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Determination of Minimum Suction Level for Collecting Oil Palm Loose Fruits

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Abstract
Loose fruits (LF) can be found at almost every stage of oil palm fresh fruit bunch (FFB) collection whether in the field or at the mill. LF contain the optimum amount of oil, which is why they need to be collected to ensure maximum Oil Extraction Rate (OER) at the mill. Various methods of LF collection were introduced for the oil palm industry, mostly comprising a simple mechanical type or the suction type. Based on systems developed in the past, the suction type was found to be more practical for collecting scattered LF around the palm base. This study seek to determine some suction parameters such as airflow and air velocity, relationships between engine and fan speeds with various fruit capacities. Results of the study showed that the minimum air velocity that is required to lift up a single LF is approximately 22.4 m/s or an airflow of 0.21 m^3/s. Results also indicated that the effective airflow to collect oil palm LF is between 0.28 m^3/s to 0.33 m^3/s (air velocity of 30 m/s to 35 m/s). It was found that engine speed will not be affected by the number of LF in the barrel; except the speed of fan, which was affected especially at lower speed. Higher air velocity was produced at the end of the suction nozzle at 80% fruits capacity in the barrel as compared to the empty barrel. The findings are expected to help in designing an effective suction machine for collecting oil palm LF.

Keywords: Oil palm, Loose fruits, Suction, Airflow, Air velocity

Introduction

Oil palm planted area in Malaysia in 2018 has reached 5.85 million hectares since it was first planted as a commercial crop in 1917 (MPOB, 2019). Upon reaching its ideal maturity stage, oil palm fresh fruit bunches (FFB) need to be harvested to enhance the quality of palm oil. Harvesting involves cutting off the ripe bunches and evacuate them immediately to the mill for oil extraction. During harvesting, handling and transportation operations, ripe fruits become easily detachable from the bunch (Mohd Ramdhan et al., 2013). The presence of 1 to 10 loose fruits (LF) on the ground are used as a visual indication that a bunch is ready for harvesting. Besides that, high number of LF are scattered due to the impact of bunches falling to the ground during the harvesting activity. Therefore, the LF must be collected and gathered together with other bunches. Currently, conventional methods of collecting LF are being widely practiced in plantations, with a productivity of between 200 to 250 kg LF/worker/day. A practical and cost-effective mechanised LF collection system is still one of the primary targets of the oil palm industry. There is a need to increase the efficiency of the LF collection but at the same time, the cost of LF is to be kept at a minimal rate. Generally, there are two approaches that have been developed to assist LF collection activity i.e. mechanical and suction methods. Several suction type loose fruit collecting machines were developed by Malaysian Palm Oil Board (MPOB) (Ahmad Hitam et al., 1995; Ahmad Zamri and Ahmad Hitam, 1999 and Rahim et al., 2012). In addition, there were also studied by Universiti Putra Malaysia, where they have developed and tested different suction methods to collect LF (Ja'afar, 1999; Rimfiel and Abadanjumi, 2007). Based on the outcomes from the systems developed by the industry in the past, it was demonstrated that suction type system was more practical for collecting scattered LF around the palm base. Currently, there is no determination on the minimum and effective air velocity or airflow that is required to lift up or to collect a single or several oil palm LF. A study by Ahmad Zamri and Ahmad Hitam (1999) gave a range of air speeds between 20 m/s to 35 m/s while Taner (2016) in his study for picking up hazelnuts from the ground (average size around 2 g to 3 g), used a backpack hazelnut harvesting machine with a specification of 100 m/s of air velocity. There is also a challenge to ensure that the fruits capacity would not affect the performance of the suction capability as the fruits are constantly being accumulated in the tank.

Materials and methods

The Machine

The oil palm LF collecting machine (MK III) was used in the study (Figure 1) with the specifications as shown in Table 1. The collection process of oil palm LF is done via vacuum (closed system) using a suction nozzle. The vacuum is created by a radial blower fan which is powered by a diesel engine. The mixture of fruits and trash, when entering the barrel, will be at a tangential angle and subjected to a cyclone atmosphere. This is to ensure that the fruits are not only able to be sucked in but also separated from trash. As the fruits circulate in the barrel, the heavier fruits will fall to the bottom of the barrel (as it loses energy) while the lighter materials, such as dried leaves or trash, will be blown into another compartment**.**

Minimum airflow to lift up oil palm loose fruit.
The end of the nozzle was put at 2 cm height from the ground. A single LF (average weight of 10 g) was then put on the ground directly under the nozzle. The engine was then ignited and the throttle for blower fan was engaged gradually until the LF lifted slightly from the ground. The position of the throttle was then maintained and air velocity at the nozzle was measured. These steps were then repeated for nine replicates. For measuring the airflow, digital anemometer (Model HH-30 by Omega Pro) with an accuracy of ±1% was used.

