PREVENTIVE MAINTENANCE THROUGH VIBERATION ANALYSIS

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ABSRACT

Some field experiences of viberation measurements and analysis in preventive maintenance are presented in this paper, the principle of preventive maintenance through viberation measurements are outlined for a CO_2 centrifugal compressor train in an Amonia plant. The compressor train consists of two compressor sasings driven by a steam turbine and a gearbox. The measurements were collected for a period of eight months. It was shown that by proper vibration measurements and analysis, any fault is rapidly detected. This resulted in immediate repairs and consequently increasing equipment age, which is the philosophy of preventive maintenance rather than to repair the damage when it occurs.

It was also shown that in most cases, complete and accurate information of the rotor dynamic response is necessary to proceed with vibration analysis. The standard methods of viberation evaluations, Rathbon, VDI 2056, are discussed

INTRODUCTION

Viberation measurements and analysis have become increasingly important in order to meet recent developments with respeat to highly stressed industerial machinery. Such practice will determine the effectivenses of maintenance work performed on those components that exhibit early failures and further protect expensive machines against total destruction. The simplest and most commonly used method of viberation measurements is by permenant electric installations, This consists primerily of a transducer detecting either bearing housing or relative motion between shaft and bearing. Those installations are coupled to alarm system and a triggering system to assure shut down at high viberation levels.

The preventive maintenance programme is a periodic check with often hand held viberation level meters. This type of preventive maintenance must be

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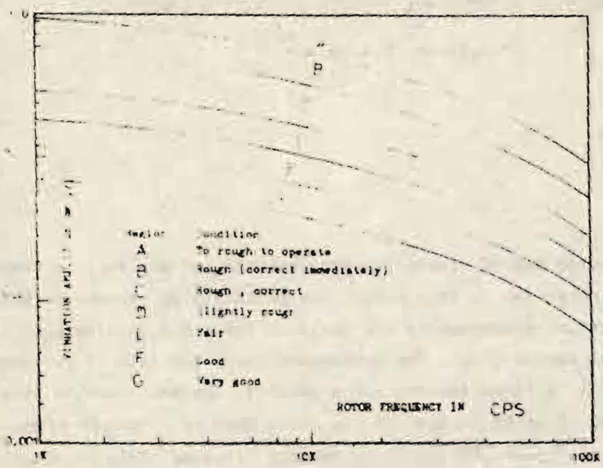


Fig. 1 Vibration criteria for rotating machinery proposed by Rathbone. VDI 2056

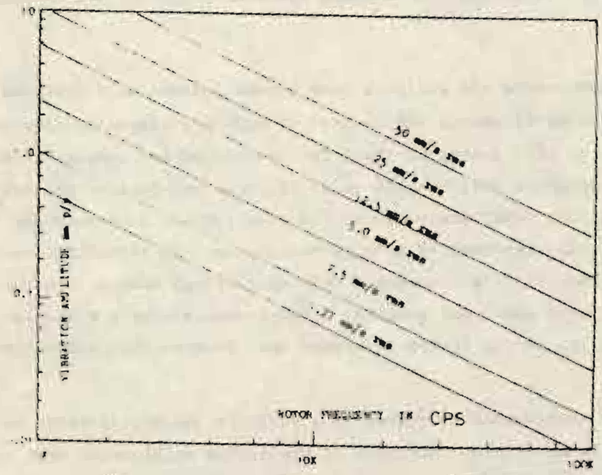


Fig. Vibration criteria for rotating machines proposed by Yates. (ref. 3) applied systematically and not only when trouble is eminent.

The cost of implementing a PMP related to vibration as the key to machinery condition is fractional compared to the probable saving in the operation. Often the routine dismantling of machinery for annual or periodic survey can be avoided, providing an authentic viberation history in properly documented form can be shown [1].

The object of this work is to review the general problems of viberation measurements and analysis applied to machine maintenance through an actual case of a compressor train.

VIBERATION CRITERIA

The viberations are measured by displacement, velocity or acceleration; the question which always arises is; "what kind of sensors should be used ? [2], in fact this depends on what we are looking for, how is the machine built, displacement proximity sensors which are suitable to be introduced in bearing housing and what is also used for; phase measurement,and shaft orbit. It has limitations in temperature and frequency response, the seismic sensors(velocity sensors) are usually used when large viberations are expected, accelerometers(acceleration sensors) which is sensetive within a wide frequency range requires often the use of a low pass filter. The guideline or the limitations of acceptability of viberation levels are governed by standards as Rathbone,Yates VDI 2056 which are widely used.

The viberation severity does not have an absolute value, it depends on the class of equipment,speed,rotor weight bearing types and seal. Rathbones curves (fig.1) are primerily based on medium speed turbines(5000RPM),the measurements were on the bearing with a seismic velocity sensor [2] .Yates produced severity charts working on massive turbine installations(fig.2), this chart is presented for bearing cap or pedstal. In Yates,the machines were installed in relativly flexible steal shells, despite the fact that Rathbone was for massive machines foundations. This will explain the differences between the aforementioned criteria. For example a viberation of frequency 10 Hz, amplitude of 10 mils is rough on Rathbone and normal on Yates.

