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Process using Laser Method on 3-Phase Induction Motor and Spray Washing Pump to Overcome Misalignment

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Abstract—The alignment process using the laser method is one of the alignment techniques that can be applied to address misalignment. The laser method operates by utilizing an infrared laser sensor to perform the alignment between the driving object, in this case the induction motor, and the driven object, namely the spray washing pump. The alignment process aims to align the shaft of the driving object (the induction motor) with the shaft of the driven object (the spray washing pump), ensuring that both shafts are properly aligned. Misalignment refers to a condition in which there is a lack of alignment between the driving shaft and the driven shaft.

Keywords: Laser method, Alignment process, Misalignment

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1. Introduction

The advancement of globalization, coupled with the rapid growth of the information age, has fostered intense competition across various sectors [1][2][3]. This competitive atmosphere has influenced nearly all aspects of human life, as evidenced by the accelerated and significant advancements in technology [4]. In response to these developments, individuals are increasingly driven to work with greater efficiency and practicality. Consequently, scientists and researchers continue to design and develop tools aimed at simplifying human activities [5]-[7]. A significant number of these tools rely on electrical energy as their primary source of power, owing to its versatility and ability to be transformed into other forms of energy, including kinetic, thermal, mechanical, acoustic, and chemical energy [8][9].

In line with the rapid advancement of technology, there is an increasing demand for highly qualified and professional human resources capable of supporting, managing, and optimizing the utilization of such technological advancements [10]-[12]. Higher education institutions, as formal centers of learning and knowledge development, are expected to play a pivotal role in producing competent graduates who are equipped not only to operate but also to innovate and further advance existing technologies [13].

The Department of Electrical Engineering at Politeknik Negeri Padang serves as an educational platform focused on engineering sciences, particularly in the field of electrical engineering. Its curriculum is designed to integrate both theoretical knowledge and practical skills. Based on this foundation, Politeknik Negeri Padang requires all students of the Department of Electrical Engineering to undertake an industrial internship as one of the graduation requirements. Based on this consideration, the author chose PT. Dok Warisan Pertama (PaxOcean) as the place to undertake the internship with the decision being made based on several factors aligned with the area of expertise studied during the academic program.

PT. Dok Warisan Pertama is a subsidiary of the major industrial group PT. PaxOcean Shipyard, which operates in the field of large vessel repair. In accordance with the author's area of expertise, the

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internship was conducted in the Electrical Workshop Department of PT. Dok Warisan Pertama, where one of the services provided is the overhaul or repair of induction motors. One such service includes performing alignment using the laser method on induction motors to address misalignment issues.

Misalignment refers to the condition in which the shaft of the driving component is not properly aligned with the shaft of the driven component, potentially resulting in damage to both the induction motor (as the driver) and the driven equipment [14],[15]. Some of the common consequences of misalignment include excessive vibration and premature wear on the induction motor's bearing housing [16]. Therefore, a corrective procedure known as alignment must be carried out to realign the positions of the driving and driven shafts [17].

Despite the widespread use of alignment techniques, studies specifically evaluating the laser alignment method in real industrial settings remain limited [18]. This study aims to fill that gap by documenting the implementation of the laser alignment process on a three-phase induction motor and a spray washing pump [19],[20]. It highlights the procedure, evaluates the results, and discusses the potential impact on performance reliability and maintenance efficiency.

2. Method

This research adopts an experimental approach to evaluate the effectiveness of laser-based alignment in addressing shaft misalignment between a three-phase induction motor and a spray washing pump [21],[22]. The study was conducted in a real industrial setting during an internship program at PT. Dok Warisan Pertama. The procedure began with identifying the degree of misalignment using a laser alignment tool equipped with infrared sensors. The tool provided digital readings on both horizontal and vertical misalignment conditions. The laser alignment process included multiple alignment trials, in which adjustments were made by adding or removing shims and repositioning the motor until acceptable tolerance levels were achieved [23].

While this study focuses solely on the laser alignment method, the resulting data were benchmarked against standard industrial tolerance values (typically ±0.05 mm) to evaluate the accuracy and effectiveness of the procedure. Comparative validation using traditional methods such as dial indicators or straightedges was not performed due to equipment availability limitations; however, the recorded alignment improvements before and after the process serve as quantitative evidence of performance.

The test process involved the following phases:

1. Initial measurement and identification of misalignment
2. Vertical and horizontal alignment correction through laser-guided procedures
3. Recording final alignment values for evaluation and reporting

This structured method enables repeatable and precise alignment, reduces human error, and enhances the reliability of mechanical systems in industrial environments.

