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Bearing Vibration Analysis on Steam Turbine

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Abstract: ***The steam turbine is a rotating machine so it will continue to experience shaft shifts axially and radially which can cause vibrations. Therefore, we need a tool such as monitoring and proximity probe sensors so that vibrations in the turbine when operating can be monitored. One of the tools that can be used to detect the cause of damage to the steam turbine bearings at PT. Supreme Energy Muara Laboh (SEML) is a System One Bently Nevada application that is connected to a turbine bearing to read the spectrum and the waveform. The resulting spectrum and waveform are then analyzed according to the Mobius Institute Standard. Based on the results of the vibration analysis on the steam turbine PT. SEML shows that bearing 1 indicates unbalance, bearing wear and angular misalignment. Bearing 2 has unbalance, bearing wear, parallel misalignment and angular misalignment, bearing 3 indicates parallel misalignment, and bearing 4 indicates unbalance, parallel misalignment and angular misalignment.***

Keywords: Turbine, Bearing, Spectrum, Waveform, Unbalance, Bearing Wear, Misalignment

1. Introduction

PT. Supreme Energy Muara Laboh (SEML) Muara Laboh, West Sumatra is a Geothermal Power Plant with a capacity of 85 MW. In operation, the steam turbine occasionally emits vibrations which indicate a symptom of damage to one of its components. If the turbine vibration is left in a high condition, the unit can trip up to ± 50% so that it is unable to supply electrical energy. Vibration is defined as the back and forth movement of the mechanical components of a machine as a reaction to the presence of internal and external forces, such as: unbalance, resonance, misalignment, bearing defects, loose retaining bolts, Oil Whirl, rubbing, and water hammering [1].

There are several methods used to detect vibrations in steam turbines, including using the System One Bently Nevada application. This application is a vibration analyzer on mechanical equipment that is connected to a turbine bearing and fitted with several proximity sensors then connected to the 3500 module. In this module the data is processed into information that can be monitored on a computer screen using the System One Bently Nevada application so that the spectrum and waveform from the vibrations that occur in the bearing will be seen clearly so that this data can be used to analyze the causes of the vibrations that occur in the turbine.The objectives to be achieved are: (1) knowing the factors that cause vibration and the type of vibration on the turbine, and (2) knowing the types of maintenance actions that can be carried out so that they can carry out maintenance steps according to turbine procedures and specifications

2. Literature Survey

The steam turbine is a power generating machine whose main part is a rotating rotor connected by coupling to an electric generator. The rotor consists of blades mounted on a shaft. VibrationSteam turbine rotors that can cause damage are rotor bending, rotor rubbing, Short Turn to Turn on the rotor and casing misalignment and rotor unbalance [2][3][4]. Vibration is the response of a system to the force received by the engine, both from within and from outside [6][7]. The force received by the system can be sourced from failure or damage to equipment or components of the equipment, for example, a rotor has high vibration due to damaged insulation, which causes short turn to turn [8].

Several studies related to turbine vibration, among others: Kurniawan [9] defined that unbalance and misalignment on the turbine shaft will increase the vibration value with a typical vibration pattern on the spectrum. unbalance has a dominant peak of 1x rpm in the spectrum, while misalignment has a dominant peak at 3x and 6x engine rpm. Looseness on machines that experience unbalance and misalignment will affect the overall vibration value and vibration pattern on the spectrum. Rotary engine model that experiences axial misalignment finds that the overall vibration trend is not always directly proportional to the increase in misalignment.

Sutar et al [10] conducted a case study of several vibration problems on a rotating machine and analyzed the frequency and phase to determine the cause of the vibration. Saleem et al [11] found a method for detecting unbalance in a rotary engine using "Deflected Shape of Shaft". Yamamoto et al [12] developed a method to detect unbalance by combining vibration analysis and FFT using a Programmable Gate Array.

