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Modification of 2fn-Recuv Test Bench

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Abstract

The objective of this study is to modify the 2fn-recuv test bench. The test bench is used to carry out drone flight simulations. It can provide a controlled environment to ensure the drone's safety. The test bench allows precise data collection and analysis for an unmanned aerial vehicle (UAV). First, a literature review is conducted to understand and analyse the design of the previous test bench. The limitations of CNC machines are also being studied to ensure the modified design can be fabricated. Based on the findings and results, a 3D drawing is created, taking into account the need for machining. The first prototype is made using a 3D printer. It allows for initial testing and checking for possible failures of the design. The completed part of the prototype is then fabricated using a CNC machine. The new test bench is made of aluminium to give it more rigidity and strength. Stress analysis is done using Solidworks 2020 to ensure the test bench can withstand the weight of the drone. The test bench is tested using Labview to record the angle of each movement of the drone, such as pitch, roll, and yaw. The maximum and minimum values indicate the angle of the test bench for the drone's flight simulation.

1. Introduction

Small Unmanned Aerial Vehicles (UAVs) or drone are an effective substitute for larger, riskier or remote system for monitoring, ground mapping, agricultural and environmental preservation techniques such as fire detection [1]. Due to the specific task, UAV systems can be equipped with a wide range of sensors. In addition, the use of microelectronic components such as microcontrollers, receivers and drivers helped to create high-precision navigation and flight stabilization system for the UAV.

For both the military and civil spheres, the analysis of existing models of the highly manoeuvrable UAV is the most promising field of research. The safety and reliability of the UAV must be well documented for research. As an aerial vehicle and a hardware-software complex, testing and evaluation of the controlled response, such as control loops, are essential to checking if the requirements are met. Real-time outdoor testing and platform testing are the two methods available to verify a drone's appropriate operation.

Real-time outdoor testing can generate a high risk for the drone, which can lose control or bump into any obstacles due to the development of a completely autonomous aerial system. Therefore, it is advisable to take into account the use of more secure and trustworthy experimental platforms, as this will enable testing and evaluation of the drone's operation in controlled environmental settings.

A drone test bench is an important tool for evaluating the performance and reliability of drones. On a drone test bench, various aspects, such as flight quality, navigation, durability and safety, may be tested. This involves assessing the drone's precision in flight, including its ability to take off, hover, and land, as well as its stability and manoeuvrability. By using a drone test bench, it can help to ensure that the drone can perform its intended tasks safely and reliably. Any issues can be identified before any technical problem occurs.

1.1 Problem Statement

The previous design of the 2fn-ReCuv test bench was made with PLA filament using a 3D printer. The design is too complicated to be fabricated using a CNC machine due to the limitations of the machine. Furthermore, the movement angle of the test bench is too big for the drone test. Thus, some modifications will be made to ensure that it can be fabricated using a CNC machine and will be made of aluminium to give it more durability.

2. Materials and Methods

In this study, the development of the test bench is divided into four phases. In phase 1, the research will start with a background study about the previous design of the test bench. Any requirements for the final model are analysed throughout the phase. The method that will be used in this project is listed. The modifications to the new design are investigated to ensure that it can be manufactured by the CNC machine. The new parameter of movement angle is set for the new model. The new design, with some modifications, was created using Solidworks. In phase 2, the best design will be selected. The design will be used to create every part of the prototype using a 3D printer. The parts will then be assembled to assure they fit the requirements.

Stress analysis of the prototype is carried out to validate the design during phase 3. It is to determining the design sensitivities and predicting possible failures of the design. The analysis may show the design is unsafe or uneconomic in which modifications will be made for the design. It will be done by using Solidworks. For final phase, the finalized design is fabricated using CNC machine. The final model will be made of aluminium to ensure it have more durability from the previous model. Test will be conducted to check the functionality and requirement of the model. Drone will be put on the model and the orientation such as yaw, pitch, roll, up and down is tested.

