The Design and Development Of An Oil Palm Fresh Fruit Bunch Cutting Device

Desa Ahmad
Faculty of Engineering
Universiti Pertanian Malaysia
43400 UPM, Serdang
Selangor Darul Ehsan

Fax: 603-9488939
E-Mail: desa @ eng.upm.edu.my

ABSTRACT

The Oil Palm industry has developed tremendously with the increasing of planted area from 54,000 hectares in 1960 to about 2.28 million hectares in 1995. This is expected to increase further to 2.5 million hectares by the year 2000. However, there has been an increasing difficulty in obtaining sufficient labour for the oil palm plantations.

At present, harvesting of oil palm fresh fruit is facing an acute shortage of workforce as the workers are much more attracted to the better working environment and salary in the industrial sector. Harvesting of short palm is easily done by using a chisel attached to a short steel pole. Cutting is done by moving the tool at high speed to the target. The weight of the tool coupled with the speed of throwing will produce enough energy to cut the bunch stalk. In this cutting method, sharpness of the cutting device, weight of tool and the speed of throwing contribute to the efficiency of the tool. For the tall palms, a sickle attached to a long pole is used and the job is more difficult compared to the short palms. Lifting of pole and cutting jobs require great effort and skills.

This paper describes the basic design needs in developing an appropriate harvesting device that is practical for field use. A prototype design was developed and tested.
Key Words: Oil Palm, Cutting Device

INTRODUCTION

The oil palm industry especially the plantation sectors, in the mid eighties, were severely hit by labour shortages. This was due to rapid economic growth in the urban areas which offerred better job opportunities and working conditions. Heavy losses were incurred. In 1987, 425387 tonnes of crop costing RM 75.6 million was lost due to the labour shortage (Anon, 1988). To overcome this problem foreign labourers were employed. However due to social problems that crop up, the government is now moving towards mechanisation.

Mechanisation in the oil palm plantation was proposed as early as 1978. It was thought that mechanisation would make the harvesting of oil palm fruit bunch more attractive and less strenuous. It would also improve infield opeation that prevent fruit wastage and formation of free fatty acid.

Harvesting operation involves a number of jobs in stages. Initially it begins with the identification of ripe fruit followed by cutting the frond and the bunch, then transporting the bunch to the collection centre. This is later followed by collection of loose fruits and clearing of fronds. These links are shown in Fig.1.

Presently harvesters are using chisel and sickle to cut the frond and the bunch. The chisel is usually attached to either a wooden pole or a short bamboo pole. The cutting procedure requires the harvester to give a hard push at the edge of the frond or the bunch. Sickle is used to harvest fruits from trees that are more than 4 meters tall. Attaching

it to the end of a pole allows the harvester to manoeuvre the sickle and hook it to the frond. The harvester will then give a hard downward pull to slice the fronds.
Past studies reveal that not many attempts were made at developing and testing tools for harvesting oil palm fresh fruit bunches. Besides they were found not practical and commercially unviable.

Shuib et. al (1988) tested two motorised cutting tools such as chain saw and rotating disc. These tools were hydraulically powered. A power pack was used and carried on the harvester's back while the cutting tools were attached to the end of a telescopic pole. From the test carried out, the saw teeth became blunt due to the fibrous material of fronds and bunch stalk that is known to contain silica. The pole too vibrated strongly. This method of cutting was difficult to succeed as the tools would be nipped during cutting once the frond starts to bend.

A claw-type cutting knife was also tested. One difficulty observed was the problem of accessibility between the fronds. However, this concept has the potential to be developed further.

Shuib et al. (1988) also reported on a motorised cutter designed by a Japanese company. The cutter was powered by a single cylinder gasoline engine. The weight of the tool was 6.4 kg and cutting was performed by the reciprocating movement of its blade. However, due to its weight and vibration, the operation was more strenuous to the harvesters.

