Design and Evaluation of a Crane Fitted to a Mini-Tractor for Mechanical Loading of Oil Palm Fresh Fruit Bunches (FFB)

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RINGKASAN

Kerja-kerja yang melibatkan merekabentuk dan membina sebuah kren yang dipasang pada mini-traktor untuk mengangkat tandan buah sawit diterangkan. Kren ini yang boleh memusing 160 darjah boleh mengangkat tandan di kedua-dua belah traktor. Kren ini diujinilai serentak dengan sebuah lagi mini-traktor yang menggunakan tenaga manusia untuk mengangkat tandan. Keputusan ujian dalam ladang menunjukkan keluaran sehari menggunakan kren adalah sedikit kurang berbanding dengan mengangkat tandan dengan tangan. Walaupun dengan kelemahan ini, pengeluaran sehari bagi seorang pekerja didapati bertambah. Ini ialah kerana dengan menggunakan kren hanya seorang pekerja sahaja diperlukan untuk memandu traktor dan mengangkat tandan. Tambahan pula pekerja mendapati lebih mudah mengangkat tandan yang besar terutamanya yang melebihi 25kg. Selain dari kegunaan mengangkat tandan, kemungkinan menggunakan kren untuk membuat kerja-kerja lain di ladang juga dibincangkan.

INTRODUCTION

Predicted rising labour costs in Malaysia have prompted investigations into the most cost effective mechanical systems by which labour can be more efficiently utilized. The introduction of mini-tractors in the early 80s for in-field FFB collection has been welcomed by the harvesters particularly those working in well-managed estates. Besides improving the productivity and earnings of harvesters, the use of the mini-tractors has also resulted in an overall improvement in harvesting standards (Yaakob and Toh, 1988). With the present system of manual loading, the mini-tractor is driven at a steady speed of about 3 km/hr along every alternate row of palms. The loaders walk ahead of the mini-tractor and pick up the bunches using an iron spike, dropping them into the trailer as the vehicle approaches. The average daily output of a mini-tractor is about 20 tonnes FFB, which is equivalent to roughly 1000 bunches. Such a large number of bunches really makes the workers collapse at the end of the day! So it was felt that if mechanical loading could be adopted, this arduous task would be reduced.

In the work described here, a crane fitted to the back of a mini-tractor was designed and developed for mechanical loading of FFB. The aim was to reduce the drudgery of work and to lower the cost. In addition, the use of this crane for other field operations such as Empty Fruit Bunch (EFB) loading for distribution in the field is also possible. Currently, loading EFB into a trailer is

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being done either by manual or mechanical means; but the latter is more costly (Abdullah *et al.*, 1988). In an attempt to reduce costs of mechanical loading further, a different type of grabber has been developed for the purpose of loading EFB.

DESIGN CONSIDERATIONS

The following design criteria were considered in establishing the basic design of the crane:

- Its design should permit the operator to perform the job without leaving his seat.
- It should be operated by one person for both driving and loading.
- It should be able to collect all the bunches lying along the pathway of the mini-tractor.
- It should be simple and easy to operate so that workers can get used to it quickly.
- It should have a correct length to weight ratio so as to avoid upsetting the well-balanced mini-tractor.
- It should be able to improve worker productivity.
- It must be economically efficient.

DESIGN AND DEVELOPMENT

The crane consists of elbow type arms, namely slew column, main arm and upper dipper arm, which are operated by hydraulic cylinders. The movement of the arms can be controlled by a joystick. The slew column to which the main arm is connected, rests on a turntable and is bolted directly to the back of the tractor. The rotation of the slew column is made possible by a rack and pinion system which allows the column to turn 160 degrees. The crane has a 2.5m radius and can lift a load of up to 70kg (loads exceeding this limit tend to destabilize the mini-tractor). To ensure weight transfer to the whole body, a main frame is fitted underneath the tractor chassis and extended on to the middle portion. The frame is also welded to the turntable (*Figure 1*).

