# Vibration Analysis to Identify Damage to Slab Caster Fan Blowers at PT. XX

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## ABSTRAK

Pemeliharaan sama pentingnya dengan fungsi perusahaan lainnya. Karena kritisnya kegiatan pemeliharaan maka diperlukan perencanaan yang matang untuk menjalankannya agar terhentinya proses produksi akibat kerusakan dapat diminimalisir hal ini dapat dicegah dengan mendiagnosa mesin untuk menentukan kesalahan atau potensi kesalahan. Beberapa metode diagnosis yang tersedia untuk pemeliharaan telah diterapkan selama bertahun-tahun termasuk analisis oli, analisis sinyal getaran, analisis partikel, pemantauan karat, dan analisis sisa-sisa keausan. Di antara analisis ini, analisis sinyal getaran muncul sebagai pilihan popular kesalahan dapat diidentifikasi tanpa menghentikan mesin perubahan sinyal-sinyal ini sering menunjukkan adanya kesalahan. Metode yang digunakan dalam penelitian ini adalah analisis vibrasi menggunakan *microlog analyzer GX* yang akan mengidentifikasi sinyal getaran yang ditangkap oleh sensor dan dirubah menjadi *spectrum* serta disimpan di *clouds solution service* sehingga sinyal tersebut bisa menjadi acuan untuk mengidentifikasi masalah keseluruhan pada *equipment* tersebut. Dari hasil yang didapat *enveloping spectrum* bantalan 22220CC sisi *horizontal* analisis FFT Indikasi pada cacat lokal pada lintasan dalam bantalan pada bantalan ditunjukan dengan frekuensi *impuls* 1X, 2X, 3X, 4X, 5X, dan 6X FFT selaras dengan amplitudo puncak spektrum vibrasi dengan nilai 18,02gE disebut *Ball Pass Frequency Outer* (BPFO). hasil yang didapat *velocity spectrum equipment* sisi *horizontal* analisis FFT Indikasi pada *equipment* terjadi ketidak selarasan *(misalignment)* yang terjadi 1X, 2X, *peak.*

**Kata kunci: Vibrasi Analisis, Kerusakan *Fan Blower, Spectrum Analysis,* Identifikasi Sinyal Getaran**

## *ABSTRACT*

*Maintenance is as important as any other company function. Because of the criticality of maintenance activities, careful planning is needed to carry it out so that the stoppage of the production process due to damage can be minimized. This can be prevented by diagnosing the machine to determine the fault or potential fault. Several diagnosis methods available for maintenance have been applied over the years including oil analysis, vibration signal analysis, particle analysis, corrosion monitoring, and wear debris analysis. Among these analyses, vibration signal analysis is emerging as a popular option as faults can be identified without stopping the machine as these signal changes often indicate the presence of faults. The method used in this study is vibration analysis using the GX microlog analyzer which will identify the vibration signal captured by the sensor and converted into a spectrum and stored in the cloud solution service so that the signal can be a reference for identifying overall problems with the equipment. The method used in this research is vibration analysis using GX microlog analyzer which will identify the vibration signal captured by the sensor and converted into a spectrum and stored in the clouds solution service so that the signal can be a reference for identifying overall problems in the equipment. From the results obtained enveloping spectrum bearing 22220CC horizontal side FFT analysis Indications on local defects in the inner track of the bearing on the bearing are shown with impulse frequencies 1X, 2X, 3X, 4X, 5X, and 6X FFT aligned with the peak amplitude of the vibration spectrum with a value of 18.02gE called Ball Pass Frequency Outer (BPFO). the results obtained velocity spectrum equipment horizontal side FFT analysis Indications on equipment misalignment that occurs 1X, 2X, peak.*

***Keywords: Vibration Analysis, Fan Blower Damage, Spectrum Analysis, Vibration Signal Identification***

## INTRODUCTION

Maintenance plays an important role in a company's production activities, concerning the smoothness or disruption of production, production volume, and enabling products to be produced on time (not late) and received by consumers, as well as ensuring that there is no idle work during production due to machine downtime and damaged resources to minimize lost production costs or, if possible, to eliminate these costs. Therefore, the maintenance function is as important as other company functions. Because of the critical nature of maintenance activities, careful

planning is required to carry them out so that the cessation of the production process due to damage can be minimized.

Since rotating machines and electric motors are used to operate industrial machinery, problems arise from vibrations in these machines, causing various anomalies such as loose bolts, rapid wear of machine parts, misaligned shafts, unbalanced rotors, and so on. These situations increase energy dissipation due to vibration, causing resonance and dynamic loads on bearings. This can lead to direct machine failure, requiring automatic shutdown due to protection from the electrical system or measuring instruments.

Good maintenance improves company performance, meets customer needs in a timely manner, and minimizes the investment allocated for equipment and machinery. Furthermore, proper maintenance can improve product quality and reduce waste, thus lowering production costs. Machine maintenance is necessary to extend the lifespan of fan blowers. Preventive measures must be taken beforehand to prevent further damage to the machine. One way to prevent this is by monitoring machine vibration. Undetected blower damage early can lead to more serious damage. A damaged steam fan can cause significant losses, as it halts production, wastes raw materials that should have been processed, and workers are laid off due to machine downtime. Vibration from a blower fan can be caused by things like misaligned or abnormal bearings.

Careful monitoring of machinery is essential, and sudden failures can result in significant losses for the company. This can be prevented by diagnosing machinery to identify faults or potential faults, such as imbalance, wear, misalignment, damaged bearings, friction swirls, and cracked gearbox teeth. Several diagnostic methods have been implemented over the years, including oil analysis, vibration signal analysis, particle analysis, corrosion monitoring, acoustic signal analysis, and wear residue analysis. Among these, acoustic and vibration signal analysis have emerged as popular options, as faults can be identified without stopping the machine, as changes in these signals often indicate faults. Figure 1 shows the vibration values and their spectrum types.

