IDENTIFICATION OF LEAKAGE TENDENCY AND OPTIMUM OPERATING PARAMETERS ON A NEWLY FITTED STERN TUBE SEAL

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ABSTRACT

Stern tube seal is widely used in marine transportation to provide improved sealing for watertight integrity at higher shaft revolution. If the operating parameters exceed the optimum operating cooling water pressure with reference to variable initial operating and boundary conditions, deformation which can lead to excessive leaking may occur. This research studies on the factors contributing to leakage tendency of a newly fitted Stern Tube Seal Seat Assembly (STSSA). The study involved verification on the STSSA current design by means of leakage tendency identification, thus proposing optimum operating parameters to avoid excessive leaking. This is implemented by using numerical modelling by means of Fluid Solid Interaction (FSI) simulation model. Numerical modelling results in terms of deformation at the STSSA running surface are compared with actual field data on a specific STSSA. The results shows leakage tendency is subject to occur at operating cooling water pressure of 3 bars based on Fluid Film Lubrication (FFL) outcome characteristic which is stress distribution and deformation. Furthermore, the operating cooling water pressure of 2.5 bars is proposed as the optimum operating parameters based on the resultant STSSA deformation on not exceeding limits of 0.025 mm.

ABSTRAK

Tiub Kedap Buritan (TKB) digunakan secara meluas dalam pengangkutan laut untuk menyediakan fungsi kekedapan yang efektif bagi memastikan integriti kedap air pada revolusi aci yang tinggi. Jika parameter operasi melebihi operasi tekanan air penyejuk optimum dengan merujuk kepada keadaaan operasi dan keadaan sempadan awal boleh ubah tertentu, ubah bentuk pada TKB boleh menyebabkan berlakunya kebocoran melampau. Kajian ini mengkaji faktor-faktor yang menyumbang kepada kecenderungan kebocoran bagi TKB yang baru dipasang. Kajian ini melibatkan pengesahan kepada reka bentuk semasa TKB dengan cara mengenal pasti kecenderungan kebocoran, sekali gus mencadangkan parameter operasi optimum untuk mengelakkan kebocoran melampau. Ini dilaksanakan dengan menggunakan kaedah berangka melalui model simulasi Interaksi Bendalir dan Pepejal (IBP). Hasil daripada kaedah berangka, keputusan ubah bentuk di permukaan TKB seterusnya dibandingkan dengan data sebenar yang diperolehi daripada TKB tertentu. Keputusan menunjukkan kecenderungan kebocoran berlaku pada operasi tekanan air penyejuk pada 3 bar, berdasarkan ciri hasil Pelincir Filem Bendalir (PFB) iaitu agihan tegasan dan ubah bentuk. Selain itu, operasi tekanan air penyejuk pada 2.5 bar dicadangkan sebagai parameter operasi optimum berdasarkan ubah bentuk TKB yang tidak melebihi had 0.025 mm.

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ϕ_x and ϕ_y	-	Pressure Flow Factor
ϕ_s	-	Shear Flow Factor
θ	-	Mean Fill Ratio
p	-	Mean Pressure
η	-	Oil Viscosity
h	-	Nominal Clearance Height Between Journal and Bearing
h_T	-	Average Clearance Height
u_1 and u_2	-	Circumferential Velocity of the Journal and Bearing Surface
σ_s	-	Composite Height Standard Deviation
σ_1 and σ_2	-	Standard Deviation of Clearance Height at Journal and Bearing Surface
m	-	Journal Mass
$\ddot{x}_j$	-	Journal Position
f_j	-	Oil Film Force Acting on the Journal
f_A	-	Outer Force Acting on the Journal

CHAPTER 1

INTRODUCTION

1.1 Research Background

Elastomer rotary seals were first introduced in the 1930s to provide improved sealing at higher speeds than the leather seal that had been used previously. They are now the most commonly found rotary shaft seal in everything ranging from domestic equipment to automotive and other transportation applications through to high-duty industrial and marine transportation which is known as a elastomer stern tube seal.

