A Study on Vibration Signals of Wind Turbine through the Condition Monitoring System

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Abstract

A study on wind turbine vibration signals caught by Condition Monitoring System, CMS, was carried out in Gasi wind farm of Jeju Island, South Korea. The vibration signal with 10khz was measured by strain gages which were installed on the gearbox of wind turbine for two months from February to April, 2016. The time domain analysis was performed with the data above 50 % of the sampling rate. The vibration data were processed with band pass filter to clearly detect the wind turbine faults. The frequency domain analysis was also performed using enveloping technique to find turbine faults with low frequency. Fast Fourier Transform, FFT, was applied to the processed vibration data. Defect frequencies of bearings of gearbox were measured in the range from 464hz to 9hz and these acceleration values were lower than the vibration acceptance level of 0.5 m/s^2. Therefore it could be confirmed that the bearings of the gearbox worked without any failure.

Objectives

This investigation aims to analyze vibration behavior on the gearbox of the wind turbine, and performs the fault diagnosis by comparing acceleration value of defect frequency with the vibration acceptance level.

Methods

The vibration signal data were gained from eight acceleration sensors which were installed at the gearbox of the wind turbine. Two domain analysis, time domain and frequency domain analysis, were performed for fault diagnosis. Especially, FFT technique was used for frequency domain analysis. Observed values from the analysis were compared with vibration acceptance levels which were presented at VDI3834 standard to determine whether the components are failing. Here, 0.5m/s^2(0.1-10Hz) and 12m/s^2(10-2000Hz) were considered vibration acceptance levels for the gearbox.