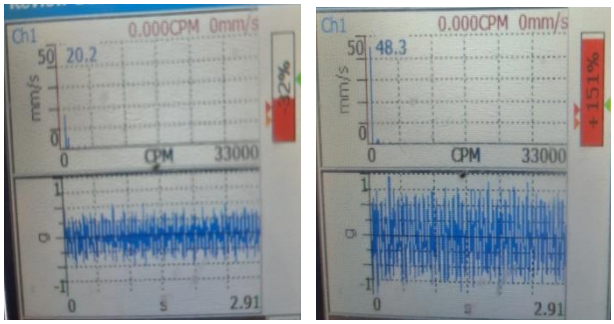



Figure 1. Signal Spectrum Steam Fan Blower Slab Caster 2

The vibration signature of damage is unique, so by analyzing the vibration signal, we can characterize the type of damage. The advantage of this method is that it does not require disassembly or downtime to determine repair needs and damage description. Monitor the condition of processing equipment and diagnose vibration with the help of the GX microlog analyzer. Machine vibration is a complex combination of signals originating from various vibration sources within the machine. Vibration can be described in its components. Vibration can be generated by imperfections in the machine, such as rotor imbalance, bearing failure, bearing defects, and gear damage, each with a unique frequency. By displaying the vibration amplitude as a function of frequency (vibration spectrum), by using a measuring tool in the form of a vibration analyzer, we can obtain an overview of the machine's condition, the cause of the machine's damage, and even downtime by knowing the vibration level and type of spectrum, as shown in Figure 2.

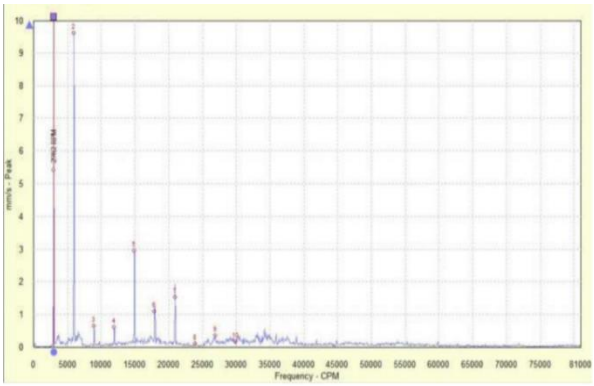


Figure 2. Example of Misalignment Vibration Signal

## RESEARCH METHODS

The stages of this research are based on the flow chart as shown in Figure 3.

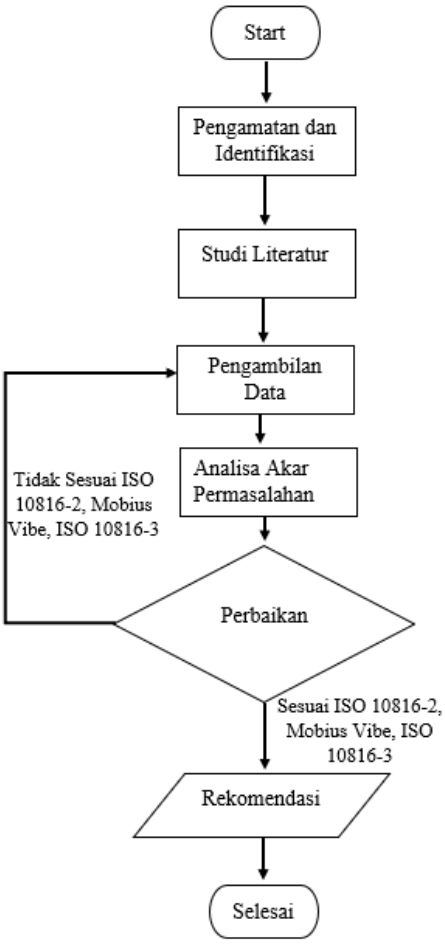


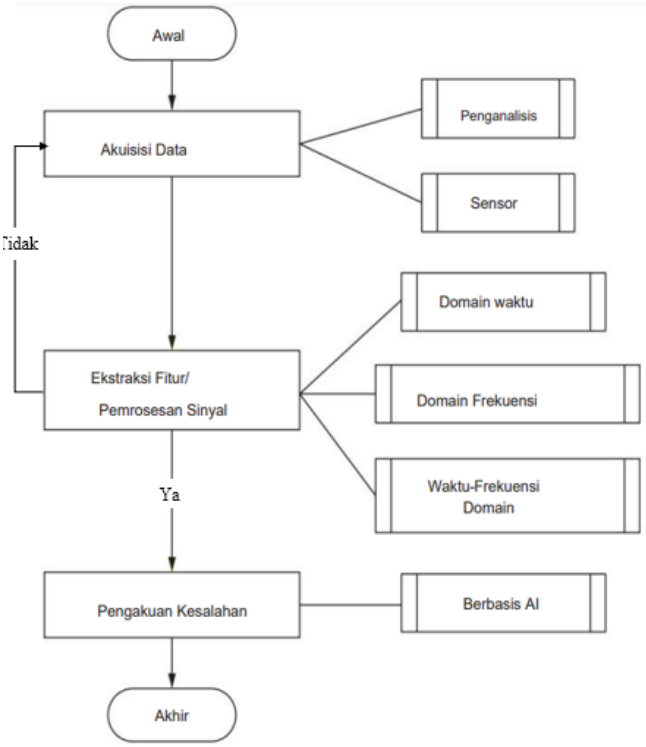

Figure 3. Research Flowchart

**Research Stages**

In this research, there are several stages that researchers will undertake to gain knowledge and solve problems faced in scientific research. There are several stages that must be passed properly. There are three stages of research that will be discussed in this discussion, namely the planning stage, the research implementation stage, and the research report stage. Research activities are a process of acquiring or obtaining knowledge or solving problems faced, which is carried out scientifically, systematically and logically. In research in any field, these stages are generally similar, although there are several things that often occur in their implementation by researchers according to the conditions and situations faced without ignoring the general principles used in the research process.

