

Development and Performance Evaluation of Hand Tractor Based Mini-Bulldozer

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Introduction

Most of farmland in Jawa Island is located in hilly area where the farming activity should be done at high slope land. The main problem of farming activity in slope land is high soil erosion. Applying terrace-farming system can reduce this problem. However, constructing terrace system is a big deal for the farmers in rural area due to high cost if they hire commercial construction machinery as well as a hard work and time consuming if they construct it manually. A huge swamp area in Indonesia is potentially converts to wet land rice field but lack of worker to cultivate the land especially in the outer island of java. Application of field machineries is the only way to solve the worker problem. In relation with low soil bearing capacity of swampland, application of field machinery should be low ground pressure type. Therefore, a small size and economically affordable construction machine like a mini bulldozer needs to be developed for constructing terrace system in rural area as well as cultivate swampland. The aim of this research was to develop a rubber track mini bulldozer by utilizing commonly used hand tractor as its prime mover.

Materials and Methods

The functional and structural design approaches are utilized in the methodology of developing the mini bulldozer. The design criteria in developing the mini-bulldozer were simple in construction and easy in operation and maintenance. The locally made hand tractor (Perkasa, PD85DI) was used as the base for developing the mini-bulldozer. Firstly, the traction device of hand tractor was modified in to the rubber track. Secondly, the rubber tracked hand tractor was attached with hydraulic system, dozer blade and control system. Finally, the performance of mini-bulldozer was evaluated.

A. Functional Design.

The developed mini-bulldozer was designed to have several functions i.e.: hydraulic system, undercarriage, straight-blade and control system. Hydraulic system is designed for operating the dozer blade up and down. The

undercarriage has function for transmitting the engine power to the traction power. Straight Made is used for cutting bulldozing the soil. Control system was design for controlling the bulldozer including speed, direction, steering and blade movement.

B. Structural Design

The structure of hydraulic system consists of hydraulic pump, valves, actuator, and reservoir. The hydraulic pump was driven by the engine power with v-belt transmission. The actuator was a double action hydraulic cylinder, which was controlled by three way directional control valves. The undercarriage consists of frame, brake system, traction drum and idler and the rubber track. The engine and power transmission of hand tractor were kept as the prime mover of the bulldozer.

The mini-bulldozer was constructed at the Farm Machinery Laboratory, Department of Agricultural Engineering, Bogor Agricultural University. The functional and performance test and evaluation were conducted to the prototype of mini-bulldozer in term of its dozing and maneuverability.

Results and Discussion

Figure 1, showed the process of developing hand tractor based mini-bulldozer. In the first step modification is replacing the iron wheel of the hand tractor (Fig. 1.a.) with the rubber track (Fig. 1.b) in order to improve the tractive ability of the hand tractor, especially for operation in low soil bearing capacity. In this step, design and construction of the undercarriage were fitted with the transmission box and engine of the hand tractor. The drawbar test showed that the maximum drawbar pull of the hand tractor equipped with rubber track was found to be 2.7 kN and its coefficient of traction was 0.6. The second step was design and construction of dozer blade and hydraulic system, which is shown in Fig. 1.c.