Razak (1996) reported on a harvesting operation using a sickle with counter shear cutting method. This prototype was pneumatically powered and attached to a harvesting machine. The drawback of this machine is its shear weight and continuous bending of the cutting blade.

Based on previous work, it is observed that most researchers conducted their experiments using low cutting speed and tested only on a few stems. Aspects like physical properties of frond and bunch stalk, material reaction against cutting edge, speed and method of cutting were not considered with the exception of work done by Hadi et al. (1993). Hadi et al. studied the effect of design parameters on the specific cutting force and cutting energy for cutting oil palm bunch stalks. Low speed tests by means of blades were conducted to investigate the effect of blade designs, mode of operation and material properties on specific cutting force and energy requirements per unit cut area. The results obtained show that the cutting force and cutting energy of bunch stalks were significantly affected by knife edge angle, oblique angle and shear angle but not by cutting speed.

The current method of harvesting is strenuous and time consuming. The cutting process requires pole manoeuvering and energy to pull the pole downwards to cut the fronds or the bunch. The harvester needs to remove bunches weighing about 23 to 30 kg from the field to the road side. A case study conducted by Webb (1977) shows that a harvester can only harvest on the average of 1.5 tonnes of oil palm bunch in a normal 8 working hours.

The time spent by the harvester for cutting the bunch and frond varies from 26% to 37% of the total infield operation time. This was, as reported, due to tiredness and manouvering operation. This makes the harvester cover less area and stops him from harvesting more than 1.5 tonnes per day. This will affect other harvesting operations. If the cutting rate is slow, the harvesting rate will drop and consequently the total area covered by the harvesters for the day will be less. With the impending labour shortage and increase in plantation area, it is important therefore that the cutting operation be mechanised to improve production.

MATERIALS AND METHODS

The aim of the project was to design and develop a prototype oil palm bunch cutter that could produce an impact cutting motion. The basic principle of the design was to transform the high torque rotation motion of the impact wrench to a vertical linear motion. The conceptual design of the system is as shown in Fig.2.

The impact wrench when operated would produce a high torque rotational motion and the power screw coupled to the impact wrench would rotate in its position. A power nut fixed to the screw was prevented from rotating with the power screw by its two gliding slider rods. The power nut, instead, would slide vertically and its speed was in accordance with the rotational speed of the impact wrench. The clockwise rotation of the impact wrench would cause the power nut to move upwards and the anti clock wise rotation would cause the slider to move down. Limit switches were fixed at the top and bottom of the frame plate.

In the harvesting operation a pole with a sickle was fixed to the power nut. The pole was made to pass through the upper frame plate. This was to avoid damage to the power screw-nut system due to the bending of the pole. The power nut motion (transformed from a high torque rotating motion) was expected to produce a strong pull. Basically the procedure of the operation would start with the sickle first being hooked to the frond. Then the impact wrench was operated to pull the pole downwards to cut the frond. Selection of the impact wrench was based on the maximum dynamic cutting force. The data on cutting force were collected using a sickle and an aluminium pole with a calibrated tension spring attached. Based on a number of tests conducted in the field, the maximum cutting force was about 8kN (Wan Shaifuddin, 1993). The impact wrench selected used pneumatic force as its driving force. The specifications for the impact wrench and its power screw are as shown in Table 1.

RESULTS AND DISCUSSION

Test were conducted at 30°, 45° and 90° cutting angles. Parameters

considered were the time taken to cut the sample, total area penetrated by the knife, rate of penetration, cutting length and the cutting speed. Table 2 shows the results of experiments conducted on five samples.
At 30° cutting angle, the pole deflected upwards. This created a slicing effect between the knife and the sample. The deflection occurred periodically during the penetration process. This eventually caused the frame to twist, adding extra stresses to one side of the power nut which eventually caused wear and tear to the power screw and the power nut.

