DESIGN AND DEVELOPMENT OF A 6X6 OIL PALM FRUIT BUNCH UTILITY TRANSPORTER LIFTER SYSTEM

MOHAMAD SAIFUL AZHAR BIN MOHAMAD RAHADI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF A 6X6 OIL PALM FRUIT BUNCH UTILITY TRANSPORTER LIFTER SYSTEM

MOHAMAD SAIFUL AZHAR BIN MOHAMAD RAHADI

A report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this project report entitled “Design And Development Of 6x6 Oil Palm Fruit Bunch Utility Transporter Lifter System” is the result of my own work except as cited in the references.

Signature : ....

Name : ....

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.

Signature : ....

Name : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

The purpose of this project was to design a new lifter system for a 6x6 oil palm fruit bunch utility transporter. In order to achieve this goal, theoretical and simulation analysis were conducted by using fluid power formula and FESTO FluidSim Software. The main parameter that was observed and compared included hydraulic cylinder and rod cylinder diameter, extension and retraction velocity, power consumed and efficiency of the volumetric flow pump. The two types of model were used in simulation which were single and dual hydraulic open circuit system. They were analyzed by varying the diameter of cylinder piston and rod piston cylinder diameter. It consist of 10cm, 13cm, 15cm and 17cm for rod piston diameters. Meanwhile for cylinder piston diameters were 13cm, 15cm, 17cm, and 19cm. The results obtained from theoretical calculation showed that double cylinder has higher volumetric efficiency which was 70.83% and single cylinder slightly lower for 68% efficiency. These findings verified that double cylinder of hydraulic model was the most practical in consuming less power by the motor but higher volume flow rate efficiency. Then for simulation result, it had slight difference in term of extend velocity and retract velocity values compared with theoretical result. Based on simulation, the highest extend velocity was 0.085 m/s while theoretical was 0.107 m/s with 20.56% deviation. Besides the highest retract velocity from simulation was 0.145 m/s while theoretical was 0.262 m/s with 44.66% deviation. The detail specification of the actuator, pump unit, directional valve, tilting angle, motor, and material of bucket were achieved from current product and previous researches data. All of those information were the key to complete this project. Hopefully, more research about 6x6 palm oil fruit bunch utility transporter will be conducted in a future because palm oil plays a major contribution in increasing Malaysia's economy. This approach might improve the productivity of palm oil industry due to the less manpower consumes to complete the loading and unloading the palm oil fruit bunches in a short time.

ABSTRAK

Tujuan projek adalah untuk mereka bentuk sistem pengangkat untuk sebuah 6x6 pengangkut tandan buah kelapa sawit. Demi memenuhi matlamat tersebut, analisis secara teori dan simulasi dijalankan dengan menggunakan formula kuasa bendalir dan perisian FESTO FluidSim. Parameter utama yang akan dilihat dan dibandingkan termasuk silinder hidraulik, diameter rod silinder, had laju kenaikan dan penurunan, kuasa yang diperlukan dan kecekapan kadar aliran isi padu pam. Dua jenis model yang telah digunakan dalam simulasi iaitu sistem litar terbuka silinder tunggal dan silinder berkembar. Model-model tersebut dianalisis dengan mengubah diameter omboh silinder dan omboh rod. Ia terdiri daripada 10cm, 13cm, 15cm dan 17cm untuk diameter-diameter omboh rod. Manakala untuk diameter-diameter omboh silinder pula terdiri daripada 13cm, 15cm, 17cm dan 19cm. Keputusan yang diperoleh daripada pengiraan teori menunjukkan bahawa silinder berkembar mempunyai kecekapan kadar aliran isi padu yang tinggi iaitu 70.83% manakala untuk silinder tunggal rendah sedikit iaitu 68% kecekapan. Penemuan uji kaji itu mengesahkan model silinder berkembar adalah yang paling sesuai dalam penggunaan kuasa motor yang rendah tetapi kecekapan kadar aliran isi padu pam yang tinggi. Seterusnya untuk keputusan simulasi, ia menunjukkan sedikit perbezaan dari segi nilai-nilai halaju pemanjangan dan halaju penarikan balik berbanding keputusan teori. Berdasarkan keputusan simulasi, halaju pemanjangan tertinggi ialah 0.085 m/s manakala keputusan teori ialah 0.107 m/s dengan 20.56% sisihan. Seterusnya, halaju penarikan balik tertinggi daripada keputusan simulasi ialah 0.145 m/s manakala keputusan teori ialah 0.262 m/s dengan 44.66% sisihan. Spesifikasi terperinci penggerak, unit pam, injap arah, sudut kecondongan, motor, dan bahan bekas beban diperoleh daripada produk semasa dan data kajian-kajian terdahulu. Seluruh maklumat tersebut merupakan tonggak utama dalam menyiapkan projek ini. Diharapkan semoga lebih banyak kajian tentang 6x6 pengangkut tandan buah kelapa sawit akan dijalankan pada masa akan datang kerana kelapa sawit merupakan penyumbang terbesar dalam menaikkan ekonomi Malaysia. Pendekatan sebegini meningkatkan penghasilan dalam industri kelapa sawit disebabkan oleh sedikit tenaga pekerja diperlukan untuk menyelesaikan kerja-kerja mengangkat dan memunggah dalam masa singkat.

ACKNOWLEDGEMENTS

I would like to express my appreciation to Encik Adzni Saad who is also known as my Supervisor for his guidance throughout the whole semester. Without his valuable assistance, this work will not have been a success. The valuable advice and suggestions for the corrections, modification and improvement did enhance the perfection in performing my work well.

I am also indebted to Encik Faizil Wasbari, Lecturer from Thermal Fluid Division for exposing the right method to use required software in analysing the model. I would like to thank Assistance Engineer, Encik Mad Nasir Ngadiman for his support and cooperation to identify standard requirement of this project. It helps me increase my knowledge and skills regarding fluid power and automotive industry.

Finally, I would like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

p	-	Pressure
F	-	Force
A_p	-	Area of piston cylinder
A_r	-	Area of piston rod
D_c	-	Piston Cylinder Diameter
d_r	-	Piston Rod Diameter
Δp	-	Difference in Pressure
v_{ext}	-	Extension Velocity
v_{ret}	-	Retraction Velocity
SG	-	Specific Gravity for Hydraulic Oil
Q_{in}	-	Volume Flow Rate
P_{ext}	-	Cylinder Power Extend
P_{ret}	-	Cylinder Power Retract
η_p	-	Pump Efficiency

CHAPTER 1

INTRODUCTION

1.1 Introduction

Palm oil fruit bunch utility transporter is a vehicle that transports bunches of palm oil in Felda operation field which consist of 6 wheels and trolley for lifting purpose. It seems that the production of this type of transportation is limited these days as there is no approach in reducing manpower requirement. It is also one of a strategic ways to improve the productivity of palm oil industry (Mohd Solah Deraman et. al.,2013). Many aspects needs to be considered so that it can meet the industrial requirement. The objectives of this vehicle development are to give realistic exposure to the students involved in the aspect of automotive engineering and general product development and to test the student’s creative thinking and robustness of technical knowledge understanding. This development processes involves the application of both soft skills and classroom textbook theories in the real working experience.

1.1.1 6X6 Oil Palm Fruit Bunch Utility Transporter

To make the design development processes become more efficient, the vehicle needs to have performance requirement. In order to build new 6x6 vehicle , three component needs to be developed. They are chassis as the mainframe, suspensions to reduce vibration and lifter to operate the lifting of palm oil product. Besides the suitable construction of joint force for the chassis and hydraulic cylinder also necessary in order to ensure that it can withstand the amount of force acting on it. As the force acting on the vehicle system is the main factor in developing these three important component, the weight of the sprung mass, trolley, passenger, engine, and payload must be considered (Amboji Sudhakar R. et. al.,2014). In addition, based on the current lifter system that already being produced, the main element that must be considered are types of material, the overall dimensions including length, width, and height, design of the bucket load, design of the joint force, design of the chassis, cost and the manufacturing method to fabricate the new lifter system.

1.2 Problem Statements

The current oil pump fruit bunch utility transporter have some disadvantages such as it does not has compact sizes and limited production in the market(Prof. Deshmukh.S.A. et. al., 2016). These major problem indirectly lead to more effort requires by human and consume lot of time to conduct the production work of transporting oil pump fruit bunch. This will cause the production work becomes inefficient.

1.3 Objectives

The objectives of the project can be referred as below:-

a) To develop 3D CAD model of 6x6 oil pump fruit bunch utility transporter lifter system by using CATIA V5 Software.
b) To analyze the performance of the propose design of 6x6 oil pump fruit bunch utility transporter lifter system by using FESTO FluidSim Software.

1.4 Scopes of Project

There are several scopes of this project which are important to accomplish the objectives. The initial work is started by developing conceptual designs of 6x6 oil pump fruit bunch utility transporter lifer system. It continues with choosing appropriate method of choosing the best conceptual design. The chosen design will be developed with details of 3D CAD Model using CATIA V5 Software. The lifter performance of chosen design will be analyzed especially in terms of structural integrity and payload. FESTO FluidSim for hydraulic will be used to simulate and obtain the graphical result.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter describes about the researches that related with the development of lifter system for 6x6 oil palm fruit bunch utility transporter. It details out regarding the with theory and technical approaches, figures and formulas given that are appropriate to be used in the analysis.

2.2 Current 6x6 Oil Palm Fruit Bunch Utility Transporter

Malaysia is one of the biggest producer of palm oil in an international marketplace. Some developer had manufactured the 6x6 oil palm fruit bunch utility transporter but the numbers are limited to certain oil palm site or field. Figure 2.1 shows the current 6x6 Oil palm fruit bunch utility transporter.

Figure 2.1 : Current 6x6 oil palm fruit bunch utility transporter

In general, six-wheel drive has a single chassis configuration in which the three axles are located and equips with six equal sized tires. Instead of having the common front wheel steering, it is also equipped with an additional steerable rear axle which can be engaged and disengaged depending on user's need. This vehicle also comes with rocking arm and grabber for picking purpose. The arm is hinged to the chassis and allows it to swing up and down by linking to the chassis to ensure better traction on uneven ground as all four rear wheels stay in contact with the ground (Abd Rahim Shuib et. al., 2009).

2.3 Performance Requirement

Many available vehicles are constantly being modified in order to assist humans better. As an example, vehicles with the tipper allow humans in performing specific tasks. The tipper truck is an important machinery in mining, construction sector to unload the material on site with minimum help of workers. The purpose of tipper mechanism is to unload the trolley of a vehicle without or with a little assistant of a human. It provides the means for unloading the trolley with the minimum time period with no effort (Barbara Steward, 2012).

In order to develop lifter system for the 6x6 oil palm fruit bunch utility transporter, performance requirement must be determined firstly. All of these requirement are obtained by observing and comparing the specification of available tipper of a truck in the oil palm sites.

2.3.1 Load Capacity

In any lifter system, the load capacity is the main aspect that must be identified so that the lifting operation is suitable with the ability of mechanism used in lifting operation. This is the priority for the system itself so that there will be no system failure or harmful accident is going to happen. According to Malaysia Palm Oil Berhad (MPOB), the maximum payload of this type of transport system is 700 kg of oil palm fruit bunch. This is the optimum capacity for the bucket to transport the load from one to another. Meanwhile, the load of the bucket without a palm oil fruit bunch is 1.5 tons which makes the total maximum load capacity of the tipper is 2.2 tons. In this case, it also requires safety design consideration of existing system in order to deliver an efficient output for the manpower usage (Mohd Solah Deraman et. al., 2013).

2.3.2 Tilting Angle

During unloading the load, tilting angle must be considered to prevent the trucks from tipping over. Minimum angle of 60^{o} which is set as to ensure no tipping over or collision occur. A collision will not only lead to damage property but also loss of lives and more often than not, a general disruption for the general public. If there is no consideration of minimum angle, this can cause many unnecessary accidents to occur (Barbara Steward, 2012). Figure 2.2 (Mr. Prakalp S. Moon et al., 2017) shows illustration of tipper truck.

