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Load and Stability Optimization Based Carbon Arm with Split Tank on Unmanned Aerial Vehicle for Foliar Fertilizer

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Abstract: This research focuses on the load and stability of unmanned aerial vehicles that are as light as possible but with optimal stability functions and increasing the capacity of liquid fertilizer lifted by unmanned aerial vehicles. The increase in lift is related to the payload and stability to be carried by the unmanned aerial vehicle. By optimizing the arm using the arm carbon method, so without reducing the strength and function of the drone, the gross weight of the components becomes much lighter, so that the weight can be focused on increasing the capacity of liquid fertilizer. With the increase in liquid fertilizer capacity, of course, the weight also increases, this raises a new problem, which is to make the balance value when the drone take-off has a large magnitude, thus affecting stability which causes the potential to fail to fly, therefore this research was carried out so that the drone has stability. maximum and can minimize the effects of shocks from increasing capacity after using arm-carbon. The measurements taken were the success rate of the system in flying over agricultural land, power testing and current measurements. After testing, it was found that by using a split tank and carbon arm system, current and power tend to be more stable, so that battery life is longer, liquid fertilizer capacity can be increased and the potential for flight failure can be minimized with a split tank system with 90% accuracy, carried out optimizing weight with carbon arms and increasing the capacity of liquid fertilizer by 30%, using a split tank system increases the stability of the drone at take-off by up to 80%.

Keywords: Load and Stability; Carbon Arm; Split Tank; Unmanned Aerial Vehicle; Foliar Fertilizer.

Abstrak: Penelitian ini berfokus pada beban dan stabilitas kendaraan udara tak berawak yang seringan mungkin namun dengan fungsi stabilitas yang optimal dan peningkatan kapasitas pupuk cair yang diangkat oleh kendaraan udara tak berawak. Peningkatan daya angkat terkait dengan muatan dan stabilitas yang akan diangkut oleh kendaraan udara tak berawak. Dengan mengoptimalkan arm menggunakan metode arm carbon, sehingga tanpa mengurangi kekuatan dan fungsi dari drone, bobot kotor komponen menjadi jauh lebih ringan, sehingga bobot dapat difokuskan untuk menambah kapasitas pupuk cair. Dengan bertambahnya kapasitas pupuk cair tentunya bobot jugabertambah, hal ini menimbulkan masalah baru yaitu membuat nilai keseimbangan pada saat drone take-off memiliki magnitude yang besar, sehingga mempengaruhi kestabilan yang menyebabkan potensi gagal terbang, oleh karena itu penelitian ini dilakukan sehingga drone memiliki kestabilan maksimal dan dapat meminimalisir efek guncangan dari bertambahnya kapasitas setelah menggunakan arm-carbon. Pengukuran yang dilakukan adalah tingkat keberhasilan sistem dalam terbang di atas lahan pertanian, pengujian daya dan pengukuran arus. Setelah dilakukan pengujian, diketahui bahwa dengan menggunakan sistem split tank dan carbon arm, arus dan power cenderung lebih stabil, sehingga daya tahan baterai lebih lama, kapasitas pupuk cair dapat ditingkatkan dan potensi kegagalan penerbangan dapat diminimalisir dengan sistem split tank dengan akurasi

90%, dilakukan optimalisasi bobot dengan lengan karbon dan membuat peningkatan kapasitas pupuk cair 30%, dengan menggunakan sistem split tank meningkatkan stabilitas drone pada saat take-off hingga 80%.

Kata kunci: Beban dan Stabilitas; Lengan Karbon; Tangki Terpisah; Kendaraan Udara Tak Berawak; Pupuk Daun.

