EXPERIMENTLAL MONITORING OF VIBRATION ON CENTRIFUGAL PUMP

Mukti Kadam[1], Prof.R.S Shelke[2]

[1] Mukti Kadam, Research Scholar , Design Engineering, SVIT, Maharashtra, India
[2] Prof.R.S Shelke, Assitant Prof., Mechanical Engineering, SVIT, Maharashtra, India

ABSTRACT

The main task of this Project was to summarize the reasons of turbo machine failure and a way of monitoring those causes during the operation of the turbo machine. Furthermore, the analysis of the results of Condition Monitoring (Vibration Monitoring) was explained with a practical experiment performed in the laboratory

The results of our measurement indicate a significant variation in vibration trend as a function of operating conditions. The experimental results demonstrated that the vibration monitoring rig modeled various modes of machine failure. Failure can be caused either by single phenomenon or simultaneous phenomenon. Such phenomenon are as follows:

- *Balancing Motor which can become unbalanced sometimes which will affect the measurement itself.*
- *Parallel Misalignment (misalignment of pump and motor)*
- *Blade pass and Vane pass*
- *Vortex shedding*
- *FEA Analysis for Modal, Random Vibrations*
- *Validation by FFT*
- *Base plate Design*

Furthermore it can be emphasized that based on my observation during the measurement, when the revolution number was approaching 1500 [RPM], the noise of the turbo machine would dramatically increase when the flow rate was at its maximum. Thus, we can indicate that the noise was as result of high vibration. However, with the same revolution number (rotational speed) but lower flow rate the noise was not that much.

Keyword : *Vibration Monitoring, Baseplate Design FEA and Welding Standard*

---

1. INTRODUCTION

The contact feeling of vibrating machines is very important because we can understand whether the machine is working properly or not. We can take drivers as an example, usually a routine driver can detect if the car has mechanical issue by the vibration of the steering wheel or by engine knock. Therefore the amplitude of the vibration is important to detect the engine’s (or machine’s) statues of operation which of course it’s natural to have some level of vibration due to small, minor defects. However, when those vibrations exceed the limit, we can assume that there is a mechanical issue. The reason for that is usually because it is unbalanced, misaligned, or worn gears and since not everyone has the experience needed to state a machine's condition based on how it feels. Various measuring equipment have been developed over the years to measure the actual level of vibration. Of course, human detection of faults through touch and feel is somewhat limited, and there are many common problems such as the early stages of bearing and gear failure that are generally out of the range of human perception. Thus, modern instrumentation for measuring vibration on rotating and reciprocating machinery makes it possible to detect developing problems that are outside the range of human senses of touch and hearing. Further, human perception differs from individual to individual. What one person may consider as bad, another may consider as normal. The attempt to follow the changes in machinery condition using human contact is nearly impossible, since engineers can’t document on how a machine feels, hence it’s incorrect and unprofessional. To overcome this problem, instruments have been developed to actually measure a machine's vibration level and assign it a numerical value. These instruments help engineers to overcome the limitations of human perception. In order to investigate the vibrations, it is necessary to identify the machine and describe the vibration monitoring of a turbo machine (condition monitoring)..

1.1 PROJECT DEFINITION

Vibration Monitoring is necessary to reduce the noise and hazardous by vibration of rotating element According to API610 vibration should be lies between 6.3 mm/displacement and for Noise 84 db. In this project we are carried out the vibration monitoring and baseplate design so that we can satisfied the customers. For Various RPM this test carried out.

For baseplate design and Vibration monitoring we have various pump like End Suction and Split case pump.

1.2 OBJECTIVE

The main objective of this work is to check the new developed pumps vibrations and monitoring the vibration on site as well as design the rigid baseplate and validate baseplate and vibration for various speed on Matlab and FEA.

Fig 1: Pump with baseplate

2. METHADOLOGY

In order to investigate the system, there are two measurements, which are operated at the same time, and these are defined in following ways. At the first step, the measurement is to determine the following characteristic of single-stage centrifugal pump at 11 deferent revolution number (from 480 to 1500 RPM). In the second step, the aim is to investigate the effect of vibration on turbo machine and by using the vibration monitoring techniques. Here it is possible to investigate the changes of amplitudes and frequencies, in order to explain the behavior of turbo machine under vibration effects.