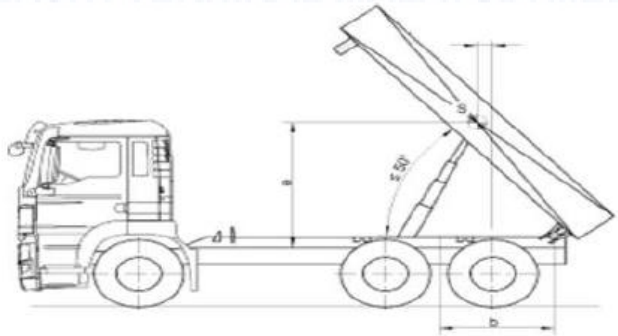


Figure 2.2 : Tipper Truck Illustration

2.3.3 Material of Trolley

The process of transporting heavy material is commonly done by using a trolley or also known as a tipper. There are various types of bodyworks used. Based on this specific case the tipper body is of the free hanging U or box-shaped type. It uses high strength steel with a modern design without any unnecessary beams and stiffeners. It is made from EN8 carbon steel(EN-8 (C-40) SAE 1040) (Mr. Prakalp S. Moon et. al., 2017). EN8 carbon steel is a common medium carbon and medium tensile steel, with improved strength over mild steel. It is constructed through-hardening of medium carbon steel. It is also readily machinable in any condition.. The basic parameters that must be defined to design bucket load specifically for this project consist of total height, total width, upper length and lower length.

Every completed design starts with the frame structure. For this bucket frame, it uses mild steel channel or mostly known as C-shaped mild steel that is produced by hot rolled processes. This type of mild steel has dimensional tolerance and grades according to ASTM A276, ASTM A479, ASME SA479, MTC EN 10204 3.1(Data Sheet Standard Channels Asia). Figure 2.3(Data Sheet Standard Channels Asia) shows cross section of mild steel channel and Table 2.1(Data Sheet Standard Channels Asia) shows general properties of mild steel channel.

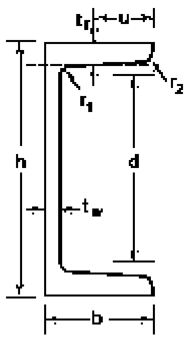


Figure 2.3 : Cross Section of Mild Steel Channel

The design for the frame structure of the bucket needs to be fitted with lower chassis by hydraulic connection. Thus, the bracket at the lower chassis is necessary to hold hydraulic base in a fix position during the operation of loading and unloading the load.

Table 2.1 : General Properties of Mild Steel

Designation		Dimensions						Dimensions for detailing	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r_1 mm	r_2 mm	A mm^2 $x10^2$	d mm
C 100 x 50 x 5 x 7.5*$^+$	9.37	100	50	5	7.5	8	4	11.71	65.3

2.3.4 Specification of Engine

Since 2004 to 2011 years, Daihatsu Motor Co., Ltd. (Daihatsu) had developed the KF engine with a 3-cylinder, 660cc engine, 63 hp, 92Nm torque and four-pole AC motors of powertrain specification. This engine has been chosen as the main power source of the vehicle specifically for this project. Besides having improved environmental performance, power, and quiet operation. It si also lighter in mass with only 47 kg weight and more compact than previous engines. Weight reduction is obtained through the use of an aluminium cylinder block and resin materials. It boosts advancements in intrinsic engine functions to ensure higher fuel efficiency, lower exhaust emissions, and a more powerful drive. Long piston stroke also able to produce higher combustion efficiency. 660cc Daihatsu Engine is shown in Figure 2.4 (Daihatsu Motor Co.,Ltd, 2005) below.

Figure 2.4 : 660cc Daihatsu Engine

Lower exhaust emissions also make Daihatsu engine to achieve world-leading environmental performance level. Transmission specification is 5-speed for manual and 6-speed for automatic which direct drive for EVT. Dimensions of this type of engine are 2 m x 1.4 m x 3.2 m that represent its height, width and length respectively with 1.82 m of wheelbase (Daihatsu Motor Co.,Ltd, 2005).

2.4 Tipper

Transportation of heavy materials such as sand, gravel, coals, and others are mostly run by tipper truck. It can be considered as advanced version of conventional trucks. In conventional truck, manpower is required to unload the material from the truck. During unloading the material, human needs to open the side walls of the trolley and use the spade (Mr. Prakalp S. Moon et. al., 2017). This process is not practical due to time-consuming and the extra cost of manpower to be paid for unloading the material.

Thus, tipper truck was invented to overcome these matters. By consisting of the hydraulic components, it enables the trolley to be lifted upward to unload the material on the rear side. The hydraulic is connected at the backside of cabin head. This provides the power to the hydraulic components which are situated just below the top of the trolley and the chassis frame. Trolley gets lift upward at the front with the help of hydraulic components that makes the material in the truck to unload at the rear side (Mr. Prakalp S. Moon et. al., 2017). This kind of trucks is much popular in these days due to the practical way of unloading mechanism.

2.4.1 Side tipper

For the side tipper, the center of gravity is low and that makes it more stable. The side tipper can be referred as in Figure 2.5 (farmtrader.co.nz) below. In order to prevent the vehicle from tipping over, trucks which can be carry heavy loads must have low center of gravity. The reason the side tipper is frequently used for transporting materials is ability to prevent any harmful accident to human when unloading the materials (Barbara Steward, 2012).

Figure 2.5 : Side Tipper

2.4.2 Back Tipper

These type of tippers can unload goods only in back side direction. For this type of unloading either hydraulic or conveyor system can be used. Trailers with conveyor system are quite effective than trailers with hydraulic jack but both of these systems can unload the goods only in back side direction. Therefore more space and time required (Barbara Steward, 2012). Back tipper is shown in Figure 2.6 (farmtrader.co.nz). This type of tipper is selected as the main mechanism for the new lifter system.

Figure 2.6 : Back Tipper

2.5 Linear Actuator

Linear actuator a system that moves a load and able to assembled to become, components, or a finished product, in a straight line or linear. It operates by converting energy into a motion or force. Besides, it is generated by pressurized fluid or air, as well as electricity (Carlos Gonzalez, 2015).

2.5.1 Pneumatic Actuator

Pneumatic actuators consist of a piston inside a hollow cylinder. The piston is moved inside the cylinders by the pressure supplied from an external compressor or manual pump. The increase of pressure allows the cylinder to move along the axis of the piston which create a linear force. The piston returns to its original position with the help of a spring-back force or fluid being supplied opposing the piston direction (Carlos Gonzalez, 2015).

2.5.2 Hydraulic Cylinder

Hydraulic cylinders are linear actuators that convert fluid energy into linear mechanical energy. For hydraulic motors, cylinders are the output devices that perform the heavy lifting for mobile equipment. Examples of work performed by the hydraulic cylinders are a haul truck dumping a heavy payload, or an agricultural tractor lifting and moving hay bales, or a combine swinging an unloading auger (Timothy W. Dell, 2015).

A hydraulic cylinder is placed below the body of truck longitudinally at one end of the truck whereas the piston end of the hydraulic cylinder is connected by the means of a pivot joint to the chassis of the truck as well as with the chassis. In the forward stroke of the cylinder it pushes the truck body upward thus gives a necessary lift for tipping. So, in forwarding stroke of the cylinder the truck gets unloaded. In the return stroke of the cylinder, the body of the truck comes to its original position (Sanjaykumar A. Borikar et. al., 2012).

2.5.2.1 Single Acting

In this model, only one hydraulic hose is required by a single-acting cylinder. It is hydraulically actuated in one direction only. The cylinder uses an external force to return the cylinder back to its origin. A spring or some type of weight is known as the most common methods of returning a single-acting cylinder (Timothy W. Dell, 2015). Schematic diagram of single acting cylinder is shown in Figure 2.7 (zeushydratech.com) below.

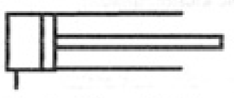


Figure 2.7 : Single Acting Cylinder

2.5.2.2 Double Acting

A double-acting cylinder uses fluid pressure to extend and retract the cylinder. It is commonly equipped with a single rod. As there is differences of piston area, it is called as a differential cylinder.

The rod side of the piston has less effective area. This is due to a portion that is displaced by the cylinder's rod, resulting in an effective area that looks like a ring. The ring's area is always less than the cap side of the piston.

Another term that is used frequently to describe one side of a cylinder is "head end." However, there are the different opinions from the certain manufacturers about this term which seems really confusing. Instead of using "head end" term, it identifies the cylinder ends as the rod end and the cap end (Timothy W. Dell, 2015). Figure 2.8 (Timothy W. Dell, 2015) shows the illustration of double acting cylinder.

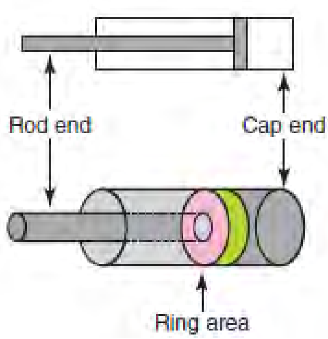


Figure 2.8 : Double Acting Cylinder

2.5.2.3 Double Rod

When manufacturers want a cylinder that delivers the same speed and force in both directions, a second rod is added to the cylinder. The most common application for double-acting, double-rod cylinders is steering. A double-rod cylinder is used for some steering applications so that, as the operator steers, the forces and speeds are equal in both directions (Timothy W. Dell, 2015). Double rod cylinder is shown in figure 2.9 (Timothy W. Dell, 2015) below.

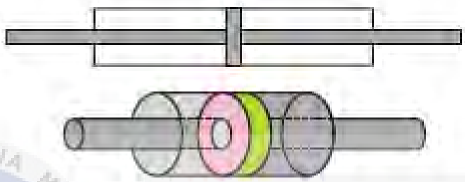


Figure 2.9 : Double Rod Cylinder

2.5.2.4 Ram

A ram is a single-acting cylinder consists of a cylinder rod that has the same diameter size as the cylinder's piston. It is applied when requiring long stroke as long as the rigidity of the rod is maintained (Timothy W. Dell, 2015). Figure 2.10 (Timothy W. Dell, 2015) below is the example of ram cylinder.

Figure 2.10 : Ram Cylinder

2.5.2.5 Telescoping

Telescoping is an extending chamber which is a direct actuator that contains up to six barrel tubes that reach out to give a long barrel stroke. Amid withdrawal, the tubes (otherwise called sleeves) fall into a reduced chamber. The chamber can withdraw to a length that is 20 to 40% of the general expanded stroke as compared with to customary barrel, which must be withdrawn to half of the barrel's general length (Timothy W. Dell, 2015). Example of telescoping cylinder is shown in Figure 2.11 (Timothy W. Dell, 2015) below. Telescoping cylinder is considered in lifting component for this final year project.

Figure 2.11 : Telescoping Cylinder

2.5.3 Electric Actuator

Electrical energy is converted into torque for an electric linear actuator . An electric motor is mechanically connected to rotates a lead screw. A threaded lead or ball nut with corresponding threads that match those of the screw is prevented from rotating with the screw. When the screw rotates, the nut gets driven along the threads. The direction the nut moves depends on which direction the screw rotates and also returns the actuator to its original position (Carlos Gonzalez, 2015).

Table 2.2 : Table of Comparison for Different Type of Linear Actuators

Type of Linear Actuators	Advantages	Disadvantages
Pneumatic	- Simplicity and lightweight - Generate precise linear motion - Low maintenance	-Low efficiency -Limited application -High cost utilities
Hydraulic	- High horsepower-to-weight ratio - Rugged and suited for high-force applications - Medium maintenance	- Slow speed - Large linear motions systems - Low efficiency
Electric	- Can be networked and reprogrammed with ease - Provide complete control of motion - High efficiency	- High cost - Not suited for all environments - Wear and tear on reduction gear if motor is continuously running

Table 2.2 above shows the comparison between three types of linear actuators. It is figured that hydraulic actuator is the best method for lifting the tipper with ease. This is due to the advanced feature of lifting the load itself that is high horsepower-to-weight ratio (Carlos Gonzalez, 2015). It uses less amount of fluid as compared than others in order to lift high load. Although the electric actuator has the most advantage than others, but it

requires the full detailed knowledge regarding to the motor, gear, fluid, and coding panel to operate which lead to high cost and time consumption. Pneumatic has limited feature that is not suitable for this project purpose. So, it can be concluded that hydraulic actuators is the most suitable for the new lifter system that has simple mechanism.

2.6 Design Requirement

2.6.1 Hydraulic Cylinder Parameters

It is assumed that load is uniformly distributed (Mr. Prakalp S. Moon et. al., 2017). The equation for area of hydraulic cylinder is given by:

$$\mathrm{P} = \frac{\mathrm{F}}{\mathrm{A}} \tag{1}$$

Where P is the pressure [kg/m^3], F is the force of maximum load to be lifted [N] and A is the area of hydraulic cylinder [m^2].

2.6.2 Volume Flow Rate for Pump

For a constant cylinder speed, the summation of the forces on the hydraulic cylinder must be equal to zero. Thus, (Mr. Prakalp S. Moon et. al., 2017).

$$-W - p_1 A_p + p_2(A_p - A_r) = 0 \tag{2}$$

Where W is the weight, A_p is the piston area (p_2=ΔP), p_1 is the pressure-relief valve and A_r is the piston rod area.