Kumar et al [13] observed the engine unbalanced condition at several shaft rotational speeds. Dang et al [14] conducted an unbalance experiment on a rotary machine and calculated several coefficients from each experiment to find the mass of unbalance correction. Yanto [15] conducted an experiment by placing a mass on two prototype rotor disks at various angle orientations to get a location where the unbalanced vibration has the smallest amplitude. Senthilkumar and Sendhilkumar [16] conducted experiments and found different frequency characteristics in the spectrum for different coupling types. Wang and Chen [17] carried out numerical modeling of the looseness machine to analyze the characteristics of asynchronous responses. Yang et al [18] conducted an experiment to determine the relationship between fatigue and bolt looseness. Wang et al [19] performed a looseness simulation using a rotor model with several looseness conditions and concluded that the vibrational waveform has periodic impact, asymmetry, and has several frequencies. Nataraj and Baskaran [20] suggested that the Bartlett Power Spectral Density (BPSD) method can be used to diagnose problems on the rotor if there are misalignment and looseness problems. Wei et al. [21] conducted experiments on a loose rotor system with different torsional loads, then performed a calculation simulation based on the experimental data. An and Zhang [22] conducted an experiment using the mode decomposition method to diagnose looseness in the rotor system.

3. Methods/Approach

The research was conducted at the Geothermal Power Plant, PT. Supreme Energy Muara Laboh (SEML) Muara Laboh, West Sumatra, Indonesia. Data collection starts in September-December 2020. Data collection methods are set out as follows:

1) Vibration measurements are taken at each sensor mounting point on each turbine and generator bearing as shown in Figure 1, namely 2 bearings on the turbine and 2 bearings on the generator. Each bearing is installed with 2 vibration sensors (Proximity sensors (Figures 2 and 3)) which are connected to a vibration monitoring system using the System One Bently Nevada app.

Information:
Turbine bearing 1, radial direction X (T1X)
Turbine bearing 1, radial direction Y (T1Y)
Turbine bearing 2, radial direction X (T2X)
Turbine bearing 2, radial direction Y (T2Y)
Generator bearing 1, radial direction X (G1X)
Generator bearing 1, radial direction Y (G1Y)
Generator bearing 2, radial direction X (G2X)
Generator bearing 2, radial direction Y (G2Y)

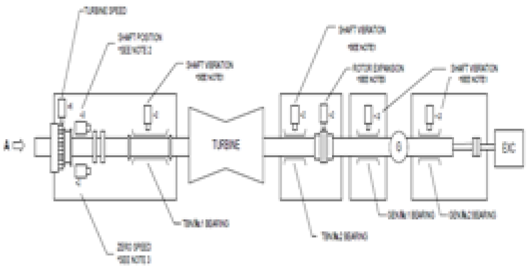

Figure 1: Data Collection PointVibration

Figure 2: Proximity Sensor

Figure 3: Sensor Installation on Turbine Bearing

2) The vibration value is obtained from the observation of trending vibrations on the System One Bently Nevada monitor screen (Figure 4) in the Central Control Room (CCR) of PT SEML in September 2020-December 2020. Data collection is carried out once a week.

Figure 4: System One ApplicationBentlly Nevada

3) Vibration value data on applications that cause alarms or trips are based on the standards applied to the steam turbine operating safety system, namely: if the vibration value has reached 125 m pk-pk then the turbine safety system will give an alarm, if the vibration value reaches 250 m pk-pk then the turbine safety system will instruct to trip the turbine to avoid damage. Standard vibration values used to protect turbines from potential damage. The Steam turbine vibration value standard is PT. SEML uses the ISO 20816-2: 2017 (E) standard as shown in Table 1.

Table 1: ISO 20816-2: 2017 (E) Standard

ISO 20816-2:2017(E)

Table — Values for shaft absolute vibration peak-to-peak displacement at zone boundaries

		Shaft *absolute* vibration peak-to-peak displacement at zone boundaries µm		
	Shaft rotational speed r/min	Zone boundary		
		A/B	B/C	C/D
Steam turbine, generator	1 500	120	240	385
	1 800	110	220	350
	3 000	100	200	300
	3 600	90	180	270

Zone A: The vibration of newly commissioned machines normally falls within this zone.
Zone B: Machines with vibration within this zone are normally considered acceptable for unrestricted long-term operation.
Zone C: Machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.
Zone D: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

4) The recorded data is analyzed one by one to obtain information when the vibration value changes far from the average when the turbine is running. Furthermore, it is checked when there is a drastic change in the vibration value. This becomes the basis for identifying the cause of vibration. In addition, the vibration value will be compared with the steam turbine alarm and trip level to determine the vibration value within the permissible range (the basis of the analysis is shown in Table 2).

