# MISALIGNMENT OF THE CENTRIFUGAL PUMP CAUSED BY TENSION LINES

*Adriele Barbosa dos Santos [a], Jerfeson Silva dosa Santos [b], Larissa Luz dos Santos[c].*

[a] *Curso Técnico em Mecänica Industrial, Senai Cimatec, Salvador/Bahia, Brasil, adriele.santos@ba.estudante.senai.br*
[b] *Curso Técnico em Mecänica Industrial, Senai Cimatec, Salvador/Bahia, Brasil, jerfeson.santos@ba.estudante.senai.br*
[c] *Curso Técnico em Mecänica Industrial, Senai Cimatec, Salvador/Bahia, Brasil, larissa.luz@ba.estudante.senai.br*

**Abstract:** Tensioning in lines is a common problem and related to it is misalignment, one of the main failure modes in rotating assemblies. This study sought to understand the relationship between in-line tensioning and misalignment in centrifugal pumps. The research aimed to explore methods for this phenomenon to be corrected and avoided. To do this, a qualitative exploratory research literature review was employed. The results indicated that when alignment and maintenance processes are not followed correctly misalignment of the assembly can occur. It is concluded that following maintainability processes is essential to avoid tensioning in lines and misalignment of the centrifugal pump.

**Keywords:** Tension lines; Misalignment; Centrifugal pumps; Procedures.

## Desalinhamento da bomba centrífuga causado por tensionamento em linhas.

**Resumo:** O tensionamento em linhas é um problema comum e atrelado a este têm-se o desalinhamento, um dos principais modos de falhas em conjuntos rotativos. Este estudo buscou entender a relação entre o tensionamento em linhas e desalinhamento das bombas centrífugas. A pesquisa teve como objetivo explorar métodos para que este fenômeno seja corrigido e evitado, para isso, empregou-se uma revisão de literatura do tipo pesquisa exploratória na modalidade qualitativa. Os resultados indicaram que quando os processos de alinhamento e manutenção não são seguidos de forma correta o desalinhamento do conjunto pode ocorrer. Conclui-se que, seguir processos de manutenibilidade é essencial para evitar o tensionamento em linhas e o desalinhamento da bomba centrífuga.

**Palavras-chave:** Tensionamento em linhas; Desalinhamento; Bombas centrífugas; Procedimentos.

ISSN: 2357-7592

## 1. INTRODUCTION

Currently, when it comes to misalignment in rotating equipment, we work on cheap and effective solutions. The misalignment, which is one of the occurrences responsible for several failure modes, when not corrected immediately, can generate damage to equipment, the correction of this failure can be done with the replacement of machine elements, and with a low repair cost.

In the industrial environment, this problem can be caused by the tension between the process piping and the pump nozzles. These tensions are transmitted to the casing of the assembly causing misalignment and consequently the occurrence of failures.

Thinking about the reduction of these failures in the industrial sector and the reduction of maintenance costs in a simple and accessible way, this work is directed towards the awareness of the importance of compliance and continuous improvement of Maintenance Procedures focused on the alignment service in centrifugal pumps.

This study was based on the analysis of reports, books, manufacturers' manuals and maintenance procedures, and on the data and observations of the problems that currently occur in the industrial environment.

In view of what was proposed, the general objective was to show the relationship between misalignment in centrifugal pumps and tensioning in lines. The specific objectives were to identify the relationship between tensioning and misalignment of centrifugal pumps, analyze technical maintenance reports, as well as the execution of maintenance on centrifugal pumps and indicate improvements in the execution procedure.

## 2. THEORETICAL FOUNDATION

The purpose of this chapter is to expose and present references that indicate the connection of misalignment in centrifugal pumps and tensioning between suction, discharge and cooling lines and nozzles. Also addressed are points about the preparation and execution of procedures for performing maintenance activities, as well as the possible damage that can reduce the life of the equipment due to misalignment.

Even though it is an old problem within the industries and that puts the life of any rotating assembly at risk, the lack of alignment is still one of the failure modes that most occurs in equipment, thus being a potential risk for a possible production stop.

