

Improving rotating equipment reliability through laser alignment: a Case study in the pulp and paper industry

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ABSTRACT

Reliability of rotating equipment is crucial to maintaining production continuity in the pulp and paper industry. Equipment 432P082 in the Fiberline 2 area of PT. XYZ has a low Mean Time Between Failures (MTBF) of about one month, which can disrupt operations and increase maintenance costs. This study aims to evaluate alignment methods to improve equipment reliability and extend MTBF. The research methods include field observation, collecting historical failure data, vibration measurements, laser alignment, and MTBF analysis before and after repair. The results show that a more precise alignment method can reduce misalignment and vibration levels to meet ISO 10816 and ANSI/ASA S2.75-2017 standards. The MTBF value increased from approximately one month to more than ten months without equipment failure during the observation period. In addition, component failures became less frequent, and maintenance became more effective. Prior to the repair, the company incurred maintenance costs of Rp74,210,400 per month due to the high frequency of failures. Therefore, implementing proper alignment methods has been proven to improve equipment reliability, extend MTBF, and provide cost savings and operational efficiencies for companies.

Keywords: Alignment, equipment reliability, MTBF, vibration, condition monitoring.

INTRODUCTION

Reliability of rotating equipment is critical to maintaining continuous production in the pulp and paper industry. A main cause of reduced equipment reliability is misalignment between the driving and driven shafts. Misalignment can increase vibration levels and accelerate damage to

bearings, couplings, and other power-transmission components, thereby increasing downtime frequency and maintenance costs.

Equipment 432P082, operating in the Fiberline 2 area of PT. XYZ, is one of the critical pieces of equipment with a history of recurring failures associated with high vibration levels.

Based on the initial inspection, the alignment condition and V-belt tension were found to be outside the optimum condition, potentially reducing the Mean Time Between Failures (MTBF). Therefore, an evaluation of the alignment method used is required to improve equipment reliability.

Reliability of rotating equipment is an important factor in maintaining the continuity of production processes in the pulp and paper industry. High reliability supports production targets, reduces downtime, and lowers equipment maintenance costs (Syaefudin et al., 2025). A main cause of reduced equipment reliability is misalignment between the driving and driven shafts. Misalignment can increase vibration levels and accelerate damage to bearings, couplings, and other power-transmission components, thereby increasing downtime frequency and maintenance costs (Yudha Satria Utama and M. Arif Batutah, 2025).

Equipment 432P082, operating in the Fiberline 2 area of PT. XYZ, is a critical piece of equipment with a history of recurring failures due to high vibration levels. Vibration levels exceeding standard limits may indicate shaft misalignment, imbalance, or other mechanical problems that affect component service life (ISO 10816). Based on the initial inspection, the alignment condition and V-belt tension were outside the optimum range, potentially reducing the Mean Time Between Failure (MTBF). Therefore, it is necessary to evaluate the alignment method used to improve equipment reliability and extend the

interval between failures (Naufal et al., 2026).

This study aims to evaluate the application of an alignment method to Equipment 432P082 in the Fiberline 2 area of PT. XYZ by analysing changes in vibration levels, alignment conditions, and the increase in Mean Time Between Failure (MTBF). In addition, this study aims to determine the potential maintenance cost savings obtained after implementing a more accurate alignment method.

RESEARCH METHODS

Research Location and Period

The study was conducted on Equipment 432P082 located in the Fiberline 2 area of PT. XYZ, Riau, Indonesia. The research activities were carried out from February to March 2026.

Research Procedure

The research method consisted of several stages, including problem identification, literature review, collection of historical failure data, measurement of initial alignment and vibration conditions, implementation of laser alignment, remeasurement after alignment, data analysis, and evaluation of the increase in MTBF. These research stages were arranged to obtain representative data for evaluating the effect of alignment on rotating-equipment reliability (Moreno et al., 2020).

The study began by collecting historical equipment failure data, vibration data, alignment data, and equipment operating data. The researchers then measured alignment using a laser alignment device, while measuring V-belt tension using the

belt vibration-frequency method. The researchers selected laser alignment because it provides higher accuracy than conventional methods, minimising measurement errors and improving shaft-alignment quality (SKF PHL FM 10/400). V-belt tension was measured using the belt vibration-frequency method recommended by SKF to obtain a more accurate belt-tension value (SKF PHL FM 10/400).