**Vibration Data Collection Procedure**

1. Prepare the Skf clouds vibration, then enter the rpm data, motor kW, bearing type and bearing number, lubrication type and vibration data collection point data on the clouds vibration then download the data on the microlog analyzer GX, the processing flowchart can be seen in Figure 4.Gambar 4. *Flowchart* Pemrosesan *Microlog Analyzer*




2. Collect vibration data on the equipment at radial (vertical, horizontal) and axial points.
3. Collect bearing data on the horizontal envelopment.
4. After the data is saved in the GX microlog analyzer, upload it to SKF Cloud Vibration.
5. Analyze the data in the software, taking into account the equipment's vibration history, as shown in Figure 5.

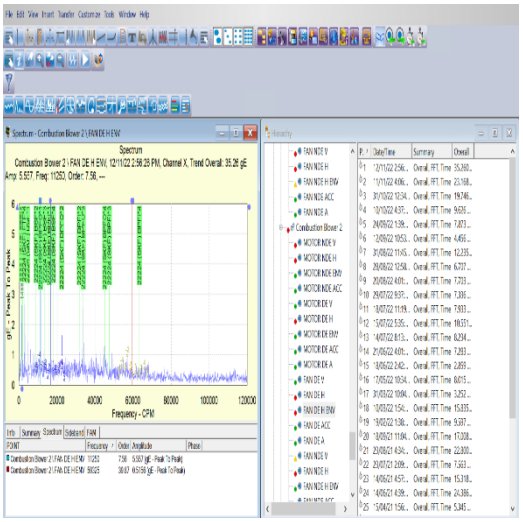


Figure 5. *Clouds Solution Service*

## RESULTS AND DISCUSSION

### NDE Motor Monitoring Results

Table 1. NDE Motor Monitoring Results.

| No | Date | Freq Hz (CPM 0-33000) | Motor NDE | | | |
|---|---|---|---|---|---|---|
| | | | Vertical (mm/s) | Horizontal | | |
| | | | | Velocity (mm/s) | ACC (g) | Enveloping (gE) |
| 1 | 22-Jul-23 | 0 - 550 | 6,172 | 3,69 | 0,332 | 1,35 |
| 2 | 10-Agust-23 | 0 - 550 | 6,2 | 3,7 | 0,514 | 1,87 |
| 3 | 11-Agust-23 | 0 - 550 | 6,01 | 3,85 | 0,756 | 1,57 |
| 4 | 13-Agust-23 | 0 - 550 | 6,2 | 3,79 | 0,5 | 1,29 |
| 5 | 17-Sep-23 | 0 - 550 | 6,89 | 11,52 | 0,35 | 2,23 |

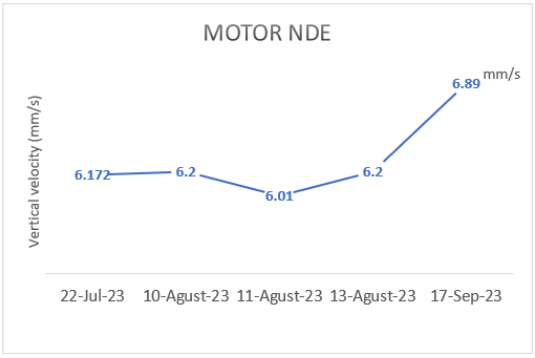



Figure 6. Motor NDE Vertical Velocity Curve

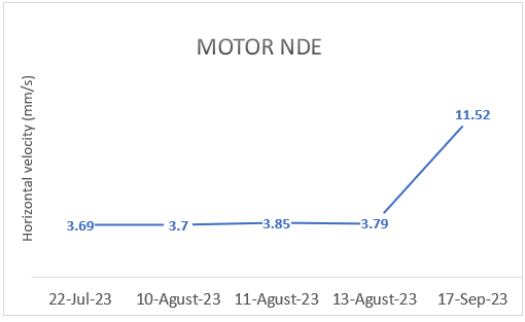



Figure 7. NDE Horizontal Velocity Motor Curve

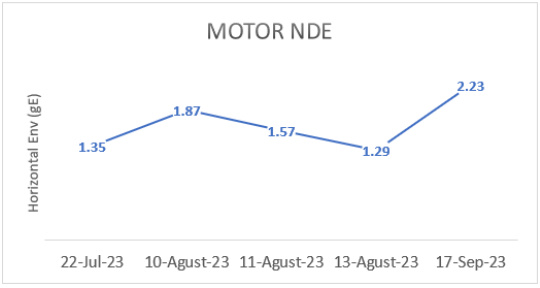



Figure 8. Horizontal Enveloping NDE Motor Curve

If we look at the curve, there is an increase and decrease in vibration in the vertical velocity as in Figure 6. The position on the horizontal velocity NDE motor also experiences an increase and decrease in vibration as in Figure 7. The position on the horizontal enveloping NDE motor experiences an increase and decrease in vibration as in Figure 8.

### DE Motor Monitoring Results

Table 2. DE Motor Monitoring Results.

| No | Date | Freq Hz (CPM 0-33000) | Motor DE | | | | |
|---|---|---|---|---|---|---|---|
| | | | Vertical (mm/s) | Horizontal | | | Axial (mm/s) |
| | | | | Velocity (mm/s) | Acc (g) | Enveloping (gE) | |
| 1 | 22-Jul-23 | 0 - 550 | 8,77 | 5,31 | 0,141 | 4,4 | 4,33 |
| 2 | 10-Agust-23 | 0 - 550 | 9,8 | 9,5 | 0,398 | 1,2 | 4,8 |
| 3 | 11-Agust-23 | 0 - 550 | 9,9 | 9,2 | 0,273 | 2,06 | 4,4 |
| 4 | 13-Agust-23 | 0 - 550 | 9.91 | 9,16 | 0,225 | 2,46 | 4,9 |
| 5 | 17-Sep-23 | 0 - 550 | 5,1 | 5,48 | 0.228 | 3,12 | 4,11 |

