DESIGN OF LIFTING FRAME FOR BUNDLE PULLER

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This report is submitted

in fulfillment of the requirements for the degree of

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Faculty of Mechanical Engineering

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DECLARATION

I declare that this project report entitled "Design of Lifting Frame for Bundle Puller" is the result of my work except as cited in the references

Signature : .....

Name : Mohamad Ikhwan Bin Mohamed Aliasrudin

Date : 19.6.2021

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.

Signature : .....

Name of Supervisor : Ir. Dr. Mohd Shukri Bin Yob

Date : 30/7/2021

DEDICATION

This project is dedicated wholeheartedly to my beloved parents, Mrs Norriah Binti Ibrahim and Mr Mohamed Aliasrudin Bin Abdullah 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.

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ABSTRACT

Bundle puller is important in oil refinery plant since this machine is used to extract the tube bundle from heat exchanger. Bundle puller consist of a cradle which is use to carry a mainframe and an engine compartment, a winch that can be attachable to a tube bundle with a hydraulic powered screw drive to push the sled on the mainframe, a hydraulic elevator on the mainframe for holding and adjusting the position of tube bundle and adjusting the length of the front side of mainframe by using an extension. This project aim to design a lifting frame for bundle puller that can be used for variable size in diameter of tube bundle which the range is from 600 mm to 2000 mm and the maximum weight of the tube bundle is 20 ton. The study involve a few process which are designing conceptual design, designing the test rig to test the locking part of lifting frame, and finite element analysis on both of the design. The purpose of the analysis of the final design is to determine the maximum equivalent von-Mises stress on the design while the analysis on the test rig is to determine the maximum load that the test rig can withstand. This analysis have been done in order to define the suitable size of specimen from the final design at the locking part to be test on the test rig. The result shows that the final design of bundle puller is in good condition to be used by the company. From the analysis, the maximum stress for bundle puller is 156.86 MPa and the safety factor is 1.5938 while for test rig, the maximum stress is 206.85 MPa and the safety factor is 1.21.The result also shows that the test rig can be used to test the locking part of lifting frame for bundle puller. Finally, both of the design are to be a good guideline for further development or research on this project.

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LIST OF SYMBOLS

%	-	Percentage
P	-	Force
Δ	-	Increment
σ_r	-	Radial Stress
θ	-	Angle
σ_y	-	Longitudinal Stress
°C	-	Degree Celcius
D_p	-	Pin Diameter
D_h	-	Hole Diameter
σ_v	-	Von-Mises Stress

LIST OF ABBREVIATION

UTeM	-	Universiti Teknikal Malaysia Melaka
Ansys	-	Analysis System
PDS	-	Product Design Specification
FEA	-	Finite Element Analysis
CATIA V5	-	Computer Aided Three Dimensional Interactive Application
Sdn Bhd	-	Sendirian Berhad
HCL acid	-	Hydrochloric acid
$FeCL_2$	-	Ferrous Chloride
Mn	-	Manganese
HSS	-	Hollow Structural Section
TIG	-	Tungsten Inert Gas
MIG	-	Metal Inert Gas
DC	-	Direct Current
AC	-	Alternative Current
SCC	-	Stress Corrosion Cracking
ID	-	Inner Diameter
OD	-	Outer Diameter
IGES	-	Initial Graphics Exchange Specification

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Bundle puller is a machine use to extract the tube bundle from its shell. This kind of machine is usually use at oil refinery plant. Heat exchanger usually located at high place of the oil refinery plant. Generally, this machine consist of main frame, lifting frame, winch and engine compartment. There are also other auxiliary component attach on the bundle puller such as hydraulic cylinder and lifting lug on the top of lifting frame. Winch of the bundle puller is used for pulling the tube bundle from its shell.

There are also few sizes of hydraulic cylinders attached to the current design. There are two same sizes of sling cylinders to attach the extractor to the shell flange and one longer balance cylinder connect to the lifting frame to balance the bundle puller. In the industry oil refinery plant, there is various size of tube bundle used for the heat exchanger. The range size of the tube bundle is from 600 mm to 2000 mm in term of diameter and have 6 m to 12 m in term of length. The tube bundle that has been extracted will be sent to the cleaning area for the cleaning process of the tube bundle. There are some processes of extraction of tube bundle from its shell is shown in figures below.