The major part of the structure is made of high yield mild steel plates welded together with the appropriate grade of welding rods. Most of the arms are 4mm thick box section. The stress levels chosen should give the crane a structural life of 7500 hours.

For the FFB grabber a three-finger design was adopted, with metal plates welded to the bottom part of the fingers. This is to avoid bunches falling off as the fingers close together during the grabbing process. The joints of the fingers were made by bolting to a hollow, circular metal hydraulic ram housing with the hydraulic ram inside it (*Figure 2*). The whole structure was fitted to the end of the crane boom.

For EFB loading, a different type of grabber was constructed. The basic design of this unit is similar to that of the FFB grabber except that five fingers were welded to two bars, and these bars were connected to a hydraulic ram housing (*Figure 3*). This grabber was also attached to the end of the crane boom.

The crane is powered by a hydraulic system. The hydraulic pump is connected to the engine via a flexible rubber coupling which also acts as a safety feature. In the event of shock loadings the rubber will break, preventing damage to the engine shaft and hydraulic pump. Since the hydraulic pump is driven by the tractor engine, a hydraulic tank is located close to it. Control levers (joysticks) are fixed at the right hand side of the tractor driver. There are four levers for operating the

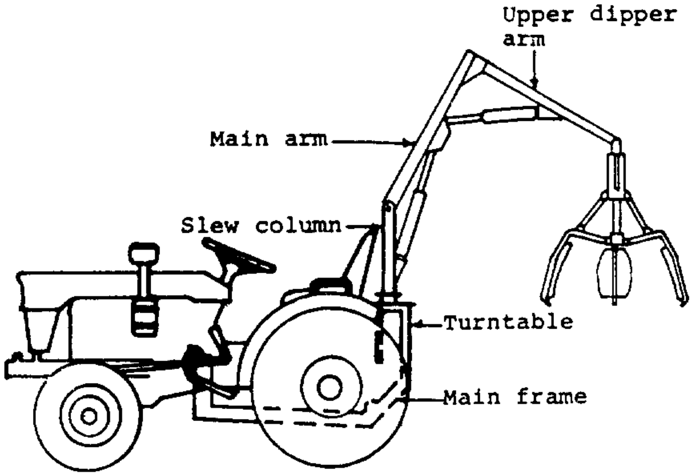

Figure 1. Crane fitted at the back of the mini-tractor (trailer not shown).

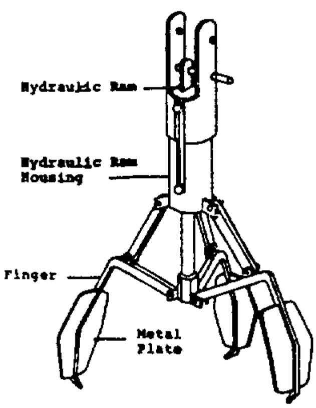

Figure 2. FFB Grabber

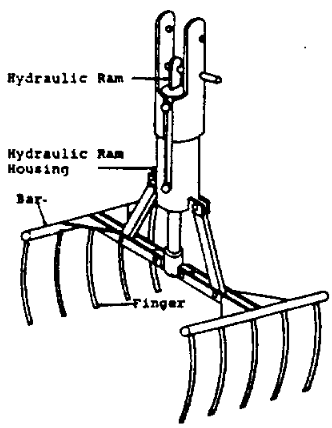

Figure 3. EFB Grabber

crane. One is for crane rotation, one for the grabber and two for main and upper dipper arm movement. The tractor driver can operate this crane without leaving his seat.

FIELD EVALUATION

Evaluation of FFB grabber

The trials were conducted by using conventional time and motion study techniques. A series of field trials, covering several blocks, was carried out over a period of seven days. In order for us to be able to assess the performance of this crane as compared with manual loading, the output with another tractor which used manual loading was recorded. The comparison was simultaneous with both tractors running on adjacent blocks.

Tests were carried out on a marine clay soil near the east coast of Carey Island, Selangor. The field conditions were dry and hard due to lack of rain. The pathways were not gravelled but the ground was flat. The weather was clear during the preceding period.