For a sharp-edged orifice, the equation is written as ;

$$Q = C_v\sqrt{\frac{\Delta P}{SG}} \quad (3)$$

Where Q is the flow quantity [LPM], SG = 0.87, is the specific gravity of hydraulic oil and Cv = 0.72, is the capacity coefficient.

2.6.3 Piston velocity

The equation of piston velocity during the extending stroke is

$$v_{ext} = \frac{Q_{in}}{A_p} = \frac{Q_{in}}{\frac{\pi d_c^2}{4}} [m/s] \quad (4)$$

The equation of piston velocity during the retracting stroke is

$$v_{ret} = \frac{Q_{in}}{A_p - A_r} = \frac{Q_{in}}{\frac{\pi (d_c^2 - d_r^2)}{4}} [m/s] \quad (5)$$

2.6.4 Cylinder power

The equation of cylinder kW power during the extending stroke is

$$P_{ext} = F_{ext} \times v_{ext} [\text{kW}] \quad (6)$$

The equation of cylinder kW power during the retracting stroke is

$$P_{ret} = F_{ret} \times v_{ret} [\text{kW}] \quad (7)$$

2.6.5 Pump efficiency, η_p

$$\eta_p = \frac{\text{ACTUAL FLOW RATE OUTPUT(GPM)}}{\text{THEORETICAL FLOW RATE OUTPUT(GPM)}} \quad (8)$$

2.7 Verdict

After gathering all the information from many researches, the required components are able to be identified with specific variables and parameters. From these finding, the component that will be used are back side tipper, telescoping cylinder system, and 660cc engine. Meanwhile, the performance requirement are 60^o minimum tilting angle and 2.2 tons of total or maximum load for loading operation. It also consist of a few required equations in order to get the proper measurement of hydraulic cylinder diameter, power of motor, volume flow rate of pump, cylinder velocity, cylinder power and pump efficiency.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter provides all the required procedures, start from designing until the fabrication processes. The flowchart from the beginning until the end to complete this final year project is also provided, which acts as the reference and to ease the process of completing this project by following the right steps. The Gantt chart of this final year project is also provided in order to show the working progress in each weeks.

3.2 Flowchart

In order to ease the processes in completing this final year project, flowchart is constructed which act as a guideline. Thus, an organized working structure is able to be practiced for a future working environment.

The flowchart is provided in Figure 3.1 below.

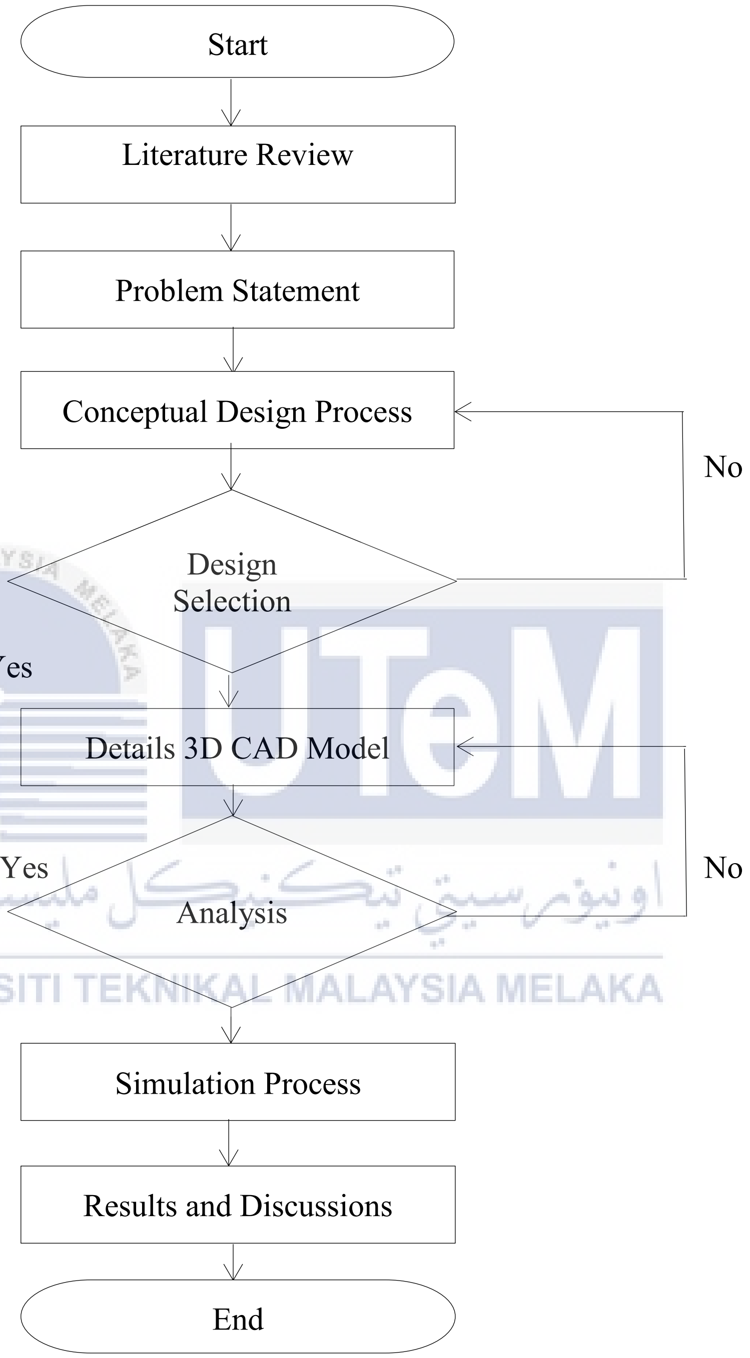


Figure 3.1 : Flowchart

3.3 Product Design Specification

The product design specification (PDS) is a document that is created during the problem statement process at a very early in the design process. It details out the requirements that must be met in order for the product or process to be successful. The PDS for this lifter system for 6x6 palm oil transporter fruit bunch utility transporter is showen below.

3.3.1 Performance

i. The lifter system is developed for loading and unloading a palm oil fruit bunches.

ii. The maximum weight of the payload is 700kg.

iii. The shape and structure of the bucket load is able to withstand the force of payload without any mechanical failure.

iv. The lifting mechanism is suitable for loading and unloading total weight of 2.2 tons without any tipping over or collapsing accident.

3.3.2 Ease of maintenance

i. The product can be serviced easily if breakdown occurs.

ii. Less time is consumed for maintenance of the product.

3.3.3 Ease of installation

i. The lifter system is simple and must be easy to use.

ii. The user can easily understand the function and behaviour of the lifter system simply by looking at the lifter appearance.

iii. The user can use less effort during the loading and unloading of the palm oil fruit bunches.

3.3.4 Safety

i. Sharp corners and edge must be avoided.

ii. The design of any hinges, pin, trigger, mechanisms must not allow fingers or part of the human body to be trapped.

3.3.5 Cost

i. The cost of materials that will be used to make the lifter system must be affordable

3.3.6 Manufacturability

i. Easy to manufacture and fabricate with the available power tools and machines.

ii. The design must fulfill the standard requirements of functional lifter system.

3.3.7 Materials

i. The material used is mild steel which refers to low carbon steel; typically the AISI grades 1005 through 1040

ii. Able to be welded and waterproof

3.4 Pugh Total Design Method

One method called as Pugh method or also known as Decision-Matrix Method or Pugh Concept Selection developed by Stuart Pugh is used in selecting the design that will be invented as a product. This method gives benefits in helping engineers in design decisions by establishing a procedure to choose the best design from the conceptual designs. Figure 3.2 below shows Flowchart of Pugh Total Design Method.

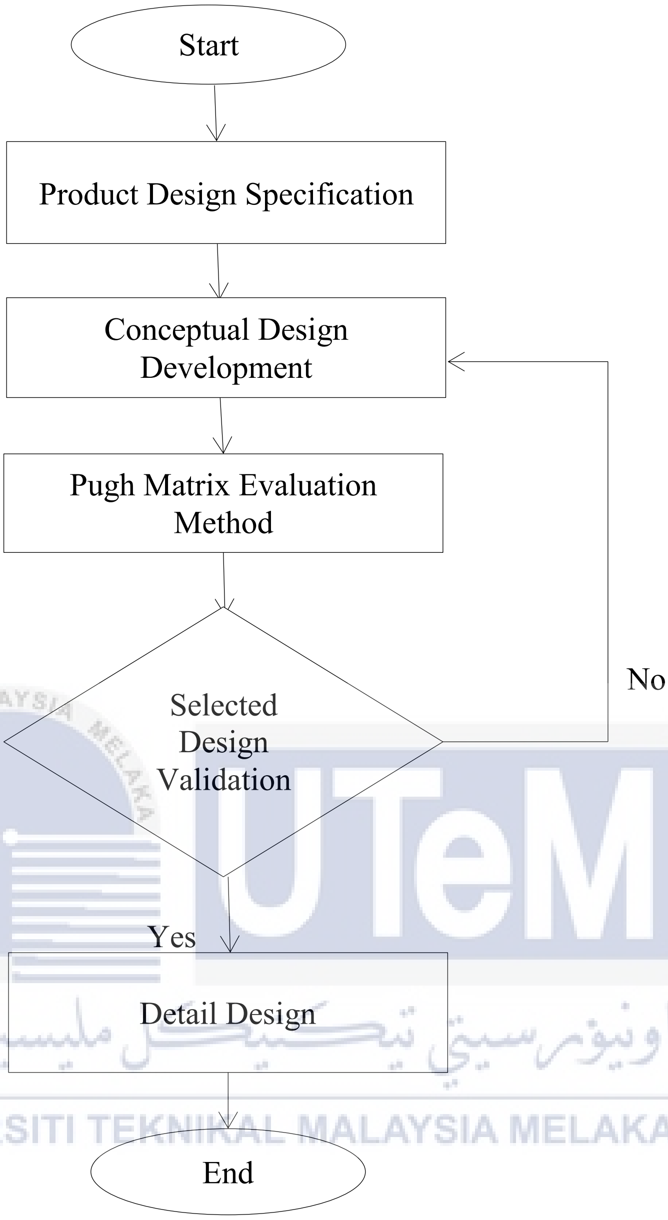
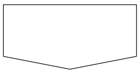
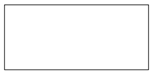
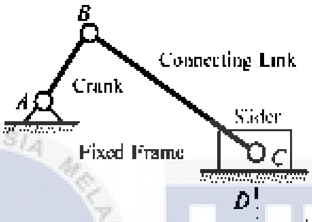


Figure 3.2 : Flowchart of Pugh Total Design Method

3.4.1 Concept Design Development

This concept design development act as the basic design of each of desired component in making the design concept. It also acts as the main idea generation before drawing the design concept by matching all the different component design. This product design development is used to produce the design concepts of this lifter system. The main idea is presented as the Morphological chart in Table 3.1 which is the graphical method based on desired function.

Table 3.1 : Morphological Chart

Criteria	Option 1	Option 2	Option 3
Shape of Bucket Load			
Hydraulic Cylinder Position	Front	Middle	Left/Right
Linkage			

3.4.2 Conceptual Design

After designing the pattern of the required part in Morphological Chart, three conceptual design are produced. Brief explanation of each conceptual design is provided for better understanding on the ideas whether it bring more advantages or disadvantages.

3.4.2.1 Design 1

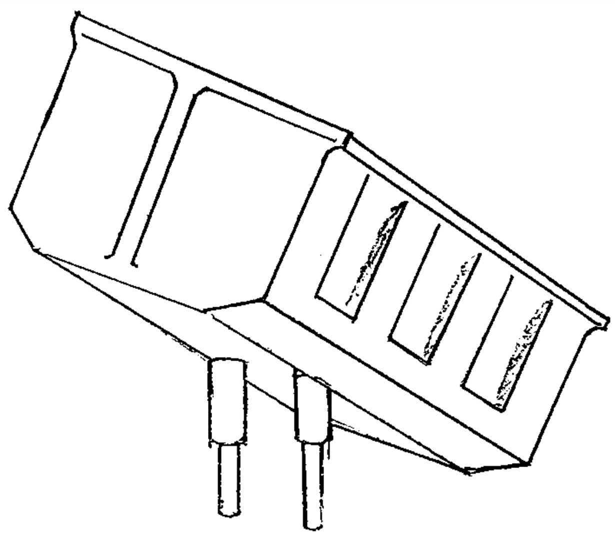


Figure 3.3 : Concept Design 1

Figure 3.3 shows a concept design 1. This conceptual design has U-shape of bucket load. At a glance, it look durable to withstand the force of palm oil fruit bunches, but it is difficult to be manufactured. This is due to a lot of angle that needed to be checked during fabrication otherwise it will not become symmetry. Besides, it also use two hydraulic cylinder at left and right side. The advantage of this system is the ease of unloading and loading operation as each hydraulic cylinder can withstand only half the load force.