Table 2: Vibration Data Records

DATE	NO	VIBRATION POS	AVG VALUE	ALARM um P-P	TRIP um P-P	STATUS
01/09/2021	1	TURBINE BRG 1X	100	125	250	ACCEPTABLE
	2	TURBINE BRG 1Y	150	125	250	CONCERN
	3	TURBINE BRG 2X	250	125	250	PROBLEM
	4	TURBINE BRG 2Y	255	125	250	PROBLEM
	5	GENERATOR BRG 1X	100	125	250	ACCEPTABLE
	6	GENERATOR BRG 1Y	150	125	250	CONCERN
	7	GENERATOR BRG 2X	250	125	250	PROBLEM
	8	GENERATOR BRG 2Y	255	125	250	PROBLEM

125 (µm-P-P)	ACCEPTABLE
≤ 125 (µm-P-P)	CONCERN
≥ 250(µm-P-P)	PROBLEM

5) If the vibration value is below 125µm pk-pk, it will be categorized as "ACCEPTABLE" so that value needs to be monitored for potential damage that may occur. If the vibration value reaches 125 m pk-pk, then it is categorized as "CONCERN" so it is necessary to further analyze the causes of vibration and limit the operation of the turbine. If the vibration value reaches 250 m pk-pk then it is categorized as a "PROBLEM" so it is necessary to stop the turbine operation and make repairs.
6) Next, analyze the spectrum and waveform patterns to determine the cause of damage to the bearing and rotor of the steam turbine. The formed spectrum and waveform patterns are then compared with the damage patterns and diagnosed using a spectrum pattern approach based on the Mobius Institute Training Center Standard (Figure 5).

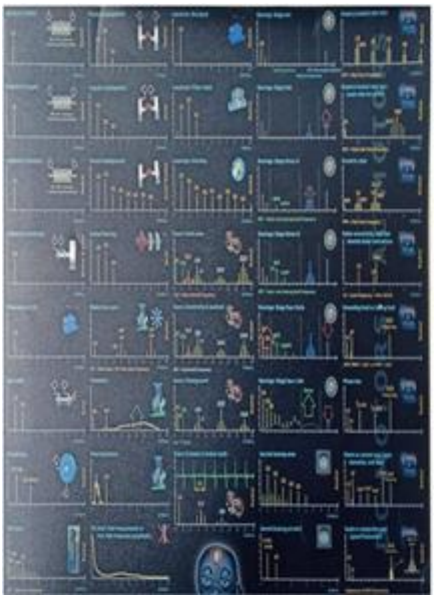

Figure 5: Vibration Spectrum Standard Mobius Institute Training

4. Results and Discussion

The results of the collection of Vibration data on the Steam Turbine are shown in Table 3.

Table 3: Vibration Data of Steam Turbine

Date	TURBINE BRG 1X (µm-P-P)	TURBINE BRG 1Y (µm-P-P)	TURBINE BRG 2X (µm-P-P)	TURBINE BRG 2Y (µm-P-P)	GEN BRG 1X (µm-P-P)	GEN BRG 1Y (µm-P-P)	GEN BRG 2X (µm-P-P)	GEN BRG 2Y (µm-P-P)	ALARM VALUE (µm-P-P)	TRIP VALUE (µm-P-P)
01-Sep-20	17,09	7,93	18,77	7,17	17,55	18,92	33,12	19,38	125	250
08-Sep-20	23,50	8,70	23,20	6,41	15,72	20,91	30,98	21,98	125	250
17-Sep-20	12,66	8,70	16,79	15,57	25,79	17,24	51,14	19,69	125	250
22-Sep-20	Plant Shutdown								125	250
29-Sep-20									125	250
06-Oct-20	73,27	32,51	73,12	44,57	33,58	21,67	53,27	36,63	125	250
13-Oct-20	29,76	11,90	21,21	9,46	20,45	23,50	31,75	19,38	125	250
20-Oct-20	28,24	12,05	21,21	9,46	19,69	23,50	31,75	19,38	125	250
27-Oct-20	28,85	12,21	26,25	9,46	19,84	23,50	28,39	19,38	125	250
03-Nov-20	24,42	9,92	23,05	9,46	17,55	23,50	32,97	19,38	125	250
09-Nov-20	25,95	9,92	26,40	9,46	18,92	23,50	30,22	19,38	125	250
14-Nov-20	28,69	14,95	31,29	16,79	19,53	21,82	36,63	21,06	125	250
15-Nov-20	60,45	45,03	109,45	59,68	25,64	42,64	42,13	30,68	125	250
24-Nov-20	26,71	10,07	20,30	7,93	18,16	19,38	30,98	18,16	125	250
01-Dec-20	23,81	9,00	22,28	7,63	17,70	19,23	31,14	18,62	125	250
08-Dec-20	26,40	9,00	18,92	7,93	15,57	19,84	32,66	18,16	125	250
15-Dec-20	23,05	9,82	22,13	7,83	17,24	19,08	30,22	19,08	125	250
22-Dec-20	24,88	9,15	19,08	7,83	16,18	19,08	30,83	18,47	125	250
29-Dec-20	22,13	9,15	20,45	7,83	16,48	19,08	29,46	20,45	125	250
Average	29,40	13,53	30,23	14,38	19,74	22,14	34,57	21,13	125	250