> Misalignment of shafts is a common effect in several areas of manufacturing operations, and occurs when the axes of rotation of two machines are not concentric with each other. Such nonconformity changes the system's operation mode, generating damage to it (LIMA[1], 2014, P 27).

The misalignment in rotating assemblies is characterized in three ways: parallel, angular and mixed, and is one of the main failure modes that can lead to damage to equipment and its components causing unexpected failures and production stops.

ISSN: 2357-7592

## 2.1 Misalignment due to tension in centrifugal pump

There are numerous failure modes that will result in misalignment of a centrifugal pump, such as: foundation problems of the bases, lack of concentricity between the corresponding parts, failures at the time of installation, tensioning of lines, among others.

As previously mentioned, misalignment caused by tensioning is a recurrent problem and needs a careful look since it can be a potential source for compromising the operation of a centrifugal pump and any other equipment. This type of failure mode can only be identified with the disconnection of the lines connected to the pump, because it is at this moment that the piping will return to its natural position, where there are no forces acting on it.

That said, it can be stated that misalignment by tensioning occurs due to the force exerted on the lines connected to the equipment. According to a study presented by Telles[2] (1999) taking into account the strength of materials point of view, each part of a pipeline can be classified as a structural element, subjected to various loads and also transmitting several others to the system of supports and equipment that are in direct connection with the pipeline. One of the main loads acting on a pipe is the stresses arising from assemblies, that is, when a forced alignment occurs, due to the absence of parallelism and perpendicularism as can be seen in figure 1.

Figure 1: Piping without parallelism Source

Source: Own authorship

In the pictures above it is noticeable the misalignment between the flanges, and for this specific case we have the configuration in the tension-free position. If, in this context, the piping were connected in a forced way, the result would be load transfer and consequently a possible misalignment of the shaft. Another important point is that, depending on the configuration of the pump, we may also have the presence of water lines entering and leaving to make the cooling process of the equipment, and these lines should also not present unevenness. Even though they are normally smaller diameter lines, they must also be taken into consideration, because they will transmit and receive force in the same way as the larger diameter lines, and as seen previously and confirmed by Silva[3] Et al. (2008), the effort generated can cause distortion in the casing when the equipment is in operation, and consequently misalignment of the shaft, which can lead to the rotor dragging on the volute in severe cases.

## 2.2 Alignment processes

ISSN: 2357-7592

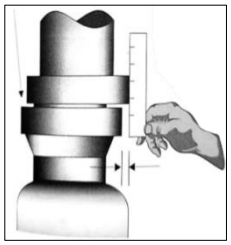
The ideal alignment for any rotating assembly is to achieve perfect concentricity in relation to the imaginary shaft line. To achieve this it is necessary to use tools and accessories that identify and help correct misalignment, the most common ones are: rulers, dial indicators, and laser aligners. This failure mode can still be previously identified within the predictive maintenance techniques through thermographic imaging where the relationship given is abnormal heating, because when there is wear there is also temperature rise and vibration analysis which assumes that each piece of equipment has an established vibration frequency and that is changed if there is any abnormality in the equipment components.

As presented by Lifetime Reliability Solutions[4] (2017), the alignment process can be divided into three stages: Pre-alignment, which focuses on ascertaining and repairing what has the potential to influence the final result of the alignment, rough alignment, also called rough alignment, where the goal is to leave the machine's center line close to the naked eye, and the third stage consists of precision alignment, which will only be achieved by using dials or lasers. It is important to point out that the verification of the eccentricity between the flanges are in the pre-alignment stage, and the accessories used are rulers and feeler gauges.

### 2.2.1 Flange Alignment Process

The flange concentricity check is as important as any other installation or maintenance step of a centrifugal pump, however, it is not always taken seriously, having as consequences the failures stated by Lima[1] (2014) and already mentioned in item 2.1 of this work. As with the shafts, the need for alignment adjustment between the connection flanges that exist in the pump should also be checked. To check for the absence of parallelism between the piping flanges and the pump nozzle, a ruler can be used as shown in Figure 2.

Figure 2: Verification of misalignment between line and nozzle.