1. Introduction

Foliar fertilizer is a term for fertilizer that is applied by spraying it onto the leaves [1]. The fertilizer is in the form of a liquid in its use mixed with water with a certain composition. This fertilizer mixed with water will be carried by the unmanned aerial vehicle as a liquid foliar fertilizer load. The application of foliar fertilizers has 3 advantages, among others, for the absorption of the nutrients provided to take place more quickly, foliar fertilizers prevent further soil damage and have a more complete nutrient content. However, for the results of an effective and efficient application of foliar fertilizer, it is necessary to pay attention to the rules. The rules for instructions that need to be considered when applying foliar fertilizers are the right technique, the right target, the right type, the right time and the right dose/concentration.

The right way to foliar fertilizer is by spraying, spraying is done until the leaves look wet. The leaves have a leaf mouth called stomata, the stomata are located on the back of the leaf, therefore, in order to apply foliar fertilizer on target, when spraying, the nozzle is directed to the leaf facing downwards [2]. The type of foliar fertilizer to be used is adjusted to the objectives to be achieved, if it aims to stimulate vegetative growth then the foliar fertilizer used is foliar fertilizer specifically for leaves. The dose used must be according to the instructions on the package, if excessive will cause the leaves to burn. The ideal time for application of foliar fertilizers is in the morning or evening, in the morning around 8-9 or in the afternoon from 15.00 to sunset, at this time the stomata will open perfectly, do not do it during the day because hot weather causes fertilizer Many leaves evaporate before being absorbed by plants.

Split tank that it can adjust to the needs of its use, the way a split tank works is similar to a fuel tank car. so that the fuel in the tank car does not leak due to external shocks. The number of bulkheads for each tank car is also different [2]. The bulkheads can be 1, 2, 3, 4, and even 5. Apart from being a split tank divider, this also serves to reduce the effects of shocks during vehicle movement, so with minimal potential for movement due to liquid objects [3]. of course, it is easier to control than without a bulkhead containing a liquid object in a large capacity which results in having a push or attraction when a frontal movement occurs which can result in system failure due to the strong pushing or pulling force of a liquid object in a large capacity [4].

This research focuses on the weight of the UAV so that it is as light as possible but with optimal function and increasing the capacity of liquid fertilizer lifted by the UAV. The increase in lift is related to the payload to be transported by the UAV. This research targets to be able to lift the liquid foliar fertilizer load of 4 L. By optimizing the arm using the arm carbon method, so that without reducing the strength and function of the UAV, the gross weight of the components becomes much lighter so that the weight can be focused on increasing the capacity of liquid fertilizerIn addition, with the increasing capacity of liquid fertilizer, of course, the weight will be heavier, this deficiency causes problems, namely making the balance PID value can change with a large enough value which results in shock and can cause flight failure or the UAV to fall, therefore research is carried out to improve this condition is by using the split tank method, so that later it can minimize the shaking effect of the large ca-pacity and heavy weight lifted so that the chance of the UAV failing to fly. Measurements taken are the level of success of the system in flying over the plant field, testing power and current measurements. After testing, it was found that by using a split tank and carbon arm system, the current and power tend to be more stable, so that the battery life is longer, the capacity of liquid fertilizer can be increased and the potential for flight failure can be minimized.

Figure 1. Unmanned aerial vehicle for foliar fertilizer with carbon arm based split tank

2. Related Work

The UAV will fly with liquid foliar fertilizer (liquid) and spray it on a predetermined land using a flight path that has been programmed in the UAV. In previous studies, we have used a multirotor type UAV combined with a foliar spraying system with 3 liters of liquid, which can only spray a limited area of land. The limited liquid capacity will be a problem for the UAV because it will need to refill the liquid many times if it is used to spray a larger area. Therefore, it is necessary to optimize the fluid load on the UAV to increase its capacity. If the capacity of UAV liquid foliar fertilizer increases, the area of foliar fertilizer spraying will increase. This research focuses on increasing UAV capacity and designing a UAV system equipped with a sprayer. The increase in lift is related to the payload that the UAV must carry. In another study the measurements made were the success rate of the system in flying over the fields, testing the measurement of power, current, battery capacity, and different loadings of 40, 45,50, 55 percent of the total weight of the unmanned aerial vehicle [1].