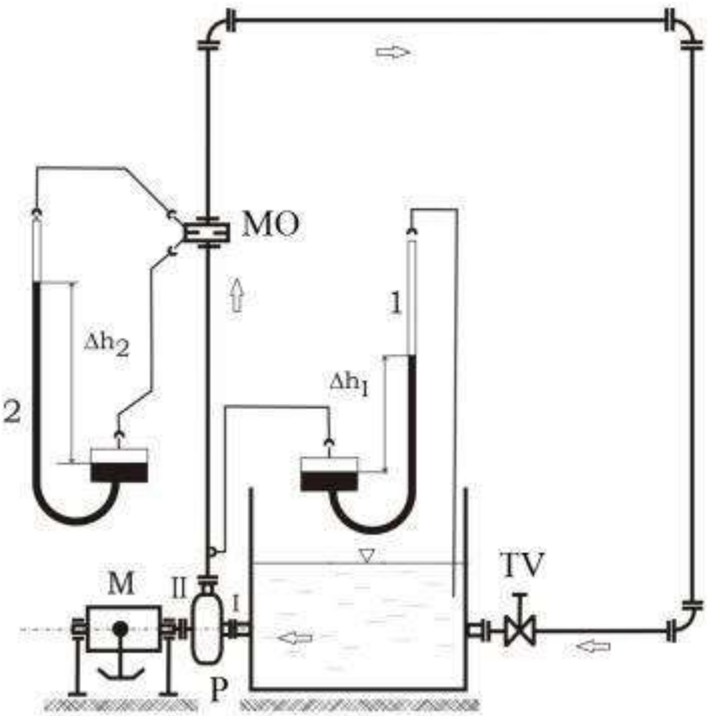
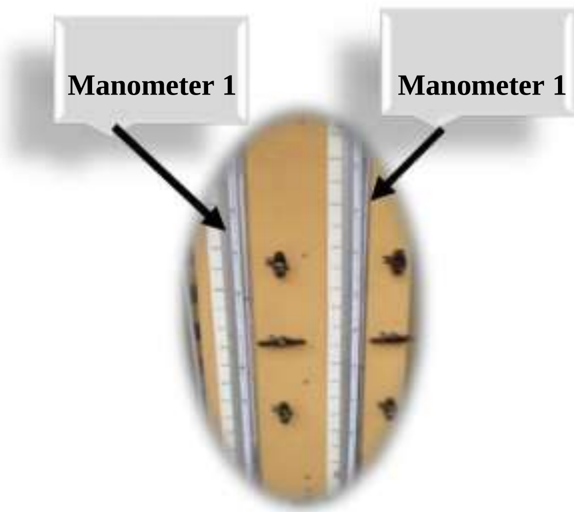
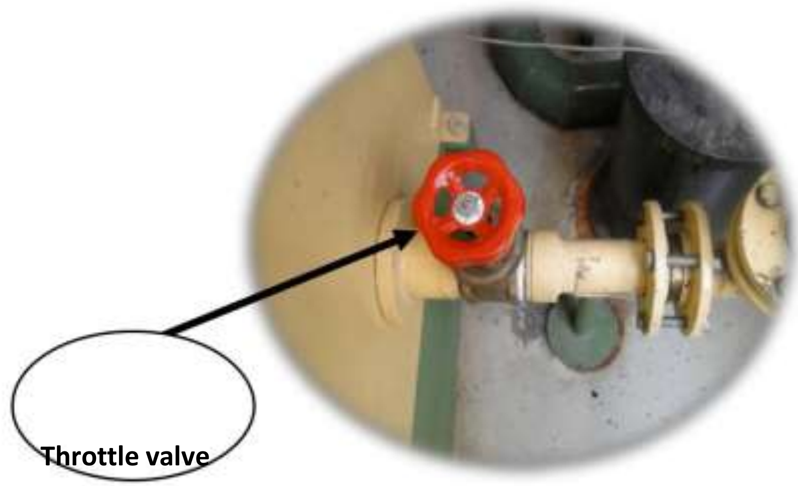


Fig 2 – Test rig





2.1. GIVEN DATA

Although I tried to give a short explanation of used quantities and equations. During the measurement operating point is set by the help of the throttle valve (TV).