Analysis Method

The analysis compared equipment conditions before and after implementing alignment. Vibration data were analysed per ISO 10816 to determine vibration severity in rotating equipment (Ulfiana, 2011). In addition, the alignment condition was evaluated using alignment tolerances referring to ANSI/ASA S2.75-2017 (Vogel, 2018).

Table 1. Angular and Offset Misalignment

Machine RPM	Angular Misalignment (mm/100 mm)	Offset Misalignment (mm)
< 1800	≤ 0.3	≤ 0.15
1800–3600	≤ 0.2	≤ 0.10
> 3600	≤ 0.1	≤ 0.05

Source: ANSI/ASA S2.75-2017 [9]

We evaluated equipment reliability using Mean Time Between Failure (MTBF). MTBF indicates the average operating time between

failure events in a piece of equipment and is frequently used in maintenance-system reliability analysis [4]. We calculated the MTBF value using Equation (1).

$$\text{MTBF} = \frac{\text{Total Waktu Operasi}}{\text{Jumlah Kegagalan}} = \text{Jam/}$$

Hari /Bulan

We then compared the MTBF values before and after implementing alignment to determine the improvement in equipment reliability. In addition, we analysed potential maintenance cost savings based on the increased interval between failures and the reduced frequency of repair activities (Alfionita & Alifin, 2023).

3. Results

Initial Condition of Equipment 432P082

Based on the initial inspection of Equipment 432P082 in the Fiberline 2 area of PT. XYZ, we found indications of misalignment in the transmission system, causing increased vibration in the motor and pump. This condition can impose additional loads on bearings, accelerate component wear, and reduce equipment reliability (Ulfiana, 2011). In addition to the suboptimal alignment, the V-belt tension inspection showed that the belt tension did not meet the recommended value. This condition can cause transmission-system slip, reduce power-transmission efficiency, and shorten the service life of supporting components (ISO 10816).

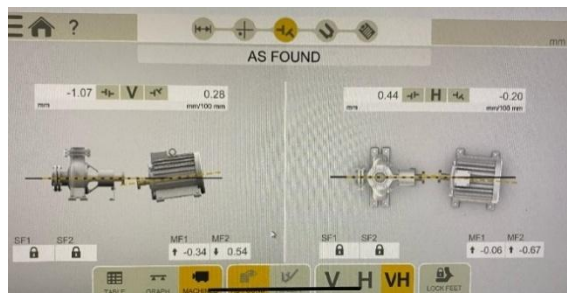


Figure 1. Initial Alignment Condition

Table 2. Initial Alignment Data

Parameter	Before (mm)	Tolerance (mm)	Status
Horizontal Offset	-1.07	≤ 0.10	Abnormal
Vertical Offset	0.44	≤ 0.10	Abnormal
Horizontal Angular	0.28	≤ 0.05	Abnormal
Vertical Angular	0.20	≤ 0.05	Abnormal

Alignment Results

The alignment process used the laser alignment method to achieve higher accuracy than conventional methods. After alignment, the offset and angular misalignment values improved, bringing the motor and pump shaft positions within the tolerance limits recommended by ANSI/ASA S2.75-2017 (Vogel, 2011).

The improved alignment is expected to reduce additional forces on the bearings and coupling, improving equipment operating stability.



Figure 2. Alignment Results

Table 3. Alignment Results

Parameter	Before (mm)	After (mm)	Tolerance (mm)	Status
Horizontal Offset	-1.07	-0.03	≤ 0.10	OK
Vertical Offset	0.44	-0.07	≤ 0.10	OK
Horizontal Angular	0.28	0.02	≤ 0.05	OK
Vertical Angular	0.20	0.04	≤ 0.05	OK

Vibration Analysis

The vibration measurement results were analysed to evaluate the effect of the alignment implementation on the mechanical condition of Equipment 432P082. The evaluation compared vibration values before and after alignment at several measurement points, including the motor, plumper block, and pump. The analysis used velocity (VEL), envelope (ENV), and axial parameters to identify misalignment and changes in the system's dynamic response. The measurement results were then analysed for trends in vibration changes to determine the effectiveness of alignment in improving operating conditions and its contribution to reliability and MTBF improvement.

