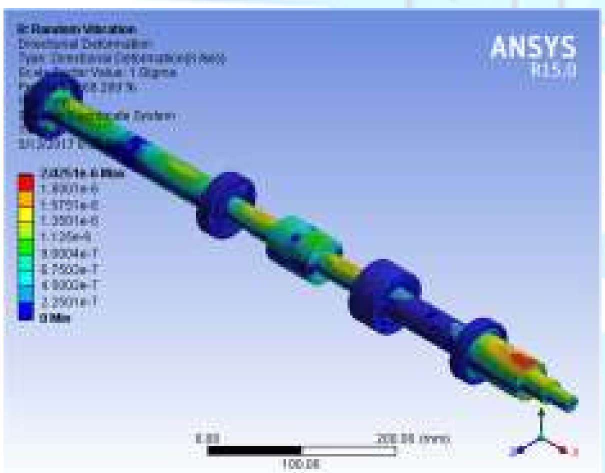

Fig 13: Directional Deformation along X Axis

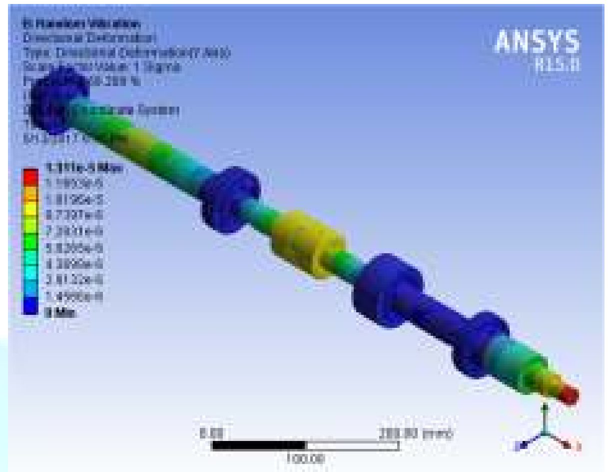

Fig 14: Directional Deformation along Y Axis

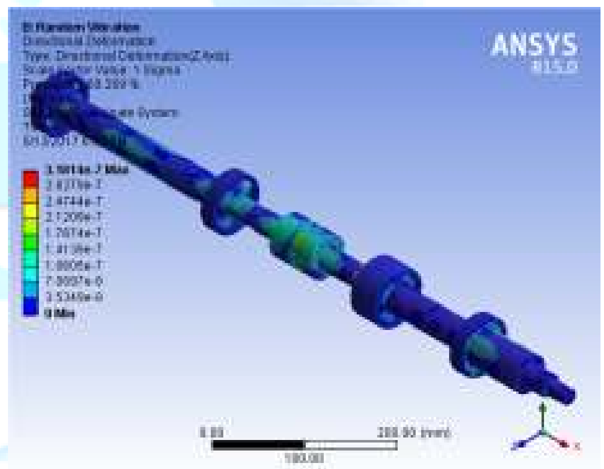

Fig 15: Directional Deformation along Z Axis

The above three analysis figure are showing the directional deformation along different axis. From this analysis we can see that the deformation along the all axis is very small (range of 10^{-5} to 10^{-8} mm).

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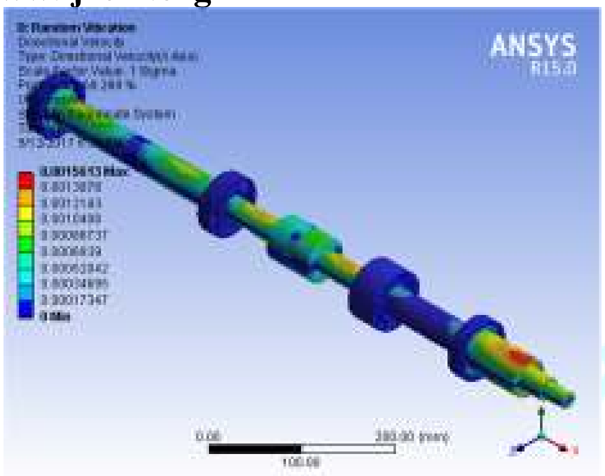