Based on the vibration measurement data, the vibration value categories are shown in Table 4.

Table 4: Categories of vibration Values in Steam Turbines

Date	TURBINE BRG 1X (µm-P-P)	TURBINE BRG 1Y (µm-P-P)	TURBINE BRG 2X (µm-P-P)	TURBINE BRG 2Y (µm-P-P)	GEN BRG 1X (µm-P-P)	GEN BRG 1Y (µm-P-P)	GEN BRG 2X (µm-P-P)	GEN BRG 2Y (µm-P-P)	ALARM VALUE (µm-P-P)	TRIP VALUE (µm-P-P)	STATUS
01-Sep-20	17,09	7,93	18,77	7,17	17,55	18,92	33,12	19,38	125	250	ACCEPTABLE
08-Sep-20	23,50	8,70	23,20	6,41	15,72	20,91	30,98	21,98	125	250	ACCEPTABLE
17-Sep-20	12,66	8,70	16,79	15,57	25,79	17,24	51,14	19,69	125	250	ACCEPTABLE WITH NOTE
22-Sep-20	Plant Shutdown								125	250	ACCEPTABLE
29-Sep-20									125	250	ACCEPTABLE
06-Oct-20	73,27	32,51	73,12	44,57	33,58	21,67	53,27	36,63	125	250	ACCEPTABLE WITH NOTE
13-Oct-20	29,76	11,90	21,21	9,46	20,45	23,50	31,75	19,38	125	250	ACCEPTABLE
20-Oct-20	28,24	12,05	21,21	9,46	19,69	23,50	31,75	19,38	125	250	ACCEPTABLE
27-Oct-20	28,85	12,21	26,25	9,46	19,84	23,50	28,39	19,38	125	250	ACCEPTABLE
03-Nov-20	24,42	9,92	23,05	9,46	17,55	23,50	32,97	19,38	125	250	ACCEPTABLE
09-Nov-20	25,95	9,92	26,40	9,46	18,92	23,50	30,22	19,38	125	250	ACCEPTABLE
14-Nov-20	28,69	14,95	31,29	16,79	19,53	21,82	36,63	21,06	125	250	ACCEPTABLE
15-Nov-20	60,45	45,03	109,45	59,68	25,64	42,64	42,13	30,68	125	250	ACCEPTABLE WITH NOTE
24-Nov-20	26,71	10,07	20,30	7,93	18,16	19,38	30,98	18,16	125	250	ACCEPTABLE
01-Dec-20	23,81	9,00	22,28	7,63	17,70	19,23	31,14	18,62	125	250	ACCEPTABLE
08-Dec-20	26,40	9,00	18,92	7,93	15,57	19,84	32,66	18,16	125	250	ACCEPTABLE
15-Dec-20	23,05	9,82	22,13	7,83	17,24	19,08	30,22	19,08	125	250	ACCEPTABLE
22-Dec-20	24,88	9,15	19,08	7,83	16,18	19,08	30,83	18,47	125	250	ACCEPTABLE
29-Dec-20	22,13	9,15	20,45	7,83	16,48	19,08	29,46	20,45	125	250	ACCEPTABLE
Average	29,40	13,53	30,23	14,38	19,74	22,14	34,57	21,13	125	250	ACCEPTABLE

4.1 Vibration Value Fluctuation

Based on the vibration value category, there are 3 vibration spike conditions that occur in the steam turbine and generator, namely on September 17, 2020, October 6 2020, and November 15, 2020. The graph of the spike in the vibration value and the tendency of the spectrum pattern formed from the vibration are then analyzed to determine the cause of vibration. The fluctuation graph of the vibration value is processed using the Microsoft Excel application by inputting the vibration value data as shown in Figure 6.