Previous research has been doing using UAVs to facilitate agricultural activities. Even the spraying capability is limited to crop protection [4] and flight speed, spraying rate at the targeted surface droplet deposition density. This research aims to evaluate operating parameters such as UAV flight speed. Trials were carried out using UAVs with different flight speeds (2.6 & 6 m / s), at a constant altitude of 2 m above rice plants using foliar fertilizer, with different spraying speeds. (0.75, 1.5, 2.25 and 3.00 L / min) used water-sensitive paper as samples and analyzed statistically. The experimental results show that droplet uniformity and droplet deposition density are higher when the UAV flight speed is maintained at a lower speed (2 m / s) compared to higher flight speeds (4 and 6 m / s) [5] [6]. Optimizing weight with arm carbon and increasing the capacity of liquid fertilizer on unmanned aerial vehicles to increase the capacity of spraying foliar fertilizer and split tanks to adjust the balance of PID values so that apart from reaching a wider area of land, it also minimizes flight failures

3. Material and Method

This research focuses on the weight of the UAV so that it is as light as possible but with optimal function and increasing the capacity of liquid fertilizer lifted by the UAV. The increase in lift is related to the payload to be transported by the UAV. This research targets to be able to lift the liquid foliar fertilizer load of 4 L. By optimizing the arm using the arm carbon method, so that without reducing the strength and function of the UAV, the gross weight of the components becomes much lighter so that the weight can be focused on increasing the capacity of liquid fertilizer [7]. In addition, with the increasing capacity of liquid fertilizer, of course, the weight will be heavier, this deficiency causes problems, namely making the balance PID value can change with a large enough value which results in shock and can cause flight failure or the UAV to fall, therefore research is carried out to improve this condition is by using the split tank method, so that later it can minimize the shaking effect of the large capacity and heavy weight lifted so that the chance of the UAV failing to fly or falling does not occur. Measurements taken are the level of success of the system in flying over the plant field, testing power and current measurements. After testing, it was found that by using a split tank and carbon arm system, the current and power tend to be more stable, so that the battery life is longer, the capacity of liquid fertilizer can be increased and the potential for flight failure can be minimized [8].

(a) (b)

Figure 2. Split tank to reduce shock of foliar fertilizer

As shown in Figure 2, you can see the difference in the shaking effect between the presence of a split tank and without a split tank, figure (a) this also happens to the UAV tank for foliar fertilizer, the larger the capacity, the greater the shaking effect which has the potential to make the UAV fail to fly, Storage container This is called the tank compartment which is given a bulkhead or dividing line. The goal is to minimize fluid shock when the UAV flies, so that the UAV is easy to control. However, the speed of the UAV is limited between 45 km/hour to 60 km/hour. The increase in lifting power is related to the payload to be transported by the UAV, figure (b) shows no split tank resulting in a major shock to the UAV.

In spraying as shown in figure 2,unmanned aerial vehicle fly while spraying carrying a load of liquid foliar fertilizer. The multirotor type UAV vehicle can fly by utilizing the lift from each propeller [9]. The propeller is driven by each motor that rotates in the opposite direction [10]. where F_{thrush} as the total lifting force of the UAV is obtained from the sum of FM1, FM2, FM3, FM4, FM n... as the force of each motor, with the following equation :

$$Fthrust = \begin{bmatrix} 0 & 0 \\ [Fm1 + Fm2 + Fm3 + Fm4] & 0 \end{bmatrix} \quad (1)$$

