Multi-role hovercraft for agricultural

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Abstract. This research was aimed to study, design, fabricate and test the Prototype of Hovercraft for Agricultural Product Handling. The Hovercraft composed of 1) tube axial fan 2) body structure 3) engine 4) wooded-tray 5) electrical system 6) drive system. Hovercraft can move on land and on water continuously without stopping or switching system driven. It is a good choice in its use in agricultural areas, such as fish farming, farmlands, wetlands, beaches etc. The result shows that at the tested on three areas: 1) Concrete floor, 2) Grass floor, and 3) slush floor (semi-water). The best area that hovercraft can travel through is semi-water/slush floor. This hovercraft has the best maximum load at 350 kg. The best hovercraft speed was 39.5 km per hour at the weight of 50 kg in the slush floor. Rate of fuel consumption is 0.25 litter per km. of the loading weight at 150 kg.

1. Introduction
Nowadays, agriculture is the occupation which Thai people choose to be their main occupation most. The current agriculture in Thailand is of various forms such as flat land agriculture, piedmont alluvial plains, agriculture, and bodies of water agriculture. However, there is one interesting form of agriculture – sea shore or mudflat agriculture. In the case of agricultural yields transportation, ships and boats are used in bodies of water such as rivers and canals. However, it cannot be applicable in mangrove forest area because its topographic condition comprises water, slush and flat land. Hence, only a boat cannot be used there because it cannot move on the slush and land. Also, only a truck cannot be used them for it cannot move in the water or on the slush. In other words, these vehicles are not suitable for this topographic condition because it wastes time and money. At present, hovercraft is popular in transportation which can move on the land and in the water. The hovercraft does not have wheels to move about on land and does not have friction force when moving in water. This makes the hovercraft moves fast and conveniently both on land and in water. Nevertheless, the hovercraft price is expensive (at least 200,000 baht – 2 seats) since it is an imported vehicle and not popular in Thailand.

The vehicle selection must be made considering the environmental risk, the recommended pesticide dose, and the risk of operator exposure. These requirements can be met through the use of an autonomous hovercraft. By using an autonomous hovercraft, the dispersion of the pesticide and fertilizer will have higher effectiveness and will be less costly compared to an aerial vehicle due to the surface proximity on which the vehicles act [1].

A new technology of spraying pesticides and delivering fertilizer which is done in a way that does not disturb the crops will be tested using a hovercraft prototype under agricultural field-conditions [2]. The goal of this effort is to demonstrate the beneficial nature of this approach as a solution to human and crops protection. This paper deals with the first step, to develop means to control the hovercraft so
that it is a stable system. Successful completion of the first step would allow a second step consisting of the construction of a prototype to provide a platform for structured work involving agricultural applications and tests to confirm the results of the first step.

Wang et al. [3] used a nonlinear control in order to study an amphibious hovercraft. Here the hydrodynamic and aerodynamic coefficients based on the angular speed and orientations were considered. They introduced an adaptive multiple model approach to acquire a linearized model of the hovercraft and from there to set the different parameters based on weighting methods.

Lindsey [4] modeled a remote controlled (non-autonomous) hovercraft using Newton’s second law, where the hovercraft had two thrust and lift fans providing two separate sources of actuation. The open and closed loop behavior of the system was simulated using the Matlab/Simulink environment. The author mentioned that the model was successfully and accurately controlled.

In the work of Fantoni et al. [5, 6], two different control strategies were designed for stabilizing the surge (linear), sway (linear), and angular velocities of the hovercraft frame. The authors used a Lyapunov formulation with the surge force and the angular torque as outputs of the controller. In addition, the mathematical model of the hovercraft system was derived based on Newton’s second law and an Euler-Lagrange formulation.

Therefore, the researcher had designed, constructed and tried out the hovercraft used for the agricultural purpose. This study aimed to examine the hovercraft capability based on uplifting, speed, and fuel consumption rate.

2. Materials and examining method

2.1 Examining materials
The materials are included the hovercraft, counterbalance, lifting crane, field tape cartridge, timing watch, and traffic cone.

2.2 Characteristics of the hovercraft
The hovercraft (figure 1) structure was made of hard wood and plywood with one meter in width and 2.79 meters in length. It had 4 main components: 1) Hovercraft body, 2) 50 horsepower engine for boat propeller driving (with the size of 900 mm – 9 boat propellers (figure 2)), 3) Wind pressure equipment for direction control in accordance with turning of the rudder connected with a steering wheel; control panel was in front part for electrical control switches installation (figure 3); the electrical current was from a 12V 20Ah battery to the motor start; the drive system received the electrical current form the regulator and went back to the battery for electric charge of a display screen and accelerator, 4) air
cushion eliminating friction force between the hovercraft body and surface and pressurized for the hovercraft uplifting.