Figure 1.1: Connect pulling slings of the winch to the tube sheet

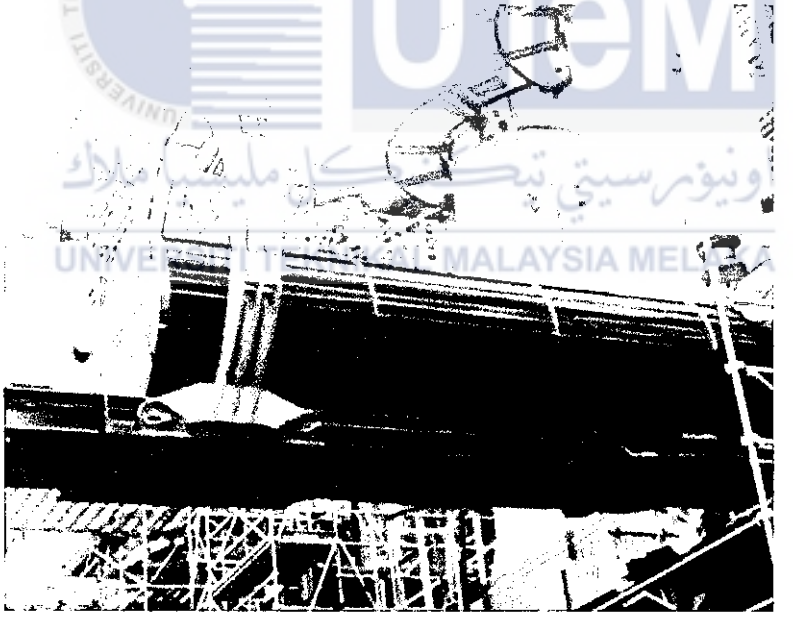

Figure 1.2: Disconnect pulling slings and move pull hook behind tube bundle

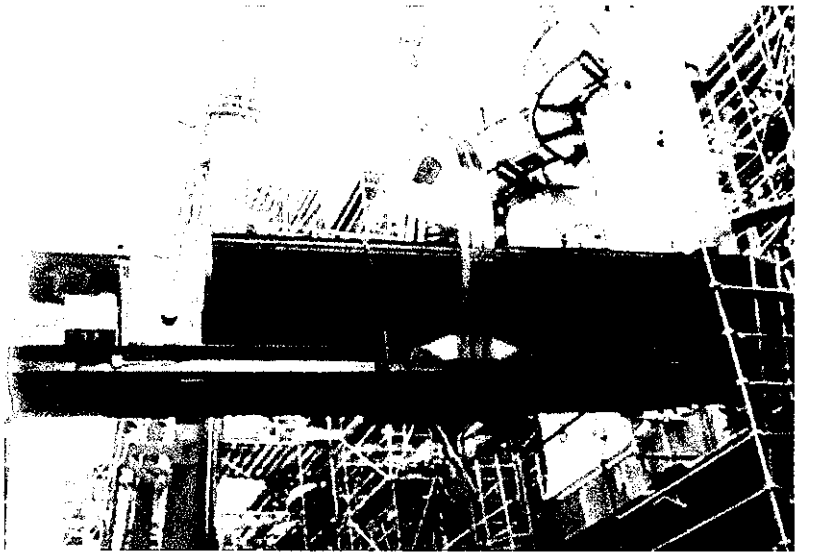

Figure 1.3: Tube bundle is fully extracted

Figure 1.1 above shows the process when the slings were connected to the shell flange and the behind of the shell flange got clamped by the front clamp. Then, the pulling slings of the winch were connected to the tube sheet. After that, as shown in Figure 1.2, the pulling slings will be disconnected and hook behind the tube sheet will be pulled. For safety factor, V-block will use to support the tube bundle. Lastly, after fully pulled out the tube bundle from the shell as shown in Figure 1.3, the clamp will be disconnected. Then, reverse process will be done to transfer the tube bundle on the truck and send it to cleaning area.

1.2 Problem Statement

The current design of bundle puller at Hydrospeed Sdn Bhd is fixed frame where all the joint of lifting frame were welded. The current design of bundle puller only can be used for specific size of tube bundle in term of diameter and length. Generally, tube bundle of heat exchanger have variety of size from 600 mm to 2000 mm. Due to this problem, the company need to buy different size of bundle puller to be use for extraction of tube bundle. This will cost their capital cost and transportation cost if need to use more than one bundle puller to change the tube bundle at oil refineries plant.

To solve the problem due to the variation size of tube bundle, extendable mechanism can be included into the design concept to suit the variable size of tube bundle. However, by doing this, stress of the connection between the lock and the arm of the lifting frame will be difficult to be determined. So, there will be failure occur at the joint area.

1.3 Objective

The objectives of this project are as follows:

1. To design extendable lifting frame for bundle puller for the use of oil and gas refinery plant.
2. To evaluate the stress for lifting frame of bundle puller using FEA software.
3. To design the test rig that will be used to evaluate the stress and deformation of extendable joint for lifting frame.