Inner diameter of the pipe	D=53 mm
Type of pump	BMS 25/48
Type of balancing motor	Efk 56 I 4
Arm length of the balancing motor	k = 716 mm
Diameter of the orifice plate	d=30 mm

3. CALCULATED QUANTITIES

In order to make the calculation easier, every units of quantities where converted to the SI units and it has been calculated on Excel.

	Δh2 pred	Δh_2[Hgmm]	Δh_1[Hgmm]	m [kg]
1	0	0	387	0.18
2	1	1	385	0.19
3	3	3	378	0.2
4	6	6	374	0.22
5	12	12	366	0.24
6	18	18	352	0.26
7	26	26	333	0.27
8	35	35	311	0.28
9	46	46	286	0.28
10	58	58	261	0.3
11	72	72	223	0.3
12	87	87	189	0.31
13	104	104	141	0.32
14	122	122	98	0.32

Q	H	M	P_{useful}	P_{input}	η	η [%]
0	4.8762	1.018474	0	106.6544	0	0
0.000226	4.851068	1.088714	10.75749	114.0098	0.094356	9.435578
0.000392	4.763003	1.158953	18.29427	121.3653	0.150737	15.07372
0.000554	4.712806	1.299433	25.59934	136.0763	0.188125	18.81249
0.000783	4.612412	1.439912	35.43172	150.7872	0.234978	23.49783
0.000959	4.436418	1.580391	41.73902	165.4982	0.252202	25.22023
0.001153	4.19756	1.650631	47.4632	172.8536	0.274586	27.45861
0.001337	3.920969	1.72087	51.43999	180.2091	0.285446	28.54461
0.001533	3.606713	1.72087	54.24554	180.2091	0.301014	30.10144
0.001722	3.292525	1.861349	55.60535	194.9201	0.285273	28.52726
0.001918	2.814673	1.861349	52.9624	194.9201	0.271713	27.17134
0.002108	2.387288	1.931589	49.3785	202.2755	0.244115	24.41151
0.002305	1.783638	2.001829	40.33638	209.631	0.192416	19.24161
0.002497	1.243056	2.001829	30.44698	209.631	0.145241	14.52408

The mathematic way to evaluate the number of measurement to predict the different heights on manometer 2 which defines the sets of changes in flow rates is explained in Appendix

4. ANALYSIS RESULTS

Our measurement consisted 11 different amount of revolution number which was controlled by an electronic setting board Fig.(4) with each having various amount of different flow rate where the maximum flow rate was measured when the throttle valve was fully open. Than as we controlled the throttle valve we obtained different flow rates, until the throttle valve was fully closed. Each time the flow rate was set, we calculated the head at each throttle valve position since their relationship is fundamental for the characteristic curve of the centrifugal pump. The characteristic curve contains the different points with respect to the number of flow rates with the number of heads. Fig.(5).