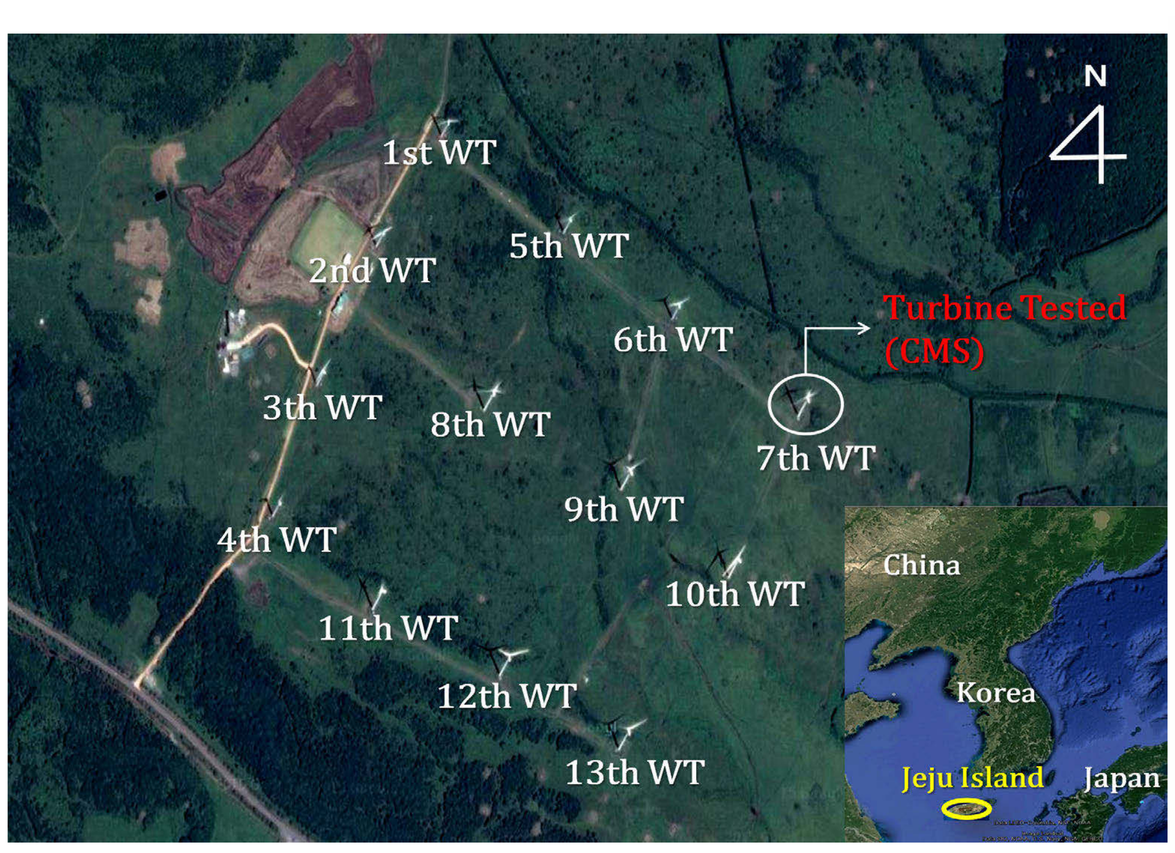

Fig. 1 Gasi wind farm, Jeju Island of South Korea where CMS was installed

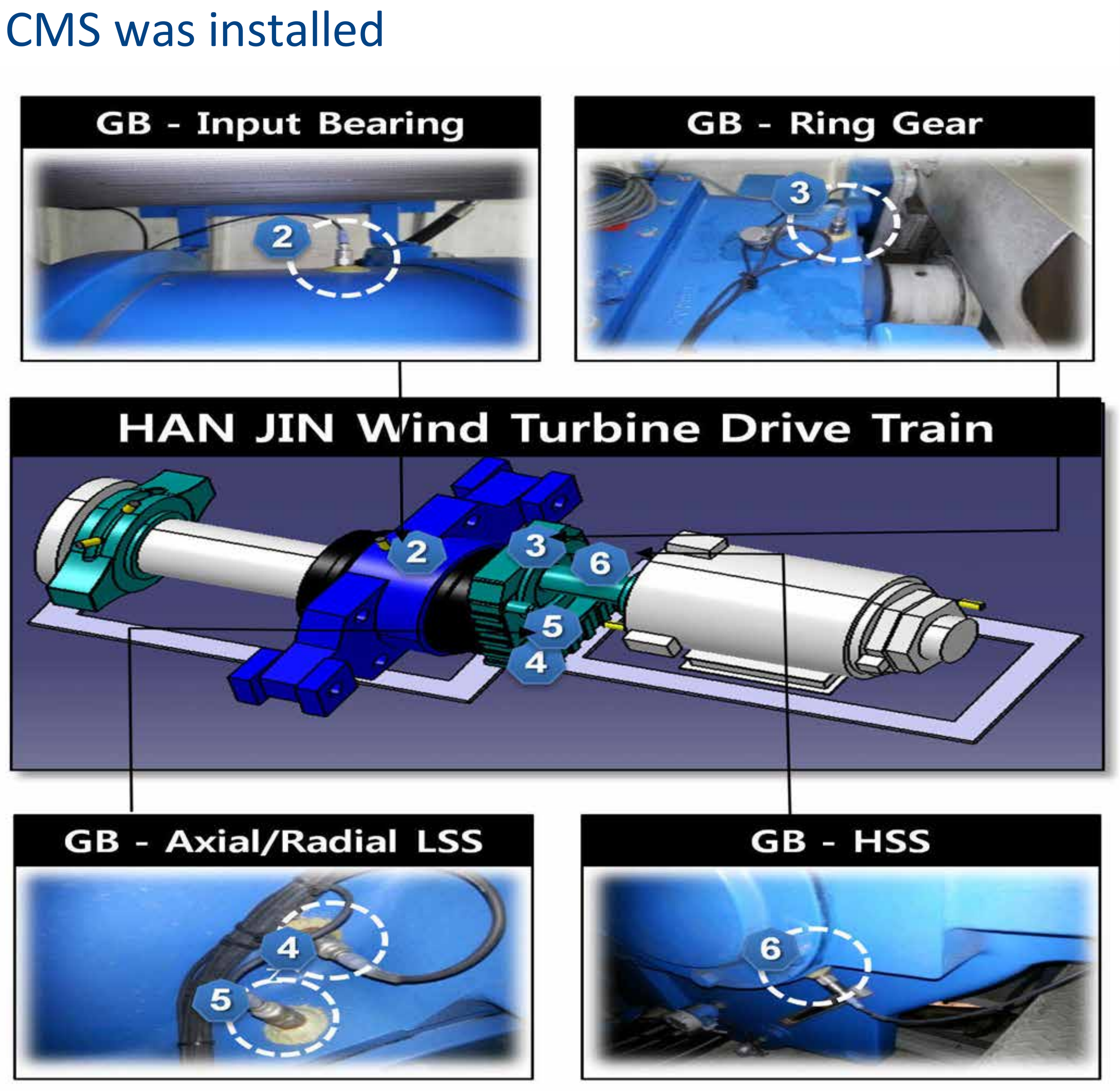

Fig. 2 Sensor locations of CMS at 7th wind turbine

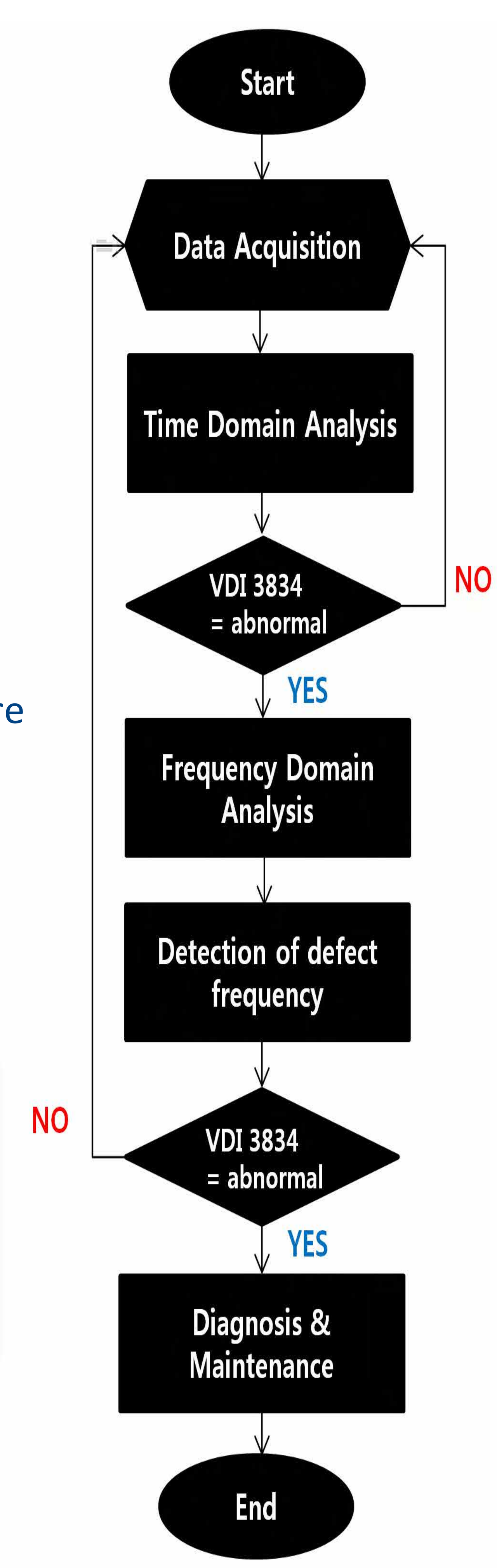

Fig. 3 Flow chart for analysis

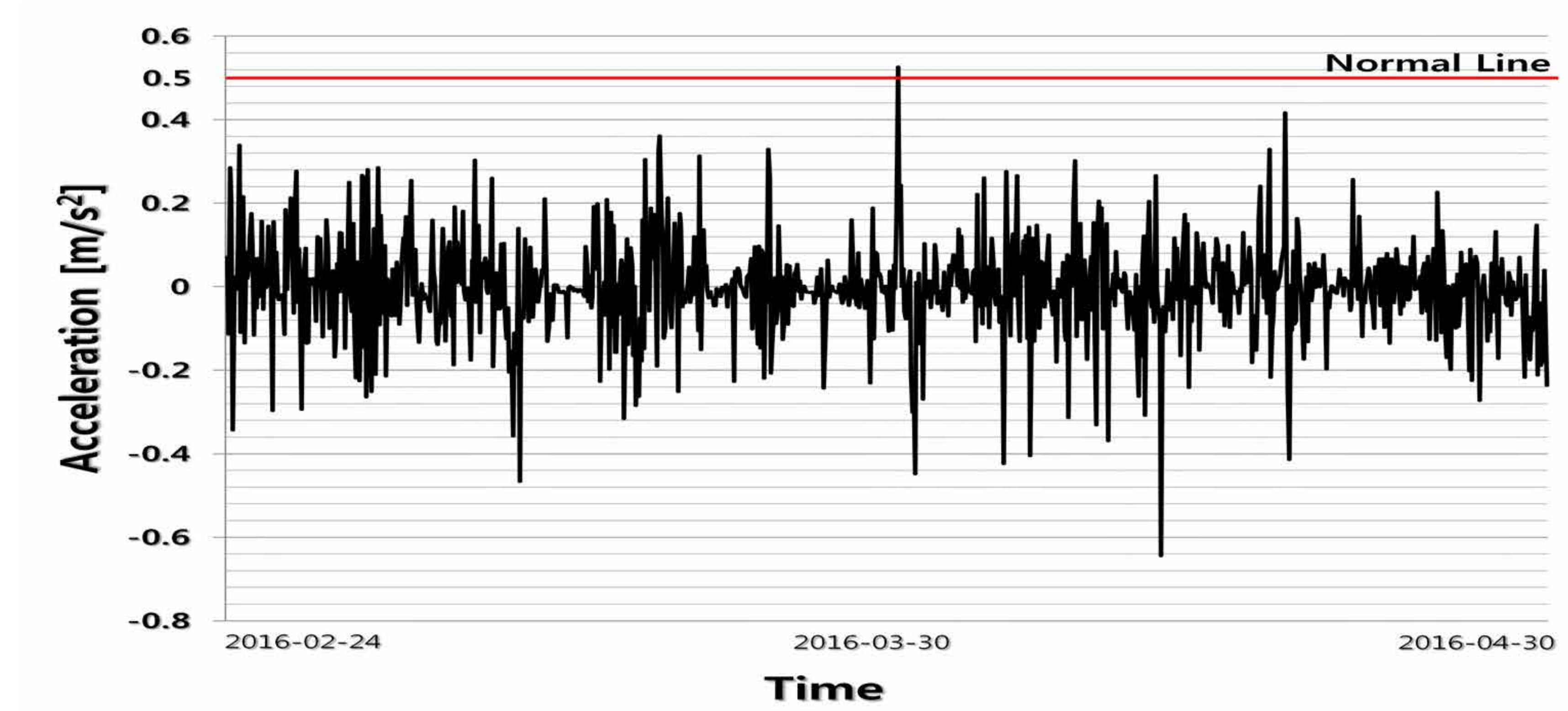

Fig. 4 Trend signal of HSS at gearbox (Normal level : 0.5[m/s^2], Source: VDI3834)