When the cutting angle was increased to 45°, the deflection of the pole was greater. As the test continued, the impact wrench started to wobble and caused some damage to the frame holder rod and the slider. At 90° cutting angle, the load acting on the system was even greater causing more deflection of the pole. The body of the cutter twisted to one side and had to be held very tightly. The cutting rate too was very slow.

Based on the results obtained and observation during experiments, the physical fabrication needs to be modified to strengthen the whole system for future work. The internal part of the impact wrench did not show any defect except for the rotor vane. Three of the six vanes did not function well. Instead they were stuck in their housing. This might have affected the impact wrench performance. The misalignment of the system was due to the impact wrench extension bar and the coupling unit. These components, especially the soupling unit, need to be replaced with a lighter unit that could couple the impact wrench and the power screw directly to reduce wobbling. Modification is also needed for the bearing housing at the top of the frame to avoid the forward movement of the power screw due to the pulling force.

As regards the samples being used, the harder the samples the slower were the cutting speed. The cutting speed at times was not compatible with the impact force required to cut the oil palm frond. Since speed has a significant effect on the cutting force, a high speed impact wrench might overcome the design problem.

CONCLUSIONS

Basic design needs in developing an appropriate harvesting device have been identified. A prototype design was developed and tested. Samples were successfully cut. However the cutting rate was dependent upon the cutting angle. Furtherwork requires design material that is lighter and an impact wrench that could exert greater force at a higher speed.

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REFERENCE

1. Anon (1988). Harvesting and Infield Transportation Issue No. 10. 6p. Engineering Bulletin.

2. Hadi Suryanto, Mohd. Zohadie Bardaie, Desa Ahmad and Azmi Yahya (1993) Force and Energy Requirement for Cutting Oil Palm Fresh Fruit Bunch. The Planter, Vol. 69, No. 810, 399-407.

3. Razak Jelani (1996) Design, Development and Evaluation of Oil Palm Fresh Fruit Bunch Cutting Devices. Unpublished M.Sc. Thesis. Faculty of Engineering, Universiti Pertanian Malaysia, Serdang, Selangor.

4. Shuib, A.R., Hassan, A.H. and Hitam, A. (1988) Development of Harvesting Machine for Oil Palm Mechanisation in Oil Palm Industry. Report presented to PORIM Board, pp. 35-40.

5. Wan Shaifuddin (1993). Harvesting of Oil Palm Fresh Fruit Bunch. Departmental Report, Faculty of Engineering. Universiti Pertanian Malaysia, Serdang, Selangor Darul Ehsan.

6. Webb, B.H. (1977). The Development of Suitable Infield Ffb Harvesting Systems to Improve the Efficiency of Oil Palm Production. Incorporated Society of Planters, Kuala Lumpur, pp 741-759.

Table 1 : Specifications of impact wrench and power screw

(a)	Impact Wrench		
	Maximum torque	:	312 Nm
	Air consumption	:	0.113 m^3
	Free speed	:	7000 RPM
	Air pressure	:	620 kPa
(b)	Power screw		
	Major diameter	:	25 mm
	Minor diameter	:	20 mm
	Screw lead	:	6 mm
	Length of screw	:	370 mm
	Total length	:	480 mm
	Length of nut	:	100 mm
	Linear speed	:	0.7 m/s

Table 2 : Results of Experiments

Parameters	Cutting Angle		
	30°	45°	90°
Cutting time (minutes)	2.8	3.42	5.67
Area penetrated (cm^2)	28	25	22
Cutting length (cm)	11	11	9
Cutting speed (m/hr)	2.30	1.93	0.95
Rate of penetration (cm^2 /sec)	0.16	0.12	0.06