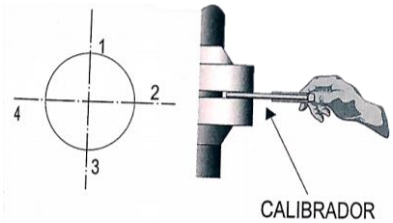


Source: Silva Et al. (2008).

In the image above it is noticeable the existence of misalignment between the flanges and according to Silva[3] Et al. (2008), this deviation can be a maximum of 3 mm and analyzed in four points as shown in Figure 8. It is important to understand that even if the deviation is detected with the naked eye, it is essential to perform the measurement with a dial so that no errors occur at the time of correction and to have a registered value. This practice also applies when checking angulation. When checking the perpendicularity and distance between the flanges, a feeler gauge must be used in four positions, 90° apart each, in accordance with figure 3.

ISSN: 2357-7592

Figure 3: Parallelism measurement with a feeler gauge.




Source: Silva Et al. (2008).

The caliper blades must have the same distance in the four points. If a gap or tightening is detected in different points, the existence of an angle can be concluded, and there is a maximum recommended limit for this deviation, as shown in figure 4.

Figure 4: Recommended flange spacing limit.

| DIÂMETRO DO FLANGE (mm) | DESVIO MÁXIMO (mm) |
|---|---|
| ATÉ 100 | 0,2 |
| DE 100 A 150 | 0,3 |
| DE 150 A 200 | 0,4 |
| DE 200 A 250 | 0,5 |
| MAIOR QUE 250 | 0,6 |

Source: Silva Et al. (2008).

In case the deviation is outside the allowed values, the correction must be made searching for the best possible configuration. If no inclination is found in the places checked, the parallel distance between the flanges must also be validated. This distance must follow a pre-established recommended value, because too much space may generate a force that will pull the pump from the skid, as well as its deficiency will result in overload in the equipment. It is worth noting that all steps of the alignment processes should be contained in the centrifugal pump maintenance procedure.

## 2.3 Maintenance procedures

All maintenance activities should be covered by execution procedures, and these should be followed and used as guides by all professionals, whether they are experienced, beginners or outsourced. In his study Viana[5] (2008) states that procedures are the union of all essential information for the perfect execution of preventive maintenance. This statement also applies to other types of maintenance, because it is in these procedures that are listed all the steps to be followed for the execution and conclusion of the equipment maintenance activities. According to

ISSN: 2357-7592

Teles[6] (2017) these documents are means that ensure the health and safety of employees, execution of the activity always with the same level of quality, time saving, equipment reliability, compliance with regulations and standards, training of new employees, and basis for accident investigation.

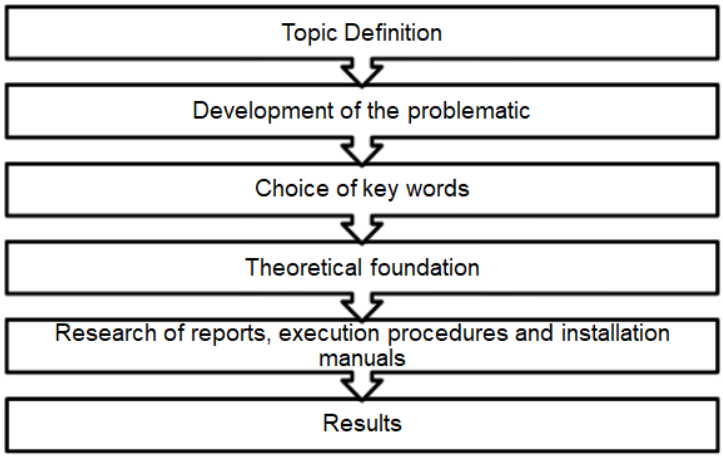
It is important to know that for the execution procedures to be followed and to have good performance, the culture of good practices must be developed in all employees, because it is useless to have a well-designed procedure that is not followed. It is natural that over time the professionals believe that they have all the step by step memorized, so some steps can be skipped, especially when there is a document review, and this is a behavioral problem that must be taken into account in the implementation of this work process, because it can directly influence the return of the equipment to operation.

## 3. MATERIALS AND METHODS

The methodology of exploratory qualitative textual production was adopted, in which the information collected to compose this article was extracted from manuals of pump manufacturers, books, articles, reports, and procedures of the mechanical maintenance area. Seeking to reinforce the theories of authors who address the subject, we found that most of the damage was related to the support structure of the pipes that impact directly on the equipment causing stress and misalignment.