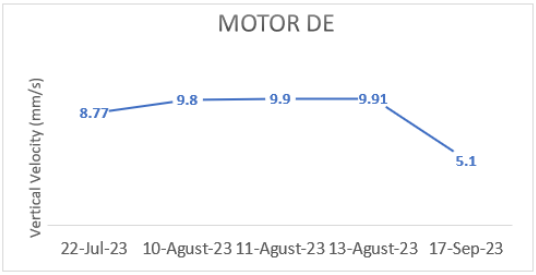



*Figure 9. Motor DE Vertical Velocity Curve*

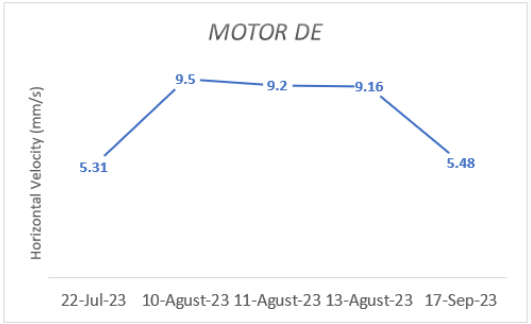



Figure 10. DE Horizontal Velocity Motor Curve

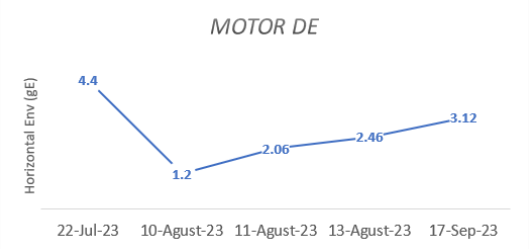



Figure 11. Horizontal Enveloping DE Motor Curve

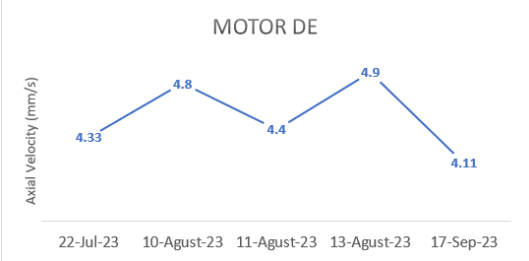



Figure 12. Motor DE Axial Velocity Curve

If we look at the curve, there is an increase and decrease in vibration in the vertical velocity as in Figure 9. The position on the DE horizontal velocity motor also experiences an increase and decrease in vibration as in Figure 10. The position on the DE horizontal enveloping motor experiences an increase and decrease in vibration as in Figure 11. The position on the DE axial velocity motor also experiences an increase and decrease in vibration as in Figure 12.

**Monitoring Results and DE**

Table 2. Monitoring and DE Results.

| No | Date | Freq Hz (CPM 0-33000) | FAN DE | | | | |
|---|---|---|---|---|---|---|---|
| | | | Vertical (mm/s) | Horizontal | | | Axial (mm/s) |
| | | | | Velocity (mm/s) | ACC (g) | Enveloping (gE) | |
| 1 | 22-Jul-23 | 0 – 550 | 3,3 | 3.92 | 0,347 | 3,46 | 2,57 |
| 2 | 10-Agust-23 | 0 – 550 | 6,1 | 6,2 | 0,664 | 6,83 | 2,6 |
| 3 | 11-Agust-23 | 0 – 550 | 6,4 | 6,9 | 0,798 | 6,73 | 3,7 |
| 4 | 13-Agust-23 | 0 – 550 | 7,59 | 8,4 | 0,889 | 7,36 | 5,01 |
| 5 | 17-Sep-23 | 0 – 550 | 9,37 | 10,8 | 2,369 | 27,6 | 4,66 |

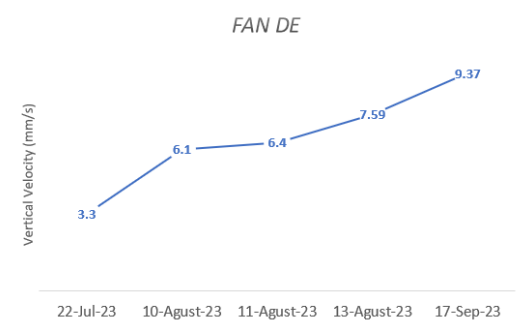



Figure 13. Fan DE Vertical Velocity Curve

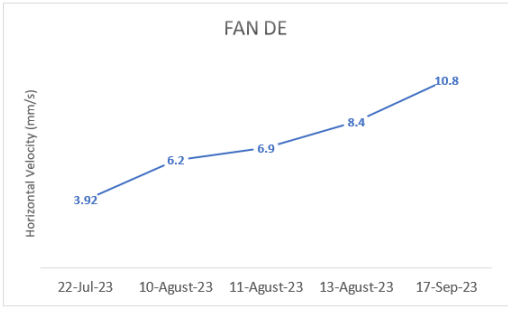



Figure 14. Fan DE Horizontal Velocity Curve

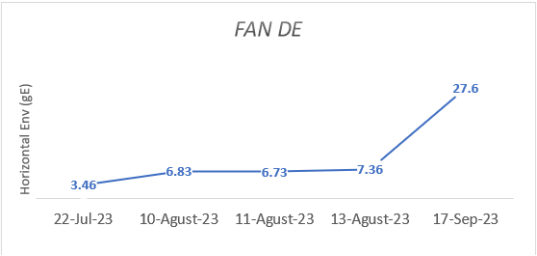



Figure 15. Horizontal Enveloping Fan DE Curve

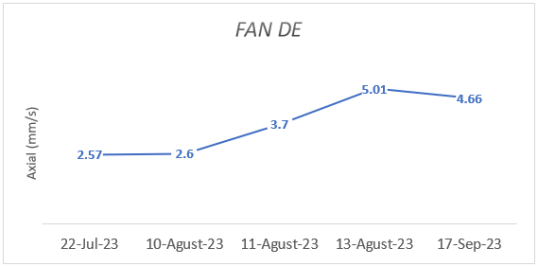



Figure 16. Fan DE Axial Velocity Curve

If we look at the curve, there is an increase and decrease in vibration in the vertical velocity as in Figure 13. The position of the DE fan horizontal velocity also experiences an increase in vibration as in Figure 14. The position of the DE fan horizontal enveloping experiences an increase in vibration as in Figure 15. The position of the DE fan axial velocity also experiences an increase in vibration as in Figure 16.