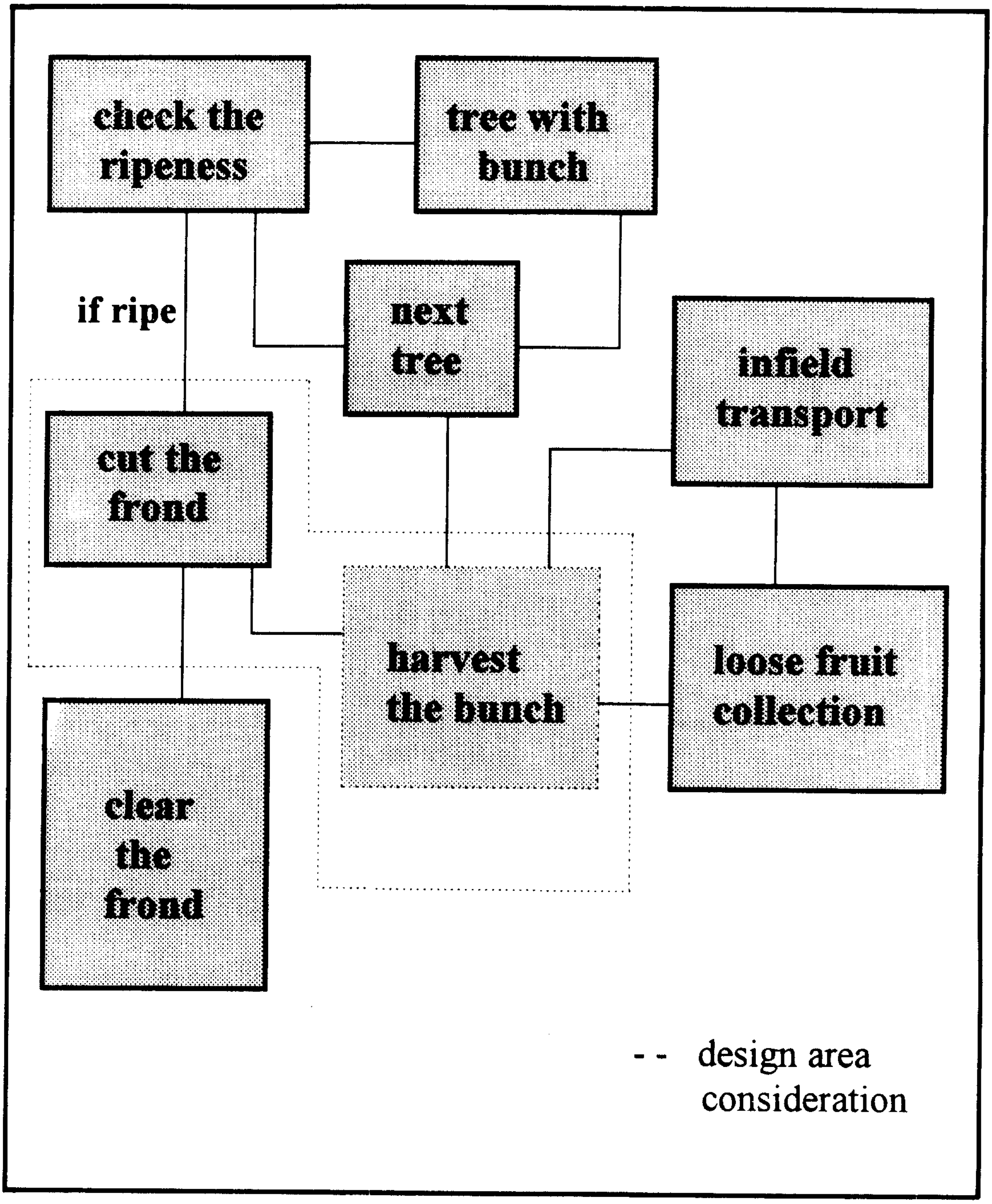

Fig. 1 : Infield operation schematic Chart

A	Top Frame Plate	G	Bottom Frame Plate
B	Power Nut	H	Aluminium Pole
C	Mid Frame Plate	I	Reinforcement Rod
D	Coupler	J	Slider Rod
E	Extention Bar	K	Power Screw
F	Impact Wrench		