3. Results and Discussion

3.1 Test Bench Structure

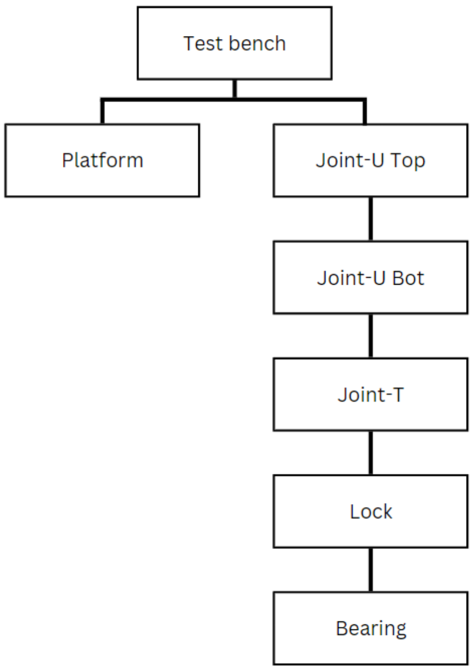

Fig. 1 *Test bench structure*

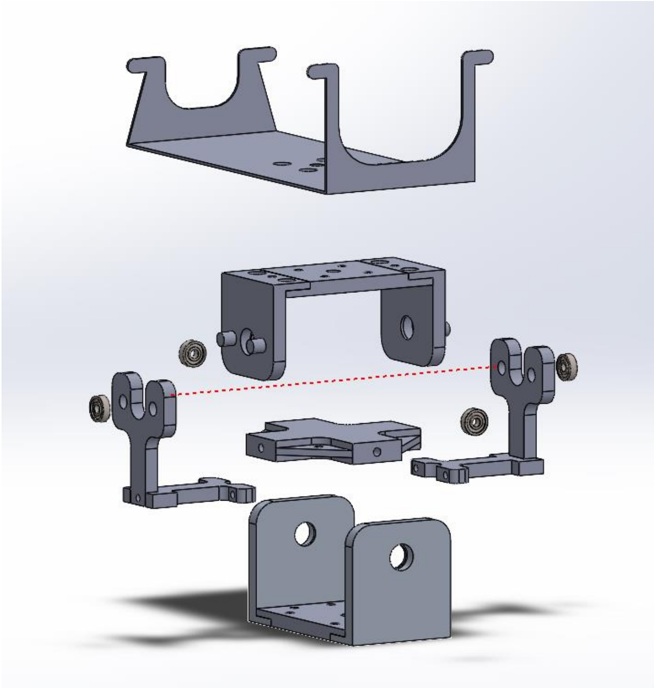

Fig. 2 *Exploded view of the test bench*

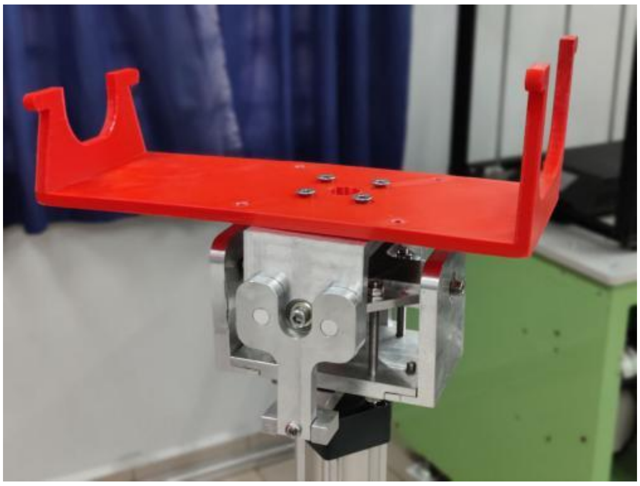

Fig 3 *Fabricated test bench*

Figure 1 shows the structure of the test bench. The test bench is made of aluminium to give more strength to the test bench. It is fabricated using Computerized Numerical Control (CNC) machine. Figure 2 shows the exploded view of the test bench that is created using Solidworks 2020. It consists of six parts which is platform, joint-u top, joint-u bot, joint-t, lock and bearing. Figure 3 shows the fabricated test bench. All parts are made of aluminium except for platform which is made from PLA filament using 3D printer.

