DESIGN AND ANALYSIS OF WINCH FOR EXTENDABLE BUNDLE PULLER

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DECLARATION

I declare that this project report entitled “DESIGN AND ANALYSIS OF WINCH FOR EXTENDABLE BUNDLE PULLER” is the result of my own work except as cited in the references

Signature : .....

Name of Supervisor : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovative).

Signature :. .....

Name of Supervisor : .....

Date : .....

DEDICATION

To my beloved mother and father This project is dedicated wholeheartedly to my beloved parents, Mrs Haslawati binti Mohamed and Mr Saiful Azman bin Amat who have been always there for me along the way to complete the study in Universiti Teknikal Malaysia Melaka and continually support me spiritual, moral, and also in term of financial.

Besides that, I would like to dedicate this project to my siblings who always help me with study, moral and also in financial support. I also like to dedicate this project to my friends who help me by giving some knowledge to complete this project.

Lastly, I would like to dedicate this project to whoever that ever exist in my life along the journey to complete my study and also my project.

ABSTRACT

Bundle pullers are useful in the power plant sector because they are used to extract the tube bundle from the heat exchanger. Bundle pullers are made up of a cradle that holds a mainframe and a power source, a sled that is attached to a tube bundle and has a hydraulic powered screw drive that pushes the sled on the mainframe, a hydraulic elevator on the mainframe that holds and adjusts the position of the tube bundle, and an extension that adjusts the length of the mainframe. Bundle pullers for extracting exchangers already have a variety of designs for the lifting frame. There are several designs that use merely a beam with a string tied to it, as well as the current design where the winch could extract the bundle tube. The goal of this project is to design a winch capable of extract a variety of tube bundles weighing up to 80 tonnes. Measurements of the bundle tube were taken as a reference for the next design of bundle puller. The maximum load that the chosen design of the winch can hold was determined using Finite Element Analysis (FEA) with ANSYS. The FEA results from the winch will decide the size of the gear and motor power to be used for the winch bundle puller.

ABSTRAK

Penarik berkas berguna dalam sektor loji kuasa kerana ia digunakan untuk mengekstrak berkas tiub daripada penukar haba. Penarik berkas terdiri daripada buaian yang memegang kerangka utama dan sumber kuasa, kereta luncur yang disambungkan pada berkas tiub dan mempunyai pemacu skru berkuasa hidraulik yang menolak eretan pada rangka utama, lif hidraulik pada rangka utama yang memegang dan melaraskan kedudukan berkas tiub, dan sambungan yang melaraskan panjang kerangka utama. Penarik berkas untuk mengekstrak penukar sudah mempunyai pelbagai reka bentuk untuk bingkai pengangkat. Terdapat beberapa reka bentuk yang hanya menggunakan rasuk dengan tali yang diikat padanya, serta reka bentuk semasa di mana win boleh mengeluarkan tiub berkas. Matlamat projek ini adalah untuk mereka bentuk win yang mampu mengekstrak pelbagai berkas tiub dengan berat sehingga 80 tan. Ukuran tiub berkas diambil sebagai rujukan untuk reka bentuk penarik berkas seterusnya. Beban maksimum yang boleh dipegang oleh reka bentuk winch yang dipilih telah ditentukan menggunakan Analisis Elemen Terhad (FEA) dengan ANSYS. Keputusan FEA daripada win akan menentukan saiz gear dan kuasa motor yang akan digunakan untuk penarik bundle win

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CHAPTER 1

INTRODUCTION

1.1 Background

Oil refinery is an industry that uses fractional distillation to convert crude oil into more useful petroleum products such as gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas. (Kundnaney and Kushwaha, 2015).

Heat exchangers are essential in the oil and gas processing industry. They are used in the refining process, specifically in cracking units, as well as in natural gas liquefaction. Cracking is the process of dispersing the hydrocarbons that make up crude oil. A heat exchanger is a device used to transfer heat from one medium to another efficiently in order to transport and process energy (Alawa and Egwanwo, 2012).