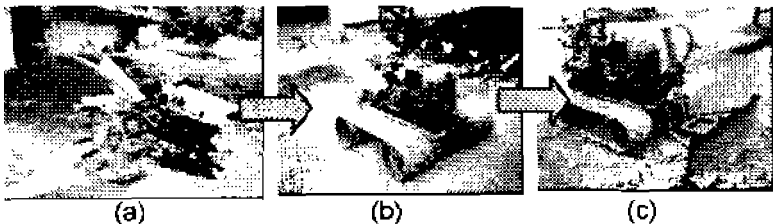


Figure 1. Development of hand tractor based mini-bulldozer

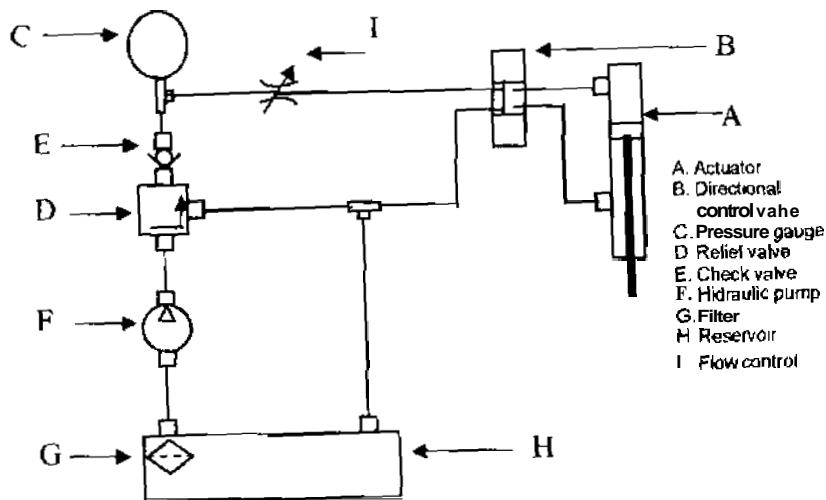


Figure 2. The hydraulic system for mini-bulldozer

The hydraulic system (Fig 2) was a controlled loop adaptive self-tuning (Bolton, 1995). The hydraulic system was tested based on ASAE standard (ASAE S349.2) and the results shows that the static and dynamic hydraulic force was found to be 4905 N and 4.46 N/rpm respectively. This hydraulic force is sufficient to operate the bulldozer blade, where lifting force requirement is only 2500 N.

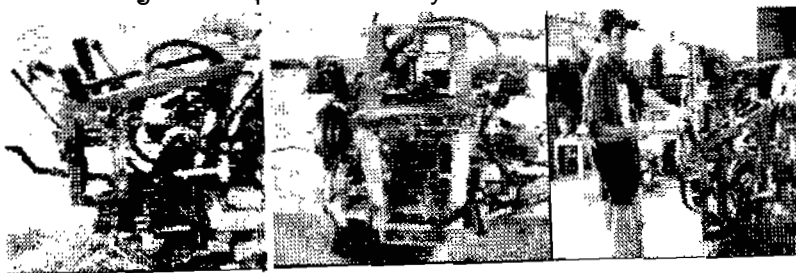


Figure 3. Control system of mini-bulldozer

Control system (Fig. 3) was designed and tested ergonomically where the location of each control lever can be reached by the operator easily, and the force to operate the control lever do not exceed the capacity of human hand which is 220.5 N. The average force to operate steering clutch lever, main coupling lever, blade control lever and main transmission lever were found to be 32.7 N, 85.3 N, 63.7 N and 109.8 N, respectively.

Tam:

The straight blade was attached to the mini-bulldozer (Fig. 3.a.), where the angle of blade can be adjusted from 0° to 10° (Fig. 3.b.) in order to allow soil movement to the left or the right side of the mini-bulldozer. The width and height of bulldozer blade were 1.3 m and 0.35 m respectively. Based on the maximum drawbar pull of the mini-bulldozer it was predicted that the capacity of cutting depth was 2.5 cm, while the optimum cutting angle of the blade was found to be 25° . From the performance test, it was revealed that the prediction of cutting depth was close to the field test where the cutting depth of 2.5 cm gave a maximum dozing volume (Fig 3 c.). The average volume of bulldozed soil was found to be 0.165 m^3 at 0.06 m/s forward speed. The relation between cutting depth, forward speed and dozing volume is shown in Fig. 4.

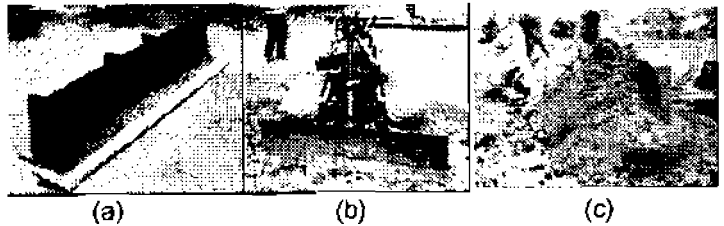


Figure 3. Bulldozer blade

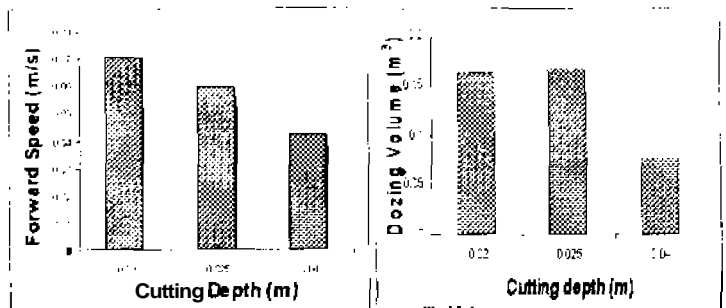


Figure 4. Relationship between cutting depth, forward speed and dozing volume

Conclusion

The results of performance test revealed that the mini bulldozer could work satisfactorily for soil cutting as well as for soil dozing process. The average forward speed was found to be 0.06 m/s and the average volume of dozed soil was found to be 0.165 m^3 . It was also evaluated that the control system can be operated ergonomically.

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