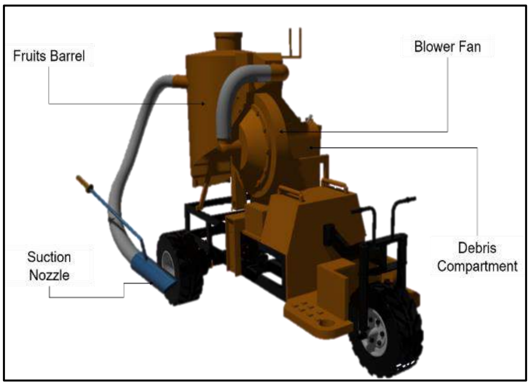

Figure 1: The isometric view of the machine.

Table 1: General specifications of the machine

Engine	**10 hp. diesel - air cooled**
Tank size, m^3 (est.)	0.15
Blower fan	
Type	Aluminium radial fan with 30^0 inclination
	12
No. of blades:	19 x 9 x 0.3
Size (L x W x T), cm:	
Suction nozzle	
Material:	PVC pipe
Diameter, cm:	10
Inlet area, A (Oval shape), m^2:	9.42 x10^{-3}
	5.5
Hose length, m:	

Air velocity at the end of nozzle, engine and blower fan rpm at 0% and 80% fruit capacity.
0% capacity is referring to an empty barrel (no LF in the barrel) and 80% capacity is referring to approximately of 80% capacity of the barrel being filled up with LF (approximately 62.5 kg). A 100% capacity is not recommended for this experiment due to the possibility of fruits entering debris compartment or being hit by the blower fan. It is recommended that the operator should empty the LF from the barrel at 80% of the capacity before continuing the operation. Digital tachometer **(Model:** RM1500) by Prova Instrument Inc. with an accuracy of 0.04% ± 2 digits ±0.06 rpm was used to measure the speed (revolution per minute, rpm) of the fan and engine at their rotating shaft. Measurements were taken to determine the speed at different throttle positions (No.1 – No.4) for nine replicates. For measuring the airflow, the anemometer was put at approximately 2 cm from the suction nozzle and the airflow was then calculated using the airflow equation.

Calculation of Air Flow.
Airflow is the volume of air necessary for sucking the LF in the suction area. Airflow in the suction area can be calculated by the formula:

$Q = V \times A$
Note:
Q = Airflow of Suction Area (m^3/s)
V = Air Velocity (m/s)
A = Suction Area (m^2)

Data Analysis.
For statistical analysis, a comparison of means was performed using t-tests, where appropriate.

Results and discussion
Minimum airflow.
From the study, it was found that the minimum mean air velocity of 22.4 ±1.8 m/s or calculated of an airflow around 0.21 m^3/s is required to lift up and hovered a single LF with an average weight of 9.7 ± 0.4 g. From the observations, it was found that this airflow rate is not sufficient to lift up a group of LF (3 to 5 LF) simultaneously. These findings are crucial in order to design a mechanism to collect a number of LF simultaneously and channel them through a hose into a barrel or fruit compartment. Hence, extra air velocity is required for effective loose fruits collection in the field. The results, which were obtained in a lab environment, should also consider other factors such as ground surface condition, the material of nozzle and hoses, air temperature, turbulence in the hose etc. when operating in the field. The hose length plays an important role in determining the effective air velocity required. A longer hose will normally

cause higher loss (David V. H. and Dan W., 2006). The oil palm LF collecting machine is equipped with 5.5 m hose length which was found to be sufficient and practical to be used in field operation. With this length, the machine is having better coverage to collect the scattered LF around palm circle and able to cover both sides of palm rows.

Effect of fruits capacity

Figure 2 shows that although there were a slight drop of engine revolution per minute (rpm) between empty (0%) and 80% fruit capacity of the barrel, however the difference were not significant ($p>0.05$). Thus, engine rpm was not affected by the number of LF in the barrel. Figure 3 indicates that there was a significant difference ($p<0.05$) of the fan's rpm between empty and 80% fruit capacity of the barrel at lower throttle positions (No. 1 & No. 2). It was believed that it was caused by the lower energy build-up and the fan was not at its peak performance at lower rpm. Once the fan had achieved its peak performance, the barrel capacity will not affect the fan's rpm. Higher air velocity is produced at the end of the suction nozzle during 80% of fruits capacity in the barrel as compared with the empty barrel as shown in Figure 4. As the fruits are being accumulated in the barrel, the volume of empty space is getting smaller thus reducing the air loss in the barrel. In another words, the suction generated by the fan is now being transferred directly to the hoses or suction nozzle without the need to build up its vacuum in a larger sized barrel. From the study, it was also found that the air velocity between 30 m/s to 35 m/s (airflow of 0.28 m^3/s to 0.33 m^3/s) and blower fan's between 3000 rpm to 3500 rpm are sufficient to collect several oil palm LF effectively.

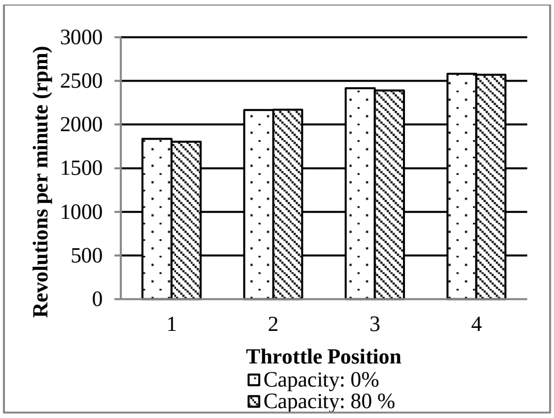

Figure 2: Comparison of engine speed at 0% and 80% fruits capacity.