3.4.2.2 Design 2

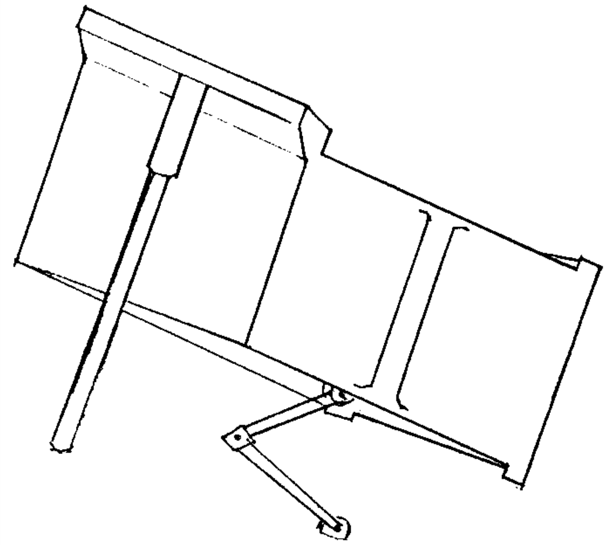


Figure 3.4 : Concept Design 2

Conceptual design 2 is shown in Figure 3.4 above and it is based on the Option 2 for the shape of bucket load. It is the easiest type of bucket load to be manufactured as well as can reduce the time consumption. The disadvantage for this conceptual design is that, the linkage system is really complex to install and can cause the fabrication cost to be higher compared to concept design 1. The long telescopic cylinder at the front is the most convincing element to adopt this concept design as the new lifter system.

3.4.2.3 Design 3

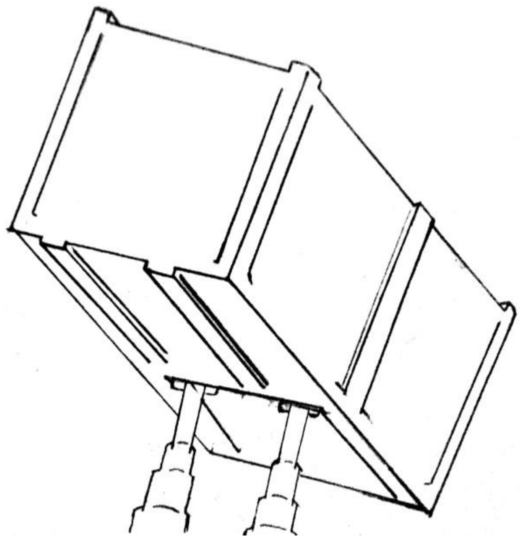


Figure 3.5 : Concept Design 3

Based on concept design that is shown in Figure 3.5 above, there are many advantages that can be identified. One of them is the both side of hydraulic system are using four time level adjuster. It is one of the new innovation as compared to the current lifter system that does not has level adjuster. Furthermore, it has box-shape of bucket load that can ease the material preparation and fabrication processes.

3.5 Pugh Matrix Evaluation Chart

A fundamental concept for decision matrix consists of establishing a set of criteria. These criteria includes the potential options that can be decomposed, scored, and summed to gain a total score. Thus each design concept can be ranked. The criteria are not weighted to ensure a quick selection process.

This approach gives advantage to decision making is that subjective opinions about one alternative against another can be made more objective. Another advantage of this method is that sensitivity studies can be performed. The highest score means that the concept design can deliver the most valuable criteria competing with other alternatives. Hence, it is selected as the best concept design to proceed with detail design and fabrication processes.

Table 3.2 : Pugh Matrix Evaluation Chart

Concept / Criteria	Datum	1	2	3
Performance	0	+	1	+
Ease of Installation	0	-	-	+
Ease of Maintenance	0	-	-	+
Safety	0	1	1	1
Cost	0	-	+	-
Manufacturability	0	-	-	+
Materials	0	1	1	1
Sum of '+' s	0	1	2	4
Sum of '1' s	0	2	3	2
Sum of '-' s	0	4	3	1
Net Score	0	-1	2	5
Rank	0	3	2	1

Based on the Pugh matrix evaluation is shown in Table 3.2 above, the highest rank is for design 3 because it has the most advantages at all of criteria as compared to the other design for the new lifter system for 6x6 oil palm fruit bunch utility transporter. So it is selected as the best lifter design to be fabricated as it is already fulfilled all the requirements to make the new lifter system for loading and unloading the oil palm fruit bunches to become more efficient.

3.6 FluidSim Software for Hydraulic Analysis

Before fabricating the lifter system, the complete schematic circuit of the hydraulic cylinder must be designed. In order to achieve this, FluidSim Software for hydraulic is used to present the entire hydraulic system when installed to the chassis of 6x6 palm oil utility transporter. Its is called as FluidSim hydraulic open circuit system.

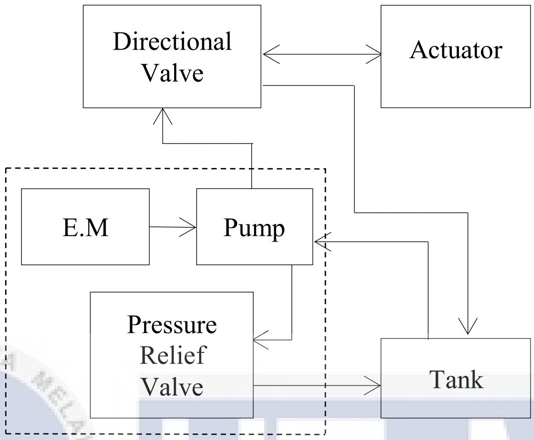
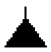
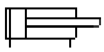
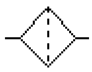
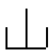
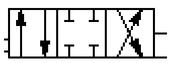
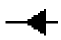
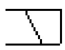


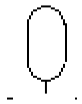
Figure 3.6 : A Simplified hydraulic system scheme

Figure 3.6 above shows simplified hydraulic system scheme that indicates the flow line throughout hydraulic system. FESTO FluidSim™ software is used for simulation of fluid power system. FluidSim was developed as a joint venture between the University of Paderborn, Festo Didactic GmbH & Co. KG, and Art System Software GmbH, Paderborn.

The symbol of main components are listed in the table 3.3 below.

Table 3.3 : Component of Hydraulic System

Symbol	Name of Component	Function/Description
	Pump Unit	-device that converts mechanical power into hydraulic energy -consist of motor, pressure relief valve and variable displacement pump
	Double Acting Cylinder	- transmit hydraulic power in two different directions, with both pulling and pushing force
	Filter	-to filter dirt, rust, and particles introduced into the system by a cylinder rod.
	Tank	-Place to recycle the hydraulic oil
	Directional Valve(4/n Way Valve)	-Act as a controller unit wheather to retract or extend the hydraulic cylinder
	Manually calibrated	-Symbol attached at the 4/n Way Valve which represent calibrating method during loading and unloading operation
	Electrically calibrated	
	Hydraulic calibrated	

	Reservoir	-Act as storage to store hydraulic oil for the system

The hydraulic system consist of pump unit, double or single acting cylinder, filter, tank, configure way valve, and reservoir. Each component has its own function as discripted in the Table 3.3 above. All the dimension of cylinder diameter, cylinder rod diameter, stroke distance travelled, payload, and pressure supplied by the pump must be considered before simulation. The results of this simulation are represented by a state diagram which provide the stroke displacement, velocity, acceleration, and position of piston during extend and retract againts time.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, the results of the conceptual design selection, manufacturing process, calculation and FluidSim analysis are obtained and explained. Several results will be explained with detail information based on theoretical and technical research. It then conclude several information obtained from literature review.

4.2 The Best Concept Design

There are three conceptual designs that have been proposed for the lifter system. Among those designs, only one of them has been chosen as the best concept for the lifter system. The best conceptual design was chosen after doing the Pugh Matrix Evaluation Method. Figure 4.1 shows the best concept design of lifter system for 6x6 palm oil fruit bunch utility transporter

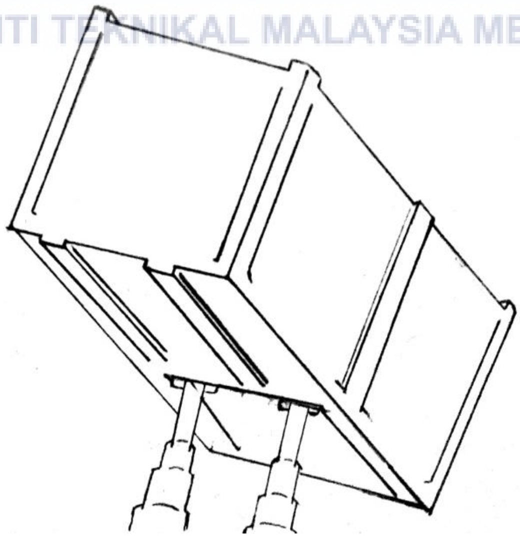


Figure 4.1 : Best Concept Design

The concept design 3 is selected to be the best concept that are going to be proceeded with the fabrication process. According the matrix evaluation method, this concept is the most feasible and meet the industry requirements among other concepts. The concept comes with a good hydraulic joint member position that can be extended to increase the tipper stability. Besides, this concept provides with advanced hydraulic system that has 4 times of extending level. Furthermore, this system is available in the market.

In addition, the hydraulic cylinder arrangement can reduce the force of load. Thus it can reduce load on motor during lifting operation. The tipper does not show good appearance, but it is suitable for maintenance purpose.

4.3 Theoretical Data

The calculation for both single and double cylinder are conducted according to the fluid power formula. It consists of velocity of cylinder during extending and retracting based on given value of cylinder and piston rod diameter. Both value are important in order to find the required power required of the motor for loading and unloading 2200kg of payload.

4.3.1 Calculation

Assume that;	Volume Flow Rate,	Q_{in} = 85 LPM
	Pressure relief valve,	p_1 = 50 bar

Specific Gravity of Hydraulic Oil, SG = 0.87

Diameter of Cylinder, D_c = 0.13m

Diameter of Cylinder Rod, d_r = 0.10m

Load, m = 2200kg

I) Forward velocity, V_{ext}

Converting volume flow rate unit ;

$$Q_{in} = 85\ \text{LPM} \times \frac{1\text{m}^3}{10^3\text{L}} \times \frac{1\text{min}}{60\text{s}} = 0.00142\ \text{m}^3/\text{s} \tag{1}$$

$$V_{ext} = \frac{\text{Volume Flow Rate}}{\text{Area of cylinder}} = \frac{v_{ext}}{A_p} = \frac{0.00142}{\frac{\pi(0.13)^2}{4}} = 0.107\ \text{m/s} \tag{2}$$

II) Cylinder kW power during extending, P_{ext}

$$P_{ext} = \text{Extend force} \times \text{Forward velocity} = F_{ext} \times V_{ext} \tag{3}$$

$$= \frac{2200\text{kg}}{2}(9.81) \times 0.107\ \text{m/s}$$

$$= 1.155\ \text{kW}$$

III) Retracting velocity, V_{ret}

$$V_{ret} = \frac{\text{Volume Flow Rate}}{\text{Different in Area of cylinder}} = \frac{v_{ext}}{A_p - A_r} = \frac{0.00142}{\frac{\pi\left(0.13^2 - 0.10^2\right)}{4}} = 0.2620\ \text{m/s} \tag{4}$$

IV) Cylinder kW power during retracting, P_{ret}

$$P_{ret} = \text{Retract force} \times \text{Forward velocity} = F_{ret} \times V_{ret} \tag{5}$$

$$= \frac{2200\text{kg}}{2}(9.81) \times 0.2620\ \text{m/s}$$

$$= 2.827\ \text{kW}$$

V) Pump efficiency, η_p

$$\eta_p = \frac{\text{ACTUAL FLOW RATE OUTPUT(GPM)}}{\text{THEORETICAL FLOW RATE OUTPUT(GPM)}} = \frac{85}{125} = 0.7083 \tag{6}$$

The force is calculated at critical level during hydraulic cylinder still in horizontal position. Thus, there value of an angle can be neglected for obtaining cylinder power for both extending and retracting.

4.3.1 Single Cylinder Theoretical Data

After conducting the calculation, the value of velocity and power for single cylinder is obtained. The value of volume flow rate is fixed to 85LPM throughout the calculation. Theoretical data of single cylinder is shown in Table 4.1 below. The same mass of 2200kg is used for each different diameter sizes. This analysis value will be compared with theoretical data of dual cylinder.