The heat exchanger system has a significant impact on the time of the plant's turnaround. When the plant resumes normal operation following turnaround, a failing heat exchanger within a short period of normal plant operation, even if the contractor's warranty is still valid, might result in a significant financial loss due to reduced downtime or production loss.. (Saffiudeen et al., 2020)

Figure 1.1 Heat exchanger bundle tube (Industry Review, 2021).

As a result of the invention of the bundle puller, a better cleaning device for tubes in a plant was created that does not require removing the tubes from their installed positions in the plant in order to clean them. The lance drive is positioned to reduce buckling of the lance. (Cradeur and Cardone,1976)

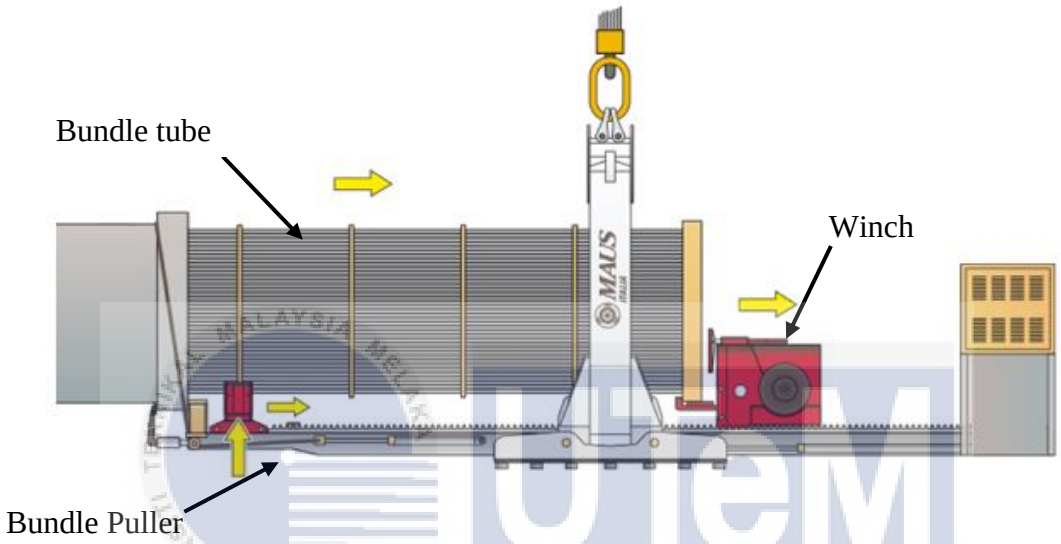

Figure 1.2 Aerial Bundle Puller (Maus,2019).

1.2 Problem Statement

Bundle Puller is one of the important products that is often used in the oil and gas industry, especially when there is a shutdown and bundle tube cleaning work needs to be done quickly and effectively. Current design bundle puller is use for the specific pulling force, length and diameter of bundle tube. To safe cost extendable bundle puller that can be used for various size of bundle tube should be designed.

In this project, 40 T bundle puller will be upgraded to 80 T bundle puller by maintain the existing engine and hydraulic accessories. Also, since the design of the balancing and main frame is extendable. The design of the winch should be considered about the additional components for extendable bundle puller.

As an improvement, it was proposed to design a winch for upgrade the existing 40T bundle puller. However, gear ratio for the winch to move and suitable gear to match with the gear rack need to be considered. Thus, a new winch system and specifications need to be designed

1.3 Objective

The objectives of this project are as follows:

1. To design winch of bundle puller that can pull until 80 tonnes bundle tube
2. To design the winch that can be used for the extendable bundle puller mainframe and balancing frame.
3. To carry out FEA analysis to ensure the new design of a winch is safe to use for 80T pulling force.