**NDE Fan Monitoring Results**

Table 3. NDE Fan Monitoring Results

| No | Date | Freq Hz (CPM 0-33000) | FAN NDE | | | | |
|---|---|---|---|---|---|---|---|
| | | | Vertical (mm/s) | Horizontal | | | Axial (mm/s) |
| | | | | Velocity (mm/s) | ACC (g) | Envelopin g (gE) | |
| 1 | 22-Jul-23 | 0 - 550 | 7,05 | 6,91 | 0,672 | 11.21 | 3,67 |
| 2 | 10-Agust-23 | 0 - 550 | 7,25 | 7,1 | 0,895 | 13,5 | 3,4 |
| 3 | 11-Agust-23 | 0 - 550 | 7.015 | 6,84 | 0,91 | 14,5 | 3,3 |
| 4 | 13-Agust-23 | 0 - 550 | 7,029 | 6,93 | 0,923 | 14,9 | 3,1 |
| 5 | 17-Sep-23 | 0 - 550 | 7,48 | 8,51 | 1,368 | 18,02 | 3,93 |

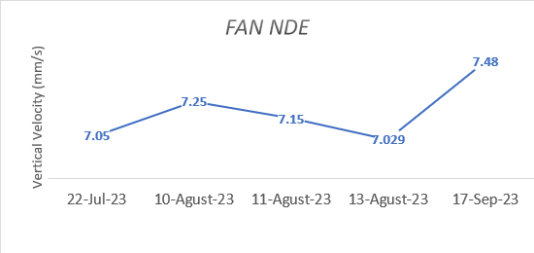



Figure 17. Fan NDE Vertical Velocity Curve

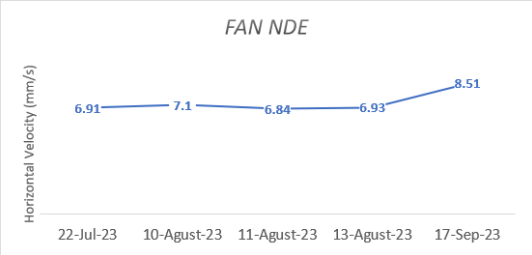



Figure 18. Fan NDE Horizontal Velocity Curve

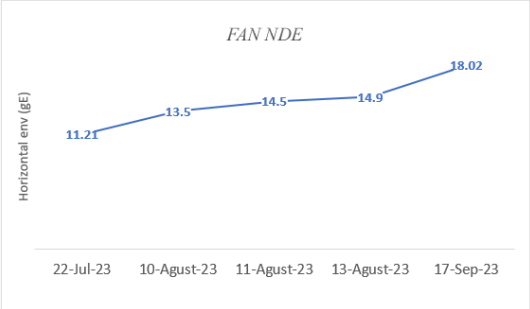



Figure 19. Fan NDE Horizontal Enveloping Curve

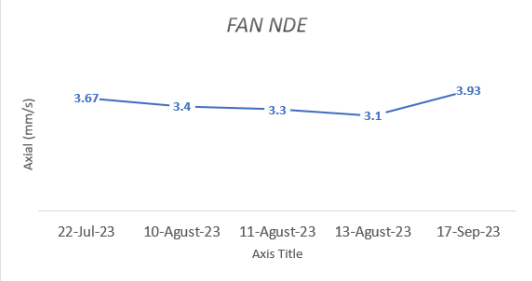



Figure 20. Fan NDE Axial Velocity Curve

If we look at the curve, there is an increase and decrease in vibration in the vertical velocity as in Figure 17. The position of the NDE horizontal velocity fan also experiences an increase and decrease in vibration as in Figure 18. The position of the NDE horizontal enveloping fan experiences an increase in vibration as in Figure 19. The position of the NDE axial velocity fan also experiences an increase in vibration as in Figure 20.

**Spectrum Enveloping and Acceleration Analysis**

Table 4 shows the results of the acceleration sideband analysis and spectrum enveloping which indicate damage to the cage, balls, inner and outer rings of the bearing as seen in Figure 21 with a peak value of 10.8 mm/s.

Table 4. Sideband Analysis of DE Fan Horizontal Velocity

| Active Trace | | | | |
|---|---|---|---|---|
| POINT | Information | Value | Value | Value |
| Steam Fan 2 \ FAN DE H | Measurement | 17/09/23 2:54:28 PM | | |
| | Speed | 1485 | | |
| | POINT description | | | |
| | Machine description | | | |
| | SET name | CASTER STEAM FAN \ Steam Fan 2 \ FAN DE H | | |
| | Location | | | |
| | Orientation | None | | |
| | Units | mm/s | | |
| | Full scale | 10 | | |
| | Low frequency cutoff | 300 | | |
| | Frequency range | 0 - 33000 CPM | | |
| | Detection | Peak | | |
| | Window | Hanning | | |
| | Lines | 1600 | | |
| | Averages | 2 | | |
| | Save Data | FFT and time | | |
| | Threshold | 1 | | |
| | Spectrum Overall | 10.8 | | |
| | Sync | 10.37 | | |
| | Subsync | 0.8163 | | |
| | Nonsync | 2.906 | | |

| POINT Summary | | |
|---|---|---|
| POINT | Information | Value |
| Steam Fan 2 \ FAN DE H | POINT description | |
| | Units | |
| | Measurement | 17/09/23 2:54:28 PM |

| Single Cursor | | | | |
|---|---|---|---|---|
| POINT | Frequency | Order | Amplitude | Phase |
| Steam Fan 2 \ FAN DE H | 1485 | 1 | 9.814 (mm/s - Peak) | |