Table 4.1 : Theoretical Data of Single Cylinder

Diameter(m)		Velocity(m/s)		Power(kW)		Mass(kg)
Cylinder	Piston Rod	Extend	Retract	Extend	Retract	
0.13	0.10	0.107	0.262	2.310	5.654	2200
0.15	0.13	0.080	0.323	1.727	6.971	2200
0.17	0.15	0.063	0.283	1.360	6.108	2200
0.19	0.17	0.050	0.743	1.080	16.036	2200

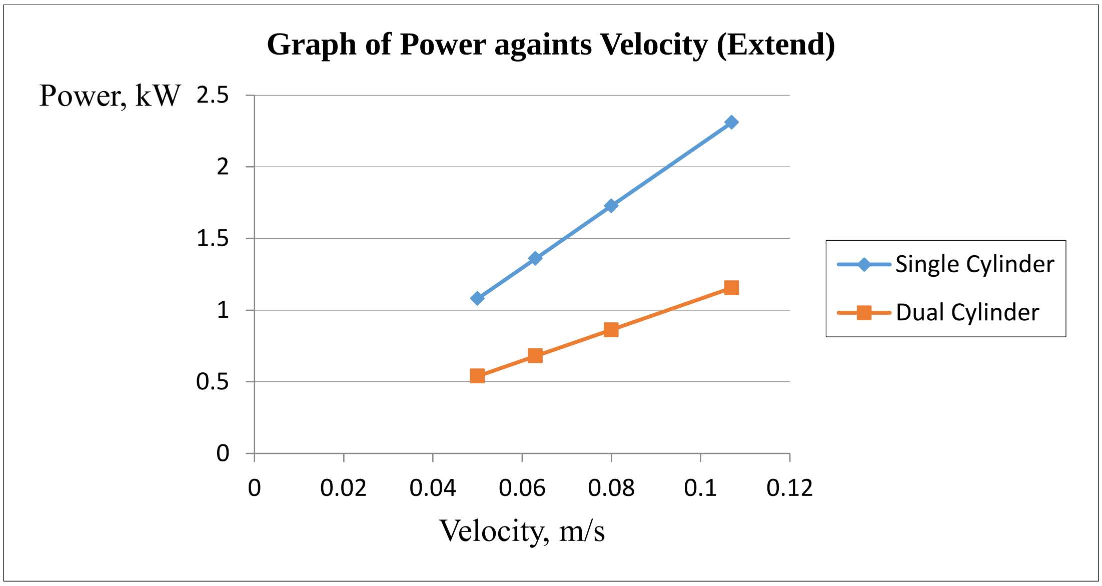


Figure 4.2 : Graph of Power against Velocity(Extend)

Single cylinder consumes high power than the dual cylinder based on graph of power against velocity(extend) shown in Figure 4.2 above. This is due to the bigger force that must be withstand by the single cylinder. Meanwhile dual cylinder only need to withstand half value of force exerted. The minimum power, 1.155kw can be obtained by using 13cm cylinder diameter with 10cm piston rod diameter. Then, the maximum power, 2.310kW is consumed when using 19cm cylinder diameter with 17cm piston rod diameter with velocity, 0.050m/s.

4.3.2 Double Cylinder Theoretical Data

Table 4.2 below shows theoretical data of dual cylinder based on fluid power formula. In this dual cylinder analysis, force for cylinder is reduced by half which resulting less value of power generated by motor at the pump unit during extend and retract.

Table 4.2 : Theoretical Data of Dual Cylinder

Diameter(m)		Velocity(m/s)		Power(kW)		Mass(kg)
Cylinder	Piston Rod	Extend	Retract	Extend	Retract	
0.13	0.10	0.107	0.262	1.155	2.827	2200
0.15	0.13	0.080	0.323	0.863	3.485	2200
0.17	0.15	0.063	0.283	0.680	3.054	2200
0.19	0.17	0.050	0.743	0.540	8.018	2200

Based on both analysis in Table 4.1 and Table 4.2, it is found that single cylinder requires twice of power compared to dual cylinder. It is due to the load of 2200kg mass that has been divided into half value for dual hydraulic cylinder. Hence, the motor at pump unit supply less power to move the dual cylinder during extend and retract.

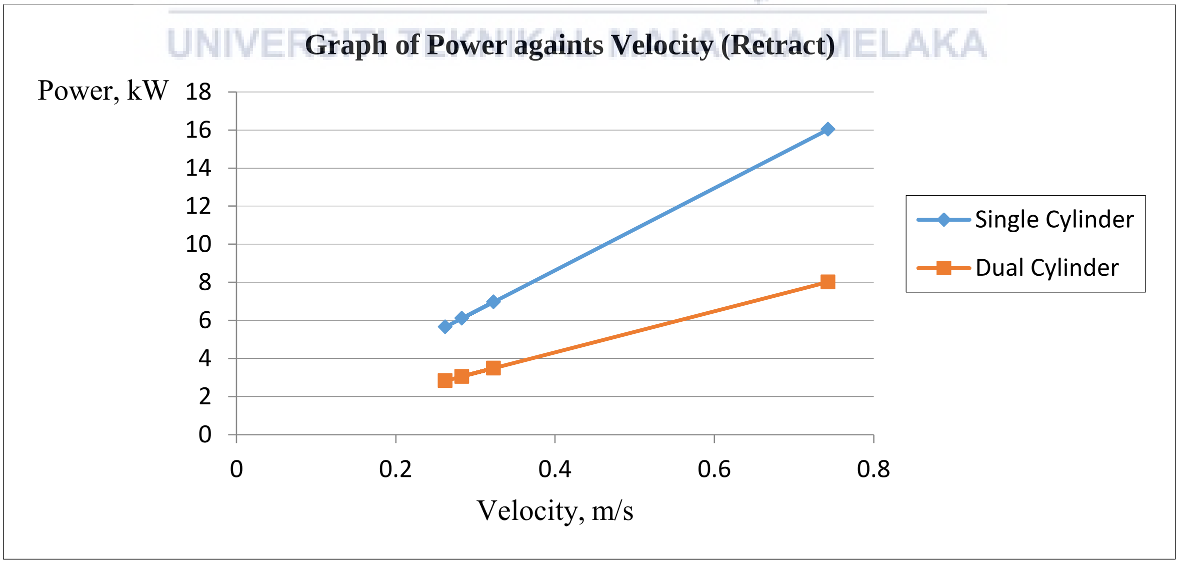


Figure 4.3 : Graph of Power against Velocity(Retract)

Based on graph of power against velocity(retract) shown in Figure 4.3 above, single cylinder required highest 16.036 kw of power to retract the hydraulic cylinder. However, it is the most efficient to retract the bucket with fastest velocity of 0.743 m/s. In this case, dual cylinder required only 2.827 kW power which is low compared to dual cylinder required 5.654kW when using 13cm cylinder diameter with 10cm piston rod diameter. Somehow, it has minimal 0.262 m/s velocity compared with 0.743 m/s when using 19cm cylinder diameter with 17cm piston rod diameter.

Table 4.3 : Pump Efficiency Between Single and Dual Cylinder

Number of Cylinder	Diameter(cm)		Volumetric Flow Rate(LPM)		Pump Efficiency (%)
	Piston	Piston Rod	Theoretical	Actual	
Single	13	10	125	85	68.00
Dual	13	10	120	85	70.83

Table 4.3 above shows pump efficiency of both single and dual piston cylinder which highest efficiency of 70.83% is obtained by using dual cylinder. Both cylinder dimension is 13cm diameter and 10cm rod diameter that consist of three stages of stroke to withstand high force. Dual piston pump supplies high volume, low pressure flow until the increased force is needed, at which time it automatically switches to high pressure, lower volume.

4.4 FluidSim Hydraulic Model

The main parameter is applied at each component with proper value based on current product and previous research for 6x6 palm oil utility fruit bunch transporter lifter system. This FluidSim hydraulic open circuit system consist of single and double types of theoretical analysis. The list of main parameters for this analysis shown in Table 4.4.

Table 4.4 : List of main parameters

Parameters	Value
Load Capacity	2200 kg
Cylinder Diameter	13cm
Max Stroke	50cm
Pressure Relief Valve	90 bar
Volume Flow Rate	85 LPM

Type of configure valve used for this schematic circuit is 4^{th} Way Valve which both side of actuation is electrically operated. This valve is connected to the tank containing a finite amount of liquid fluid that must be stored and reused continually as the circuit works. Two units of double acting cylinder are used with identical specification of cylinder diameter, max stroke and load capacity.

Pressure relief valve is supplying about 90 bar of pressure to ensure loading and unloading of 2200 kg of palm oil fruit brunch without any mechanical failure with optimum of time consumption. Pump unit act as the main component in this system which consists of motor, pressure relief valve and variable displacement pump.

Finally hydraulic filters with 0.0001 MPa of hydraulic resistance is connected to the pump. Hydraulic filters keep the hydraulic fluid contaminant free thus hydraulic oil is always in clean condition. Otherwise, fluid power system can not be completed without the use of a filter. Figure 4.4 shows single hydraulic open circuit system. The pressure of hydraulic oil flow from pump unit to the actuator during extend and return back to the tank during retracting. The flow of hydraulic oil is controlled by 4th Way Valve which performing the desired input from switch button.

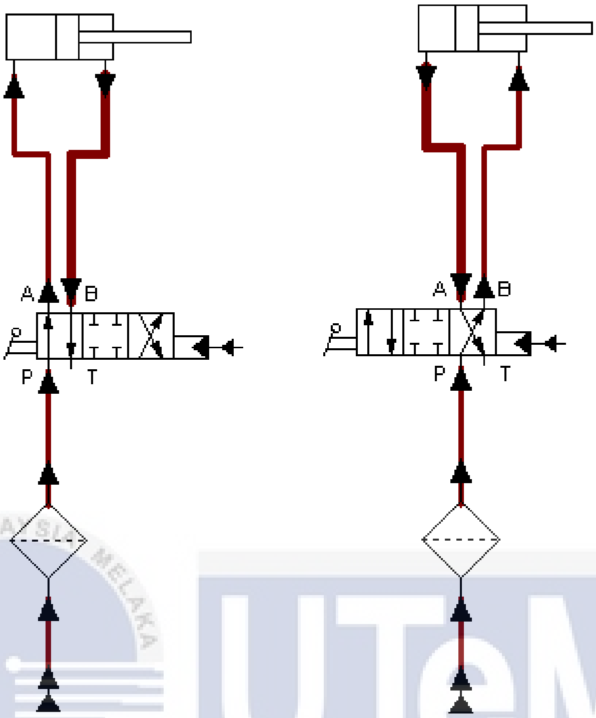


Figure 4.4 : Single Hydraulic Open Circuit System

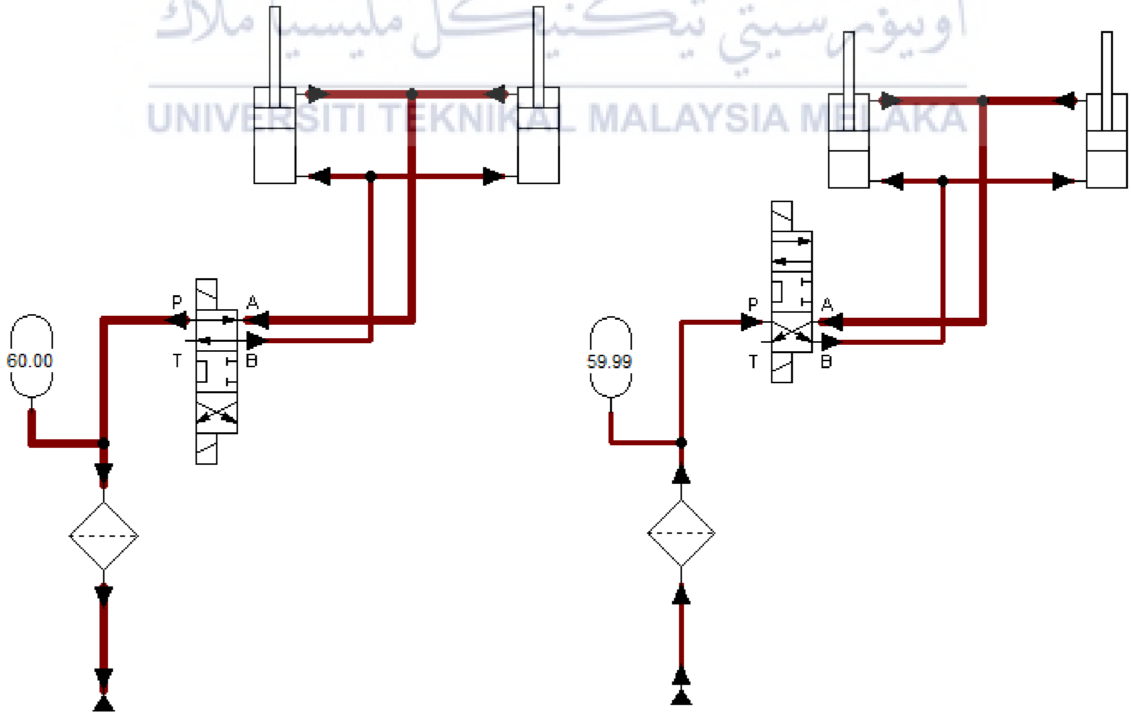


Figure 4.5 : Dual Hydraulic Open Circuit System

Figure 4.5 shows dual hydraulic open circuit system which using one unit of 4th Way Valve switching either to extend or retract. The reservoir contain the pressure required to flow the hydraulic oil from pump unit towards both actuator. The switching method for this circuit system is electrical method to ease loading and unloading operation.

