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Pilot Implementation of High Band Frequency Vibration Analysis in Nuclear Power Plant

Hee-Seung Chang*, You-Soo Shin,
Korea Hydro & Nuclear Power Co. (KHNP),
**Corresponding author: daniel.chang@khnp.co.kr*

1. Introduction

It is very important to detect a degradation of a rotating component before its failure to enhance component reliability. Several methodologies have been developed and implemented to detect a flaw or a degradation of rotating components.

Korea Hydro & Nuclear Power Co. (KHNP) has implemented vibration analysis as a condition monitoring technology to detect a flaw of rotating components to prevent failure during its operation.

In general, a vibration analysis for rotating components is mainly analyzed a low-mid band frequency which is useful to recognize a fault of components or its major parts.

However, there is a limited time to take corrective action when an abnormal condition is found from such a fault frequency. It is usually found that a component with an abnormal condition is damaged severely when the component is disassembled.

To enhance a condition monitoring effectiveness for a rotating component, it is required to detect a flaw in an initial stage of a failure. One of the methodologies to detect initial flaw of a rotating component is a high band frequency vibration analysis.

In this paper, a pilot implementation of high band frequency vibration analysis in a nuclear power plant will be discussed. Some result of the implementation will also be introduced in the last section.

2. Vibration Analysis Currently Used at NPP

2.1 Spectrum analysis of a low-mid band frequency

A spectrum analysis depends on a type of a component and its major part because a range of the analysis should cover sufficiently a fault frequency of a component and a part as described on ISO 7919 part 1 [1].

Details of a fault frequency range for components and its major parts are shown in Fig. 1. As shown in the Fig. 1, a spectrum analysis is mainly used within the low-mid range of 5000 Hz

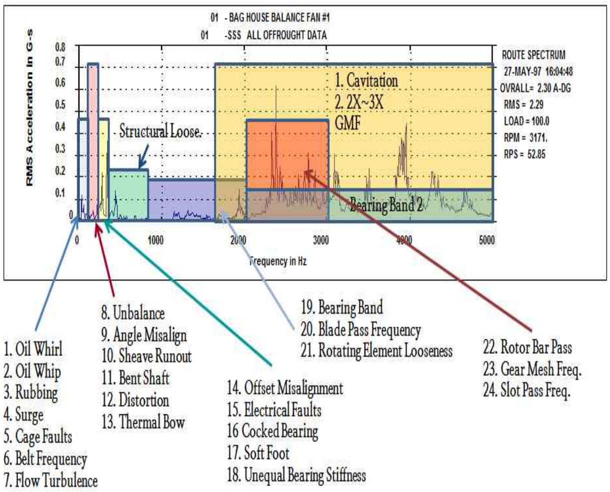


Fig. 1 Details of the fault frequency range

2.2 Fault frequency recognition and utilization

A fault characteristic of a component and its parts is able to provide an effective finding of a flaw. This also provides a cause of the flaw to determine a suitable maintenance to resolve a problem. However, the low-mid range frequency spectrum analysis has a limitation to prevent damage on a rotating component because fault frequency appears when a component or a part is already damaged.

3. New method for early detection of a flaw

3.1 High band frequency analysis

It is recommended to analyze a high band frequency for earlier recognition of defect on a rotating component as described in industrial standard ISO 13373-2 [2].

When a minor defect generates in the interior component, it can be shown a haystack in high band frequency as depicted in Fig. 2.

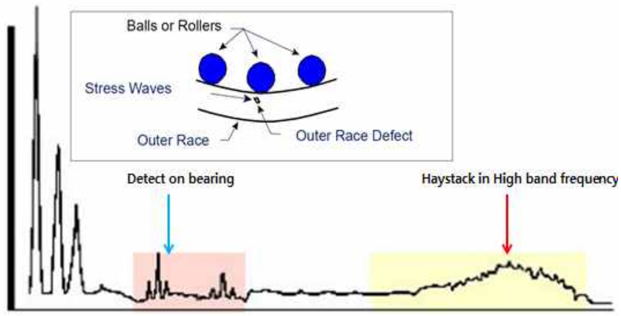


Fig. 2. Defect generate haystack in high band frequency

To determine initial defect from a haystack, a signal process is required. An envelope method is one of the signal processes to find a repeatable impact spectrum from a haystack as shown in Fig. 3, which enables to recognize an initial defect of a component.

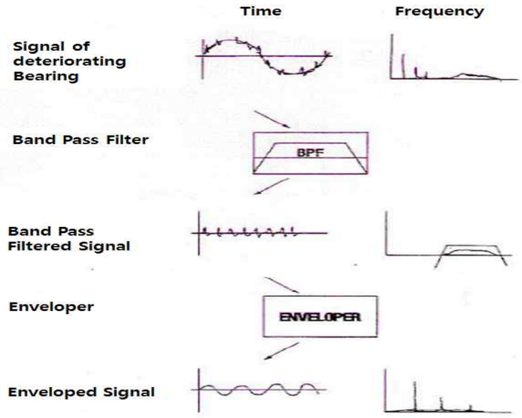


Fig. 3 Signal processes in high band frequency

4. Pilot test of low-medium rotating components

4.1 Pilot test at nuclear power plant

A has been performed for ninety seven rotating components at a nuclear power plant as a pilot. Meanwhile, the low-mid range frequency analysis has been done to compare the results.