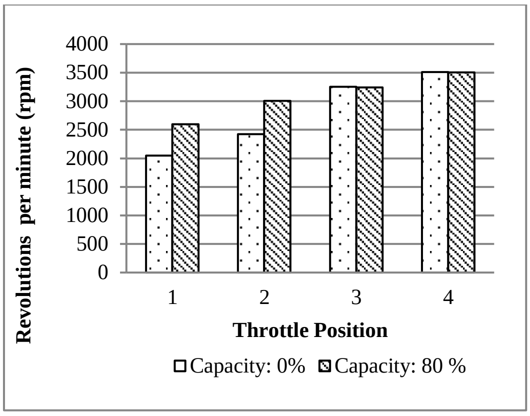

Figure 3: Comparison of blower fan speed at 0% and 80% of fruits capacity.

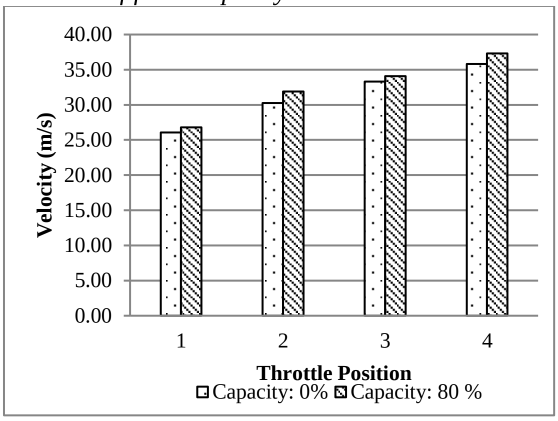

Figure 4: Air velocity at nozzle for different fruit capacities

Some recommendations that should be considered when designing the vacuum type collecting machine:

1. Minimising installation of fittings such as an elbow or bends along the system the fan discharge, which may cause non-uniform flow and increase the system's resistance.
2. Blower fan should be made from light materials but should be able to resist high sudden impact from small objects at high velocities. There are some cases where the fruits were accidently hit, which damaged the fan blades or wear and tear occurs due to impact from particulate matters that is constantly hitting the fan blades.

Regular checking on the machine should be conducted before and during the operation such as ensuring that the fan impeller is rotating in the appropriate direction i.e. clockwise or counter-clockwise. For belt-driven fans, a motor and fan sheave should be aligned properly with proper belt tension. Last but not least, the passages in the hoses and inlets, need to be regularly checked to ensure fan blades and its compartment, are in good conditions and no build-up of dirt or obstructions such as dried mud other foreign matters inside the fruit barrel.

Conclusions

The minimum airflow required to lift up a single LF and effective airflow to collect several LF were determined. Furthermore, the amount of LF in the barrel is not a major issue that could affect the suction capability. With these findings, it is hoped that more improvements can be made to the loose fruits collecting machine.

References

Abd Rahim, S., Mohd Ramdhan, K., Mohd Solah, D. and Aminulrashid, M. (2012). Oil palm loose fruits collecting machine (MK III). MPOB Information Series No. 592. palmolis.mpob.gov.my/ publication/TOT/TT-505.pdf.

Ahmad, H., Ahmad Zamri, Y. and Mohd Salih, J. (1995). Loose fruit collector. PORIM Information Series No.19. palmoilis.mpob.gov.my/publications/TOT/TT-19.pdf.

Ahmad Zamri, Y. and Ahmad, H. (1999). Mechanical loose fruit collector (MKII). PORIM Information Series No. 57. palmoilis.mpob.gov.my/publications/TOT/TT-57.pdf.

David, V. H. and Dan, W. M. (2006). Friction Loss in Wildland Hose Lays. Fire Management Tech Tips. United States Department of Agriculture Forest Service, Technology & Development Program: 1-12

Ja'afar, M. S. (1999). Teknik pemungutan buah kelapa sawit terlerai: cabaran dan pendekatan baru. National Conference on Engineering Smart Farming for the Next Millennium, 14-16 Mac 1999, UPM, Serdang, Selangor. (Unpublished)

MPOB (2019). Oil palm planted area as at December 2018 (hectares). http:// http://bepi.mpob.gov.my/images/area/2018/Area_summary.pdf, accessed on 1 Feb. 2019.

Mohd Ramdhan, K., Abd Rahim, S. and Mohd Solah, (2013). Mechanization: From field to mill. The Planter, Vol. 89 No. 1052, Nov. 2013: 827-838.

Rimfiel, J and Abadanjumi, E (2007). Performance evaluation of a terrain accommodating oil palm loose fruit collector. Pertanika Journal Science & Technology Vol. 15 No.1: 15-23.

Taner, Y. (2016). Labor Requirements and Work Efficiencies of Hazelnut Harvesting Using Traditional and Mechanical Pick-Up Methods. Turkish Journal of Agriculture and Forestry (2016). 40: 301-310.