The UAV will successfully fly if the F_{thrush} is 30-40% greater than the total mass of the AUW (All Up Weigh). AUW is the total mass of the UAV vehicle which consists of the empty mass of the vehicle itself and the payload of the vehicle [11]. The empty blank mass is the mass of the electronic system, the mass of the frame and the mass of the motor. Meanwhile, the mass of the unmanned aerial vehicle is the mass that will be lifted by the unmanned aerial vehicle. With the following equations :

$$Wsum\ (AUW) = Wnon\ payload + W\ payload \quad (2)$$

$$Fthrust = Wsum\ (AUW) + (40\% * Wsum(AUW) \quad (3)$$

With arm carbon, reducing the weight of the UAV, it increases the capacity of liquid fertilizer so that it adds liquid fertilizer that is transported by unmanned aerial vehicles, in addition to the split tank method, the UAV has a more stable PID value, so it can expand the area for spraying foliar fertilizer and minimize the possibility of failing to fly. Split tank is a tank that contains barriers, where the function is so that in one tank it can contain several types of liquid fertilizer with different characteristics, so that it can adjust to the needs of its use [12]. Apart from being an insulator, this split tank also serves to reduce the effects of shocks during the movement of unmanned aerial vehicles, so that with the minimal potential for movement due to liquid objects, of course, it is easier to control than without a bulkhead by containing liquid objects in large capacities which result in having a push or attraction to the body. when there is a frontal movement that can result in system failure due to the strong pushing or pulling force of a large capacity liquid object.

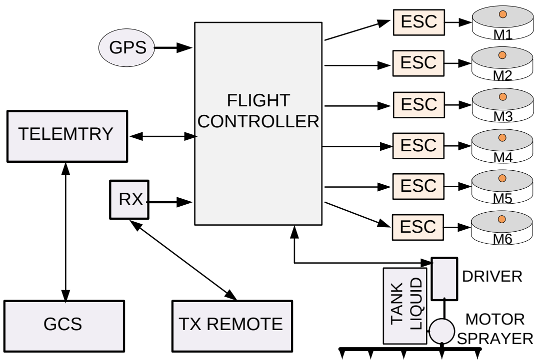


Figure 3. Design of unmanned aerial vehicle with arm carbon and split tank

The design of the UAV system is shown in Figure 3 UAV system equipped with a sprayer. The UAV drive system uses six motors (M1-M6) controlled by their respective ESC. ESC (electric speed controller) serves to regulate the rotation of the motor based on the control of the flight controller [13]. On the other hand, the sprayer system is also controlled from the flight controller via the driver. The driver controls the sprayer motor to work to pump the liquid in the liquid tank to be sprayed through the nozzle. Flight controller based on information from compass and GPS sensors, barometer sensors to control the course of the UAV. The flight controller receives a command in the form of the coordinates of the longitude and latitude (way point) from the GCS (Ground Control Station). GCS in this case is a PC (personal computer) running mission planner software. Telemetry uses a frequency of 433Mhz to connect the Flight controller with the GCS [14]. TX remote serves to control the UAV mission mode connected to the Flight controller via RX with a frequency of 2.4 GHz [9].

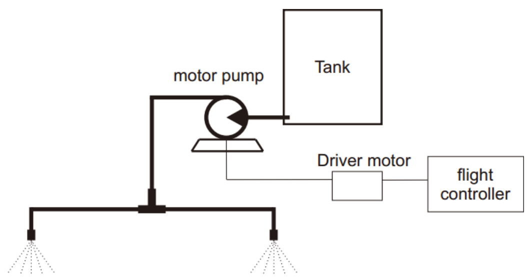


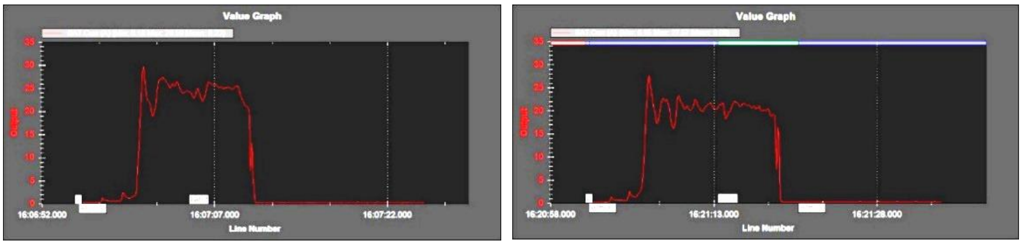
Figure 4. Desain of sprayer on unmanned aerial vehicle for foliar fertilizer