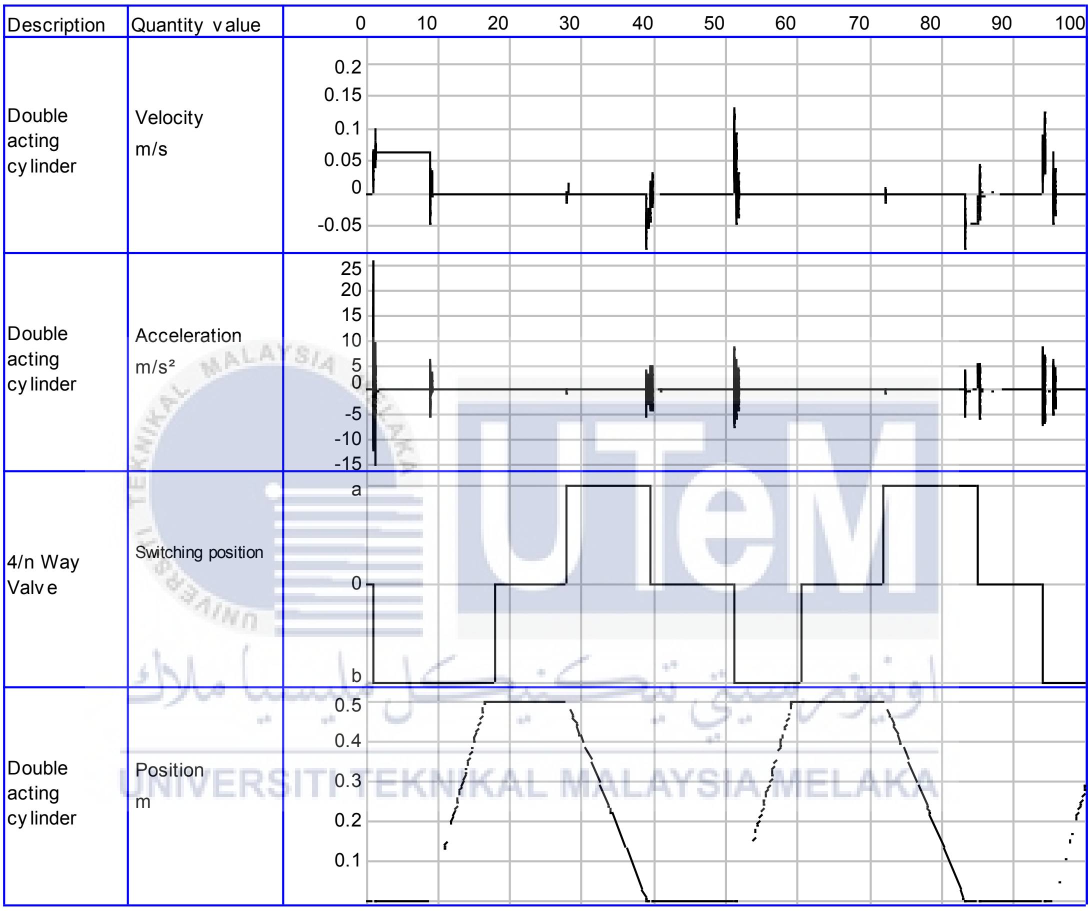


Figure 4.6 : State diagram of an open circuit hydraulic system in FluidSim

The performance of the model is shown in Figure 4.6 above. It is illustrated with a cylinder rod velocity and time for a cylinder to reach the whole range of travel (s = 0.5m). For the switching position, ‘a’ indicates extension while ‘b’ indicates retraction of 2200kg load. The highest velocity, 0.145m/s occurred during retraction while the lowest velocity, 0.085m/s occurred during extension. However, the value for difference in pressure, ΔP and power consumes during extension and retraction are unable to be obtained from the simulation.

4.3 Comparison Between Theoretical Against Simulation Result

After the simulation and theoretical analysis is done, several variables seems to have different value when using dual cylinder hydraulic system that has a 13cm hydraulic piston diameter with a 10cm piston rod diameter. The comparison between theoretical against simulation result shown in Table 4.5 below.

Table 4.5 : Comparison Between Theoretical Against Simulation Result

Parameter	Theoretical	Simulation
Extend Velocity(m/s)	0.107	0.085
Retract Velocity(m/s)	0.262	0.145

As being stated before, theoretical value should have better performance compared with simulation value. In a case of theoretical, it consumes V_{ext} = 0.107m/s, while simulating in FluidSim consumes V_{ext} = 0.085m/s. Result shows deviation of a minus ~20.56%. Meanwhile for retract velocity, theoretical consumes V_{ret} = 0.262m/s, while simulating in FluidSim consumes V_{ret} = 0.145m/s. Result shows deviation of a minus ~44.66% which is much higher. This might be due to the ideal condition that do not really affect the hydraulic system itself such as internal leaking, hydraulic resistance and force coefficients factor. The setting option within the hydraulic directional valve such as coefficient of discharge, CD and orifice diameter, d values does not exist except hydraulic resistance.

The design for new lifter will use dual cylinder that has 13cm piston diameter with 10cm piston rod diameter which each cylinder consist of three stages elongation stroke.

Besides it will use 4th Way Control Valve with Thus, the pump for the new lifter must be capable of generating 813.581 kPa, reservoir will be at least 13.274 Litre. In addition, the motor will be capable to generate power and rotate at a speed for about 6.3 kW and 1750 rpm respectively to operate the hydraulic system. The specification sheet for motor unit with different load and operating speed is shown in Table 4.6 below.

Table 4.6 : Motor Unit Specification Sheet

Operating speed	0.63 m/s	0.8 m/s	1 m/s	1.2 m/s	1.6 m/s
Q= 630kg F= 1000kg	TW45C, 41:2, TS 440 3234 kJ/h, 3,8 kW 7,9 A / 12,3 A 1121 1/min, (NBS) MFC 20-15 V1	TW45C, 41:2, TS 440 3969 kJ/h, 5,2 kW 11 A / 14,5 A 1424 1/min, (NBS) MFC 20-15 V1	TW45C, 41:2, TS 590 5039 kJ/h, 7 kW 12,4 A / 17,8 A 1327 1/min, (NBS) MFC 20-15 V1	TW45C, 40:3, TS440 5555 kJ/h, 7 kW 13,8 A / 19,7 A 1389 1/min, (NBS) MFC 20-15 V1	TW63B, 43:3, TS 675 8150 kJ/h, 10 kW 25,1 A / 40,4 A 1298 1/min, (NBS) MFC 20-32 V1
Q= 1000kg F= 1500kg	TW45C, 32:1, TS 520 5388 kJ/h, 7 kW 13,4 A / 16,1 A 1481 1/min, (NBS) MFC 20-15 V1	TW45C, 40:3, TS 360 5956 kJ/h, 6,3 kW 15,8 A / 22,2 A 1132 1/min, (NBS) MFC 20-15 V1	*TW45C, 40:3,TS 360 6597 kJ/h, 7 kW 15,9 A / 21,9 A 1415 1/min, (NBS) MFC 20-15 V1	TW63B, 43:3, TS 510 9060 kJ/h, 10 kW 27,7 A / 43,4 A 1288 1/min, (NBS) MFC 20-32 V1	*TW63B, 43:3, TS 675 11370 kJ/h, 13 kW 30,2 A / 47,9 A 1298 1/min, (NBS) MFC 20-32 V1
Q= 1600kg F= 1800kg	TW63B, 33:1, TS 590 7744 kJ/h, 10 kW 23,7 A / 31,8 A 1346 1/min, (NBS) MFC 20-32 V1	TW63B, 48:2, TS 590 9716 kJ/h, 12,9 kW 25,6 A / 37,4 A 1243 1/min, (NBS) MFC 20-32 V1	TW63B, 43:3, TS 450 11577 kJ/h, 12,7 kW 31,1 A / 45,1 A 1217 1/min, (NBS) MFC 20-32 V1	TW130, 43:3, TS 540 14134 kJ/h, 15,6 kW 35,9 A / 53,4 A 1217 1/min, (NBS) MFC 20-48 V1	TW130, 43:3, TS 640 17993 kJ/h, 27,5 kW 46,8 A / 65,6 A 1369 1/min, (NBS) MFC 20-48 V1
Q= 2000kg F= 2200kg	TW63B, 48:2, TS 450 9333 kJ/h, 10 kW 28 A / 38,1 A 1283 1/min, (NBS) MFC 20-32 V1	TW130, 45:2, TS540 11736 kJ/h, 16 kW 29,3 A / 42,1 A 1273 1/min, (NBS) MFC 20-32 V1	*TW130, 45:2, TS640 13668 kJ/h, 16 kW 34 A / 48,1 A 1343 1/min, (NBS) MFC 20-48 V1	TW130, 43:3, TS 540 17425 kJ/h, 20 kW 43,9 A / 65,2 A 1217 1/min, (NBS) MFC 20-48 V1	TW130[1], 43:3,TS640 21916 kJ/h, 27,5 kW 56,8 A / 77,8 A 1369 1/min, (NBS) MFC 20-60 V1
Q= 2500kg F= 2500kg	TW130, 35:1, TS 640 12048 kJ/h, 16 kW 30,2 A / 40,8 A 1316 1/min, (NBS) MFC 20-32 V1	TW130, 45:2, TS 540 14447 kJ/h, 16 kW 36 A / 49,4 A 1273 1/min, (NBS) MFC 20-48 V1	TW130, 45:2, TS 640 17805 kJ/h, 20,5 kW 44,6 A / 60,4 A 1343 1/min, (NBS) MFC 20-48 V1	*TW130[1], 43:3, TS 540 18859 kJ/h, 26,8 kW 47,2 A / 71,3 A 1217 1/min, (NBS) MFC 20-48 V1	TW130[1], 43:3, TS540 25128 kJ/h, 33,5 kW 67 A / 80,3 A 1622 1/min, (NBS) MFC 20-105 V1
Q= 3000kg F= 2800kg	TW130, 35:1, TS 640 14468 kJ/h, 16 kW 36,2 A / 47 A 1316 1/min, (NBS) MFC 20-48 V1	TW130, 45:2, TS 540 17357 kJ/h, 20,5kW 42,8 A / 58,5 A 1273 1/min, (NBS) MFC 20-48 V1	TW130, 45:2, TS 540 19078 kJ/h, 27,5 kW 50,9 A / 61,1 A 1592 1/min, (NBS) MFC 20-60 V1	TW130[1], 43:3, TS 540 23444 kJ/h, 32,6 kW 59,5 A / 86,1 A 1217 1/min, (NBS) MFC 20-60 V1	TW160, 41:3,TS 640 31911 kJ/h, 42 kW 79,4 A / 129 A 1305 1/min, (NBS) MFC 20-105 V1

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

After this project is completed, the new lifter system for the 6x6 palm oil fruit bunch utility transporter is successfully designed and analysed. There are two types of software that have been used throughout this project which are CATIA V5 and FESTO FluidSim-H software. Several minor and major problem occurred during analysing the data due to the lack of experience and technical skills in this hydraulic industry. They are countered, however, by repeating and correcting the certain variable until the correct result has been achieved. It can be concluded that theoretical data is more accurate because the formula involved is already has been proved by other researches compared to simulation data.

Dual piston hydraulic cylinder shows the highest efficiency, 70.83%. Dual piston pump supplies high volume. It supplies low pressure flow until the increased force is needed, at which time it automatically switches to high pressure, lower volume.

FluidSim has some disadvantages, although results can be within an acceptable range in cases where fast response rate and precision can be somewhat neglected. However, there is limited access to manually setting component features when modelling the system.