Table 1. Specification and defect frequency of gearbox bearing

Number of bearing		1th	2th	4th	5th	6th	7th	8th	9th	10th
Type of bearing		Cylindrical Roller Bearing								
Number of rollers		19	14	4	4	4	4	4	13	17
Reference speed (rpm/60)		40	40	11	5	4	8	8	30	37
Roller diameter		54	68	58	53	63	51	51	82	65
Pitch diameter		243	224	280	590	745	400	400	272	268
Defect Frequency (Hz)	Inner race	464	365	25	12	9	17	17	254	387
	Outer race	296	195	17	10	7	13	13	136	236
	Roller	86	59	20	27	22	26	26	35	57
	Cage	16	14	4	2	2	3	3	10	14
Bearing Model										

N = Number of rollers

ω = Inner race speed

d = Roller diameter

D = Roller pitch diameter

α = Contact angle

$$f_{inner} = \frac{1}{2}N\omega\left(1+\frac{d}{D}\cos\alpha\right)$$

$$f_{outer} = \frac{1}{2}N\omega\left(1-\frac{d}{D}\cos\alpha\right)$$

$$f_{roller} = \frac{1}{2}\omega\left(\frac{D}{d}\right)\left[1-\left(\frac{d}{D}\cos\alpha\right)^2\right]$$