VDI 2056(fig.3) is based on fine separate classes of machines[3], and places no restriction on the viberation measurements. It should be remembered that all this criteria are however subject to subjective opinion with little regard to the dynamic system to which they are applied.

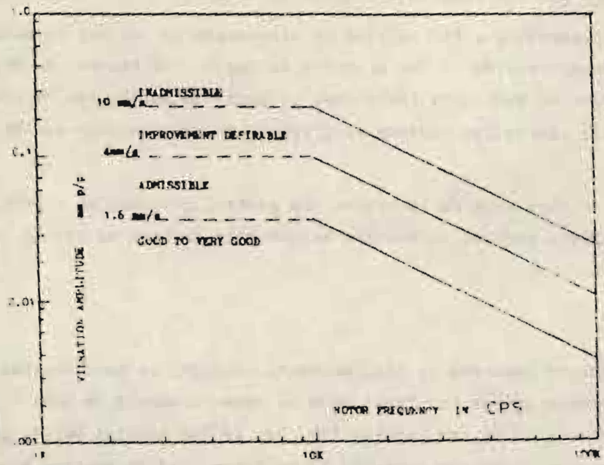


Fig. 3 Viberation criteria for rotating machines V.D.I.2056

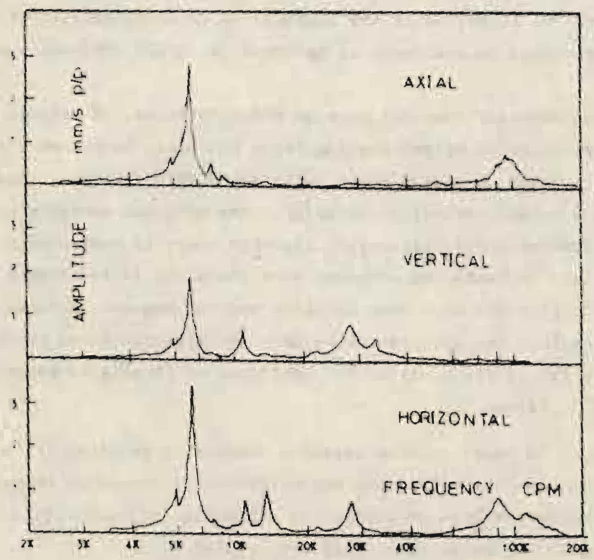
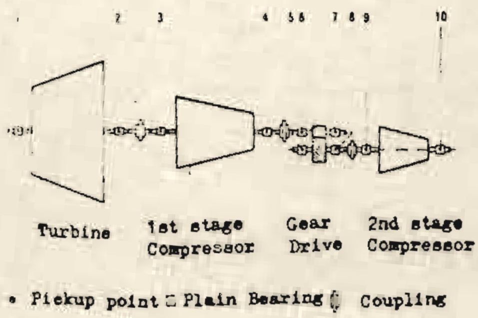


Fig. . Example of the out put of the bearing number 9 of the gearbox.

TECHNIQUE OF MEASUREMENTS



Low pressure compressor:
running speed 7050 RPM
1st critical speed(NC1) 3500 RPM
2nd critical speed(NC2) 11500 RPM

High pressure compressor:
running speed 13693 RPM
NC1 8300 RPM
NC2 14700 RPM

Steam turbine:
running speed 7050 RPM
NC1 13800 RPM

Fig. 4 Lay out of the compressor train

The vibrations were measured at ten locations in bearing housings as shown in fig. 4 . A velocity pick-up is used with frequenay analyser connected to X,Y recorder, an example of the output is given in fig. 5 ,for bearing number 9. The high pressure compressor is running at 13693 RPM.

There are a record of eight months , only a sample of the measurements is presented, ; actually one bearing only considered in this paper; bearing number 5 of the gearbox high speed shaft. Also it should be mentioned that the highest vibration level is encountered in this position. The measurements were taken monthly for each bearing in three directions , horizontal, vertical, and axial. These measurements are reported in the vibration trend chart(VTC). Usually when the fault is detected the next measurement is to assure the validity of the correction work.

ANALYSIS AND DISCUSSION

The preventive maintenance programme for this train was started right after the errection of the factory. The vibrations are measured monthly, the available records are for a period of seven months.