Giving the fact for Naval Authorities in operating high activity and high speed ships, such used of elastomer stern tube seal is unavoidable. It is to be noted, that stern tube seal is a main component in a ship shafting arrangement which also complete the main propulsion system in order to propel the ship. Furthermore, it is used to maintain the ship water tight integrity and also acts as a mounting to support the shaft from axial and radial loads. Friction cause between the rotating shaft and the stern tube seal surface or more specific the seat assembly, generate heat to the stern tube seal housing which require continues cooling. Its cooling system is design such as a fluid film lubrication system which uses seawater as lubrication.

For better understanding, the stern tube seal location as in Figure 1.1 is at the inner end of the stern tube which is below the water line. The highlighted blue area shows the seawater boundary throughout the shafting arrangement, thus defining the stern tube seal function as a deep sea seal to maintain the ship water tight integrity. Giving the consistency distance between each cutless bearing, shaft line bearing and the stern tube seal, it clearly defined the used of stern tube seal as a mounting as well as journal bearing to support the shaft from axial and radial movements.

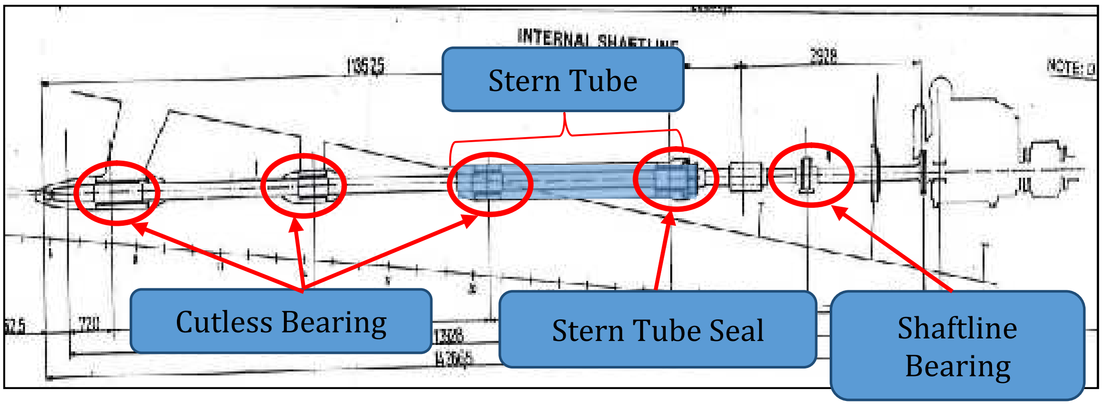

Figure 1.1: Schematic of a Ship Shafting Arrangement

An overview of a stern tube seal mounted to a shaft is shown in Figure 1.2. As the shaft rotates at certain RPM, Magnus effect will occur. In this condition the shaft is slightly lift up from its original axis which causes vibration and misalignment. Furthermore frictions will occur, which will effect certain elastomer components (o-cord seal) and major metal components (seat assembly) having direct contact with the shaft resulting in degrading of the contact surface. Therefore the cooling system is design such as pressurize cooling system in order to provide Elastohydrodynamic Lubrication (EHL) for continuous cooling. However it is to be noted that the lubricant use is seawater, which is circulated continuously inside the cooling jacket by means of the cooling water inlet and discharged through the stern tube seal outlet opening.

