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Study on vibration characteristics affected by condition of bearing support system in nuclear steam turbines

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1. Introduction

As turbines in nuclear power plants are large and high speed rotating machineries, it is very important to operate without any trouble. One of important factors related to integrity of turbines is vibration phenomenon, but it has been gradually increased and irregularly hunting in spite of minor change in operating condition such as condenser pressure in these days in some nuclear power plants. This kind of unstable and high vibration phenomenon can be harmful to integrity of turbines for continuous operation. So, it is necessary to investigate carefully the characteristics of vibration phenomenon and prepare the countermeasure to get rid of sources for unstable vibration for continuous operation.

2. Vibration characteristics and Countermeasure

In this section it is necessary to model the bearing support system for turbine, but it is not practical to model correctly the irregular contact conditions same as field condition between ballseat and support ring of bearing. Therefore, I have carefully reviewed and analyzed vibration phenomenon in view of structure and its deformation. Based on the results of analysis, impact test was performed to find out the change of stiffness for bearing support system, and several countermeasures were suggested and applied them to bearing support system on low pressure turbine in nuclear power plant. With this results, vibration characteristics according to condition of bearing support system are defined.

2.1 Status of Vibration Phenomenon

In order to compare the vibration characteristics due to operating hours in nuclear turbine, vibration status have been analyzed in the two units which have been operated for more than 20 years. In one unit which got started commercial operation in late 1980s' and which bearing pedestals installed on the hood of LP turbine in Korea, the absolute shaft vibration has been gradually increased, irregularly hunting of about 30 micrometer amplitude in a day, and used to be over or close to the alarm limit(178 micrometer) during summer season according to the change of operating condition as following Fig.1 and Table.1. But, in the other unit which bearing pedestals installed separately from the hood and not affected by any deformation of hood of LP turbine, the absolute shaft vibration has been stable over a year and maintained almost same magnitude of vibration from the start up.

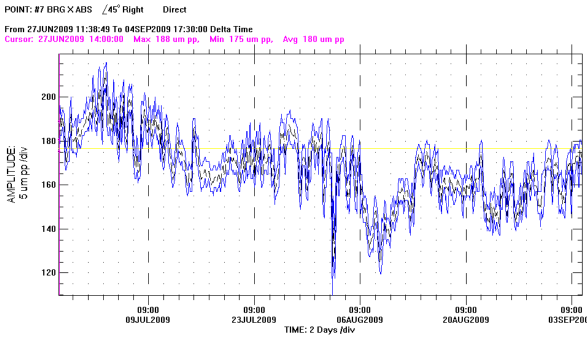

Fig. 1. Vibration amplitude trend of bearing #7 on LP Turbine. in ○○ nuclear power plant

Table. 1. Operating condition on LP Turbine

	Date	Vib.Amp(㎛)		L.O.Temp(℃)	Vacuum (㎜ Hga)	Power (Mwe)	S.W.Temp(℃)
		#7	#8				
1	8.01 22:40	135	115	44.6	40.7	977	27.3
2	8.07 15:35	167	146	45.4	42.6	964	28.5
3	8.10 13:11	147	128	46.2	46.5	971	28.9
4	8.19 02:27	142	124	46.0	44..1	974	28.4
5	8.22 08:50	165	146	45.9	41.5	975	28.5
6	8.28 07:53	164	141	45.4	41.0	980	27.3
7	8.30 05:55	175	156	46.6	38.6	980	27.1
8	9.01 10:10	162	141	46.2	38.1	980	26.8

2.2 Analysis of Structure of Bearing Support System

In this type of bearing support system which bearing pedestals were installed on the hood of LP turbine as Fig.2, bearing pedestals could be moved toward inside and down due to rotor weight and deformation caused by vacuum pulling in condenser. As a result, it is expected that rotor alignment be changed and vibration amplitude be also changed, but those are not sensitive to vibration phenomenon based on operating and maintenance histories of this power plant if bearing support system is maintained correctly.

In the Fig.3, there is a possibility of operating without contact on top spherical seat at rated power because there is a cold gap of 0.30~0.40 mm to give allowance for thermal expansion in radial direction but this value was not considered the condition of its structure such as deformation, corrosion and irregular contact surface.