The pump motor in figure 4 functions to pump the liquid contained in the reservoir to be flowed to the nozzles [15]. The boom sprayer functions as a path for the liquid that has been pumped to get to the nozzles [16]The nozzle is used to spray liquid foliar fertilizer onto the land. The electronic control circuit functions to run a DC motor so that liquid can flow on the boom sprayer and into the nozzle so that the liquid can be sprayed perfectly [17]. The sprayer pump motor, fertilizer discharge can be adjusted by changing the voltage value of the pump motor through the motor driver. the motor driver regulates the pump motor voltage with the pwm of the flight controller which is remotely connected to the GCS. so that the fertilizer discharge can be adjusted via the remote UAV on the GCS [18].

4. Experimental Result

The success rate of the system will be measured in optimizing weight with arm carbon and also stabilizing current and power when spraying foliar fertilizer using an unmanned aerial vehicle, so the UAV flies according to a predetermined waypoint, the waypoint that has been determined is the plane area. flying over the plant area to be sprayed with foliar fertilizer, in addition to flying according to the waypoint, the measurement of power, current and area that can be sprayed by the UAV is also carried out, because with the added liquid load to 5L, is there a potential for power loss in the UAV, resulting in less than maximum power?. The current in the UAV, especially the motor current, is also measured if there is a potential increase in the current in the motor exceeding the data in the motor datasheet, it will cause damage to the UAV motor.

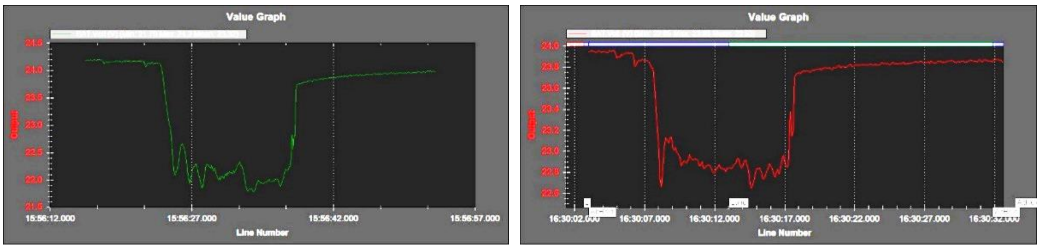
With the split tank and also optimization using carbon on the weight side of the unmanned aerial vehicle, the data obtained from the following graph. with the split tank and also optimization using carbon on the weight side of the unmanned aerial vehicle compared to before without a split tank and using an aluminium frame, here is a graph of the power and current comparison.



(a) (b)

Figure 5. Power comparison when using aluminum arm with carbon

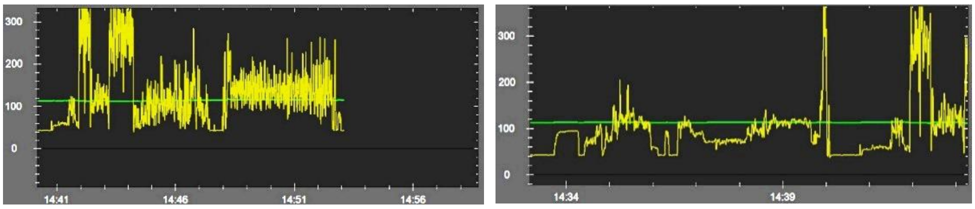
In Figure 5, it can be seen in the graph on the figure 5 part (a) that the power and current of the unmanned aerial vehicle when it is still using the aluminium arm, where it can be seen that the magnitude of the current is very high when the conditions are from start to altitude hold, while in the graph on the part (b) in Figure 5, it is the graph after optimization using arm carbon, where the current required is very stable and does not increase significantly, so it can be concluded that by using arm carbon the current and power used are very efficient and this also affects battery saving and also the potential for failure to fly minimized.