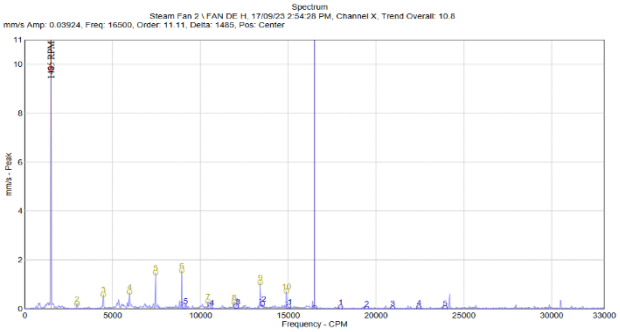



Figure 21. Spectrum of Data Collection Results and DE H

**DE Fan Condition Monitoring Results**

From the monitoring results obtained in the horizontal Fan DE measurement direction, there was a 1X peak increase with an overall spectrum of 10.8 mm/sec and followed by the presence of harmonics.

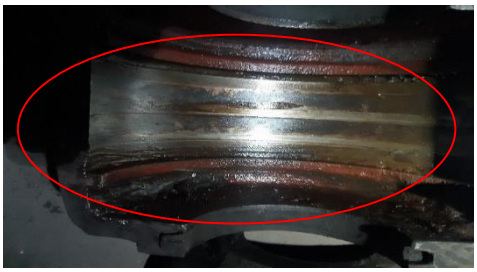


Figure 22. Erosion on the Bearing Housing

From the results of spectrum identification, harmonics appear after the peak point in the radial direction caused by loose bearing mountings as seen in Figure 22. In addition, structures such as machine feet, machine plates, and foundations are loose and prone to failure, as seen in Figure 23.



Figure 23. Looseness in Structure

**Enveloping Condition Monitoring Results**

From the results obtained enveloping spectrum of 22220CC bearing horizontal side on September 17, 2023 FFT analysis Indications of local defects in the inner track of the bearing on the bearing are indicated by impulse frequencies of 1X, 2X, 3X, 4X, 5X, and 6X FFT in line with the peak amplitude of the vibration spectrum with a value of 27.6gE as shown in Figure 24 and sideband analysis in Table 5 called Ball Pass Frequency Outer (BPFO). This also causes failure as shown in Figure 25 with sideband analysis shown in Table 6, as well as diagnostic order in Table 7.

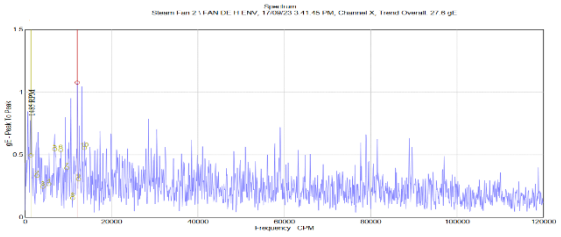


Figure 24. Spectrum Fan DE H Enveloping

Table 5. DE H Enveloping Sideband Fan

| Active Trace | | | | |
|---|---|---|---|---|
| POINT | Information | Value | Value | Value |
| Steam Fan 2 \ FAN DE H ENV | Measurement | 17/09/23 3:41:45 PM | | |
| | Speed | 1485 | | |
| | POINT description | | | |
| | Machine description | | | |
| | SET name | CASTER STEAM FAN \ Steam Fan 2 \ FAN DE H ENV | | |
| | Location | | | |
| | Orientation | None | | |
| | Units | gE | | |
| | Full scale | 25 | | |
| | Low frequency cutoff | 300 | | |
| | Frequency range | 0 - 120000 CPM | | |
| | Detection | Peak to peak | | |
| | Window | Hanning | | |
| | Lines | 1600 | | |
| | Averages | 2 | | |
| | Save Data | FFT and time | | |
| | Threshold | 2.5 | | |
| | Spectrum Overall | 9.154 | | |
| | Sync | 3.397 | | |
| | Subsync | 1.858 | | |
| | Nonsync | 8.295 | | |

| Diagnostics | | | | | |
|---|---|---|---|---|---|
| POINT | Index | Activity Index | Frequency | Order | Information |
| Steam Fan 2 \ FAN DE H ENV | 1 | 4.319 | 1375 | 0.9257 | |
| | 2 | 4.316 | 1866 | 1.257 | |
| | 3 | 3.863 | 4974 | 3.349 | |
| | 4 | 3.786 | 2685 | 1.808 | |
| | 5 | 3.424 | 12076 | 8.132 | 22220CC (SKF) BPFO |
| | 6 | 3.418 | 8089 | 5.447 | |
| | 7 | 3.314 | 9953 | 6.702 | |
| | 8 | 3.278 | 3113 | 2.096 | |

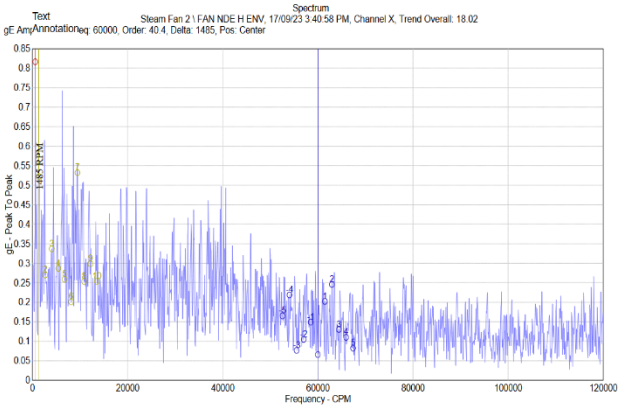



Figure 25. NDE H Enveloping Fan Spectrum

Tabel 6. Analisa *Sideband* Fan NDE H *Enveloping*

Tabel 7. *Diagnostics Order*

| Diagnostics | | | | | |
|---|---|---|---|---|---|
| POINT | Index | Activity Index | Frequency | Order | Information |
| Steam Fan 2 \ FAN NDE H ENV | 1 | 4.684 | 1358 | 0.9146 | |
| | 2 | 3.728 | 1673 | 1.127 | |