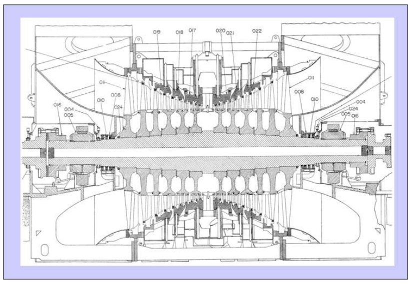

Fig. 2 Typical Section drawing of LP Turbine in ○○ nuclear power plant

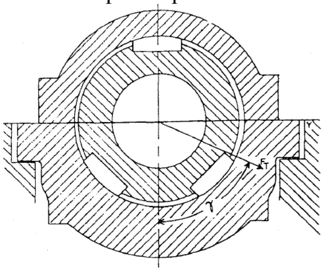

Fig. 3 Assembled bearing drawing of LP

As mentioned above, if there is a possibility of operating without contact between bearing ballseat and support, stiffness of bearing support system could be lowered compared to design condition and it could make resonance by getting close between lowered natural frequency and rotating frequency

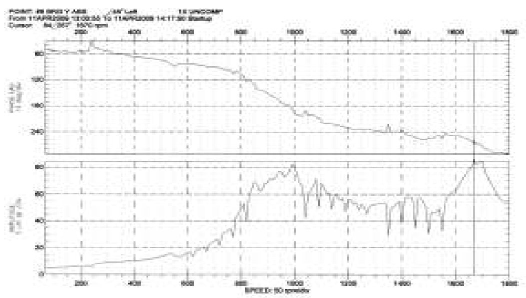

Fig. 4. Bode plot of bearing #8(Y-abs) on low pressure turbine in ○○ nuclear power plant unit 1

2.3 Analysis of Bearing Pedestal Stiffness

In order to find out the possibility of unstable vibration due to stiffness change of bearing pedestal, impact test were performed in the field in 2011 and compared to design value.

Table. 2 Stiffness of bearing pedestal on LP Turbine in ○○ nuclear power plant unit 1&2

Building Block (LP Model)	Bearing Diameter (㎜)	Kxx Vert. Stiffness (N/㎜×10^{-6})	Kyy Hori. Stiffness (N/㎜×10^{-6})
BB 381	685.8	2.21	1.52

It is common sense that stiffness in vertical direction is higher than that in horizontal direction because of assembling features as shown Table.2, but measured value of 1.60×10^6 N/㎜ in vertical direction revealed that stiffness in vertical direction was lowered close to that in horizontal direction.

2.4 Stiffness Improvement of Bearing support System

When considered this kind of stiffness change, there could be possibility of unstable vibration phenomenon, so it was suggested to replace bearing ballseat and support with correctly machined to improve contact area by using spare parts.

2.5 Analysis of Vibration Phenomenon after Replacement of Bearing Support

After replacement of bearing support with correctly machined ballseat and support, shaft absolute vibration phenomenon revealed that there is minor change in amplitude within a day, but max. amplitude is below 110 micrometer and stable within 30 micrometer instead of over 100 micrometer for 3 months including summer season as shown on Fig. 5.

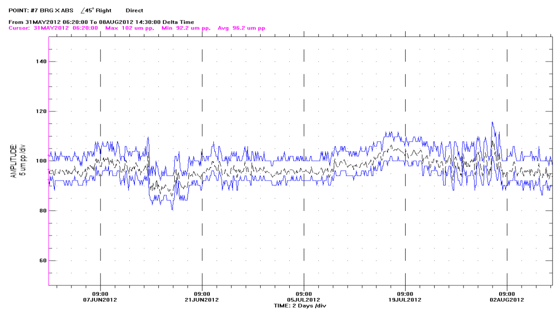

Fig. 5 Vibration trend of bearing #7 on LP Turbine in ○○ nuclear power plant unit 1 (2012.8.8)

3. Conclusions

In some nuclear power plant, the unstable vibration phenomenon was occurred especially on summer season. For analysis, it is necessary to model the bearing support system but not practical due to complexity of simulation of ballseat contact and its deformation during operation. So, vibration phenomenon was carefully analyzed and impact test was performed to find out degrading of bearing pedestal. Based on analysis, there was a cause on irregular contact of bearing ballseat, so countermeasure was implemented for that. In the results, it was found that vibration phenomenon became lowered and stable by improving the contact ratio between bearing ballseat and its support.

REFERENCES

[1] Woo-Sig Ko, Analysis Report for high and unstable vibration on LP turbine in ○○ nuclear power plant unit 1, 2009. 9.