1.4 Scope

The scope of the project are:

1) Design the lifting frame with height when reduced below than 3.5 m.
2) Design the lifting frame that can endure for 30 t.
3) Design the model by using CATIA V5 software.
4) Use static structural for finite element analysis on the model by using Ansys software.
5) Design the lifting frame for 600 mm to 2000 mm.
6) Design the test rig that can endure the load of 5 t.
7) Use the design of test rig for small scale of model to test the joint.

1.5 Hypothesis

In this study, the design for new lifting frame bundle puller is proposed. In order to improve the design, analysis of load to the lifting frame and its durability has been included into the consideration in the analysis by using Ansys software. Besides, there also need to do finite element analysis on the strength of the locking system that have been design for the product design. So, in order to achieve that, a design of test rig by using CATIA software has been created to test the locking part. At the end of this study, the result of analysis for the product design and test rig will be shown.

CHAPTER 2

LITERATURE REVIEW

2.1 Bundle Puller

The first bundle puller was invented in the late of 60's by William R Postlewaite. Since then, there are many design of bundle puller have been developed. Figure 2.1 shows the design of bundle puller or also called as bundle extractor. According to Krajicek & Cradeur (1991), bundle puller consisted of a cradle that support a carriage frame and a power source, a sled, connected to the tube bundle. The design of bundle puller have hydraulic powered screw drive to adjust the sled on the carriage frame. The bundle puller was designed in 1987. The objective of the designed was to provide a relatively simple method to carry and adjust the tube bundle on the main frame. Another objective was to create a tube bundle puller that can be extended in term of length in order to be able to use for another size of tube bundle.

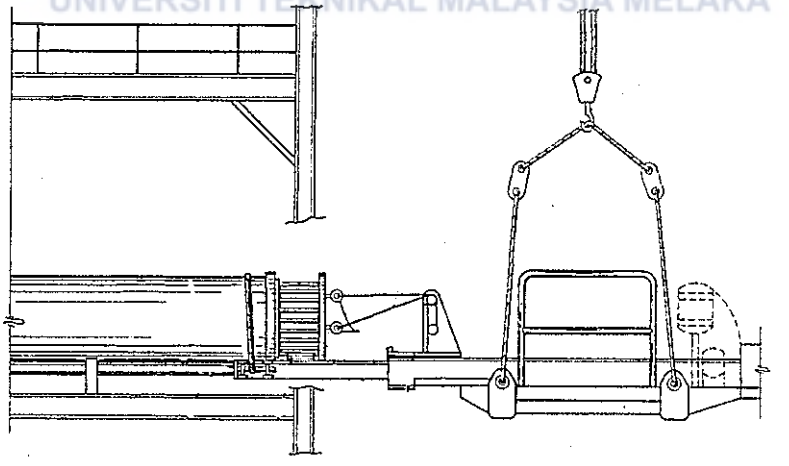

Figure 2.1: Design of tube bundle (Krajicek & Cradeur,1991)

Besides that, figure above is the side view of tube bundle being extracted. Based on Figure 2.1, the bundle puller was suspended at hook by superstructure. Support frame is design with rectangular shape of steel frame while number is its diesel engine. Extension was used to allow the bundle puller to adapt to different length of tube bundle.

Next, a different designed of bundle puller is shown in Figure 2.2. Referring to the figure, the designed is a bit different to bundle puller that was designed by R.W.Krajicek in 1968. According to Travis (1971), this invention relates generally to the application of linear force for the insertion or removal of a first item with respect to the second item, particularly when the first item is tightly engaged with the second item. The preceding configurations are enhancements to the previously stated widely accepted winch and cable setups. However, each of the equipment types indicated in the preceding patents need either a screw-type drive, arrangement, or chain or cable actuation, all of which are subject to the breakage and damage risks inherent in the current technique and equipment for tube bundle extraction.

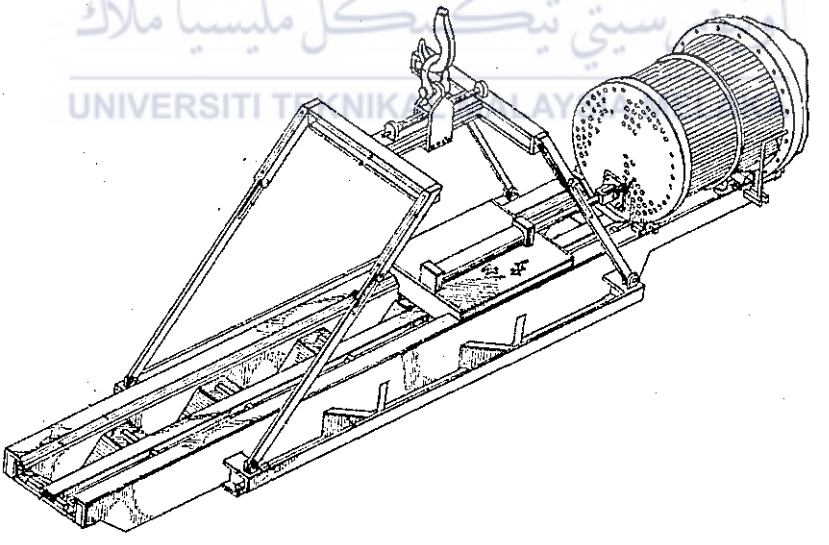

Figure 2.2: Bundle puller designed (Travis, 1971)