| Sideband Cursor | | | | | | |
|---|---|---|---|---|---|---|
| POINT | Position | Frequency | Order | Amplitude | dB | Delta Freq. |
| Steam Fan 2 \ FAN NDE H ENV | -5 | 52575 | 35.4 | 0.1648 | 7.96 | 1485 |
| | -4 | 54060 | 36.4 | 0.2185 | 10.41 | 1485 |
| | -3 | 55545 | 37.4 | 0.07629 | 1.271 | 1485 |
| | -2 | 57030 | 38.4 | 0.1044 | 3.992 | 1485 |
| | -1 | 58515 | 39.4 | 0.1489 | 7.081 | 1485 |
| | Center | 60000 | 40.4 | 0.0659 | 0 | --- |
| | 1 | 61485 | 41.4 | 0.202 | 9.73 | 1485 |
| | 2 | 62970 | 42.4 | 0.2453 | 11.42 | 1485 |
| | 3 | 64455 | 43.4 | 0.13 | 5.902 | 1485 |
| | 4 | 65940 | 44.4 | 0.1099 | 4.439 | 1485 |
| | 5 | 67425 | 45.4 | 0.08239 | 1.94 | 1485 |

**Horizontal Motor Condition Monitoring Results**

From the results obtained velocity spectrum equipment horizontal side on September 17, 2023 FFT analysis Indications on the equipment there is a misalignment that occurs 1X, 2X, peak or more FFT aligned with the peak amplitude of the vibration spectrum with a value of 11.52 mm / s at a frequency of 1485 Hz. The amount of measurement data obtained based on the threshold limit. Determination of the threshold limit depends on the measurement data to be stored for analysis, and the following misalignment data that occurred before and after repair in Figure 26. From the type of damage based on the frequency spectrum can be seen in Table 8 and recommendations for the level of bearing damage can be seen in Table 9.

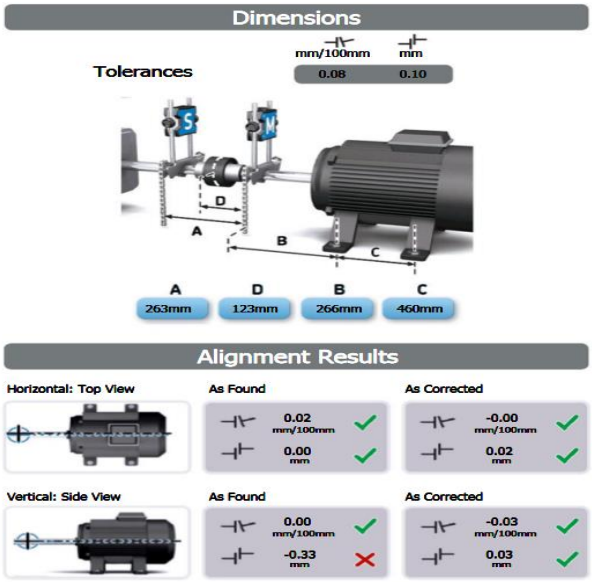



Figure 26. Misalignment Repair Data

| Active Trace | | | | |
|---|---|---|---|---|
| POINT | Information | Value | Value | Value |
| Steam Fan 2 \ FAN NDE H ENV | Measurement | 17/09/23 3:40:58 PM | | |
| | Speed | 1485 | | |
| | POINT description | | | |
| | Machine description | | | |
| | SET name | CASTER STEAM FAN \ Steam Fan 2 \ FAN NDE H ENV | | |
| | Location | | | |
| | Orientation | None | | |
| | Units | gE | | |
| | Full scale | 25 | | |
| | Low frequency cutoff | 300 | | |
| | Frequency range | 0 - 120000 CPM | | |
| | Detection | Peak to peak | | |
| | Window | Hanning | | |
| | Lines | 1600 | | |
| | Averages | 2 | | |
| | Save Data | FFT and time | | |
| | Threshold | 2.5 | | |
| | Spectrum Overall | 6.832 | | |
| | Sync | 2.751 | | |
| | Subsync | 1.358 | | |
| | Nonsync | 6.104 | | |

| POINT Summary | | |
|---|---|---|
| POINT | Information | Value |
| Steam Fan 2 \ FAN NDE H ENV | POINT description | |
| | Units | gE |
| | Measurement | 17/09/23 3:40:58 PM |

| Single Cursor | | | | |
|---|---|---|---|---|
| POINT | Frequency | Order | Amplitude | Phase |
| Steam Fan 2 \ FAN NDE H ENV | 600 | 0.404 | 0.8161 (gE - Peak To Peak) | |

Table 8. Types of System Damage Based on Frequency Spectrum

| No | *Machine Fault* | *frequency and axis found* | *Component found* | *Advanced severity* |
|---|---|---|---|---|
| 1 | *Parallel Misalignment* | *1X - Radial & tangential* | *Both sides of coupling* | *Higher amplitude 2X* |
| 2 | *Angular Misalignment* | *1X - Axial* | *Both sides of coupling* | *Higher amplitude 1X* |
| 3 | *Looseness* | *1X harmonics - All direction* | *On affected component* | *More harmonics, higher* |
| 4 | *Rolling element bearing loose in housing* | *Non-integer -All direction* | *On affected component* | *Harmonic, sidebands noise hump, noise floor* |

Table 9. Bearing Damage Level

| No | Nilai | *Severity* | Rekomendasi | Prioritas | Deskripsi Prioritas |
|---|---|---|---|---|---|
| 1 | 0 - 6,35 | *Slight* | Tidak perlu tindakan | 1 | Tidak ada rekomendasi perbaikan |
| 2 | 6,35 - 9,525 | *Moderate* | Monitoring vibrasi, Tidak perlu dilakukan perbaikan | 2 | Tidak ada tindakan perbaikan segera yang diperlukan |
| 3 | 9,525 - 10,795 | *Serious* | Perencanaan perbaikan | 3 | Perlu untuk segera dilakukan penjadwalan perbaikan |
| 4 | 10,795 - 13,97 | *Extreme* | Segera dilakukan perbaikan atau penggantian | 4 | Segera dilakukan perbaikan |