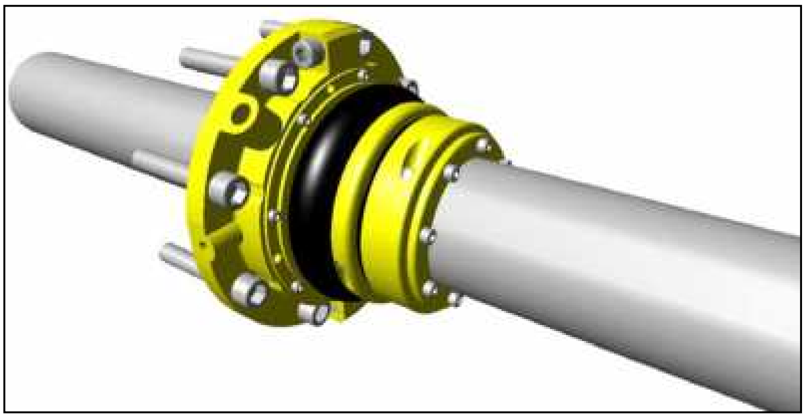

Figure 1.2: Overview of a Stern Tube Seal Mounted to a Shaft

Figure 1.3 shows a cross section view of the stern tube seal housing defining the location of the main components as mentioned earlier, and giving an overview of the pressurize cooling system which provide EHL. EHL in principle applied to rolling body such as roller bearing, journal bearing and gear meshing. It is commonly known as a mode of fluid film lubrication (FFL) in which the mechanism of hydrodynamic film formation is enhanced by surface elastic deformation and lubricant viscosity increase due to high pressure [1]. There are two types of FFL surface, which is the non-conformal and conformal surface. The non-conformal surface involved a small contact region, which contribute to high contact pressure. As for the conformal surface, the contact region is widely spread having the highest projected pressure lower than the non-conformal surface.

In this research, the area of concern is on the FFL conformal surfaces between the shaft surface and the stern tube seal seat assembly. As mentioned earlier, upon operation friction is subject to occur which contribute to heat generation. Therefore, in order to ensure the stern tube seal is operating within the required condition, the boundary conditions of the pressurized cooling system must be maintained by controlling certain operating parameters. However these parameters (cooling water pressure) are subject to change if the initial condition changes in the case of a newly fitted stern tube seal. Being stated so, optimum cooling water pressure is require to avoid deformation on the seat assembly and misalignment which may contributes to excessive leaking. In order to identify leakage tendency cause by deformation, FFL outcome characteristic and operating parameters for a newly fitted stern tube seal are observe using numerical approach by means of fluid solid interaction (FSI) simulation model.

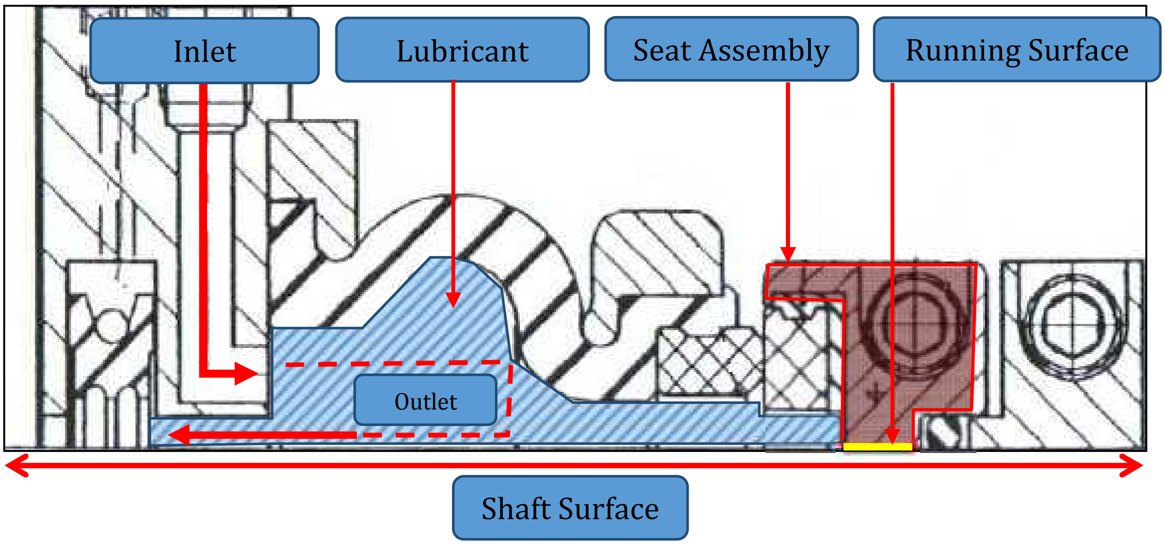

Figure 1.3: Cross Section of a Stern Tube Seal Attaching to a Shaft

1.2 Research Objectives

Research objectives are as follows:

1. To verify current design by means of leakage tendency identification .on newly fitted Stern Tube Seal Seat Assembly (STSSA)

2. To propose optimum operating parameters on a newly fitted STSSA.

1.3 Problem Statement

Stern tube seal is usually subject to wear and tear. Therefore replacing some of the major components is a normal practice onboard a ship in order to maintain the ship's watertight integrity. However by fitting new STSSA, the operating parameters and FFL characteristic is subject to be affected due to the clearance deviation between the STSSA and the shaft surface. It is to be noted that the clearance deviation is only temporary, where the STSSA running surface is subject to wear by means of polishing. During the polishing period, the operating parameters is require to be increased in terms of its pressure in order to maintain the stern tube seal operating temperature.