3. Result and Discussion

3.1. Laser Alignment Process on an Induction Motor and Spray Washing Pump to Address Shaft Misalignment

The alignment process on the induction motor and spray washing pump is closely related to the issue of misalignment. In this study, the author utilizes a three-phase induction motor and a spray washing pump as the primary objects for testing and analysis. The focus of the discussion is to examine how shaft misalignment between the driving and driven components affects equipment performance, and how the laser alignment method can be applied as an effective solution to restore proper alignment.

3.2. Laser Alignment

The true definition of alignment refers to a method or technique used to ensure the proper centering and alignment between the shaft of the driving component in this case, the induction motor and the shaft of the driven component, namely the spray washing pump [26],[27]. The goal is to

achieve precise linear alignment between the two interconnected shafts [4], as illustrated in the following figure:



Figure 1. Laser alignment

As illustrated in Figure 1, the laser alignment system setup is shown. Although the shafts may be considered aligned or symmetrical, in practice, a certain degree of tolerance is accepted in this method typically ranging from 0.05 to 0.10 mm. This is because achieving a perfectly straight, parallel, and symmetrical alignment is rarely 100% attainable [4].

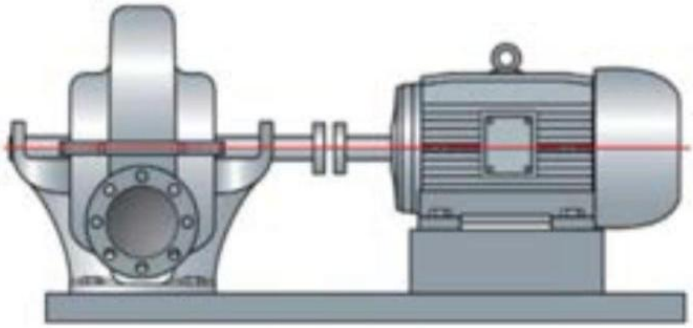


Figure 2. Induction Motor and Pump Alignment

Figure 2 shows the induction motor and pump alignment process.. Essentially, there are four methods commonly used to perform alignment between an induction motor and a pump. These four methods include [5]:

1. Straightedge Method
2. Dial Indicator Method
3. Laser Alignment Method
4. Precision Level Method

However, in this scientific article, the author focuses on discussing only one alignment method, namely the laser method [28],[29]. The laser alignment method utilizes infrared laser sensors to align the shaft of the driving component—in this case, the induction motor—with the shaft of the driven component, namely the spray washing pump. The degree of shaft alignment is measured using a laser beam emitted by the infrared sensor [30],[31]. This method is considered efficient as it provides fast and accurate results, primarily because the entire alignment process is performed automatically. Advantages of Performing Alignment Using the Laser Method Include:

1. Fast process
2. High precision and accuracy
3. Automatic calculations
4. Automatically recorded measurement reports
5. Measurement data is stored and can be reviewed later
6. Laser beam is not affected by gravity or bracket deflection

7. The laser device rotates around the shaft's center of rotation, focusing solely on measuring the center and not being affected by coupling eccentricity or run-out
8. Capable of measuring in both vertical and horizontal directions
9. Can measure more than two machines combined in a single measurement process

3.3. Laser Alignment Operation

Steps for Operating Laser Alignment:

1. Position the induction motor and spray washing pump on a flat surface or area to facilitate the alignment process.
2. Tighten the bolts on the induction motor to obtain significant data when adding shims.
3. Attach the shaft V brackets to both the M (Measuring) unit and the S (Sensor) unit.
4. Mount the M measuring unit with the shaft V brackets onto the shaft of the induction motor as the driving object, as shown in the image below.
5. Secure the shaft V bracket chain to lock the M measuring unit in place on the motor shaft. Tighten the chain using the chain tensioner.
6. Mount the S measuring unit with the shaft V brackets onto the shaft of the spray washing pump as the driven object, as shown in the image below.
7. Secure the shaft V bracket chain to lock the S measuring unit in place on the pump shaft. Tighten the chain using the chain tensioner.
8. Ensure that the infrared beams from the M and S measuring units are aligned parallel to each other to obtain accurate measurement parameters.
9. Once the M and S measuring units are properly mounted on the shafts of the induction motor and spray washing pump, as shown in the image below, the system is ready for the laser alignment process.

