IMMPROVMENT OF SELF ALIGNMENT FOOTING SYSTEM FOR MOTOR-PUMP ROTATING SHAFT

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MASTER OF MANUFACRUING ENGINEERING (QUALITY SYSTEM ENGINEERING)

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A report submitted in fulfilment of the requirements for the degree of Master of Manufacturing Engineering (Quality System Engineering)

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DECLARATION

I declare that this report entitled “Improvement of self-alignment footing system for pump-motor rotating shaft” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Maged Abdullah Alkhanbashi

Date : .....

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Quality Engineering System).

Signature :……...

Supervisor Name: Dr. Mohammed Shahir

Date :……...

Dedication

To my beloved father and mother

ABSTRACT

This project described the development of motorized shaft alignment system to be used in motor-pump machineries. Shaft alignment is vital to ensure the equipment able to operate for longer duration. It was well known that poor alignment causes the bearing failures, coupling wear or failure, increase energy consumption, bearing housing damage and bent rotors or crankshafts. In the past, misalignment issues were solved manually by using shims, however, this method having problematic issue such as skill requirement and time consuming. Alternatively, the shimless footing system were introduced to overcome this problem. This project described the improvement of current shimless design by introducing motorized system. It was notified the root causes of the previous design problems due to manufacturing quality (t-slot and normal screw that used). A new motorize self-alignment system was developed along with fabricate a new footing system. A new feature will be added to overcome delay response time, backlash, not accurate positioning, and ease for maintenance. A linear bearing and backlash free screw are the major component to solve the backlash problem, reducing response time needed to settle down the misalignment correction, and become more precise. The new design of block was fabricated with size of 100 mm x 200 mm x 100 mm. The drawing of the prototype is done by using solidworks software. The block made of aluminum and machined by CNC milling machine. Vibration sensor was added to measure the response of misalignment. The PID controller will do correction by controlling shaft position by mean of step motor drive. Finally, the test on the fabricated system will be done by using test rig. As expected the project got improved in terms of response time with more accurate position. The lowest record score 7 seconds to correct the misalignment in shaft speed 100 RPM, while it took 86 second for correction in shaft speed 1000 RPM.

ABSTRAK

Projek ini menggambarkan perkembangan sistem penjajaran aci bermotor yang akan digunakan di jentera pam motor. Penjajaran shaft sangat penting untuk memastikan peralatan dapat beroperasi untuk tempoh yang lebih lama. Adalah diketahui bahawa penjajaran yang buruk menyebabkan kegagalan galas, pakai gandingan atau kegagalan, meningkatkan penggunaan tenaga, menyebabkan kerosakan perumahan dan rotor bengkok atau crankshafts. Pada masa lalu, isu-isu misalignment telah diselesaikan secara manual dengan menggunakan shims, bagaimanapun, kaedah ini mempunyai masalah bermasalah seperti keperluan kemahiran dan memakan masa. Sebagai alternatif, sistem pijakan tak berkilau diperkenalkan untuk mengatasi masalah ini. Projek ini menggambarkan peningkatan reka bentuk tanpa sinaran semasa dengan memperkenalkan sistem bermotor. Ia telah diberitahu penyebab utama masalah reka bentuk sebelumnya disebabkan oleh kualiti pembuatan (t-slot dan skru normal yang digunakan). Sistem penjajaran diri bermotor baru telah dibangunkan bersama-sama dengan mengarang sistem pijakan baru. Ciri baru akan ditambah untuk mengatasi masa tindak balas kelewatan, tindak balas, kedudukan tidak tepat, dan kemudahan untuk penyelenggaraan. Garis lurus linear dan backlash percuma adalah komponen utama untuk menyelesaikan masalah tindak balas balik, mengurangkan masa tindak balas yang diperlukan untuk menyelesaikan pembetulan misalignment, dan menjadi lebih tepat. Reka bentuk baru blok dibuat dengan saiz 100 mm x 200 mm x 100 mm. Lukisan prototaip dilakukan dengan menggunakan perisian solidworks. Blok yang diperbuat daripada aluminium dan dimesin oleh mesin pengilangan CNC. Sensor getaran telah ditambah untuk mengukur tindak balas salah jajaran. Pengawal PID akan melakukan pembetulan dengan mengawal kedudukan aci dengan min memandu pemanduan. Akhir sekali, ujian pada sistem fabrikasi akan dilakukan dengan menggunakan rig ujian. Seperti yang dijangka projek itu bertambah baik dari segi masa tindak balas dengan kedudukan yang lebih tepat. Skor rekod paling rendah 7 saat untuk membetulkan salah jajaran dalam kelajuan aci 100 RPM, sementara ia mengambil masa 86 saat untuk pembetulan dalam kelajuan aci 1000 RPM.