$$f_{cage} = \frac{1}{2}\omega\left(1-\frac{d}{D}\cos\alpha\right)$$

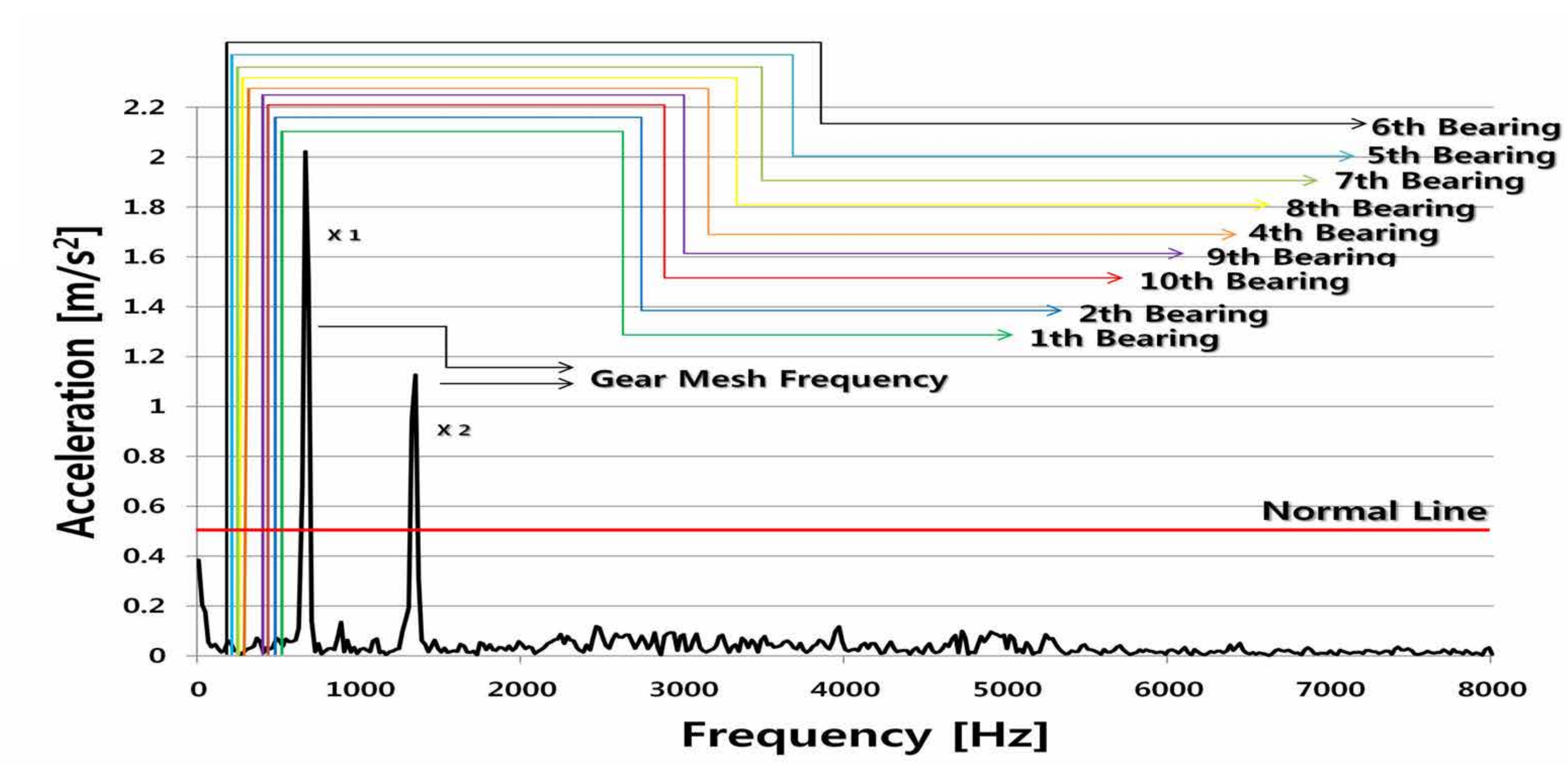

Fig. 5 Frequency spectrum of HSS at gearbox and Defect frequency of bearing inner race (Normal level : 0.5[m/s^2], Source: VDI3834)

Conclusions

1. Defect frequencies of bearings of gearbox were estimated in the range from 464hz to 9hz and these frequencies were found to be nearly the gear mesh frequency.
2. Based on the vibration acceptance level which was suggested by VDI3834 standard, the acceleration values of defect frequency were lower than normal level, 0.5 m/s^2.
3. It was estimated that vibration behavior of the bearings was within the range of normal operation, which led to the conclusion that there were not any defects for the bearings.

References

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