3.4. Alignment Process on 3-Phase Induction Motor and Spray Washing Pump

The steps in the alignment process are as follows:

1. Ensure that all laser alignment components are properly installed on the induction motor and spray washing pump, and that all bolts are tightly secured.
2. Turn on the M and S measuring units by pressing the red power button located on each unit.
3. Turn on the display unit by pressing the power button located at the lower left corner of the display.
4. Once the display unit is powered on, select "New Alignment" to begin a new alignment process.
5. After selecting "New Alignment," you will be prompted to input several initial data related to the condition of the induction motor and spray washing pump.
   These include:
   1) The radius between the M measuring unit chain and the S measuring unit chain.
   2) The distance between the M measuring unit chain and the front foot bolt of the induction motor.
   3) The distance between the front foot bolt and the rear foot bolt of the induction motor.
   4) The diameter between the M measuring unit chain and the S measuring unit chain.
6. Perform measurements using a tape measure to obtain the data required for input into the display unit.
7. Once all measurements are complete and the necessary data is obtained, input the data into the display unit one by one. After entering each data point, press the right arrow button to move to the next input field. Repeat this step until all data is correctly entered.
8. After all data has been entered into the display unit, press the right arrow button again. The display will now prompt you to input the RPM (revolutions per minute) of the induction motor by selecting the appropriate RPM category. The RPM can be found on the nameplate attached to the induction motor.

9. Once all the required data is entered, begin the alignment process, starting with the vertical phase.
    1.) Rotate the shaft to the 9 o'clock position (-90º) until the M and S measuring units align within the blue target zone. When aligned, the blue will turn green, indicating correct positioning.
    2.) Press the right arrow to proceed to the second rotation. Rotate the shaft to the 12 o'clock position (0º), again aligning within the blue zone until it turns green.
    3.) Press the right arrow again for the third rotation. Rotate the shaft to the 3 o'clock position (+90º) and align as before. When alignment is achieved (blue turns green), press the right arrow to view vertical misalignment data.
10. Click the right arrow again. You will be asked to rotate the shaft 90º to the 3 o'clock position. The display unit will now show vertical misalignment between the induction motor and spray washing pump.
    1.) Begin the vertical alignment process using a 13 mm wrench, shims, and a pry bar.
    2.) Add or remove shims at the motor feet based on the display:
    - A black line shows the desired aligned position.
    - upward arrow indicates the motor needs to be raised by adding shims.
    - A downward arrow indicates the motor needs to be lowered by removing shims.
    3.) Important: Before adjusting shims, loosen the motor foot bolts to allow for shim adjustment. After shimming, retighten the bolts to ensure precise alignment.
11. Add or remove shims as indicated until the motor and pump are vertically aligned
12. Click the right arrow. Now, rotate the shaft 180º to the 9 o'clock position.
    1.) Proceed with the **horizontal alignment phase** using a hammer and 13 mm wrench.
    2.) Loosen the motor foot bolts, and gently tap the motor to the left or right to adjust alignment.
    3.) After horizontal alignment is complete, retighten the bolts.
13. Click the right arrow and rotate the shaft 90º to the 12 o'clock position. (If the final results still show misalignment, press the **Shim** button on the display to repeat the alignment process for only the misaligned phase).
14. Press the Flag icon to generate a report of the final alignment results, then click Save to store the report.
15. After completing the alignment process, remove the M and S measuring units from the motor and pump shafts, then turn off the display unit.
16. Organize and return all laser alignment components to the box in their original condition.
17. Lastly, return the laser alignment tool and shims to their proper storage location, and ensure the alignment area is clean and tidy as it was before the procedure.

Advantages of Performing the Alignment Process:

1. Induction motors that undergo regular alignment become more reliable and can operate optimally.
2. Reduces maintenance costs by preventing early equipment failure, which can lead to production loss and expensive spare part replacement.
3. Alignment minimizes excessive axial and radial loads on bearings, extending their service life.
4. Reduces premature wear on the bearing housing.
5. Lowers vibration levels in the machine, bearing housing, and rotor.
6. Prevents noise or abnormal sounds during the rotation of the induction motor.

3.5. Misalignment

Misalignment is a condition in which the driving shaft and the driven shaft are not properly aligned [33]. When misalignment occurs at the coupling, it can accelerate wear and tear on the coupling and bearings, and also cause excessive vibration [34]. To detect and correct this issue, an alignment process must be performed to ensure the driving shaft and driven shaft are properly aligned. Misalignment may result from displacement or deviation of one of the machine components from its central axis [19]. In the alignment test between the induction motor and the spray washing pump, misalignment caused early wear on the bearing housing, leading to looseness in the housing [20]. As a result, the bearing rotated inside the housing instead of with the motor rotor [21]. Continuous rotation of the bearing in this condition generated excessive heat, which could eventually cause the bearing to break [22]. Fragments from the broken bearing may strike the motor coil, potentially leading to an explosion in the induction motor. Additionally, misalignment causes vibration during the operation of the induction motor.