In a company of the industrial area located in the port of Aratu, it was observed during a period of 3 weeks the execution, use of procedures and preparation of reports of activities related to centrifugal pumps, proving the relationship commented above. In general, the entire research process was divided into six stages and can be seen in figure 05.

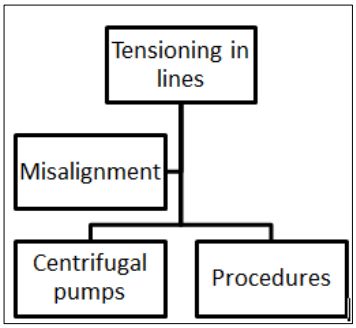
Figure 05: Methodological flowchart.




Source: Own authorship

The definition of the theme was the initial step in the construction of this work, where all the points that one wished to expose were addressed. In continuity, we sought to develop the problem, because without it it would not be possible to direct the work until the final result. The next step focused on choosing the key words that are shown in figure 06.

Figure 06: Flowchart of key words.




Source: Own authorship

The choice of words was made so as to encompass the main subjects addressed in the theoretical reference. In order to confirm all the proposed information and the central idea. A bibliographic review was also carried out, and for this, authors who worked on proposals close to the indicated theme were sought. With this, the next step was responsible for the research and analysis of centrifugal pumps installation manuals and procedures for performing the task of installing and maintaining the equipment. In this way, after the analysis, the last stage of the process of this article's realization was assigned, the results.

## 4. RESULTS AND DISCUSSION

During the analysis and construction of this work, the relationship between tensioning and misalignment in centrifugal pumps was confirmed both theoretically and practically. During the development of the literature review, through authors such as Lima[1] (2014), it became evident that this type of problem has a direct connection with the centrifugal pump assembly and disassembly process, which implies the way the task is performed and how it is structured in the execution procedure.

With this concept established, it is a fact that misalignment by tensioning can be reduced by investing in better maintenance practices and optimizing the execution procedures.

## 5. FINAL CONSIDERATIONS

This work presented and confirmed that misalignment in centrifugal pumps can result from in-line tensioning, which is caused by the misalignment of the process piping flanges in relation to the pump nozzle flanges. We sought to explain the importance of pre-alignment, the same is contained in the maintenance processes, use of procedure policy and establish a culture of habits to follow the process standards.

According to the analysis and theories presented by the authors, when the maintenance work process is followed correctly, it is possible to achieve medium-term results that will bring greater benefits to production, such as: greater availability of equipment, cost reduction, longer life and reliability of centrifugal pumps.

ISSN: 2357-7592

## 6 REFERENCES

[1]LIMA, Israel Antônio Macedo de. **Proposição de uma bancada didática para análise de vibração em manutenção preditiva.** Brasília 2014.
Available at: **<**https://fga.unb.br/automotiva/tcc/201402/titulo-proposicao-de-uma-bancada-didatica-para-analise-de-vibracao-em-manutencao-preditiva>
Accessed at: 26 Feb.

[2]TELLES, Pedro c. Silva. **Industrial piping calculations.** Rio de janeiro, 1999.

[3]Lifetime reliability. **The Lifetime Reliability Solutions Certificate Course in Maintenance and Reliability Module 4 – Precision Maintenance Techniques for Machinery.** Australia 2017. Available at: **<**https://lifetime-reliability.com/wp-content/uploads/2021/03/Maintenance-Mgt-25.-18_ShaftAlignment.pdf>
Accessed at: Mar 30, 2021.

[4]SILVA Torres. *Et al.* **Centrifugal pumps step by step.** Salvador, 2008, ed 4°.

[5]VIANA, Hebert Ricardo Garcia. **Maintenance planning and control,** Rio de janeiro, 2008.

[6] TELES Jhonata**. The Importance of Standardizing Maintenance**. Brasilia 2017
Available at: **<**https://engeteles.com.br/procedimentos-de-manutencao/>
Accessed at: Mar 30, 2021.

ISSN: 2357-7592