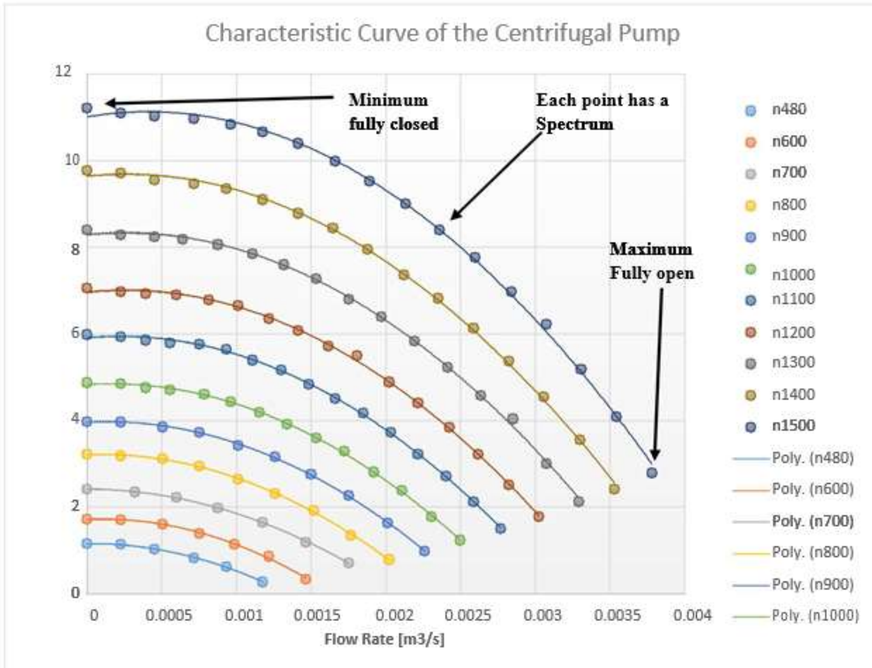


Fig 4 - Characteristic Curve of the Centrifugal Pump (Taken from Excel calculation)

5. SUMMARY AND CONCULSION

The main task of this Project was to summarize the reasons of turbo machine failure and a way of monitoring those causes during the operation of the turbo machine. Furthermore, the analysis of the results of Condition Monitoring (Vibration Monitoring) was explained with a practical experiment performed in the laboratory of the Department of Hydrodynamic Systems in indo pump.

The results of our measurement indicate a significant variation in vibration trend as a function of operating conditions. The experimental results demonstrated that the vibration monitoring rig modeled various modes of machine failure. Failure can be caused either by single phenomenon or simultaneous phenomenon. Such phenomenon are as follows:

- Balancing Motor which can become unbalanced sometimes which will affect the measurement itself.
- Parallel Misalignment (misalignment of pump and motor)
- Blade pass and Vane pass
- Vortex shedding

In this measurement an experimental test system was set up and we were able to perform practical tests on the constructed rig to confirm the expected theoretical frequencies that we needed. This experiment was offered complementary strengths in the cause of the analysis of machine failure, and natural allies in diagnosing machine condition. It reinforces indications correlation between vibration condition monitoring and fault diagnosis for centrifugal pump. Both amplitude of the dominating peak and its location along the frequency axis changes in various conditions of pump.

Furthermore it can be emphasized that based on my observation during the measurement, when the revolution number was approaching 1500 [RPM], the noise of the turbo machine would dramatically increase when the flow rate was at its maximum. Thus, we can indicate that the noise was as result of high vibration. However, with the same revolution number (rotational speed) but lower flow rate the noise was not that much.

6. REFERENCES

[1] Jardine, A. K., Lin, D., & Banjevic, D. (2006). A review on machinery diagnostics and prognostics implementing condition-based maintenance.Mechanical systems and signal processing, 20(7), 1483-1510.
[2] Comelius Scheffer “Pump Condition Monitoring Through Vibration Analysis” Pumps; Maintenance, Design, and Reliability Conference, 2008.
[3]Centrifugal Pumps 2nd ed. 2010 Edition, Springer ,ISBN 978-3-3-642-40113-8 Igor J Karassik and Ray Cartor, “Centrifugal pumps”, Tata McGraw Hill Book Company– 2nd edition, 1960.
[4] Jauregui, J. C. (2014). Parameter identification and monitoring of mechanical systems under nonlinear vibration. Elsevier.
[5] E. Oran Brigham, “The Fast Fourier Transform and its applications”, Prentice-Hall International Editions – 1st edition 1988.Entek IRD International “Introduction to vibration technology” Edition I, Jul 1984, Tata McGraw hills.
[6] Laggan PA. 1999. Vibration monitoring. IEE Colloquium on Understanding your Condition Monitoring
[7] Marcal RFM, Negreiros M, Susin AA, Kovaleski JL. 2000. Detecting faults in rotating machines. J Instrumentation & Measurement Magazine 3
[8]Wachel, J. C. (1992). Acoustic Pulsation Problems in Compressors and Pumps. Engineering Dynamics Inc.