Acknowledgment

In preparing this report, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and thought. In particular, I wish to express my sincere appreciation to my main project supervisor, Dr.Mohd Shahir Bin Kasim, for encouragement, guidance critics and friendship. I am also very thankful to the lab technician En.Mohd Hanafiah for his help in fabrication and measuring guidance, advices and motivation. Without their continued support and interest, this project would not have been same as presented here.

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LIST OF ABBREVIATIONS

CNC	Computer Numerical Control
MM	Millimeter
PID	Proportional-Integral-Derivative
MPII	Master Project 2
UTeM	Universiti Teknikal Malaysia Melaka
RPM	Revolutions Per Minute
IOT	Internet of Things

CHAPTER 1

INTRODUCTION

This particular chapter will describe shaft alignment in rotary machinery. This chapter covers the background of the study, objectives of study, problem statement, scope of the project and chapter overviews.

1.1 Background of Study

Nowadays, our daily life is surrounded by rotating dynamic machinery. After unbalance, misalignment is accepted as the second most commonly observed disturbance source in rotor systems (Patel and Darpe, 2009). Negligence of machine alignment is consuming 30% of the machine's downtime (Hariharan and Srinivasan, 2011). Misalignment happens when centerlines of the motor and the driven device shafts are not positioned in the same axis. Misalignment problem may cause up to 70% of the vibration problems observed in rotating machines (Luis *et al.*, 2014) Misalignment of rotating shaft generate, noise, coupling, exaggerated vibrations, bearing temperature increases, and premature bearing, or shaft failure. Poorly aligned shafts may cause serval machine problems: studies have shown that misalignment of the shaft is the cause for around half of machine breakdowns. Thus, proper shaft alignment affecting the smooth, effectiveness transportation of generating power to the driven equipment via the motor. Attaining a correct shaft alignment when installing rotating mechanical systems is essential apart.

1.2 Problem Statement

Misalignment is considered one of the main common problem in the machinery industry. Over the years, a lot of researches have been done just to understand the rotor dynamics phenomena. Shaft alignment is considered one of the most common form of alignment performed on rotating machines(Lin et al., 2010). The alignment of the shaft by using shim are difficult because of a pre-cut shim has its standard size, tolerances, and time consuming, moreover it's not accurate method to align the shaft due to the skills needed to perform the alignment process. Therefore, using shimless footing system is implemented in this project. There are two issues to be rectified. On the mechanical part, the quality of shimless footing system was inadequate to do alignment task. The T-slot dependent in sliding motion and ordinary screw were the major contribution to the backlash issue. It was proposed by this project to improve new design for high accuracy sliding rack to replace current T-slot to enhance the response time, along with backlash free screw for settling down the backlash issue. Second issue is the controller itself which to introduce smart system (PID) that accommodate with mechanical parts. Some controller need to be fine-tuned so that the system can performed as desired.

1.3 Research Objective

The objectives are as follows:

i. To design an improve motorize self-alignment system by using PID controller.
ii. To fabricate a system with smooth tuning and could reduce vibration during the shaft alignment process.
iii. To check the performance in terms of response time, and accuracy for motorize self-alignment system.

1.4 Scope of Work

This project is to study and analyses the current design of shimless footing system. This report explains in details the design and development of self-alignment horizontal (Z axis) and vertical (Y axis) for rotating motor-pump shaft. The correction done by this device only limited to 3 mm. The scope for the project as follows

- It was proposed by this project to introduce high accuracy sliding rack to replace current T-slot.
- The common screw to control motion to be replaced with the backlash free type lead screw.
- The self-alignment footing product that made of aluminum is fabricated using machining processes to form the final product.
- The motorize system is then implemented and integrated with PID controller to validate the performance during rotating shaft machinery.

CHAPTER 2

LITERATURE REVIEW

This chapter will explain about the literature review from the research regarding of shaft misalignment, type of misalignment, causes and effects of misalignment, methods of alignment, and methods of misalignment, PID controller system and the components involved in shaft alignment.

2.1 Introduction

This session of the study will investigate more in the effect of misalignment on the vibration and noise emission of the rotating speed machinery. This chapter reviews and explains about the previous studies that have been done. Literature review examines respectively to the source and describes to justify the statement with proof of research or study in related field.

2.2 Shaft Alignment

Shaft is defined as a rotating machine element used to transfer the power from one part to another. Shafts place members like gears or pulleys in their specific positions, torque will transmit along with members when it is connecting together. Shaft alignment is the process where two machines are positioned in collinear such that the power transferred from one shaft to another (*A Practical Guide to Shaft Alignment*. 4th edn, 2002).

Shaft alignment is a coupling machine shaft-to-shaft alignment consisting of driver and driven machine. The driver machine, such as electric motors, turbine or reciprocating machine, has been designed to provide the driven machine with a coupling to rotate mechanical power.

The driven machine like a generator, a ventilator or a pump that generated power (Wowk, 2002).