![Electrical System Diagram](image)

**Figure 3.** The electrical system

### 2.3 Examining method

#### 2.3.1 Examining the capability in uplifting of the hovercraft

Weighing the hovercraft was together with the examiner to gain constant weight. Then, weighing counter balance; adding 50 kg per each time until it reached 350 kg. Measuring propeller speed of each weight (3 replications) and making a record of propeller speed. After that computing power used by the engine (figure 4 A and B).

![Experiment Images](image)

**Figure 4.** Examining uplift of the hovercraft (A) 100 kg and (B) 150 kg.

#### 2.3.2 Examining for finding speed of the hovercraft

Measuring the examining distance at 60 meters than timing the movement from the start point to the finish point; adding the weight (100 and 150 kg) 3 replications of timing. This was conducted on the concrete floor, grass floor, and slush floor/semi water. The examining time was recorded and used for the computation of the hovercraft speed. In the test of the speed of the hovercraft, we are used 1 liter of fuel per experiment in each area and measure how many distances of meters per time can be measured, and then record. After that, we are calculated is kilometer per hour.
2.3.3 Examining fuel consumption rate of the hovercraft. Measure the examining distance at 60 meters. All examining areas were used and an observation point was constructed in all areas so as to be a reference point. The counter balance (150 kg) was loaded on the hovercraft and drove from the start to the finish point based on a fixed distance for timing. When the front of the hovercraft passed the first observation point, and reached the second observation, timing was conducted (3 replications). Then, examining the concrete floor, the grass floor, and the semi-water/slush floor and obtained data were computed for finding the fuel consumption rate (km/liter). In the test of the fuel consumption, we are used 1 liter of fuel per experiment in each area and measure how many distances of meters can be measured, and then record. After that, we are calculating is kilometer per liter.

3. Results of the examining

3.1 Results of the examining of uplifting capability of the hovercraft
For the concrete floor the weight at 50, 100, 150, 200, 250, 300 and 350 kg. The horsepower used was 1.63, 2.21, 4.70, 7.80, 11.11, 14.29, 17.89 and 23.20 hp respectively.
For the grass floor the weight at 50, 100, 150, 200, 250, 300 and 350 kg. The horsepower used was 1.74, 2.23, 4.90, 8.03, 11.32, 14.69, 18.47 and 25.11 hp respectively.
For the semi-water/slush floor the weight at 50, 100, 150, 200, 250, 300 and 350 kg. The horsepower used was 1.74, 2.22, 4.87, 7.90, 11.18, 14.53, 18.20 and 24.66 hp respectively.
According to figure 5, it was found that the concrete floor had a capability in uplifting most of the hovercraft at 350 kg.

3.2 Results of the speed examining of the hovercraft
For the concrete floor, the loading weight at 50, 100, 150, 200, 250, 300 and 350 kg. The speed was at 36.82, 31.15, 21.53, 16.74, 12.81, 8.92 and 7.95 km per hour, respectively.
For the grass floor, the loading weight at 50, 100, 150, 200, 250, 300 and 350 kg. The speed was at 31.50, 23.79, 17.78, 14.47, 11.80, 9.07 and 7.23 km per hour, respectively.
For the semi-water/slush floor, the loading weight at 50, 100, 150, 200, 250, 300 and 350 kg. The speed was at 39.50, 31.90, 24.01, 19.69, 15.69, 9.46 and 8.53 km per hour, respectively.
According to figure 6, it was found that the best hovercraft speed was 39.5 km per hour at the weight of 50 kg in the semi-water/slush floor. The reason that the hovercraft runs fast, because of on the slush floor was a fluid that can be transformed into containers that are replaced allowing the air cushion to retain air for lifting and thrusting force better on other surfaces. Therefore, the hovercraft that runs on the slush floor faster than the cement floor, and the grass floor.
3.3 Results of the examining of fuel consumption rate of the hovercraft

According to figure 7, the loading weight at 150 kg was found that had least of the fuel consumption rate at 0.21, 0.18 and 0.25 km per liter based on the concrete floor, the grass floor and the slush floor, respectively. Also, it was found that the least of the fuel consumption at 0.25 km per liter on the slush floor, because on the slush floor was a fluid that can be transformed into containers that are replaced, allowing the air cushion to maintain air for better lifting and thrusting force on other surfaces. Therefore, the hovercraft that runs on the slush floor have the fuel consumption rate will less than the cement floor and grass floors as well.

4. Conclusions

From the results of the hovercraft examining showed that the capability in uplifting of the hovercraft on the loading weight was highest at 350 kg on the concrete floor, the grass floor, and the slush floor with the horsepower used at 23.20, 25.11 and 24.66 horse power, respectively and the fastest speed was used on the concrete floor, the grass floor and the slush floor at 39.50, 36.82 and 31.50 km per hour, respectively. The fuel consumption was used at 0.21, 0.18 and 0.25 km per liter based on the concrete floor, the grass floor, and the slush floor, respectively of the loading weight at 150 kg.
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Acknowledgements
The researcher would like to thank the Faculty of Engineering, KMITL for financial support and the Agricultural Engineering Division for providing place and equipment in this study.