However the optimum operating parameters in terms of its inlet pressure (operating parameters) with reference to the initial operating conditions and boundary conditions are not specifically mentioned by the Original Equipment Manufacturer (OEM). This is consistent with the difference value of operating cooling water pressure used throughout the sea acceptance trial for a newly fitted elastomer stern tube seal. It is also to be noted that if the operating parameters exceed the optimum cooling water pressure, deformation and misalignment may occur which contribute excessive leaking. However if insufficient cooling pressure is provided, FFL starving effect may occur.

1.4 Scope of research

Scopes of research are as follows:

1. Observed FFL outcome characteristic to identify leakage tendency based on simplified numerical model by means of Fluid Solid Interaction (FSI) with respect to:

    a. Stress distribution.

    b. Structure deformation.

2. Obtain optimum operating cooling water pressure using numerical modelling dependent on the following initial/boundary conditions:

   a. Constant shaft speed.

   b. Clearance deviation of a newly fitted STSSA.

3. Limitation and consideration:

   a. Data for initial and boundary conditions are only limited to one type of elastomer stern tube seal.

   b. Vertical load and total friction power loss cause by multi-body dynamics from various propulsion system equipment is not considered.

1.5 Theoretical Framework

The theoretical framework of this research is presented in Figure 1.4. The critical steps will involve the requisition of initial and boundary conditions data as well as the development of FSI simulation model for a newly fitted stern tube seal pressurized cooling system.

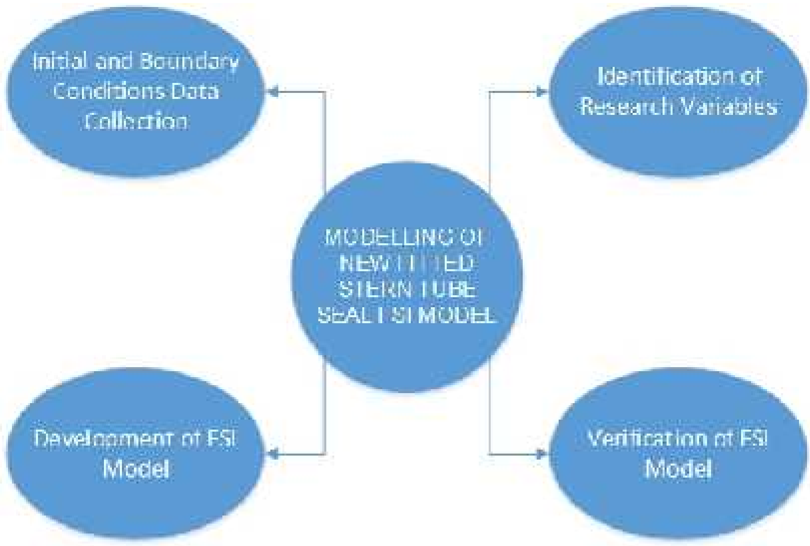

Figure 1.4: Theoretical Framework

1.6 Organization of Thesis

Chapter 1: Introduction

This chapter describes the research background of this. The objective of this project also been started in this chapter.

Chapter 2: Literature Review

In this chapter, the item that will be discussed is the related works and literature review that will supported this study.

Chapter 3: Methodology

The most significant chapter that is chapter 3 detailing on the research methodology variables and equations involved in the modelling and simulation part. Data collection method and the accuracy of the result are been listed in this chapter . It will also define the research variable and the data to be enquired.

Chapter 4: Result and Discussion

For this chapter, results and findings obtained from the FSI modelling are listed out and discussion is carried out for the result obtained. the reliability of the data obtained will also be discussed.

Chapter 5: Conclusion and Recommendation

In this last chapter it is dedicated for conclusion of the study and recommendations on future improvements for different operating parameters needed in this study.

This paper will have the reference list post and also the appendices.

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