3.2 Test Bench Properties

The finished test bench is mainly made of aluminium alloy 6061(T6) which is different from the previous test bench which made of PLA filament. This alloy's strength values will be derived from T6 tempered 6061 aluminium alloy (6061-T6), which is a common temper for aluminium plate and bar stock. It has an elasticity modulus of 68.9 GPa and a shear modulus of 26 GPa. This alloy is generally easy to weld and readily deforms into most desired shapes, making it a versatile manufacturing material. Table 1 shows the summary of mechanical properties for 6061-T6 aluminium ally.

Table 1 *Mechanical properties of 6061-T6 aluminium alloy*

Mechanical Properties	Value
Ultimate Tensile Strength	310 MPa
Tensile Yield Strength	275 MPa
Shear Strength	207 MPa
Fatigue Strength	96.5 MPa
Modulus of Elasticity	68.9 GPa
Shear Modulus	26 GPa

The previous test bench is made of PLA filament, which is a type of polyester made from fermented plant starch from corn, cassava, maize, sugarcane or sugar beetroot pulp. The sugar in these renewable materials is fermented and converted into lactic acid, which is then converted into polylactic acid, or PLA. Table 2 shows the summary of mechanical properties for PLA.

Table 2 *Mechanical properties of Polylactic Acid (PLA)*

Mechanical Properties	Value
Heat Deflection Temperature (HDT)	52°C
Density	1.24 g/cm^3
Tensile strength	50 MPa
Flexural strength	80 MPa
Impact Strength	96.1 J/m

From the tables above, the tensile strength of aluminium alloy is 310 MPa which is higher than PLA filaments with just 50 MPa. Thus, it shows that the new test bench which made from the aluminium alloy has better strength and durability compared to the previous one.

3.3 Stress Analysis

3.3.1 Joint-U Bot

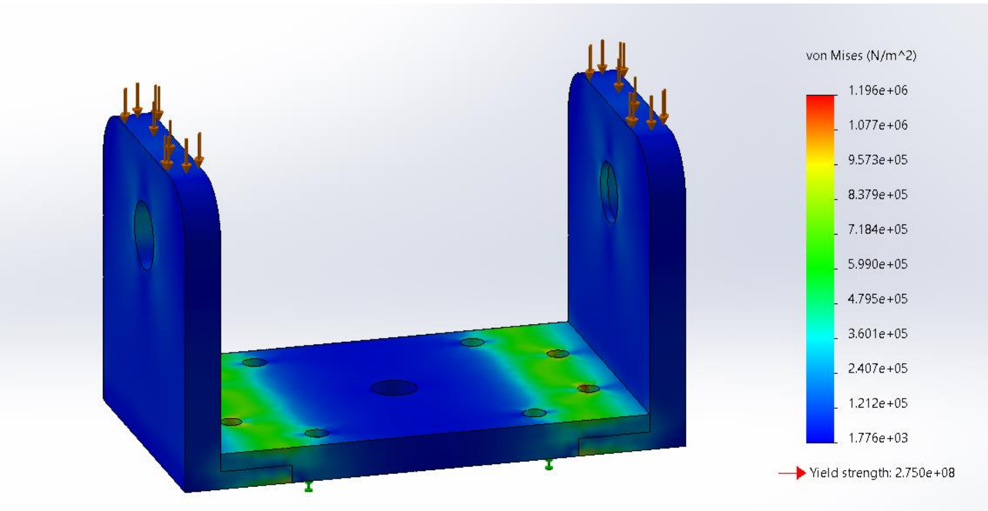

Fig. 4 *Von-misses stress analysis of Joint-U Bot*

Figure shows the the Von-Misses Stress of the Joint-U. The weight that is used to validate the design is 4.6 kg which is maximum weight of a 2fn-Recuv drone. The maximum stress is 1.196×10^6 N/m^2. The maximum yield strength of 6061 aluminium alloy is 2.75×10^8 N/m^2. Thus, the design does not fail under static load.