Taking as example the low pressure compressor casings bearing, the peak is noticeable arround 7000 RPM which corresponding to the rotating speed, the recoreded amplitude is less than 2 mm/s peak to peak (P/P) which corresponds to 0.2 miles P/P . However this obsereved peak at a frequency equal to the

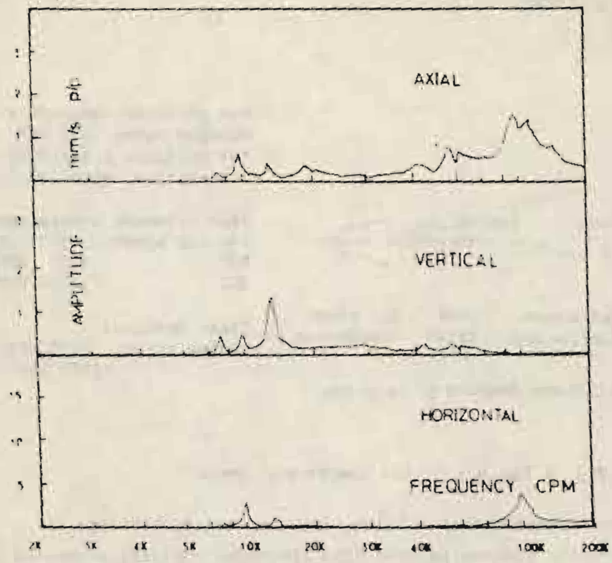


Fig. 6 Viberation level on the delivery side bearing number 3 of the low pressure compressor.

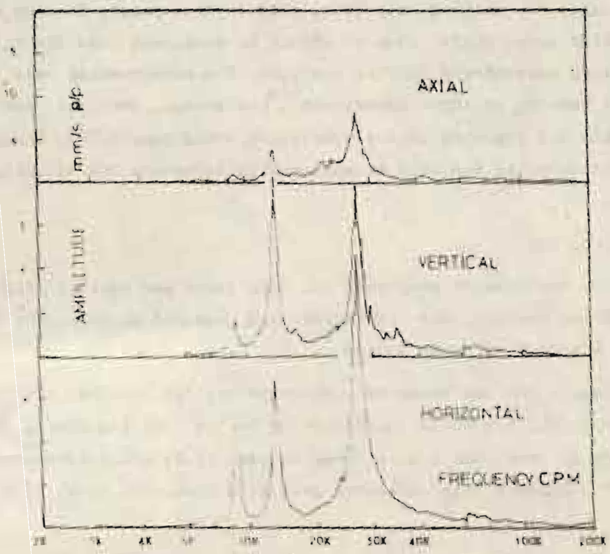


Fig.7 Viberation level on the bearing number 8 of the gearbox.

running frequency of the machine may be due to eccentric journals as a result of unbalance(initial shaft deflection), And in all cases, this vibration level will be fair on Rathbone, spins like a top on Yates, and very good in V.D.I.2056 , (as shown in figure 3). The observed peak arround 100,000 RPM (fig. 6) is the harmonic frequeny and propably from the gear coupling teeth. In all cases no correction is required and the operation in this case is considered as satisfactory. Another example is bearing number (8) of high speed shaft in the gearbox, the speed is 13700 RPM here the upper position of the vibration is clear, where the high speed shaft receiving also the vibration of the low speed shaft at its frequency. A noticeable peak is observed at the running frequency then it is repeated at twise the running speed of the low pressure compressor shaft (2 x RPM), it is clear in the horizontal direction, where it reaches 6mm/s peak to peak, which is slightly rough on Yates and an imprnvement is desirable on VDI 2056. The probable reason is the missalignment together with mechanical looseness. The compressor was shut down and the gearbox bearing were checked , excessive wear was noticed, and the four bearings were changed. The next vibration check (fig. 8) shows clearly the disappearance of the high vibration level.

It is important to note that the calculation of the critical speeds may generally explain many of the vibration problems, in critical cases the rotor dynamic response should be under taken, since the critical speeds calculation are usually based on rigid supports. In the cases where critical speeds are suspected to be the reason of vibrations, the vibrations frequencies are of the order of shaft frequencies.

CONCLUSION

Based on this study the following conclusions and recommendations are offered:

1- Vibrations measurement is a good tool in preventive maintenance, the annual or periodic survey can be avoided since preventive maitenance permits the detection of the fault and consequently its correction.

2- In general if there is no specific severity chart given by the manufacturer VDI 2056 is suitable in the cases of compressors and turbines.

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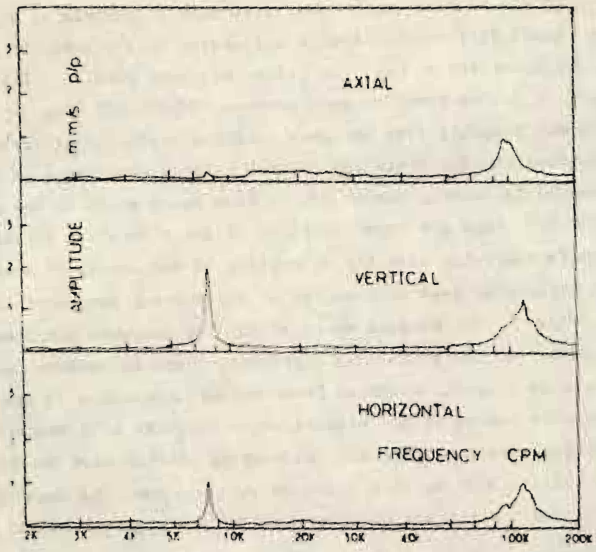

Fig. 8 Vibration level on the bearing number 8 of the gearbox after correction.

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