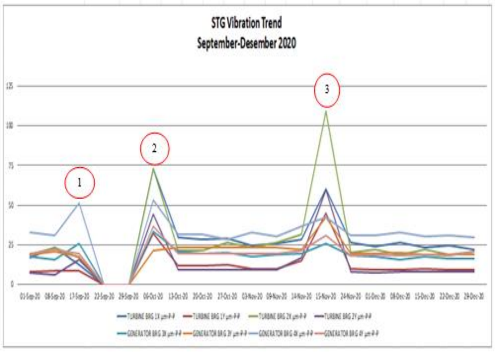

Figure 6: Vibration Data Fluctuation

Based on the vibrational fluctuations in Figure 6, it can be explained:

a) Condition-1: An increase in the vibration value occurred on September 17, 2020, a significant vibration surge value occurred in the 2Y turbine bearing from 6.41 m-PP to 15.57 m-PP, the 1X generator bearing from 15.72 m-PP to 15.72 m-PP. 25.79 m-PP, as well as 2X generator bearings from 30.98 m-PP to 51.14 m-PP.

b) Condition-2: On October 6, 2020, the vibration value spiked high during the initial operation of the turbine. Then the vibration value is stable under certain conditions. The vibration value jumped on the 1X turbine bearing from 12.66 m-PP to 73.27 m-PP, 1Y turbine bearing from 8.70 m-PP to 32.51 m-PP, 2X turbine bearing from 16.79 m-PP to 72.12 m-PP, turbine bearing 2Y from 15.57 m-PP to 44.57 m-PP, generator bearing 1X from 25.79 m-PP to 33.58 m-PP, generator bearing 1Y from 17, 24 m-PP to 21.67 m-PP, 2X generator bearing from 51.14 m-PP to 53.27 m-PP, and generator bearing 2Y from 19.69 m-PP to 36.63 m-PP. The vibration value becomes stable again until November 14, 2020.

c) Condition-3: An increase in the vibration value occurred again on November 15, 2020. The vibration value jumped in the 1X turbine bearing from 28.69 m-PP to 60.45 m-PP , the 1Y turbine bearing from 14.95 m-PP kei 45, 03 m-PP, 2X turbine bearing from 31.29 m-PP to 109.45 m-PP, 2Y turbine bearing from 16.79 m-PP to 59.68 m-PP, 1X generator bearing from 19.53 m-PP to 25.64 m-PP, generator bearing 1Y from 21.82 m-PP to 42.64 m-PP, generator bearing 2X from 36.63 m-PP to 42.13 m-PP, and at generator bearing from 21 .06 m-PP to 30.68 m-PP. The surge in the vibration value can be caused by an indication of damage to the turbine and operating conditions that are not in accordance with the SOP parameters or there are other disturbances.

4.2 Observations on Spectrum and Waveform

The spectrum and waveform obtained in the System One Bently Nevada application are shown in Figure 7. In the following explanation, only the increase in the vibration value in conditions 1. Conditions 2 and 3 are the same as in condition 1. Analysis of the vibration value of a 1-way radial turbine bearing. X(T1X), Y radial 1 way turbine bearing (T1Y), X radial 2 way turbine bearing (T2X), Y radial 2 way turbine bearing (T2Y), X radial 1 way generator bearing (G1X), and 1 way generator bearing, Y radial (G1Y), X radial 2 way generator bearing (G2X), and Y radial 2 way generator bearing (G2Y) as follows:

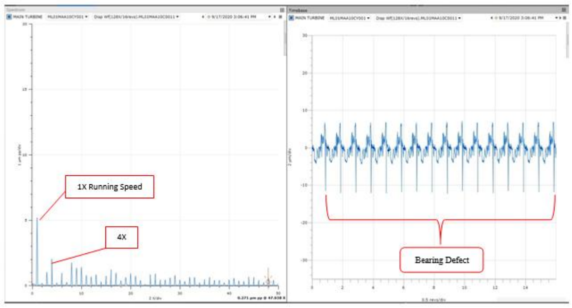

Figure 7: Bearing Vibration Spectrumat Point T1X

Figure 7 shows that the vibration spectrum at the T1X point with a frequency of 1X running speed is more dominant and harmonized (2X, 3X, 4X, etc.) at a relatively small amplitude value. This indicates an imbalance when referring to the spectrum pattern in Figure 8.

