STRUCTURAL DESIGN AND MECHANISM ANALYSIS OF OIL PALM HARVESTER

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I declare that this project report entitled "Structural Design and Mechanism Analysis of Oil Palm Harvester" 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 (Design & Innovation).

Signature : ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father.

ABSTRACT

Plantation of oil palm becomes focus in Malaysia as it is the top contributors of the economy. In order to match the supply of oil palm fruit with demand, different harvesting methods and tools are used in oil palm estate such as the motorized cutter named Cantas. Although it can reduce the harvesting time and the number of labors involved in harvesting process, the tight arrangement of oil palm fronds and long manually adjusted harvesting pole may cause the inconvenient to the labors. Therefore, this project studies the design of a circular cutter and automatically adjusted telescopic pole with rotational mechanism. It is designed onto an oil palm harvester so that it can reach the oil palm tree with maximum height of 4m. This project is done according to the product development process in designing a product. The concept development of harvester is based on the scientific study on the limitations, customer requirement and engineering characteristics of existing harvesters. It is followed with the selection of best design of harvester that can solve the problems that faced by labors in existing harvester. Different analysis and calculations are also carried out in term of rotational speed, deflection and bending moment for different components in the oil palm harvester. After the selection of suitable materials and dimensions for each component, the design of harvester is done with the aid of CAD software in form of part detail design, orthographic view and exploded view. The automatically adjustable telescopic pole is designed in this project to replace the manually adjusted harvesting pole. Besides, the vibration method in vertical direction that used in the sickle of existing harvester is replaced by circular cutter with rotational harvesting mechanism.The17cm diameter of inclined teeth circular cutter with rotational mechanism and 3.7m maximum length of telescopic pole with automatically controlled are designed in this project and it could facilitate the harvesting process. With the rotational cutting mechanism, the harvester is not restricted by reaching constraints which was experienced in conventional harvesters. Labors no longer need to find the suitable position to insert the sickle in the middle of fronds with tight arrangement, they can easily reach and harvest the oil palm FFB from the bottom of the bunches with the support of automatically controlled telescopic pole.

ABSTRAK

Perladangan kelapa sawit menjadi fokus di Malaysia kerana ia adalah penyumbang utama untuk ekonomi negara. Bagi memastikan sumber buah kelapa sawit dapat memenuhi permintaan, kaedah dan alat penuaian yang berbeza telah digunakan dalam ladang kelapa sawit seperti pemotong bermotor yang dinamakan Cantas. Walaupun ia boleh mengurangkan masa dan bilangan buruh yang terlibat dalam proses penuaian, susunan pelepah kelapa sawit yang sempit dan batang penuai yang panjang serta dilaraskan secara manual boleh membawa kesukaran kepada buruh dalam proses penuaian. Oleh itu, projek ini mengkaji reka bentuk pemotong bulat dan batang teleskopik yang diselaraskan secara automatik dengan menggunakan mekanisme putaran. Ia juga direka dalam penuai kelapa sawit supaya ia dapat mencapai pokok kelapa sawit yang ketinggiannya maksimum 4m. Proses pembangunan produk digunakan di dalam projek ini untuk mereka bentuk produk penuai kelapa sawit. Pembangunan konsep bagi penuai adalah berdasarkan kajian saintifik mengenai batasan, keperluan pelanggan dan ciri-ciri kejuruteraan daripada penuai sedia ada. Projek ini diikuti dengan pemilihan reka bentuk penuai yang terbaik dan dapat menyelesaikan masalah yang dihadapi oleh buruh dalam penuai sedia ada. Analisis dan pengiraan yang berbeza juga dilakukan dari segi kelajuan putaran, pesongan dan momen lentur bagi komponen yang berbeza dalam penuai kelapa sawit. Selepas pemilihan bahan dan dimensi yang sesuai bagi setiap komponen, reka bentuk penuai dilakukan dengan perisian CAD dalam bentuk lukisan secara terperinci, pandangan ortografik serta lukisan bertaburan.Batang teleskopik yang diselaraskan secara automatik telah direka di dalam projek ini bagi menggantikan batang penuai yang dilaraskan secara manual. Di samping itu, kaedah getaran dalam arah menegak yang digunakan dalam sabit penuai sedia ada juga digantikan oleh pemotong bulat yang berfungsi dengan mekanisme putaran. Pemotong bulat bergigi cenderung dengan 17cm diameter yang berfungsi menggunakan mekanisme putaran dan batang teleskopik dengan 3.7m maksimum panjang yang diselaraskan secara automatik telah direka dalam projek ini dan ia dapat memudahkan proses penuaian. Dengan menggunakan mekanisme putaran dalam pemotong, penuai kelapa sawit dapat mencapai pelepah kelapa sawit yang sempit dengan lebih senang dan dapat menuai tandan kelapa sawit dari bahagian bawah bersama dengan sokongan batang teleskopik yang dikawal secare automatik.