The frame structure is comprised of side frame members, which are made up of two spaced apart sidewalls and a top wall with an inward, re-bent flange and a slide surface. The respective side members' surfaces are inclined toward one another.

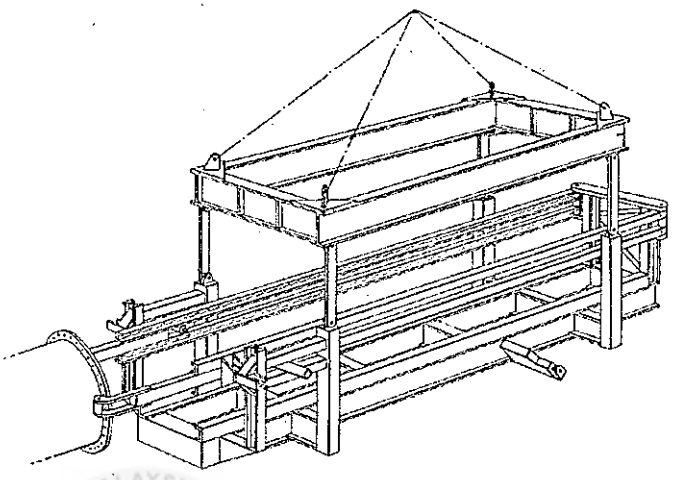

Figure 2.3: Design of bundle puller (Coffey, 1980)

According to Coffey (1980), bundle puller was define as an elongated frame structure with a pair of parallel spaced beams, a mobile carriage to support the tube bundle and mounted on the parallel beams for movement along them, clamps to connect and lock the elongated frame structure to the shell of the heat exchanger, and a mobile sub-frame carrying a hydraulically-operated crane are used to move a tube bundle out of or into a heat exchanger shell.

Base on Figure 2.3, there are a few important component in this design where make it look different from other designs. This design use 4 point of lifting point which make the distribution of force more efficiently. At the inboard end of the main arms, connecting arms and hydraulic clamps are installed. The action of the guiding cylinders changes the position of the main arms.

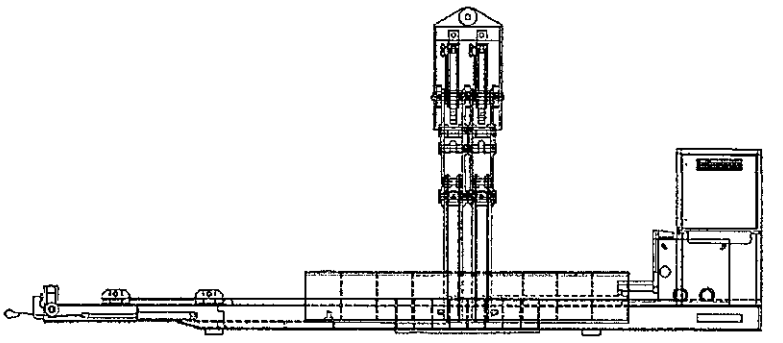

Figure 2.4: Bundle puller designed by Mizelmoe (2012)

Figure 2.4 shows the fourth design of bundle puller that have been design in 2009. This kind of design was created with modern look and almost same with the current design of bundle puller for this project. Bundle puller was a device for removing a bundle from the casing of a heat exchanger, comprising a carrier frame provided with pulling means for removing the bundle from the casing, wherein the carrier frame is adapted to hold the bundle removed from the casing, wherein the device is provided with hoisting means for hoisting the carrier frame, wherein the hoisting means comprise at least one gripper and wherein the device is also provided with connecting means for connecting the gripper is releasable to the carrier frame (Mizelmoe, 2012).

However, different from the current design of bundle puller, this design use gripper mechanism as the lifting frame. Since the distance and orientation of the gripping arm sections may be precisely fixed by the adjusting mechanism before either the carrier frame or the bundle itself is engaged, such a gripper is entirely acceptable for connection to the carrier frame according to the invention. This design also use only 1 point of lifting. Same as the current design, this kind of bundle puller also have winch and engine compartment at the back.