**Misalignment Repair Results**

Based on the data obtained from the measurement results on September 17, 2023, the velocity value was 11.52 mm/s and explained in

Figure 25 with radial readings showing activity at 1x and 2x RPM (Rotation Rotation Per Minute) and low Amplitude at the third harmonic frequency and at higher harmonics where there is a misalignment in this equipment, an angular misalignment occurs when the center lines of the two shafts intersect to form an angle with a horizontal value of 0.02 mm and 0.00 mm and a vertical of 0.00 mm and 0.33 mm. where the value of 0.33 mm is the misalignment value of the standard value below 3000 RPM which is 0.1 mm. after repairs by adding shims to the motor legs, the vertical position is obtained a perfect value because everything is below 0.1 mm where the horizontal is -0.00 mm and 0.02 mm and the vertical is -0.03 mm and 0.03 mm.

**Comparison Results Statistics**

Table 10. NDE Motor Measurement Results after Alignment

| No | Date | Freq Hz (CPM 0 - 33000) | Motor | | | |
|---|---|---|---|---|---|---|
| | | | Vertical (mm/s) | Horizontal | | |
| | | | | Velocity (mm/s) | Acc (g) | Enveloving (gE) |
| 1 | 17 Sep 2023 | 0 - 550 | 6,89 | 11,52 | 0,35 | 2,23 |
| 2 | 05 Oct 2023 | 0 - 550 | 3,02 | 3,57 | 0,09 | 0,69 |

From the results obtained from the horizontal side velocity spectrum equipment on October 5, 2023, the FFT analysis showed a change in the vibration spectrum FFT value from the previous 11.52 mm/s to 3.57 mm/s as seen in Table 10. This occurred because alignment improvements had been made and the spectrum value became better.

Table 11. Fan DE Measurement Results After Alignment and Housing Replacement

| Date | Freq Hz (CPM 0-33000) | Fan DE | | | | |
|---|---|---|---|---|---|---|
| | | Vertical (mm/s) | Horizontal | | | Axial (mm/s) |
| | | | Velocity (mm/s) | Acc (g) | Enveloping (gE) | |
| 17 Sept 2023 | 0-550 | 9,37 | 10,8 | 2,369 | 27,6 | 4,66 |
| 05 Oct 2023 | 0-550 | 3,59 | 3,45 | 0,39 | 4,29 | 2,03 |

From the results obtained velocity spectrum equipment fan side DE horizontal dated October 5, 2023 FFT analysis there is a change in the FFT spectrum value, vibration from the previous 10.8 mm / s to 3.45 mm / s as seen in Table 11, this occurs because there is no longer a long series of harmonics from the rotating frequency or half of the harmonic frequency at an abnormally high amplitude which is generally a characteristic of the presence of symptoms of mechanical looseness, or mismatch between component parts. The harmonics that occur are random and unorganized caused by the looseness. FFT Indications of local defects in the inner track of the bearing on the bearing are indicated by impulse frequencies of 1X, 2X, 3X, 4X, 5X, and 6X FFT in line with the peak amplitude of the vibration spectrum with the previous value of 27.6gE called Ball Pass Frequency Outer (BPFO) to 4.28gE. This is because the housing and bearing have been replaced.

Table 12. NDE Fan Measurement Results After Bearing Replacement

| No | Date | Freq Hz (CPM 0-33000) | Fan NDE | | | | |
|---|---|---|---|---|---|---|---|
| | | | Vertical (mm/s) | Horizontal | | | Axial (mm/s) |
| | | | | Velocity (mm/s) | Acc (g) | Enveloving (gE) | |
| 1 | 17 Sep 2023 | 0-550 | 7,48 | 8,51 | 1,368 | 18,02 | 3,93 |
| 2 | 05 Oct 2023 | 0-550 | 4,97 | 2,19 | 0,29 | 4,73 | 2,52 |

The results obtained from the horizontal side velocity spectrum equipment on October 5, 2023, the analysis obtained from the horizontal side enveloping spectrum of the 22220CC bearing, FFT analysis. Indications of local defects in the bearing inner track are indicated by impulse frequencies of 1X, 2X, 3X, 4X, 5X, and 6X FFT in line with the peak amplitude of the vibration spectrum with a value of 18.02gE called Ball Pass Frequency Outer (BPFO) and after repairs it becomes 4.73gE as shown in Table 12.

## CONCLUSION

Based on the data obtained from the research that has been conducted, the following conclusions can be drawn.:

1. From the monitoring results on September 17, 2023, at the fan drive end (DE) position, there were harmonic peaks at 2x, 3x, 4x, 5x, 6x, etc. From the monitoring results obtained in the horizontal FAN DE measurement direction, there was a 1X peak increase with an overall spectrum of 10.8 mm/sec and was followed by harmonics caused by looseness in the structure so that the fastening bolts on the structure had to be tightened.

2. The data results obtained are the enveloping spectrum value of the 22220CC horizontal side bearing on September 17, 2023, FFT analysis. Indications of local defects in the inner track of the bearing are indicated by impulse frequencies of 1X, 2X, 3X, 4X, 5X, and 6X FFT in line with the peak amplitude of the vibration spectrum with a value of 27.6 gE called Ball Pass Frequency Outer (BPFO) which is caused by erosion of the bearing housing and the bearing housing must be replaced and after replacing the bearing housing the enveloping value becomes 4.29 gE.

3. The results of the NDE motor velocity spectrum equipment position monitoring data on the horizontal side on September 17, 2023,

FFT analysis indicates that the equipment has a misalignment that occurs 1X, 2X, peak or more. The FFT is aligned with the peak amplitude of the vibration spectrum with a value of 11.52 mm/s which is caused by misalignment and after re-dial using laser alignment on the equipment, the vibration value at horizontal velocity is 3.57 mm/s.

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