1. Comparison of vibration and enveloping values at the Motor NDE before and after alignment.

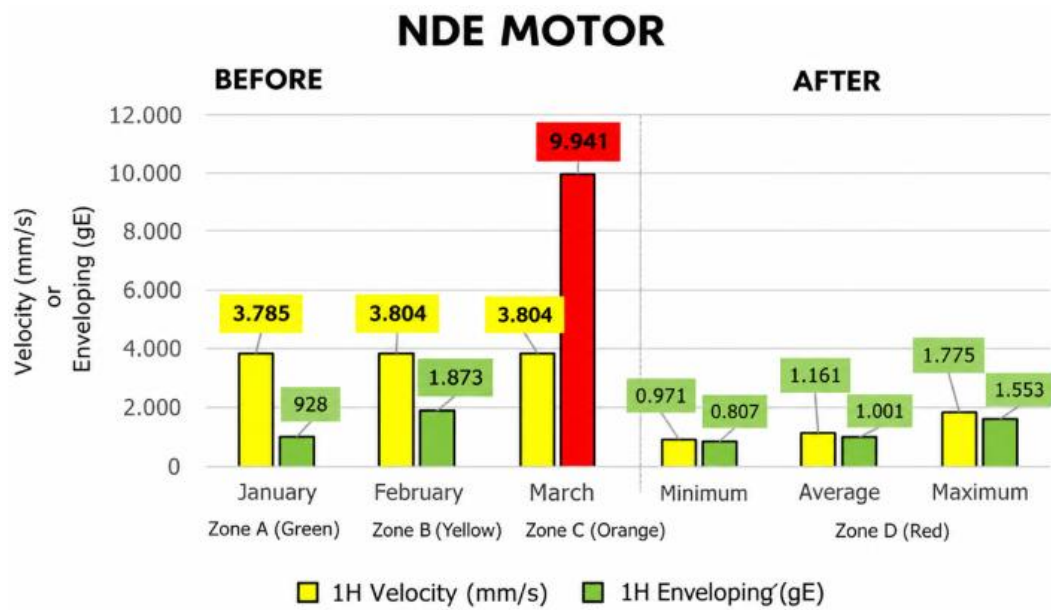


Figure 3. Comparison of vibration and enveloping values at the Motor NDE before and after alignment.

Based on Figure 3, vibration and enveloping values at the Motor NDE decreased after alignment, indicating improved operating conditions and reduced misalignment influence on the drive system.

2. Comparison of vibration and enveloping values at the Motor DE before and after alignment.

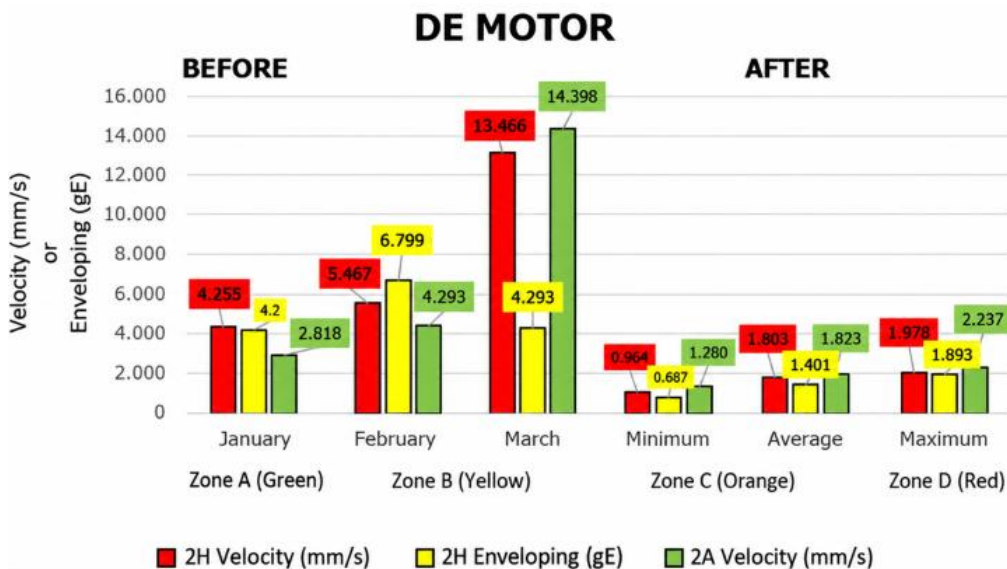


Figure 4. Comparison of vibration and enveloping values at the Motor DE before and after alignment.