The advantages of using the FluidSim system simulation toolbox are demonstrated by easy access modelling and user-friendly options. During simulation of the system software, the hydraulic system components which are cylindrical extension and retraction can be moved dynamically while the simulation itself is carried out. The result obtained in FluidSim is the better because it applied the circuit model as an testing element. It gives the advantage to modify any parameter value or component of the system that need to be improve in order to make the system well function before simulation. In addition, it simulate nearly the same as actual piping mechanism which may include losses in output pressure.

Hence, for the future study it is recommended that more teaching, laboratory experiment and software training of hydraulic power system such as Automation Studio Software for the student. Then, they will increase the experience both in soft skills and technical skills regarding mechanical fluid industry. Those skills give them benefits mostly in obtaining the worth job and facing the real work life.

The analytical discussion provides a better clear picture of the approach used in the different scenario. It also focuses on the limitations and overheads generated during the process. On the other hand, every simulator has its own limitations and cannot be completely applied everywhere. In a future study, it is recommended to conduct a real experiment in hydraulic system by varying load, number of piston cylinder, pump volumetric flow rate and relief valve pressure. It is necessary to obtain higher efficiency during loading and unloading load for the new lifter system.

REFERENCES

Mohd Solah Deraman., Abd Rahim Shuib., Zaprunnizam Mohd Ali., Aminulrashid Mohamad., and Hartini Md Hasan., 2013. Ryno : A Multipurpose Wheel Type Transporter For Oil Palm Activities On Undulating Terrain And Soggy Areas. MPOB Information Series.

Mr. Prakalp S., Dr. M. J. Sheikh., Dr. G., and V. Thakre., 2017. Moon,Development of tipper unloading mechanism. International Research Journal of Engineering and Technology (IRJET).

Amboji Sudhakar R., Humane Yogesh A., Chavan Rohan R., Patil Jyotsna C., and Kshirsagar Prashant R., 2014. Design and Fabrication of Three Way Tipper Mechanism. International Journal of Research in Advent Technology. Vol.2.

Prof. Deshmukh.S.A., Lonkar Pradip P., Bhong Tushar H., and Kale Dadaso B., 2016. Three Axis Pneumatic Modern Trailer By Using Single Cylinder. International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME).

Timothy W. Dell., 2015. Hydraulic Systems for Mobile Equipment. The Goodheart-Willcox Co. Inc. pp.1-15.

Mobile Cylinders Catalog, Mobile Cylinder Division Younstown, 2001. Parker Hannifin Corporation.

Abd Rahim Shuib., Azmi Yahya., Wan Ishak Wan Ismail., and Desa Ahmad., 2009. A Six-Wheel-Drive Transporter for Oil Palm Fresh Fruit Bunches Evacuation. MPOB Information Series. pp.1-4.

Sanjaykumar A. Borikar., Hemant V. Karkade., and Pramod G. Pokley., 2012. Development, Testing and Monitoring of the Movement of Three Directional Tipper Mechanism, International Journal of Scientific and Research Publications, pp.2-7.

Load Intensity Caculations On Tipper Body Using Dem Fem Coupling, Dr. Forsstrom, P. Jonsen, Department of Engineering Science and Mathematics, 2001.

J.Henikl., W.Kemmetmüller., and A.Kugi., 2012, Modeling and Simulation of Large-Scale Manipulators with Hydraulic Actuation, Volume 45, Issue 2, pp.780-785.

Sudhakar Amboji., Yogesh Humne., Rohan Chavan., Jyotsna Patil., and Prashant Kshirsagar., 2014. ”Design And Fabrication Of Three Way Tipper Mechanism”. IJRAT , Vol. 2, No. 4.

Prof. S A Deshmukh., Pradip Lonkar., Tushar Bhong., and Dadaso Kale., 2015. ”Three Axis Pneumatic Modern Trailer By Using Single Cylinder”. IJRRCMF. Vol.2, Issue 2, pp.111-126.

Wood., Donald., 2001. Dump Trucks. 729 Prospect Ave. Osceola, WI 54020: MBI Publishing Company. pp.6–30.

Smith J., and Clarkson PJ., 2005. Design concept modelling to improve reliability. Journal of Engineering Design 16(5). pp.473–492.

Frey DD., Herder MP., and Wijnia Y., 2009. The Pugh controlled convergence method: Model-based evaluation and implications for design theory. Research in Engineering Design 20(1). pp. 41–50.

Nakara C.P., 2005. "Basic Automobile Engineering". 7th Edition. Dhanpat Rai. Publishing company New Delhi. pp. 9-10, 13-16.

Shiwalkar B.D., 2008. "Design data for machine elements". 3rd Edition. Denett & Co. Concurrent Engineering 21(2). pp.87–102.

Nag Ko YT., 2013. Optimizing product architecture for complex design. 3rd Edition. Denett & Co. Concurrent Engineering 21(2). pp.31, 39, 93, 94.

Barbara Steward., 2012. Library.Automation Direct Website, The Difference Between A Side Tipper And A Back Tipper, PermaLink. [online]
Available at:
http://www.ampersand.org.au/the-difference-between-a-side-tipper-and-a-back-tipper/
[accessed on 20 February 2018]

Hydraulic Pump Formulas, 2018, Airline Hydraulics Corporation. [online]
Available at:
https://www.airlinehyd.com/pages/resources/hydraulic-pump-formulas [accessed on 10 October 2018]

Carlos Gonzalez , 2015, Machine Design Website, What's the Difference Between Pneumatic, Hydraulic, and Electrical Actuators?. [online]
Available at:
https://www.machinedesign.com/linear-motion/what-s-difference-between-pneumatic-hydraulic-and-electrical-actuators [accessed on 3 March 2018]

Daihatsu Website, 2005, Daihatsu Develops New 660cc Engine with Improved Environmental Performance, Power, and Quiet Operation. [online]
Available at:
https://www.daihatsu.com/news/2005/05112201.html [accessed on 5 March 2018]

E. C. Fitch, I. T. Hong, (1998), "Hydraulic component design and selection", Oklahoma, BarDyne Inc.

Marko Orošnjak, Mitar Jocanović and Velibor Karanović., 2017. Simulation and modeling of a hydraulic system in FluidSim. Department for Industrial Engineering and Management

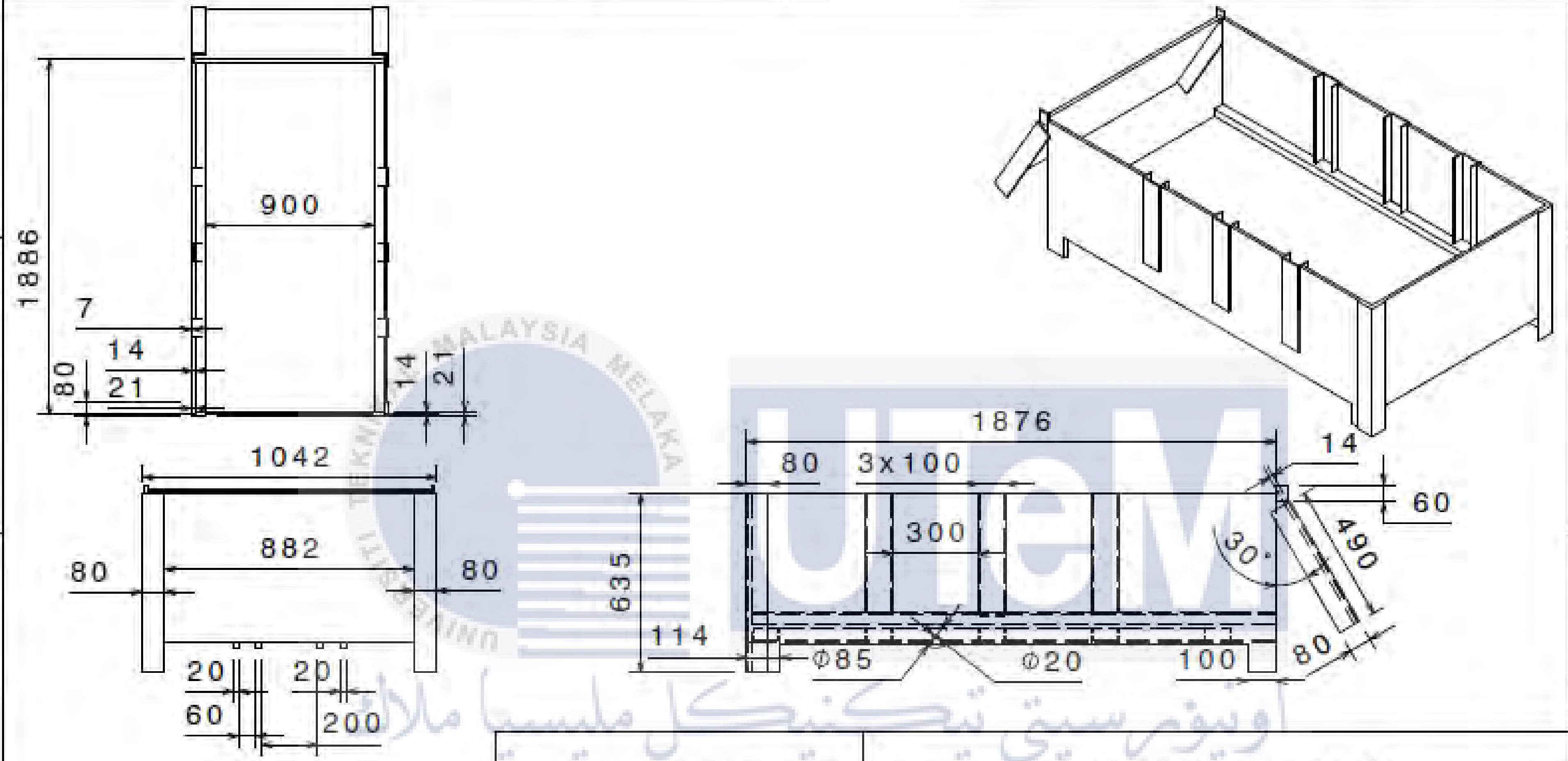
FESTO FluidSim (2016), "Festo FluidSim User's Guide", FESTO Didactic SE, Art Systems GmbH