(a) (b)

Figure 6. Rated voltage drop

Figure 6 part (a) shown the voltage drop on the graph is in the condition of using a tank without a split tank, while on the graph on figure 6 part (b) it is the result after optimization using a split tank, it can be seen that the graph on the right after optimization with a split tank looks more stable, where the graph shows the condition of the unmanned aerial vehicle is very stable at start at a predetermined latitude longitude point to the altitude hold position or in an unmanned aerial vehicle condition at a predetermined altitude.



(a) (b)

Figure 7. Comparison of stability with split tank and non split tank

in Figure 7 shown the UAV chart when flying with an altitude of 100 cm, on the figure 7 part (a) you can see an up and down graph which means the UAV condition is unstable, while on the figure 7 part (b) is a graph when using a split tank, which looks very stable to accuracy 80%.

The first experiment shows in Table 1 that a maximum weight of 55% is carried out, namely 6.6 Kg of the total thrust of the 12 Kg motor, then 50%, 45% and 40%. In this study, the total weight of the UAV can be reduced to a maximum of up to 25% by optimizing the use of carbon arm and also optimizing the power and current by using a split tank, of course this makes the unmanned aerial vehicle more stable from start to altitude hold conditions.

Table 1. The results of measuring the optimization of the UAV load on the thrust motor

Experiment	Load / thrust	Load	Vstart	Vstop	Vmin	Imin	Imax	Wp
Allumunium	50%	6.00	24.26	24.08	22.88	0.27	66.00	1595.22
Carbon	50%	6.00	24.14	23.99	23.10	0.30	54.16	1261.30
Non split	50%	6.00	24.08	23.90	23.17	1.28	51.54	1197.70
Split tank	50%	6.00	24.01	23.80	13.12	0.27	43.14	1003.00

Table 1 shown the compares of current and voltage values of the UAV when the vehicle is flying. By comparing the value of voltage and current to each load being test, it will show the load selection, which shows the average increase in current and voltage drop (according to the motor datasheet). The behaviour of an increased current or decrease voltage that occurs when the UAV is flying indicates whether or not the UAV is loaded.

Table 2. Before Weight Reduction Result

Experiment	Weight (Kg)	Stability (%)
Allumunium	3.00	40
Non split	6.00	40

Table 2 shows the load and stability conditions when using aluminum arms and non-split tubes, the stability process obtained is only 40%, while the weight when using aluminum arms is 3 kg and can accommodate as many as 6 kg non-split tanks.

Table 3. After Weight Reduction Result

Experiment	Weight (Kg)	Stability (%)
Carbon	2.20	70
Split tank	6.00	80

Table 3 shown the result of the weight of the UAV with aluminium carbon arm, the comparison of weight using carbon then the weight of the UAV is reduced by 0.8 or reduced by 27% of the total weight when using aluminium, stability when using a split tank also increases from previously without split tank stability was 40%, after using split tank stability increased from 40% to 80%.

5. Conclusions

The results of this research can be concluded that with the optimization of the unmanned aerial vehicle frame from previously using aluminum material which resulted in a very heavy weight then the tank conditions were not split, resulting in current and power at start to very large and unstable altitude hold conditions. has the potential to fail to fly, with optimization using arm carbon which can reduce its load to 900 grams, resulting in more stable currents and voltages with increased foliar fertilizer capacity, then with split tank optimization the conclusion is that split tanks are very helpful for stability unmanned aerial vehicle in the initial conditions of flight, of course with the optimization of the split tank resulting in a very stable current and power output, which means the potential for failure to fly can be minimized, where the chance of failing to fly previously was maximum at 55% and is currently increasing to 90%.

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