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LIST OF ABBEREVATIONS

ABS	Acrylonitrile Butadiene Styrene
AC	Alternative Current
BOM	Bill of Material
CAD	Computer Aided Design
CATIA	Computer Aided Three Dimensional Interactive Application
DC	Direct Current
DOSM	Department Of Statistics Malaysia
FELDA	Federal Land Development Authority
FFB	Fresh Fruit Bunches
GI	Galvanized Iron
HAVS	Hand Arm Vibration Syndrome
HOQ	House of Quality
MPOB	Malaysia Palm Oil Board
MPOC	Malaysia Palm Oil Council
PDS	Product Design Specification
PKO	Palm Kernel Oil
PM	Pugh Matrix
QFD	Quality Function Development
RM	Ringgit Malaysia

LIST OF SYMBOL

C_s	=	Critical Speed
d	=	Diameter
E	=	Young's Modulus
I	=	Moment Inertia
L	=	Length
M	=	Bending Moment
n	=	Rotational Speed
P	=	Load
p	=	Power
r_i	=	Inner Radius
r_o	=	Outer Radius
T	=	Torque
v	=	Velocity
Z	=	Section Modulus
σ	=	Stress
Δ	=	Deflection

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Oil palm is one of the most rapidly expanding equatorial crops in the world and Malaysia is one of the largest oil palm producing countries in Southeast Asia (Koh and Wilcove, 2008). Oil palm is firstly introduced as an ornamental plant to Malaysia in 1870 and the first commercial planting of oil palm took place in Tennamaran Estate in Selangor in 1917. An oil palm fruit is grown in large bunches with weight of 10kg to 50 kg where each bunch has up to 2000 fruits. The oil palm fresh fruit bunches (FFB) need to go through some processing unit operations before it produces as a palm oil product. There is difference in the level of mechanization for each unit of operation. However, the most important and primary stage is harvesting of oil palm FFB from oil palm tree.

At earlier stage, the traditional method was used in harvesting process. The oil palm harvesting involved the cutting of FFB by harvester and allowing it to fall to ground by gravity. It was done manually as the chisel in Figure 1.1(a) was used for young palms while the sickle in Figure 1.1(b) was used for taller palms. However, this manually harvesting operation led to the bruise or damage on oil palm fruits. This method was also extremely inefficient because of the height of palm tree and difficulty to access to fruit.

(a)

(b)

Figure 1.1(a) Chisel for young palm and (b) Sickle for tall palm

Realizing the problem, a motorized cutter which named as Cantas has been invented and developed by Malaysia Palm Oil Board (MPOB). The Cantas which shown in Figure 1.2 can be used to cut the frond and FFB from oil palm tree efficiently as it is powered by a 1.3 hp petrol engine (Jelani et al, 2008). The vibration method is used in designing the operational mechanism of Cantas whereby the vibration action is transferred to vertical direction so that the cutting operation can be performed vertically. Cantas not only reduces the involvement of labor in harvesting process, it also increases the productivity of oil palm with the harvesting capacity of 500 to 700 bunches per day. By comparison, the manual harvesting will only harvest 200 to 300 bunches of oil palm fruits per day (MPOB, 2016). However, there are limitations on the cutter and mechanism of the oil palm harvester. Hence, this project will focus in designing and analyzing of an oil palm harvester for better operational efficiency.

Figure 1.2 Motorised cutters, Cantas

1.2 PROBLEM STATEMENT

Production in the agriculture field becomes focus in Malaysia as it can lead to many advantages especially in economy of the country. Being one of the biggest producers and exporters of oil palm fruit, Malaysia aims to fulfil the growing global need. The rise in demand of oil palm fruits increases the work load of labour in oil palm estate as the harvesting of oil palm FFB is the vital stage of overall process. Although the motorized cutter, Cantas can reduce the harvesting time, the harvesting process of oil palm fruits normally still associated with high prevalence of ergonomic injuries (Ng et al, 2013). One of the reasons is the difficulty in cutting some of the fronds and brunches of oil palm, as the fibre bundles consist of cellulose. Labors might need to use some energy to shove the fronds and brunches physically during the harvesting of oil palm fruits. The tight arrangement of oil palm fronds and FFB on the tree also causes the difficulty in placing the sickle accurately.

During the harvesting process, the Cantas conserves the energy of labours and increases the productivity of oil palm fruits. However, the manually adjusted pole in the oil palm harvester causes the inconvenience to the labours as they need to change the height of poles manually due to various height of oil palm tree. The length of the pole is considered too long if they need to carry it for whole day long. Besides, they need to find a suitable position during harvesting process so that the oil palm FFB could be harvested accurately. Therefore, an oil palm harvester will be designed and analysed to solve these problems and provide higher operational efficiency.

1.3 PROJECT OBJECTIVES

The objectives of this project are as follows:

1. To design a circular cutter with rotational harvesting mechanism onto an oil palm harvester.
2. To develop a structure of automatically adjustable telescopic pole in the oil palm harvester.

1.4 SCOPE OF PROJECT

The scope of this project is emphasizing on the design of circular cutter and automatically adjustable telescopic pole onto an oil palm harvester that used to harvest oil palm FFB effectively. The oil palm harvester is designed for palm tree with maximum height of 4m. Besides, the operational mechanism of the cutter and telescopic pole are analysed in this project. The CAD work in designing the oil palm harvester is presented in CATIA V5R20.