1.4 Scope of Project

- Investigate the current design and mechanisms 40 Tonne of winch
- Come out new design of winch that can come out pulling force until 80T bundle tube
- Carry out finite element analysis to the winch

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will be included study and research of published material like journals, thesis, case studies, technical document, book and online library. Generally, the purpose of their view is to analyse critically a segment of a published body of knowledge through summary, classification, approach used in their project, and any technique that used in their study, review of literature and theoretical articles. This chapter will describe topics that related of winch, winch mechanisms, gear systems, gear forces, Computer Aided Design (CAD), design, conceptual design, Optimization, Finite Element Analysis (FEA), Design Process and other relevant topic for this project. These chapters to carry out any approach that can use in drain cover frame design and analysis using Finite Element Analysis method and carry out current product design.

2.2 Definition of Winch

Winch is a type of driving equipment used to raise and lower large items. It is frequently utilised in the field of mechanical mechanisms. It is built as a pulling mechanism, with rope wound around a horizontal drum that is normally driven by a motor. According to the driving system, it is classed as an electrical winch, a mechanical drum-style winch, a mechanical capstan-style winch, a hydraulic winch, a mechanical hand-operated winch, a mechanical portable winch, or a hybrid winch. A winch is composed of numerous components, including a drum, a shaft, a rope, a winch gearbox, and a drive system. It is

frequently used to tow large loads and is seen in mines and marine applications. Winches are a critical component of crane and mooring systems used to activate cable cars, lifts, and, in fact, whenever dynamic pull from a flexible rope is required. To produce a strong draw and accurate control during winching operation, it is required to modify the conventional design of winches. The purpose of this review is to identify areas for improvement in the design of winch systems in order to provide high-performance winches for a variety of technical applications. (KachareSavita2015).

A winch is designed to pull objects that are either parallel to the ground or have a very slight gradient. A hoist is required if you need to lift something out of a pit, such as a tractor. Additional brakes are included on a hoist to safeguard the safety of both the dragged item and you (Emanuel, 2014).

Winches are categorised into numerous subcategories based on their mechanism of operation. They are propelled by hydraulic, pneumatic, electrical, and mechanical systems. As a result, they are classed according to their power source as hydraulic winches, pneumatic winches, electrical winches, or mechanical winches. They are used in a number of technical applications, such as portable water well equipment, the maritime environment, on a boat or ship, on an oil rig, and for vehicle recovery. (KachareSavita,2015)

Hydraulic winches are frequently used in engineering applications. A hydraulic motor is used to drive the hydraulic winch, which is controlled by an electronic hydraulic proportional valve. When a hydraulic winch is required to follow a specific movement, the reaction speed significantly affects the control accuracy. (Entao,2011)

Hydraulic winches are often constructed with a high rated weight, making them ideal for the most difficult tasks on land and sea. This heavy-duty winch is frequently used on ships, coastlines, and docks for a variety of purposes. The winch is hydraulically powered,

which enables it to transmit a high force capable of handling a considerable amount of labour. Energy efficiency is critical when selecting winches for marine applications. Hydraulic winches are the ideal choice for large ships due to the size of the hydraulic system and equipment. (Fulton et al., 2006).

The hydraulic transmission utilises oil as the working medium, communicates movement by changes in the seal volume, and transfers power via changes in the oil pressure. When several hydraulic cylinders are employed, the pressure applied at any location on a given volume of liquid can be evenly transferred in all directions, which implies that each hydraulic cylinder will pull or push at its own pace, which is determined by the pressure required to move the load. When hydraulic cylinders have the same carrying capacity range, the hydraulic cylinder carrying the lightest weight moves first, and the hydraulic cylinder carrying the heaviest load moves last. To ensure that the hydraulic cylinder moves synchronously and the load is lifted at the same speed at all points, control valves or synchronous lifting system components must be included in the system. Hydraulic winches are primarily consisting of a hydraulic motor (low or high speed), a hydraulic typically closed multi-disc brake, a planetary gearbox, a clutch (optional), a drum, a support shaft, and a frame. The hydraulic motor is very efficient mechanically, has a high starting torque, and can be provided with a variety of distributors depending on the operating conditions, or the valve group can be directly incorporated into the motor oil distributor. The drum houses the brake and planetary gearbox. The drum, support shaft, and frame are all built to meet mechanical specifications. The winch's general structure is straightforward and acceptable, with a high level of strength and rigidity. In terms of performance, the winch equipment is safe, efficient, has a large beginning torque, is stable, produces little noise, and operates reliably. (Skjong, 2014)