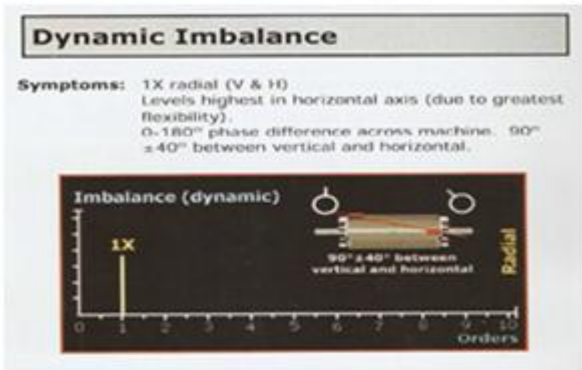

Figure 8: Unbalance Spectrum Pattern

Unbalance spectrum pattern in Figure 8, the dominant vibration amplitude appears at 1X running speed or called order. Order is a frequency multiple of the driving speed. If the turbine rotation speed is 3000 rpm (50 Hz), then the 1X order is equal to 50 Herzt.

Furthermore, the presence of spike vibration on the waveform shows an indication of bearing wear on the number 1 turbine bearing with reference to the shape of the waveform pattern from the Mobius Institute Standard in Figure 9.

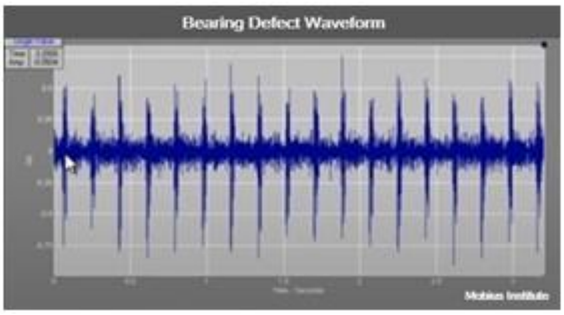

Figure 9: Bearing Waveform Pattern Defects

The bearing vibration spectrum at the T1Y point (Figure 10) with a frequency of 4X is more dominant than the frequency of 1X running speed and is harmonized (2X, 3X, 4X, etc.) at a relatively small amplitude value, indicating an angular misalignment, referring to the angular misalignment spectrum pattern in Figure 11, the dominant vibration amplitude appears at 1X running speed or at 1X order and is followed by multiple orders with a strong enough value, namely 4X orders. If 1X order is 50 Hz, then 4X order is equal to 200 Hz.

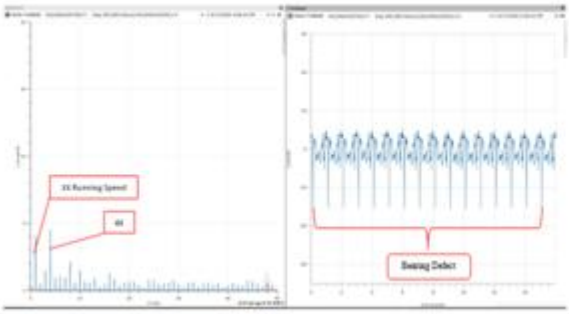

Figure 10: Bearing Vibration Spectrum at Point T1Y

In turbine bearing number 2 point T2X (Figure 12) with a frequency spectrum of 1X the running speed is more dominant than the 2X frequency and is in harmony (2X, 3X, 4X, etc.). This condition indicates an angular misalignment that occurs because of the angular misalignment spectrum pattern (Figure 11), the dominant vibration amplitude appears at 1X running speed or at 1X order and is followed by multiple orders with a strong enough value, namely at 2X orders. If 1X order is 50 Hz, then 2X order is equal to 100 Hz.