APPENDICES

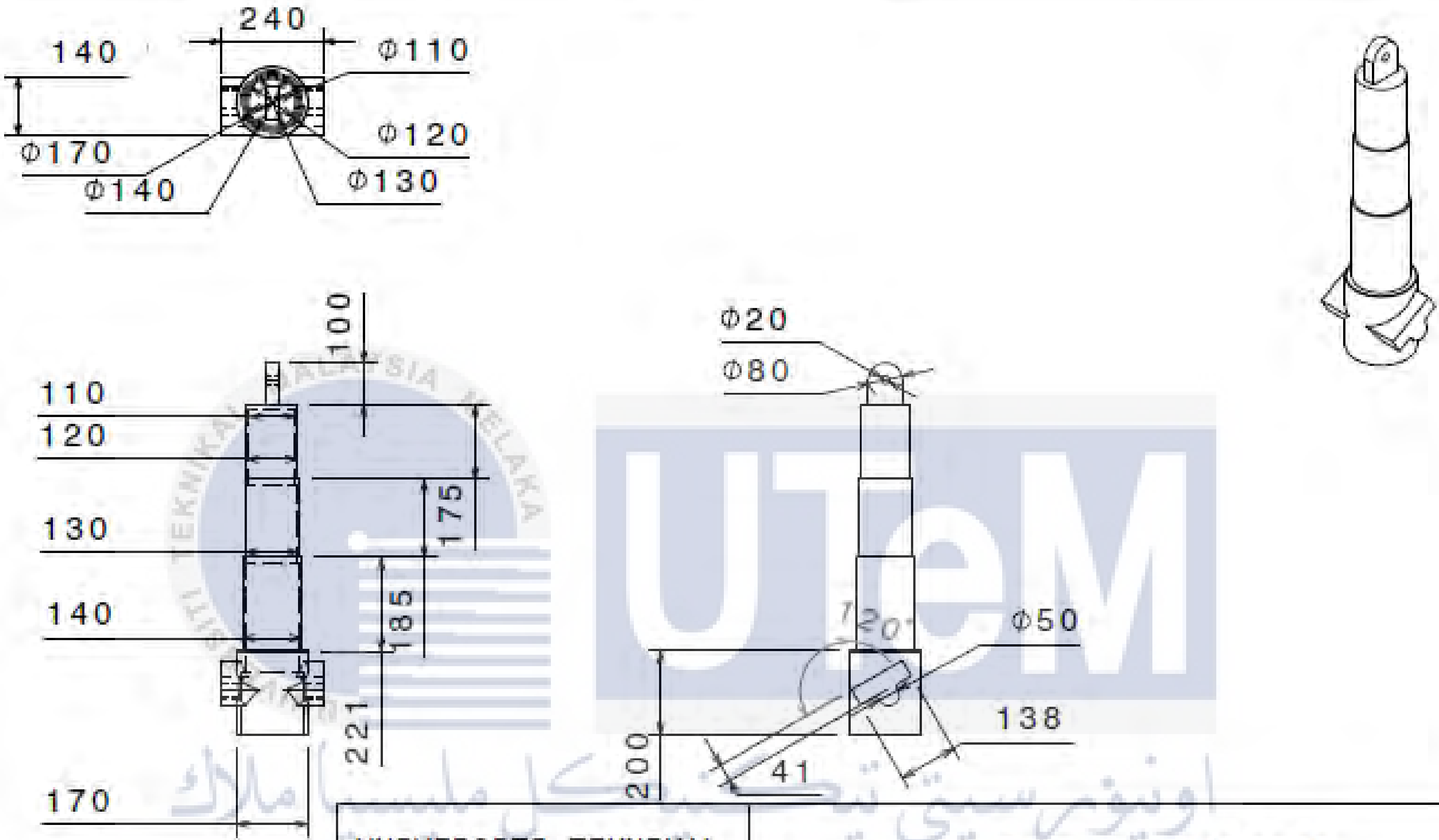
Appendix A

PSM Gantt Chart

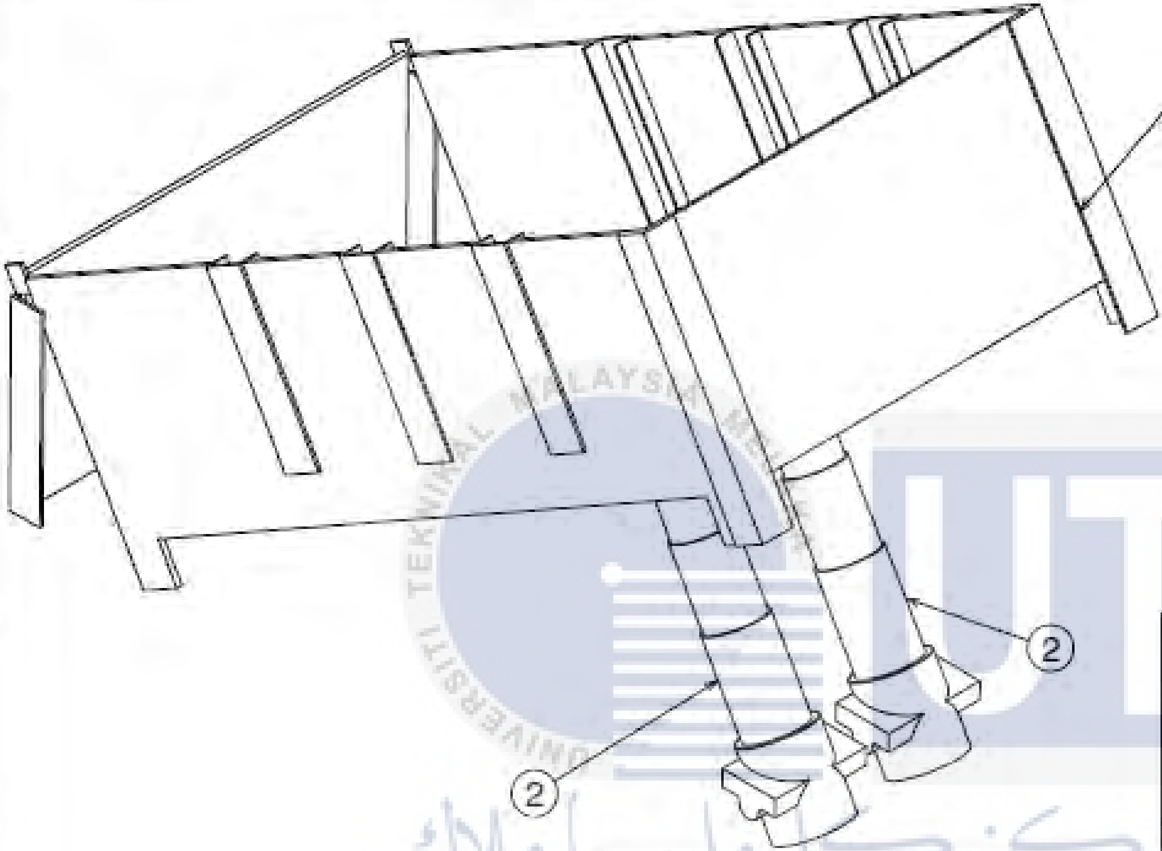
	WEEK / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PSM I	Title, objectives, and scope of project															
	Project planning and literature review															
	Identify the parametric of current design															
	Development of preliminary product design															
	Best design selection															
	Theoretical design															
	Optimization of design															
	CAD modelling															
	Technical PSM I Report Submission															
PSM II	Laboratory Experiment															
	Development of Open Hydraulic Circuit															
	Optimizing Variables															
	FESTO FluidSim Software Simulation															
	Theoretical Calculation															
	Theoretical Analysis															
	Finalizing Hydraulic System Selection															
	Technical PSM II Report Submission															



UNIVERSITI TEKNIKAL MALAYSIA MELAKA		LIFTER SYSTEM	
		DRAWING TITLE	
DRAWN BY SAIFUL AZHAR	DATE 10/9/2018	BUCKET LOAD	
CHECKED BY EN. ADZNI	DATE xxx	SIZE A4	DRAWING NUMBER 1 / REV X
DESIGNED BY SAIFUL AZHAR	DATE 10/9/2018	SCALE 1:20	WEIGHT(kg) XXX / SHEET 1/1



UNIVERSITI TEKNIKAL MALAYSIA MELAKA		LIFTER SYSTEM			
		DRAWING TITLE HYDRAULIC CYLINDER			
DRAWN BY SAIFUL AZHAR	DATE 7/9/2018				
CHECKED BY EN. ADZNI	DATE XXX	SIZE A4	DRAWING NUMBER 2		REV X
DESIGNED BY SAIFUL AZHAR	DATE 7/9/2018	SCALE 1:15	WEIGHT(kg) XXX		SHEET 1/1

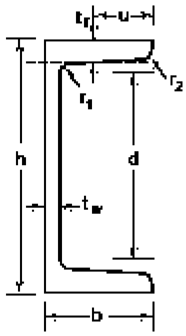


Bill of Material : Lifter System			
No.	Part	Quantity	Type
1	Bucket Load	1	Part
2	Hydraulic Cylinder	2	Part

UNIVERSITI TEKNIKAL MALAYSIA MELAKA		LIFTER SYSTEM			
		DRAWING TITLE			
DRAWN BY SAIFUL AZHAR	DATE 5/11/2018	LIFTER ASSEMBLY			
CHECKED BY EN. ADZNI	DATE XXX	SIZE A4	DRAWING NUMBER		REV X
DESIGNED BY SAIFUL AZHAR	DATE 5/11/2018	SCALE 1:13	WEIGHT(kg) XXX		SHEET 1/1

Appendix E

General Properties of Mild Steel



Designation		Dimensions						Dimensions for detailing	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r_1 mm	r_2 mm	A mm^2 $x10^2$	d mm
C 100 x 50 x 5 x 7.5*+	9.37	100	50	5	7.5	8	4	11.71	65.3

Appendix F

Motor Specification Sheet

Operating speed	0.63 m/s	0.8 m/s	1 m/s	1.2 m/s	1.6 m/s
Q= 630kg F= 1000kg	TW45C, 41:2, TS 440 3234 kJ/h, 3,8 kW 7,9 A / 12,3 A 1121 1/min, (NBS) MFC 20-15 V1	TW45C, 41:2, TS 440 3969 kJ/h, 5,2 kW 11 A / 14,5 A 1424 1/min, (NBS) MFC 20-15 V1	TW45C, 41:2, TS 590 5039 kJ/h, 7 kW 12,4 A / 17,8 A 1327 1/min, (NBS) MFC 20-15 V1	TW45C, 40:3, TS440 5555 kJ/h, 7 kW 13,8 A / 19,7 A 1389 1/min, (NBS) MFC 20-15 V1	TW63B, 43:3, TS 675 8150 kJ/h, 10 kW 25,1 A / 40,4 A 1298 1/min, (NBS) MFC 20-32 V1
Q= 1000kg F= 1500kg	TW45C, 32:1, TS 520 5388 kJ/h, 7 kW 13,4 A / 16,1 A 1481 1/min, (NBS) MFC 20-15 V1	TW45C, 40:3, TS 360 5956 kJ/h, 6,3 kW 15,8 A / 22,2 A 1132 1/min, (NBS) MFC 20-15 V1	*TW45C, 40:3,TS 360 6597 kJ/h, 7 kW 15,9 A / 21,9 A 1415 1/min, (NBS) MFC 20-15 V1	TW63B, 43:3, TS 510 9060 kJ/h, 10 kW 27,7 A / 43,4 A 1288 1/min, (NBS) MFC 20-32 V1	*TW63B, 43:3, TS 675 11370 kJ/h, 13 kW 30,2 A / 47,9 A 1298 1/min, (NBS) MFC 20-32 V1
Q= 1600kg F= 1800kg	TW63B, 33:1, TS 590 7744 kJ/h, 10 kW 23,7 A / 31,8 A 1346 1/min, (NBS) MFC 20-32 V1	TW63B, 48:2, TS 590 9716 kJ/h, 12,9 kW 25,6 A / 37,4 A 1243 1/min, (NBS) MFC 20-32 V1	TW63B, 43:3, TS 450 11577 kJ/h, 12,7 kW 31,1 A / 45,1 A 1217 1/min, (NBS) MFC 20-32 V1	TW130, 43:3, TS 540 14134 kJ/h, 15,6 kW 35,9 A / 53,4 A 1217 1/min, (NBS) MFC 20-48 V1	TW130, 43:3, TS 640 17993 kJ/h, 27,5 kW 46,8 A / 65,6 A 1369 1/min, (NBS) MFC 20-48 V1
Q= 2000kg F= 2200kg	TW63B, 48:2, TS 450 9333 kJ/h, 10 kW 28 A / 38,1 A 1283 1/min, (NBS) MFC 20-32 V1	TW130, 45:2, TS540 11736 kJ/h, 16 kW 29,3 A / 42,1 A 1273 1/min, (NBS) MFC 20-32 V1	*TW130, 45:2, TS640 13668 kJ/h, 16 kW 34 A / 48,1 A 1343 1/min, (NBS) MFC 20-48 V1	TW130, 43:3, TS 540 17425 kJ/h, 20 kW 43,9 A / 65,2 A 1217 1/min, (NBS) MFC 20-48 V1	TW130[1], 43:3, TS640 21916 kJ/h, 27,5 kW 56,8 A / 77,8 A 1369 1/min, (NBS) MFC 20-60 V1
Q= 2500kg F= 2500kg	TW130, 35:1, TS 640 12048 kJ/h, 16 kW 30,2 A / 40,8 A 1316 1/min, (NBS) MFC 20-32 V1	TW130, 45:2, TS 540 14447 kJ/h, 16 kW 36 A / 49,4 A 1273 1/min, (NBS) MFC 20-48 V1	TW130, 45:2, TS 640 17805 kJ/h, 20,5 kW 44,6 A / 60,4 A 1343 1/min, (NBS) MFC 20-48 V1	*TW130[1], 43:3, TS 540 18859 kJ/h, 26,8 kW 47,2 A / 71,3 A 1217 1/min, (NBS) MFC 20-48 V1	TW130[1], 43:3, TS540 25128 kJ/h, 33,5 kW 67 A / 80,3 A 1622 1/min, (NBS) MFC 20-105 V1
Q= 3000kg F= 2800kg	TW130, 35:1, TS 640 14468 kJ/h, 16 kW 36,2 A / 47 A 1316 1/min, (NBS) MFC 20-48 V1	TW130, 45:2, TS 540 17357 kJ/h, 20,5kW 42,8 A / 58,5 A 1273 1/min, (NBS) MFC 20-48 V1	TW130, 45:2, TS 540 19078 kJ/h, 27,5 kW 50,9 A / 61,1 A 1592 1/min, (NBS) MFC 20-60 V1	TW130[1], 43:3, TS 540 23444 kJ/h, 32,6 kW 59,5 A / 86,1 A 1217 1/min, (NBS) MFC 20-60 V1	TW160, 41:3, TS 640 31911 kJ/h, 42 kW 79,4 A / 129 A 1305 1/min, (NBS) MFC 20-105 V1