2.3 Winch Mechanisms

A winch is composed of multiple distinct components, each of which contributes to the accomplishment of a broader objective. A drum with a circular form that allows wire to be wrapped neatly around it. Due to a spool inside the winch, the drum of the winch can rotate in a circular motion, winding the cable in or out. To avoid tangling, a steel cable or synthetic wire will most likely be wrapped around a drum. (McBratney,2016)

A winch motor is the component of the winch that actually powers the cable, rope, or chain. Not only is the winch motor responsible for the winch's pulling force, but it also powers the cable, rope, or chain out of or onto the winch. The horsepower of the winch motor dictates the winch's pulling and lifting capabilities. Numerous big industrial-type winches are propelled by massive electric motors. These motors are connected to the winch via a series of rubber belts and pulleys. On the other hand, the winch motor is frequently a direct drive motor that is coupled to the transmission gears through a coupler. This avoids the chance of belts or gears slipping due to moisture or debris accumulation. (Kilchermann, 2021).

Whether hydraulic or electric prime movers are used, mechanical efficiency is critical for optimising a winch gearbox's performance. Certain conventional gear systems can have a mechanical efficiency of as little as 50%. In comparison, even at very low speeds, a single stage planetary gearbox unit is approximately 98 percent efficient. Additionally, by distributing loads among numerous planet gears (usually three or four), a planetary gearbox's torque capability is superior than that of alternative solutions of comparable physical size. (He, 1970).

Additionally, the gearbox enables the use of much smaller motors than would be required to move the heavy weights. For instance, if you peek inside a music box, you will notice the mechanism's gears. In a spur gear system, a smaller gear spins a larger gear. The size of the larger gear dictates the size of the object that the winch can pull. (Carral et al., 2021).

2.4 Spur Gear System

A gear is a mechanical component made up of a toothed wheel attached to a spinning shaft. Gears operate in pairs to transmit and change rotational motion and torque (turning force) without slipping, with the teeth of one gear engaging the teeth of the mate gear. If the teeth of a set of matching gears are arranged in circles or if the gears are toothed wheels, the ratios of the rotational speeds and torques of the shafts are constant. (Kia et al., 2015).

A gear is a circular wheel with teeth that rotates in conjunction with another toothed item to transmit torque or power. Spur gears are the simplest type of gear, having teeth cut parallel to the shaft to which the gear is mounted. Spur gears are used to transfer energy between parallel shafts. The spur gear has a 98-99 percent efficiency rating. (Rani, & Khalandar, 2013).

Spur gears or straight-cut gears are the most frequent type of gear. They are typically made up of parallel shafts with straight teeth placed to transfer power. When coupled in pairs, these gears convey motion and power via the parallel axes design. Depending on the application, they may be paired with another spur gear, an internal gear (as in a planetary gear system), or a gear rack (such as in a rack and pinion gear pair). Their shafts are parallel and coplanar. (Eng et al., 2018).

Spur gears have been used since ancient times. They include teeth that protrude radially and parallel to the shaft's axis. A spur gear with teeth on the exterior of a disc is referred to as an external spur gear.If the teeth are on the inner face of the disc, the gear is called an internal spur gear. In the vast majority of applications, external spur gears are used. Internal spur gears are frequently used in epicyclic gearing to achieve a small centre distance. When the pinion and gear mesh, the teeth make contact with two convex profile curves through which the driver applies tangential force to the driven gear at the radius of the pitch circle. The torque generated at the shafts is equal to the moment of the tangential force in the direction of the shaft centres. When the gearset rotates in this manner, it delivers power proportional to the torque. (Mott et al., 2018).