1. Offset / Paralel Misalignment
   Offset or parallel misalignment occurs when the two shafts are not aligned on the same centerline and are at different elevations or positions. This condition arises when the centerlines of the two shafts are parallel but not collinear [23]. Offset misalignment is typically identified by the distance between the centerlines of the two shafts and is usually measured in thousandths of an inch. Offset or parallel misalignment can occur in both the vertical and horizontal planes. The offset misalignment type is illustrated in Figure 3.

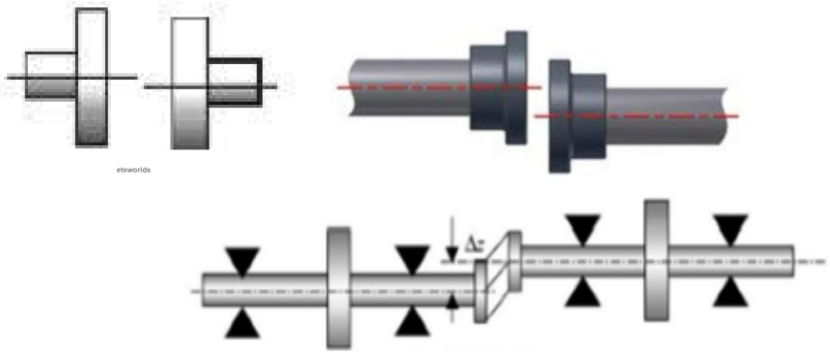


Figure 3. Offset / Paralel Misalignment

2. Face / Angular Misalignment
   Angular misalignment occurs when the two shafts are not collinear and form an angle with each other, even though both shaft ends are at the same elevation [24],[25]. This condition results in an angular difference between the two shaft axes, commonly referred to as "slope" or "rise over run," which is typically measured in thousandths of an inch. The actual angle formed is measured in degrees. Angular misalignment can occur in both the **vertical** and horizontal planes. Figure 4 shows angular misalignment.

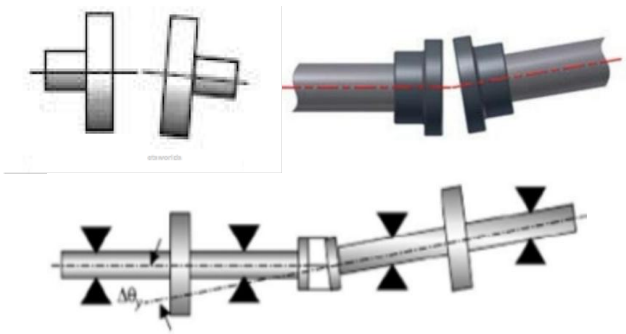


Figure 4. Face / Angular Misalignment

3. Skewed / Combination Misalignemnt

   Combination misalignment occurs when the two shafts are both angularly misaligned and offset, meaning they form an angle with each other and their ends are not at the same elevation. This condition is one of the most commonly encountered problems in shaft misalignment. Combination misalignment can occur in both the vertical and horizontal planes. Combination or skewed misalignment is shown in Figure 5.

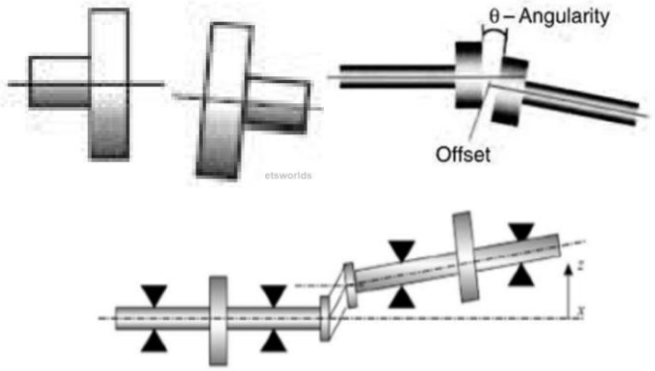


Figure 5. Skewed / Combination Misalignemnt

4. Softfoot

   Softfoot is a condition where a machine rests unevenly on the foundation or floor, resulting in instability. This situation can occur due to the nature of the floor foundation or the materials used for the machine base. Figure 6 shows the softfoot condition.

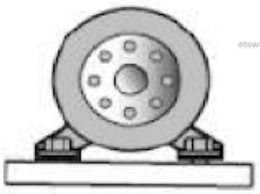


Figure 6. Softfoot

Consequences of Misalignment include:

1. Damage to components such as bearings, shafts, seals, couplings, and others.
2. Elevated temperatures in the casing, bearings, and lubricating oil.
3. Leaks in the bearing area, overheating of couplings, and rapid wear.
4. Coupling bolts become loose easily.
5. Increased vibration in the induction motor during operation, both in the **radial** and **axial** directions.