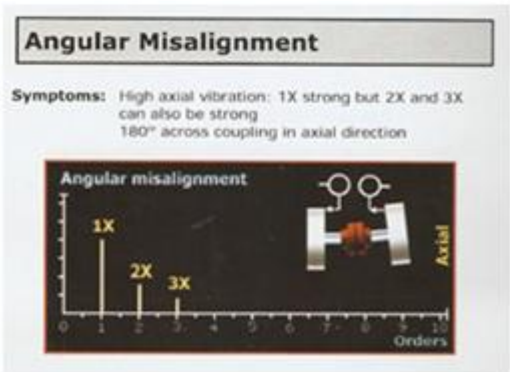

Figure 11: Angular spectrum pattern misalignment

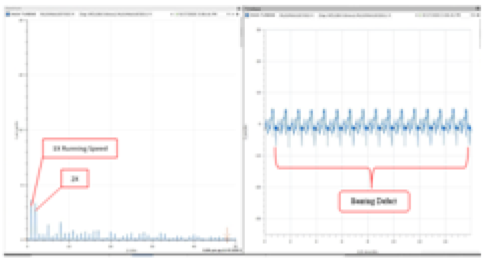

Figure 12: Vibration SpectrumBearing at Point T2X

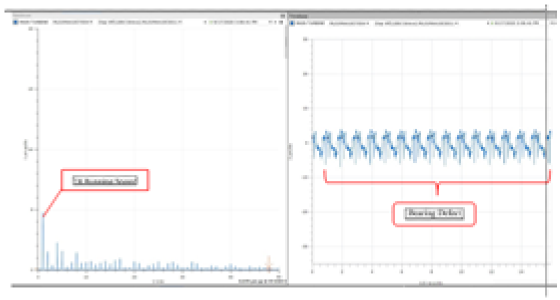

Figure 13: Bearing Vibration Spectrumat Point T2Y

At the T2Y point (Figure 13) it also shows that the vibration at the 1X running speed frequency is more dominant than the 4X frequency and is harmonized (2X, 3X, 4X, etc.) so that it is an indication of an unbalance referring to the reference spectrum pattern. In the spectrum patterns, the dominant vibration amplitude appears at 1X the running speed (order). If the turbine rotation speed is 3000 rpm (50 Hz), then the 1X order is equal to 50 Herzt.

Bearing number 3 on the generator side at points G1X (Figure 14) and G1Y (Figure 15) shows that the frequency is 2X more dominant than the 1X running speed frequency and is in harmony (2X, 3X, 4X, 8X, etc.). This indicates that there is a parallel misalignment that occurs in the turbine with the generator referring to the parallel misalignment spectrum pattern (Figure 16), the dominant vibration amplitude appears at 2X running speed or at 2X order and is followed by multiple orders with a lower value, namely at 1X, 4X and 8X orders. If 1X order is 50 Hz, then 2X order is equal to 100 Herzt. At high values, misalignment can cause fatigue, bearing wear, and an increase in bearing temperature.

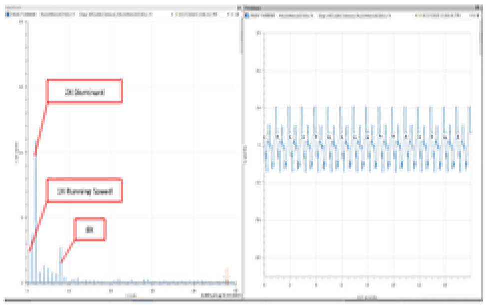

Figure 14: Bearing Vibration Spectrum at Point G1X

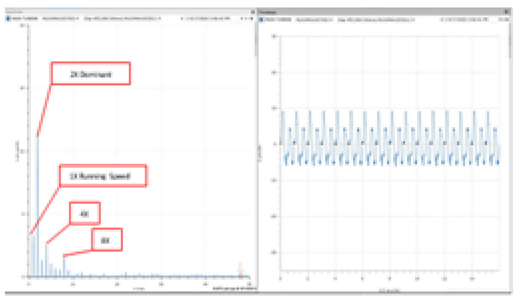

Figure 15: Bearing Vibration Spectrum at Point G1Y

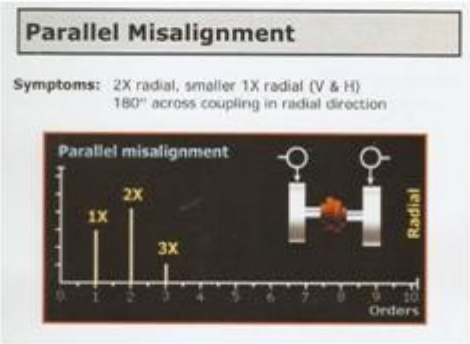

Figure 16: Parallel Spectrum Pattern Misalignment

Similar to points G1X and G1Y, bearing number 4 on the generator side at points G2X and G2Y with the vibration spectrum shown in Figure 17 and Figure 18 also shows that the frequency is 2X more dominant than the 1X running speed frequency and is harmonized (2X, 3X, 4X, 8X). , etc.). This indicates that there is a parallel misalignment of the turbine with the generator, referring to the parallel misalignment spectrum pattern. The dominant vibration amplitude appears at 2X running speed or 2X orders and is followed by multiple orders with lower values, namely 1X, 4X and 6X orders. If 1X order is 50 Hz, then 2X order is equal to 100 Hz.