Based on Figure 4, the vibration and enveloping values at the Motor DE decreased after alignment. The average vibration value decreased to 1.803 mm/s, while the average enveloping value decreased to 1.401

gE. These results indicate that the alignment process reduced the influence of misalignment, resulting in more stable motor operation.

3. Comparison of vibration and enveloping values at the DE Plummer Block before and after alignment.

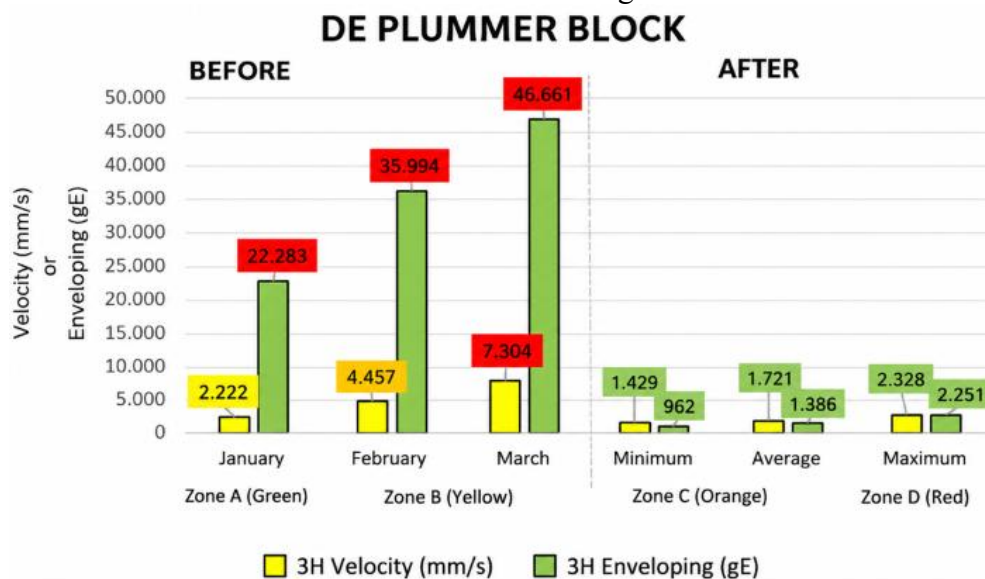


Figure 5. Vibration and enveloping values at the DE Plummer Block before and after alignment.

Based on Figure 5, the vibration and enveloping values at the DE Plummer Block decreased significantly after alignment. Before the repair, the enveloping value reached 46.661 gE, whereas after alignment it decreased to 1.721 gE. This reduction indicates lower

dynamic loading and improved mechanical condition of the transmission system.