4.2 Pilot test results

It has been found that four components are in defect through the high band frequency analysis as shown in Fig. 4.

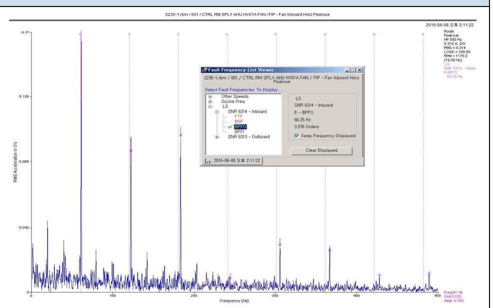
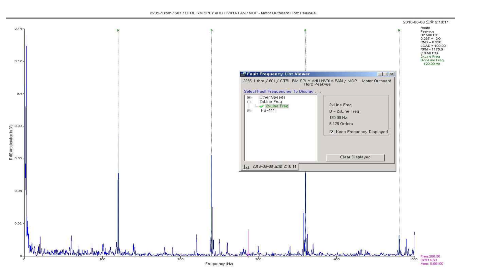
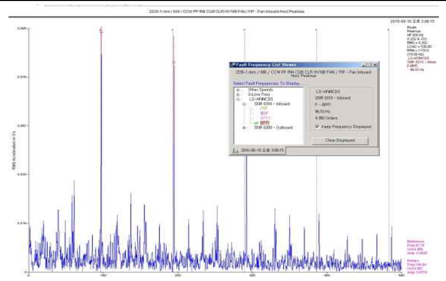
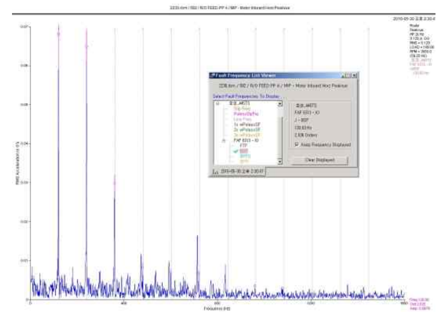
Component	Fault
Control Room Fan	 Bearing Outer ring Fault
Control Room Motor	 Air gap Uneven
Room Cooler	 Bearing inner ring Fault
Water Feed Pump	 Bearing Case Fault

Fig. 4 Initial defects derived from High band Frequency Analysis

It has not been detected by the low-mid band frequency analysis as shown in Fig. 5.

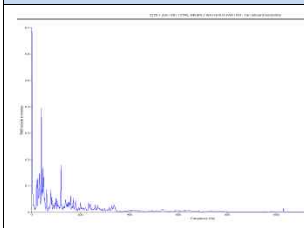
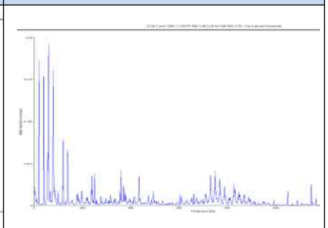
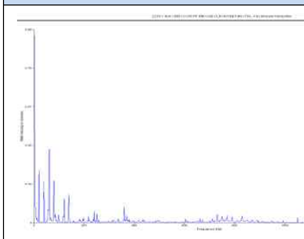
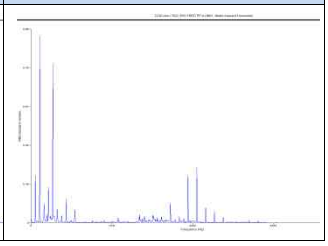
Bearing Outer ring Fault (3.07×RPM)	Air gap Uneven (2×RPM)
	
Bearing inner ring Fault (4.9 × RPM)	**Bearing cage Fault (0.38 × RPM)**
	

Fig. 5 Low-mid band spectrum of Initial defects

From a remaining service life evaluation of defective part based on empirical data [3], life of four components is much shorter than design life as shown in table 1.

It shows the high band frequency vibration analysis is effective to detect of an initial flaw of rotating components and to establish a maintenance plan to prevent failure in a timely manner.

Component	Part No.	Design Life	Duration	Remaining Life
Control Room Fan Bearing	6314	10Y	4Y	1Y
Control Room Motor	254T	30Y	4Y	1Y
Room Cooler Bearing	6319	10Y	4Y	1Y
Water Feed Pump Bearing	6313	10Y	4Y	1Y

Table 1 Remaining service life evaluation

5. Conclusion

A low-mid band frequency vibration analysis has been widely used as a condition monitoring of rotating components in nuclear power plant. Though this method is good way to detect a flaw, it is a limited time to take action to fix.

To enhance an effect of a condition monitoring and recognize a defect earlier, a high band frequency analysis is demonstrated. It has done at one of nuclear power plants in Korea as a pilot to verify an effect of newly adopted method.

Through the pilot test, four cases of initial defect have been found. And remaining service life of those is much less than design life. As a result, the high band frequency analysis is effective way to prevent eventual damage of rotating components.

REFERENCES

[1] ISO 7919 Part1, Mechanical vibration of non-reciprocating machine-Measurement on rotating shafts and evaluation criteria, Second edition pp4-8, 1996
[2] ISO 13373 Part2, Condition monitoring and diagnostics of machine, Processing, analysis and presentation of vibration data, first edition pp10, 2005.
[3] How to implement an effective condition monitoring program using vibration analysis, Use of vibration signature analysis to diagnose machine problems pp-52-95, 1997