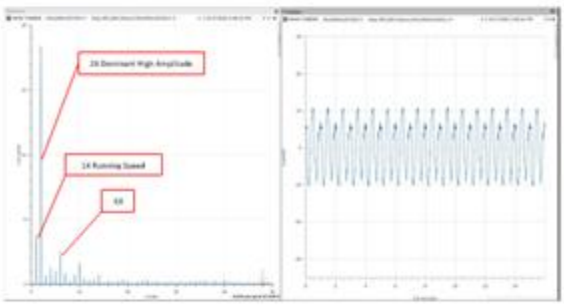

Figure 17: Bearing Vibration Spectrum at Point G2X

4.3 Bearing Fault Diagnosis

Based on the turbine damage analysis through spectrum and waveform observations obtained using the System One Bently Nevada application, it can be stated that the damage that occurred to the PT SEML steam turbine bearing system is shown in Table 5.

Table 5: Types of Bearing Damage

No.	Bearing Position	Damage Type
1	TIX	Unbalance, Angular Misalignment, Bearing Wear.
2	TIY	Unbalance, Angular Misalignment, Bearing Wear.
3	T2X	Unbalance, Angular Misalignment, Bearing Wear.
4	T2Y	Parallel Misalignment, Bearing Wear.
5	G1X	Parallel Misalignment
6	G1Y	Parallel Misalignment
7	G2X	Unbalance, Angular Misalignment
8	G2Y	Parallel Misalignment

Based on Table 5, it can be concluded that during the 4 months of operation (September 2020 - December 2020), the turbine and generator bearings experienced 3 surges and the cause of the damage can be identified, namely: unbalance, angular misalignment, parallel misalignment, and bearing wear.

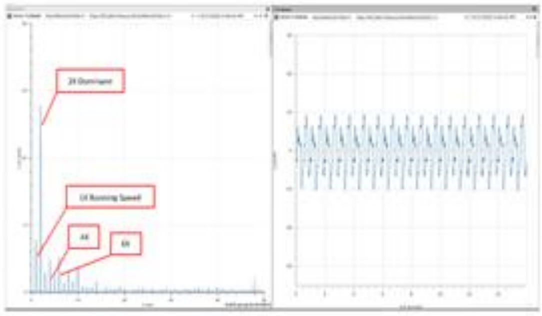

Figure 18: Bearing Vibration Spectrum at Point G2Y

4.4 Maintenance Recommendations

Maintenance recommendations for vibration on steam turbine and generator bearings at PT. SEML is as follows.

1) Angular misalignment and parallel misalignment of the steam turbine and generator bearings indicate the need to check the alignment of the turbine and generator as well as balancing during overhaul. The permissible vibration standard limit values are 125 m-P-P for the alarm limit and 250 m-P-P for the turbine trip limit.
2) Unbalance that occurs in bearings 1 and 2 of the turbine, and bearing 4 on the generator requires checking the condition of the turbine blade and turbine shaft from structural degradation. If there is a degradation of the turbine blade and turbine shaft structure, it is necessary to balance the turbine blade and turbine shaft.
3) Bearing wear indicates that there has been degradation of the babbit bearing layer, so it is necessary to check the condition of the babbit bearing for possible more severe damage, or repair/replace the bearing

5. Conclusions

Based on the results of the analysis of the spectrum and waveform on the vibration analyzer, it can be concluded that the bearing system on the steam turbine experienced a drastic increase in the vibration value for 3 times, with the highest vibration value at bearing 3 = 51.14 m-PP, bearing 1 = 73.27 m -PP), and bearing 2 =109.45 m-PP. The results of the vibration analysis on the steam turbine in bearing 1 indicate the presence of unbalance, bearing wear and angular misalignment; bearing 2 indicates unbalance, bearing wear, parallel misalignment and angular misalignment; bearing 3 indicates parallel misalignment, and bearing 4 indicates unbalance, parallel misalignment and angular misalignment.

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