Fig 16: Directional Velocity along X Axis

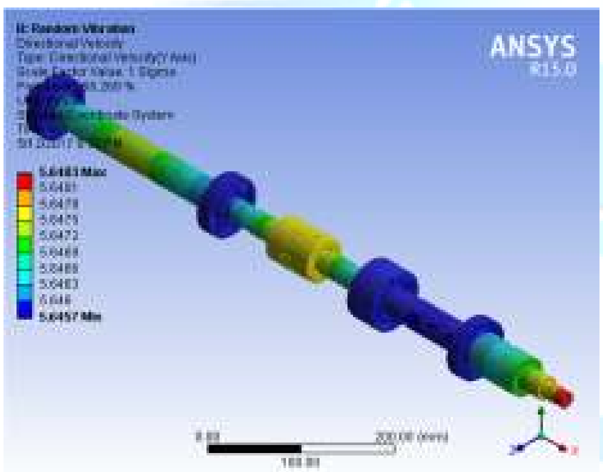

Fig 17: Directional Velocity along Y Axis

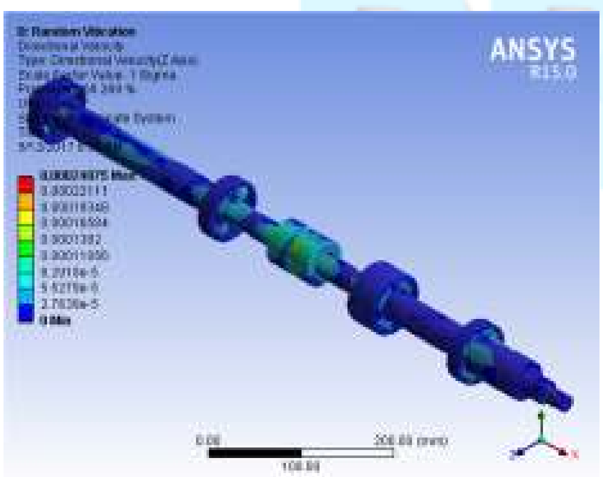

Fig 18: Directional Velocity along Z Axis

The above three figures shows the random vibration analysis of the geometry under the Power Spectral Density (PSD) 1.04G. The unit of directional velocity is measured in terms of mm/sec.

4. Result And Discussion

As we take the above assumption, if the sustains this vibration it will also sustain vibrations along transverse and longitudinal axis. In the analysis we obtained a maximum value 5.6483mm/sec in the vertical direction and for the rest direction the vibration velocity is less for this centrifugal motor (according to *Entek IRD Mechanalysis*).

5. Conclusion

According to the *Entek IRD Mechanalysis*, the allowable vibration limit for a general purpose horizontal centrifugal pump is 0-5mm/sec. From the FEA analysis we are having a maximum value of 5.6483mm/sec in the vertical direction at a PSD value of 1.04G. Thus according to the *Entek IRD Mechanalysis* the motor is having a Fair limit vibration, but which is less than the alarm value (7.5 mm/sec). And the maximum possible chance for the vibration is at the end of motor shaft. Since at the PSD value of 1.04G, the pump motor shaft is at fair stage, thus it will sustain the normal working condition vibrations. It shows the design of the motor is safe under the vibration.

For the FEA model all the parts are designed with the help of SolidWorks16 and the Random Vibration analysis done using ANSYS Workbench 15.0.

Reference

[1] N S Swansson and S C Favaloro, *Applications of Vibration Analysis to the Condition Monitoring of Rolling Element Bearings*, Department of Defense Melboune, Victoria, January 1984.

[2] Pravin P Joshi and M.R.Bachwad, *Condition Monitoring of Induction Motor with a Case Study*, IJEET Volume 6, Issue 6, June (2015), pp. 10-15.
[3] Ms Prajakta M. Patil and Prof A. U. Gandigude, *Condition Monitoring and Vibrational Analysis of Proposed Shaft through Experimental and FEA Approach*, ISSN 2248-9622, Vol. 5, Issue 2(Part 4), February 2015, pp.30-33.
[4] N. Dileep, K. Anusha, C. Satyaprathik, B. Kartheek and K. Ravikumar, *Condition Monitoring of FD-FAN Using Vibration Analysis*, ISSN 2250-2459, Volume 3, Issue 1, January 2013.
[5] Shyam Patidar and Pradeep Kumar Soni, *An Overview on Vibration Analysis Techniques for The Diagnosis of Rolling Element Bearing Faults*, IJETT-Volume4,, Issue5,May 2013.
[6] Hariharan and PSS. Srinivasan, *Vibration analysis of misaligned shaft ball bearing system*, ISSN: 0974- 6846, Vol.2 No. 9, Sep 2009.
[7] According to Manoj Kumar Chittora, *Condition Monitoring of Turbogenerator By Vibration Monitoring Technique*, IOSRJEN Vol. 3, Issue 1, Jan. 2013, pp.33-37.
[8] Asad Said Juma A Zadjali and G.R. Rameshkumar, *Condition Monitoring of Centrifugal Blower Using Vibration Analysis*, International Journal Of Multidisciplinary Sciences And Engineering, Vol. 4, No. 5, June 2013.
[9] Entek IRD International, *Introduction to vibration technology*.
[10] Prof. G R Damodaran, *Design Data*, PSG College of Technology, ISBN 978-81-927355-0-4.
[11] R.S Khurmi, J K Gupta, *Machine Design*, Eurasia Publication House,(2005),727-758.
[12] Jaw-Flex Couplings Technical Data
[13] Plants and processes- FACT Technical Society