Table 2.1: Dimensions of gears and gearing parameter (ALIPIEV and ANTONOV, 2011)

Concept Spur Gear Calculation		
Item	Symbol	Formula
Number of teeth	z	z = d/m
Module	m	m = d/z
Pitch Diameter	d	d = m x z
Outside Diameter	de	de = m (z + 2) or de = d + 2m
Root Diameter	df	df = m (z – 2.5) or df = de – 2h
Centre Distance	dc	dc = (D + d) / 2; D = (Pitch diameter of gear)

2.5 Spur Gear Forces

Gear forces are essential in the design of gears. Gear tooth forces, in particular, impact root stress and contact stress. Root stress and contact stress, which are discussed in another notebook, dictate the size of the gears. Gear tooth forces must also be considered when designing supporting shafts and bearings. Spur gears only generate forces in the gear

plane; helical gears generate axial forces as well and must be supported axially. Tangential and radial forces in the gear plane create bending moments on the supporting shafts. Axial force causes bends in the perpendicular plane. As a result, calculating gear forces is crucial in the design of shafts and bearings (Glinsky, 2020).

Between mating gears, force occurs in a direction perpendicular to the contacting surfaces. The normal force, FN, can be broken into three components: the axial force Fa, the radial force Fr, and the tangential force Ft. The tangential and radial forces in spur gears are illustrated in Figure 1.

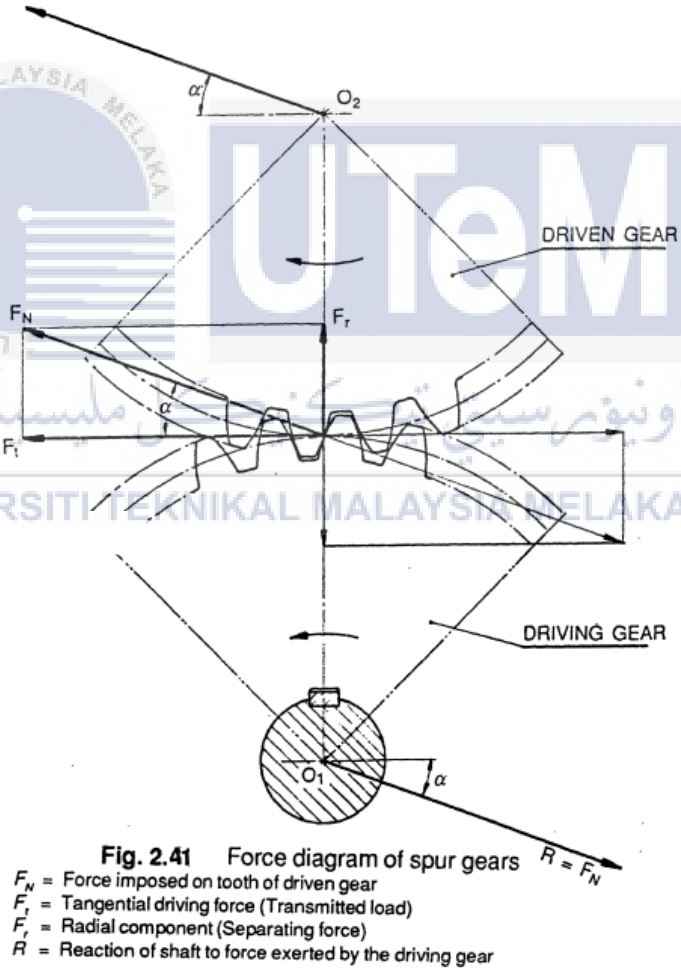

Fig. 2.41 Force diagram of spur gears

F_N = Force imposed on tooth of driven gear
F_t = Tangential driving force (Transmitted load)
F_r = Radial component (Separating force)
R = Reaction of shaft to force exerted by the driving gear

Figure 2.1 Forces on spur gears (Maitra, 2001).