3.3.2 Joint-U Top

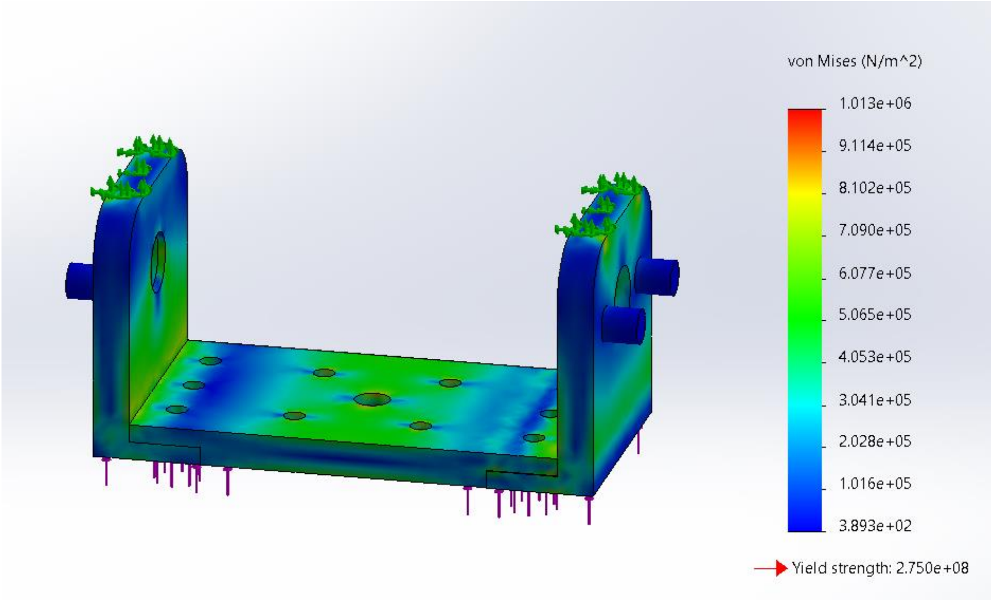

Fig. 5 *Von-misses stress analysis of Joint-U Top*

Figure shows the the Von-Misses Stress of the Joint-U. The weight that is used to validate the design is 4.6 kg which is maximum weight of a 2fn-Recuv drone. The maximum stress is $1.013×10^6$ N/m^2. The maximum yield strength of 6061 aluminium alloy is $2.75×10^8$ N/m^2. Thus, the design does not fail under static load.

3.4 Test Bench Testing

The testing of the final model is conducted by placing the drone on the platform. The movement of the drone such as yaw, pitch and roll is recorded by the sensor that is inserted in the drone.The maximum and minimum value for each position is obtained by using Labview.