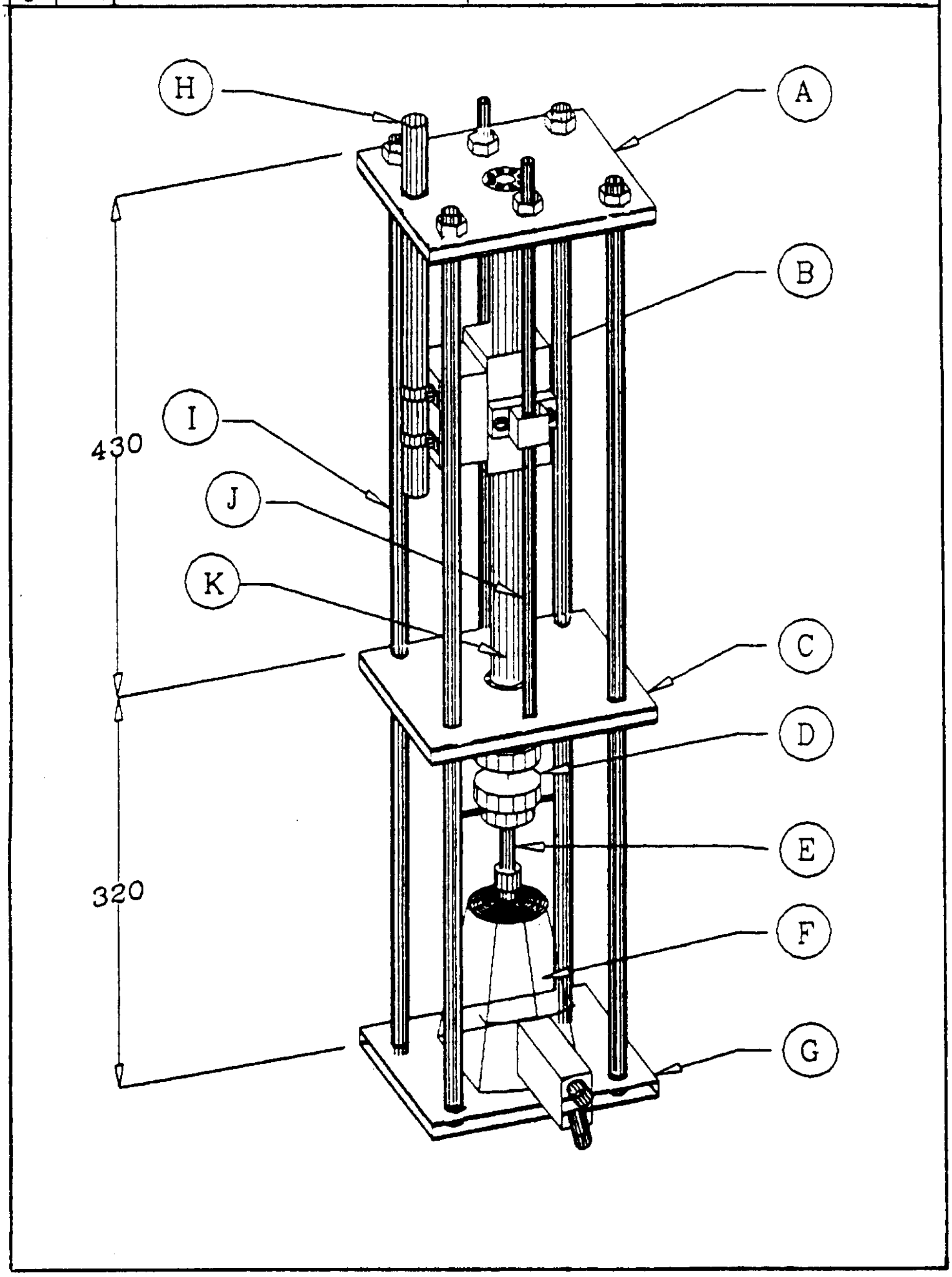

Fig.2 : Conceptual Design