Prior to collection, the fruit bunches were cut down in the normal manner before transportation started. The fruit bunches were arranged on both sides of the pathway by the harvesters. Loose fruits which were dislodged from bunches were collected (either by the harvester himself or by a member of his family) in gunny bags and put together with the fruit bunches.

Thus, both fruit bunches and bags of loose fruits were collected along the pathway. During collection, as the tractor came to the fruit bunches, the driver stopped the tractor and positioned the grabber over the fruit bunches. Once the fruits were successfully brought to the grabber, they were lifted and placed in the trailer. When the trailer was full, the driver unloaded it onto a net at the roadside before resuming the next collection. The manual method was similar except for the additional workers needed to load bunches on to the trailer using an iron spike.

Evaluation of EFB grabber

The application of EFB as organic mulching in oil palm cultivation has been recognized as a good practice from the agronomic point of view. The operations in the application of EFB include collection at the mills, transportation to the field, in-field loading and distribution. Lorries or tractors with trailers of six tonnes capacity are normally used to deliver EFB from the mill to the application sites in the fields. And, for subsequent in-field distribution from the application sites to the oil palm interrows, mini-tractors have been used. Currently, loading EFB into a trailer is done either manually or mechanically. With manual loading, a worker requires 10 minutes to load one tonne into a trailer. In an attempt to replace manual loading, the EFB grabber was fabricated for use in conjunction with the crane. A field test was carried out to assess the performance of this unit.

RESULT AND DISCUSSION

Upon completion of the prototype crane in February 1990, it was field-tested. The crane was evaluated under commercial estate field conditions and tested simultaneously with another tractor which used manual loading. The capacity of both trailers was approximately the same. The total maximum distance travelled during one trip (a loop system) was about 400 metres.

Average number of trips per hour

Manual : 3.2
Crane : 1.7

Average number of bunches per trip

Manual : 37.8
Crane : 30.8

The results showed that the lower working rate with the crane was due to the time taken to position it over the fruit bunches prior to grabbing, lifting and placing them in the trailer. However this situation can be improved once the driver becomes familiar with the crane. It was also observed that the number of bunches per trip was higher with manual loading. This was due to the fact that with manual loading, workers can arrange bunches nicely so that more can be accommodated per unit area of trailer. In the case of mechanical loading using a crane, a bigger trailer may be needed to carry the same number of bunches.

Even though the results show that the output of the crane was inferior to that of manual loading the following benefits of the former should be considered:

- Mechanical loading needs only one worker for both loading and driving, thus giving improved worker productivity as compared to manual loading.
- In the long run total manpower could possibly be reduced, hence a saving in fringe benefits can be expected.
- Human fatigue is reduced drastically, which in turn could allow the worker to work for a longer period.
- Large fruit bunches, especially those weighing more than 25 kg, are easily loaded. In fact the performance or productivity of the crane is expected to be better in areas which produce big bunches.

Regarding the performance of the EFB grabber, the results show that it managed to load a one-tonne trailer within 5 minutes as against 10 minutes required to do the job manually.

CONCLUSION

The concept of mechanical loading of FFB using a crane fitted to a mini-tractor to replace manual loading, was successfully developed. From the results obtained it was found that the prototype crane was able to meet most of the design requirements listed. However, to make this crane a marketable product, further modifications and tests are required.

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REFERENCES

ABDULLAH, S, TENG, W H and CHAN, K W (1988). Economic evaluation of mechanised application of the empty fruit bunches – Guthrie experience. Paper presented at the PORIM National Conference on Oil Palm, 11-15 October, 1988, Kuala Lumpur.

YAAKOB, H and TOH, P Y (1988). Mechanised in-field FFB collection using mini-tractor. *Proceedings of 1987 International Oil Palm/Palm Oil Conference–Agriculture* (Abdul Halim, Chew Poh Soon, B J Wood and E Pusparajah [eds.]). PORIM, Kuala Lumpur.