4. Comparison of vibration and enveloping values at the NDE Plummer Block before and after alignment.

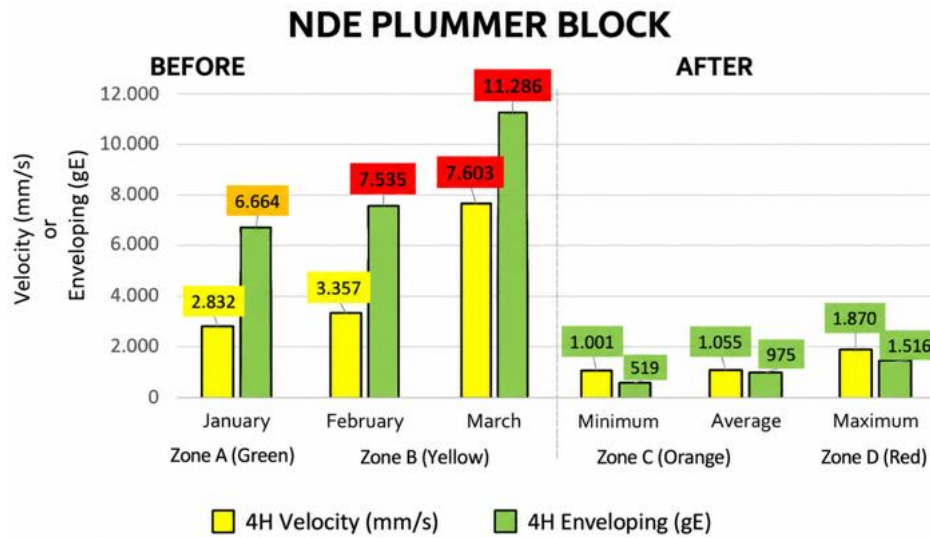


Figure 6. Comparison of vibration and enveloping values at the NDE Plummer Block before and after alignment.

Based on Figure 6, the measurement results show decreased vibration and enveloping values at the NDE Plummer Block after alignment. The average vibration decreased to 1.055 mm/s, and the average enveloping value decreased to 0.975 gE. This indicates that alignment improved operating stability and

reduced misalignment indications in the system.

- Comparison of vibration and enveloping values at the Pump DE before and after alignment.
- Figure 7. Comparison of vibration and enveloping values at the Pump DE before and after alignment.

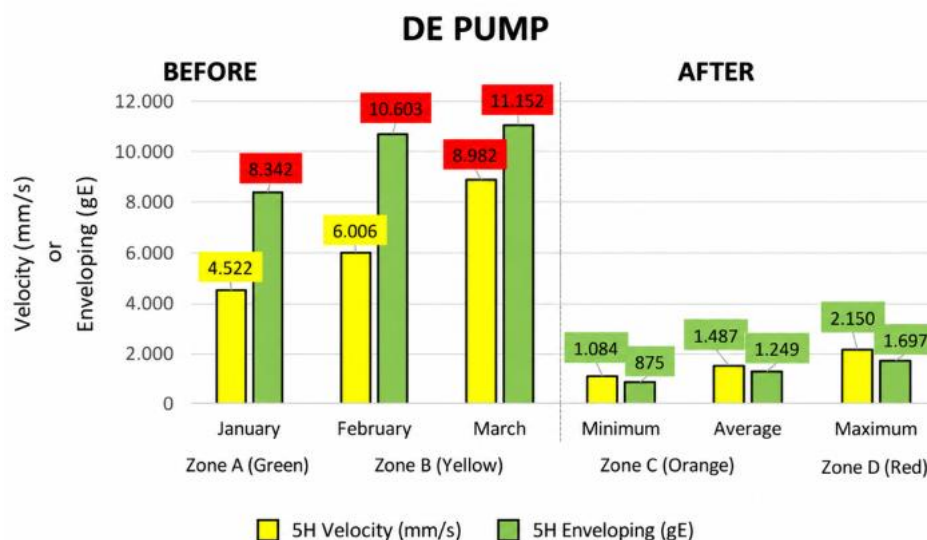


Figure 7. Comparison of vibration and enveloping values at the Pump DE before and after alignment.

Based on Figure 7, the vibration and enveloping values at the Pump DE decreased significantly after alignment. The average vibration decreased to 1.487 mm/s, and the average enveloping value decreased to 1.249 gE. These results indicate that the alignment process improved pump operating conditions and equipment reliability.

6. Comparison of vibration and enveloping values at the Pump NDE before and after alignment.

Based on Figure 8, the vibration and enveloping values at the Pump NDE decreased significantly after alignment. The average vibration decreased to 1.610 mm/s, and the average enveloping value decreased to 1.455 gE. These results indicate that the alignment process improved pump operating conditions and equipment reliability.