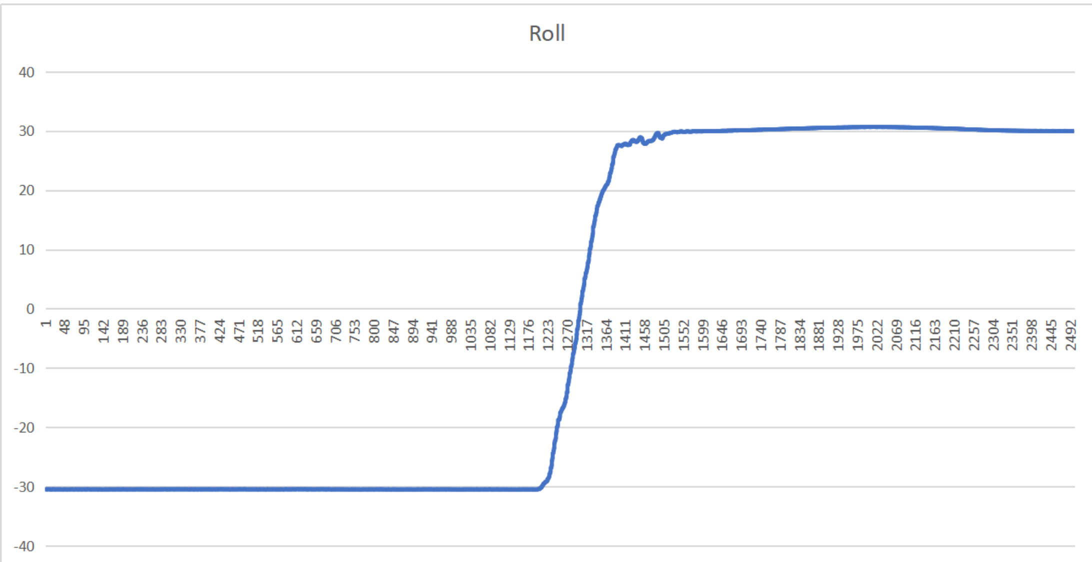

Fig. 6 *Amplitude of rolling*

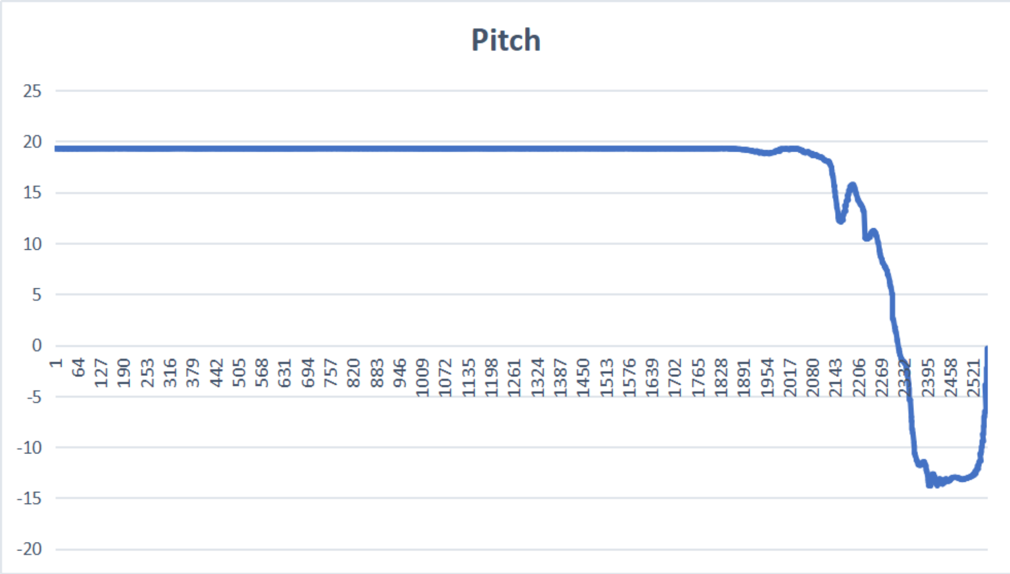

Fig. 7 *Amplitude of pitching*

Fig. 8 *Amplitude of yaw*

Table 3 *Result for test bench*

Movement	Angle (°)
Roll	Maximum : 30.034
	Minimum : -30.475
Pitch	Maximum : 19.292
	Minimum : -14.781
Yaw	Maximum : 179.626
	Minimum : -179.501

From the figures and table, the maximum and minimum value for each position of the drone is obtained. The negative sign for roll movement indicates the direction of the movement is to the left. The data shows that the test bench can roll about 30° to the right and left. For pitching, negative sign indicates downward direction. The test bench can pitch up to 19° upward and about15° downward. As for yaw, it shows that the movement can rotate about 180° due to the limitation of sensor in the drone. But in real time, the test bench can be rotated 360°.

4. Conclusion

In conclusion, the first objective of this study is achieved which is to modify the 2fn-Recuv test bench using computer aided design and drafting software application. The software used is Solidworks 2020 to create the 3-dimensional drawing of the modification. The second objective is also achieved where crucial part is being analysed to perform stress analysis. It is done to avoid any possible failure for the test bench. The fabrication of the model using CNC machine is achieved to complete the third objective. The test bench is made of aluminium to give more strength and durability than previous design which made from 3D printing. Finally, the last objective is to test the test bench's performance. It is done by placing drone on the test bench and simulate drone's maneuverability such as roll, pitch and yaw. The use of dedicated test bench can provide controllable environment for drone testing. These test helps to identify potential failures of the drone before conducting real time flight.

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