The driver was transmitting power to the driven motor by connecting the two shafts to each other. Both shafts 'centerlines must remain in one straight line as they are coupled together and rotate under their standard operating conditions. The main goal of shaft alignment is to expand the operating life span of the dynamic rotating machine.(Al-Hussain and Redmond, 2002).

The perfect alignment of the shaft will reduce the excessive axial and radial forces on the bearings in order to protect the rotor's longer life and stability under its standard operating conditions and reduce the amount of shaft bending due to the transfer of power from one connection to another (Tsiafis *et al.*, 2015). Figure 2.1 show the perfect alignment.

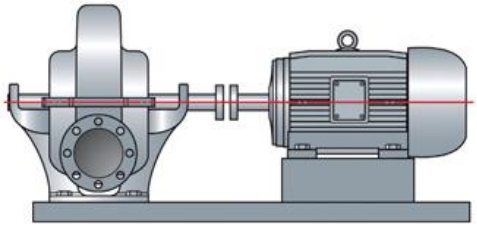

Figure 2.1: Required Alignment for a Shaft

2.3 Shaft Misalignment

Shaft misalignment is the deviation of the relative shaft position from the rotational axis measured at the power transmission points during normal operation (Baer et al., 2013). Failure to align shaft is liable for 50 percent of machine downtime and machine damage cost. Implementing proper shaft alignment can prevent a large number of damage to machinery and reduce downtime that causes loss to company and production. The alignment required is done by adjusting the machine correctly by moving its feet (Gairola, 2004). The main reason for alignment during rotation is to obtain coaxial centerlines. Company and machine downtime cost increase dramatically if the shaft or belt on rotating components not matching, causes seals and coupling damage (Luedeking, 2012c). Any misalignment between the centers of the shaft's rotation can cause vibration and additional loads that can result in premature wear,

catastrophic failure of the bearings, seals, the coupling itself and other machine components when the shaft of tow rotating machine is coupled directly by fixable coupling (Bloch, 2004).

2.4 Type of Misalignment

Failure to align shaft is liable for 50% of machine downtime and machine damage cost. Implementing proper shaft alignment can prevent a large number of damage to machinery and reduce downtime that causes loss to company and production. There are two types of misalignment parallel misalignment and angular misalignment (Huang, Zhou and Yang, 2011).

2.4.1 Parallel Misalignment

Offset or parallel misalignment occurs at the gap between two shafts centerlines. Parallel misalignment can occur in horizontal and vertical direction. Offset that present in the horizontal plane in which the movement will be left or right, and vertical plane that positioned at different level up and down (Huang, 2005). Figure 2.2 shows the parallel misalignment between the driver shaft and driven machine.

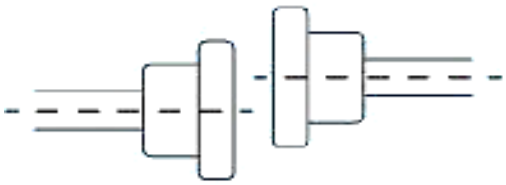

Figure 2.2: Parallel Misalignment (Mark et al., 2008)

2.4.2 Angular Misalignment

The angular misalignment is occurring when the shaft motor is set in an angle to the driven machine (not parallel). This type of misalignment may cause serious damage of the driven equipment and the motor shaft due to the difference in slope. Figure 2.3 shows an angular or face misalignment.

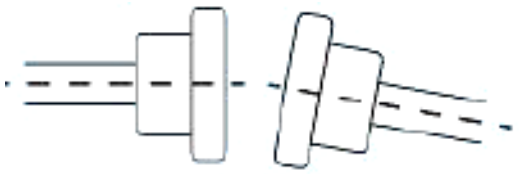

Figure 2.3: Angular or face misalignment (Mark et al., 2008)

2.5 Causes of Misalignment

There are many causes contributing to shaft misalignment. One of them is the procedure of alignment. An alignment procedure is not complete or the wrong alignment procedure can cause misalignment of human error. Foundations or also known as base plates may settle down to a lower position. This can lead to setting misalignment. Even if the equipment is realigned, misalignment can occur again if no action is taken on the machine base plates (Leso et al., 2011).

Other than that, coupling defect that originated from manufacturing due to distorted coupling. This misalignment usually occurs on new equipment or when the coupling is the breakdown. Moreover, thermal growth or expansion is due to mechanical changes in the shaft centerline location (Bourgault, 2004).

These changes are caused by process forces such as pressure, airflow and others. However, temperature changes are the most notable aspect that result to misalignment (Jang&Khonsri,2015). Different material expands when heated at different rates. It is necessary to consider about thermal growth when equipment normally operates above ambient temperature (Hermanson, 2013).

2.6 Effect of Misalignment

In dynamic rotating machinery, misalignment can be detected in several aspects that include excessive vibration, wear patterns, extreme bearing temperatures and noise. Several techniques are integrated into a system's preventive maintenance program (Bhattacharya & Yu, 2012). Inspections usually take place when the damage is occurring.