Components Commonly Damaged Due to Misalignment:

1. Shafts – due to excessive vibration in each shaft.
2. Bearings – due to excessive friction, leading to heat buildup and premature wear.
3. Pump efficiency – mechanical efficiency decreases as a result of misalignment.
4. Motor windings (coils) – can come into contact and lead to electrical short circuits.
5. Coupling bolts – may suffer damage or even break.

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3.6. Test Result

The alignment test was conducted at the Electrical Department Workshop of PT. Dok Warisan Pertama, using an induction motor and a spray washing pump as the test samples. The testing process was carried out in two stages: vertical alignment and horizontal alignment. Before starting the alignment procedure on the induction motor and spray washing pump, the operator first performed manual measurements to collect the necessary data for input into the display unit. Measurement data input into the display unit is presented in Figure 7. The measurement data collected by the operator included the following:



Figure 7. Measurement Data Input into the Display Unit

1. Initial Condition of Misalignment Between Induction Motor and Spray Washing Pump

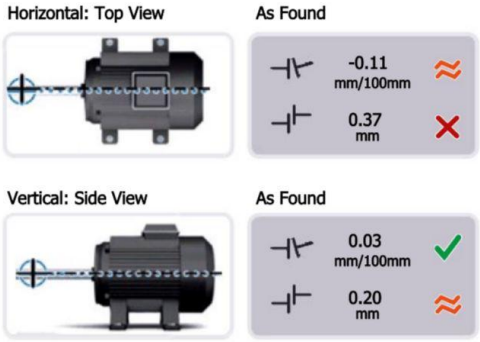


Figure 8. Initial Condition of Misalignment

The initial misalignment condition is shown in Figure 8.

2. Vertical Alignment Stage

During the vertical alignment phase, the practitioner performed three alignment attempts to obtain precise alignment, namely:

1.) First Trial



Figure 9. First trial of the vertical alignment stage

Figures 9 to 11 illustrate the vertical alignment trials.

2.) Second Trial



Figure 10. Second trial of the vertical alignment stage

3.) Third Trial



Figure 11. Third trial of the vertical alignment stage

During the third trial, proper alignment between the induction motor and the spray washing pump was successfully achieved in the vertical alignment phase.

3. Horizontal Alignment Stage

In this phase, three trials were carried out by the practitioner to obtain an aligned condition, namely:

1.) First Trial



Figure 12. First trial of the horizontal alignment stage

2.) Second Trial



Figure 13. Second trial of the horizontal alignment stage

3.) Third Trial

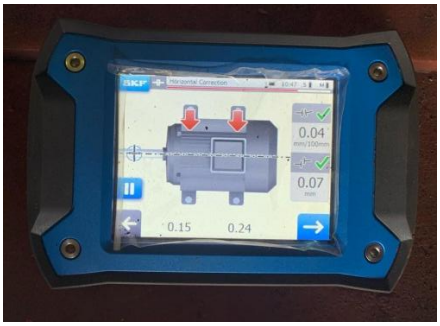


Figure 14. Third trial of the horizontal alignment stage

During the third trial, proper alignment between the induction motor and the spray washing pump was successfully achieved in the horizontal alignment phase. Figures 12 to 14 illustrate the horizontal alignment process.

3.7. Final Result of the Alignment Process

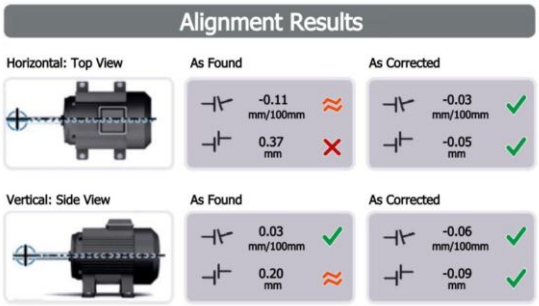


Figure 15. Final result of the alignment test

The final alignment result is shown in Figure 15.

4. Conclusion

Based on the discussion presented in this internship report, several conclusions can be drawn. Alignment is a method used to ensure that the shaft of the driving object is symmetrical and properly aligned with the shaft of the driven object. One commonly used alignment method is laser alignment, which utilizes infrared sensors to align the shafts. The degree of shaft alignment is measured using laser beams emitted by the infrared sensor. Misalignment, on the other hand, is a condition in which the shaft of the driving object is not properly aligned or straight with the shaft of the driven object. Such misalignment can lead to damage to both components and significantly reduce their operational lifespan.

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