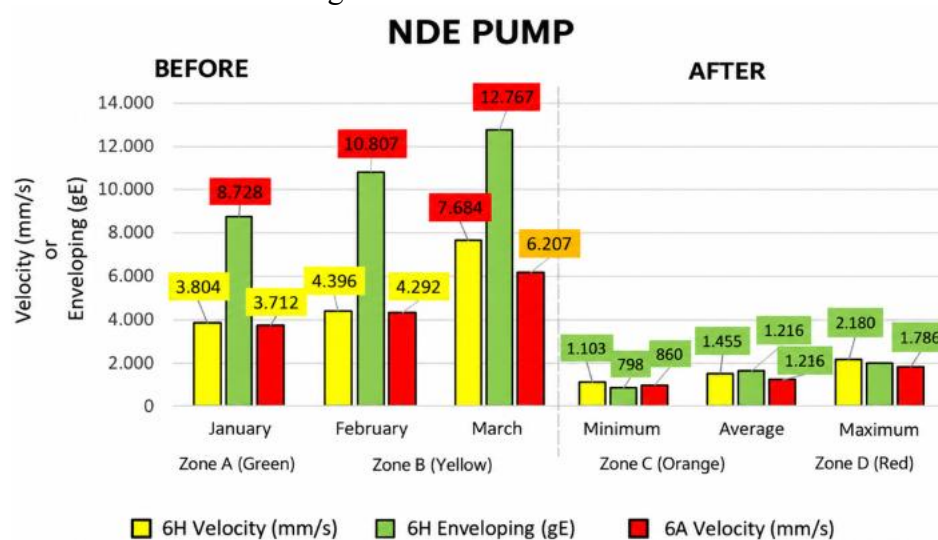


Figure 8. Comparison of vibration and enveloping values at the Pump NDE before and after alignment

7. Conclusion of the Vibration Analysis

The analysis results indicate that the elevated vibration levels before repair were influenced by misalignment, bearing damage, resonance, and an uneven load distribution. After bearing replacement and laser alignment, all vibration parameters decreased to within the ISO 10816 tolerance limits. These results indicate improved

reliability, operating stability, and equipment service life.

MTBF Analysis

The calculation results show that the MTBF before repair was 29 days, or approximately one month, indicating that equipment reliability remained low due to the high frequency of failures over a relatively short operating period. After corrective actions consisting of component replacement and laser alignment on May 14, 2025, no further failures

were recorded until the end of the observation period on March 1, 2026. This condition indicates that the MTBF increased to more than 10 months (MTBF > 10 months). This increase in MTBF indicates the alignment method's effectiveness in improving equipment reliability, extending component service life, maintaining operational continuity, and reducing the potential for unplanned shutdowns.

Cost-Saving Analysis

Table 4. Cost-Saving Analysis

No	Material	Price	Quantity	Total
1	V-Belt	USD 8.89	5	USD 44.45
2	Coupling	USD 400.00	1	USD 400.00
3	Mechanical Seal	USD 4,164.24	1	USD 4,164.24
4	Bearing	USD 29.46	1	USD 29.46
Total		USD 4,638.15		

Based on historical failure data, the total replacement cost for components such as V-belts, coupling, mechanical seal, and bearing reached USD 4,638.15 per month, equivalent to IDR 74,210,400 at an assumed exchange rate of IDR 16,000/USD. After implementation of the new alignment standard and a Predictive Maintenance program through PM Temperature Checks, no further failures of the main components were recorded during the 10-month observation period. This condition indicates a significant improvement in equipment reliability and a positive impact on operational cost efficiency. With no failures during this period, the company potentially achieved cost savings of IDR 742,104,000 over 10 months. These results indicate that appropriate alignment methods and condition-based maintenance can

improve equipment reliability while reducing maintenance costs and the risk of unplanned downtime.

CONCLUSION

Based on the study results, the application of the laser alignment method to Equipment 432P082 in the Fiberline 2 area of PT. XYZ improved the shaft-alignment condition to within the recommended tolerance limits. This improvement reduced vibration levels, increased operating stability, and increased Mean Time Between Failure (MTBF), indicating improved equipment reliability and a lower failure rate.

In addition to improving equipment reliability, implementing laser alignment also provided significant economic benefits. Based on the cost analysis, implementation of the new alignment standard and the Predictive Maintenance program resulted in potential cost savings of IDR 742,104,000 during the 10-month observation period. These results indicate that laser alignment improves equipment reliability and service life while reducing maintenance costs and the risk of production downtime.

5. Recommendations

It is recommended that PT. XYZ to improve reliability and component service life.

In addition, future studies may investigate the effect of alignment on energy consumption, pump efficiency, bearing life, and other reliability parameters to provide a more comprehensive evaluation of equipment performance.

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