



اونیورسیتی تکنیکال ملیسیا ملاک

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**THE DEVELOPMENT OF FRAMEWORK FOR A LIGHTWEIGHT
METALLIC DRONE FRAME USING SELECTIVE LASER
MELTING (SLM) 3D PRINTING MACHINE**

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Faculty of Mechanical Technology and Engineering

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Muhammad Syafiq Syazwan Bin Abu Zaki

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2024

DECLARATION

I declare that this thesis entitled “Development of Sturdy Lightweight Drone Frame Printed with Selective Laser Melting Printer” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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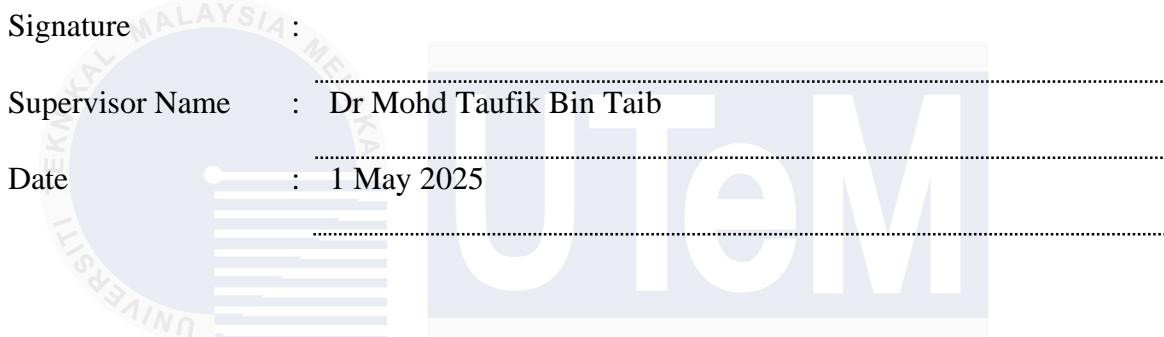
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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Science in Mechanical Engineering.

Signature : 

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Date : 1 May 2025

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DEDICATION

To my beloved parents,

Abu Zaki Bin Romli and Che Liah Binti Ahmad

Thank you for all the support, encouragement, enthusiasm, patience, and willingness.

To my honoured supervisor,

Dr Mohd Taufik Bin Taib, Prof. Madya IR. Dr Mohd Hadzley Bin Abu Bakar and all

UTeM lecturers and staff.

To my dearest friends

Thank you for always giving me guidance and persistent help to complete this thesis
project.

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ABSTRACT

The efficient execution of heavy-duty tasks by drones necessitates a robust frame capable of lifting heavy objects from a stable, elevated position. However, traditional solid materials contribute to excessive weight, accelerating battery deterioration. Moreover, complex designs pose challenges for conventional machining methods. This study aims to design a lightweight and sturdy drone frame using stainless steel via generative design. Strength and stability are evaluated through simulation and experimentation. The proposed solution leverages additive manufacturing, specifically Selective Laser Melting (SLM) 3D printing, with stainless steel powder. To design a drone frame that is suitable for that requirement, first needs to study the machine's behaviour and the mechanical properties of the material. To understand the machine's capability, the experiment that was decided is a surface roughness test by experimenting with the printing orientation of specimens. The specimens were printed using three parameters: the effect of surface area, the effect of height, and the effect of printing angle. Then, the specimens underwent a surface roughness test to determine which printing orientation was the best for manufacturing the drone frame. For the mechanical properties, the experiments that were executed were impact tests and tensile tests. The specimens were drawn first using Autodesk Fusion 360, guided by the American Society for Testing and Materials (ASTM), and fabricated using a Selective Laser Melting (SLM) 3D printing machine. The parameters for these experiments are the material state of the stainless steel powder (virgin and recycled powder), the thickness of the specimens, and the coordination of the specimens on the production bed. After finishing all the physical experiments, the process proceeds to the simulation experiment. First, sketch multiple designs of the drone frame. Those designs that were sketched will be drawn using Autodesk Fusion 360 and undergo a Generative Design process. After that process, the design file was exported to STEP format (.step) for simulation using the Static Structural study in Finite Element Analysis (FEA) within Autodesk Fusion 360. This allowed for the evaluation and selection of the best drone frame design before proceeding to the manufacturing stage. The best design that was selected from the FEA simulation test is manufactured using the Additive Manufacturing method, which is the Selective Laser Melting (SLM) 3D Printing machine using stainless steel powder as the main material. As a result, a sturdy and lightweight drone frame was successfully fabricated by combining innovative design strategies with advanced manufacturing techniques. The feasibility of generating sufficient thrust from the selected brushless motors to lift the frame was also evaluated. This research offers a practical solution to the challenges of weight, strength, and complexity in drone frame construction.

PEMBANGUNAN RANGKA KERJA UNTUK KERANGKA PESAWAT UDARA

TANPA PEMANDU (UAV) RINGAN DIBINA DENGAN PENCETAK 3D

PELEBURAN LASER TERPILIH

ABSTRAK

Pelaksanaan tugas berat yang cekap oleh dron memerlukan rangka teguh yang mampu mengangkat objek berat dari kedudukan yang stabil dan tinggi. Walau bagaimanapun, bahan pepejal tradisional menyumbang kepada berat berlebihan dan mempercepatkan kemerosotan bateri. Selain itu, reka bentuk yang kompleks menimbulkan cabaran untuk kaedah pemesinan konvensional. Oleh itu, kajian ini bertujuan untuk mereka bentuk rangka dron yang ringan dan kukuh menggunakan keluli tahan karat melalui reka bentuk generatif. Kekuatan dan kestabilan dinilai melalui simulasi dan eksperimen. Penyelesaian yang dicadangkan adalah pembuatan bahan tambahan, khususnya pencetakan 3D Peleburan Laser Terpilih (SLM), dengan menggunakan serbuk keluli tahan karat. Untuk merekabentuk bingkai dron yang sesuai untuk keperluan diatas, terlebih dahulu perlu mengkaji kelakuan mesin dan sifat mekanikal bahan tersebut. Untuk memahami keupayaan mesin, eksperimen yang diputuskan ialah ujian kekasaran permukaan dengan melakukan eksperimen dengan mempelbagaikan orientasi cetakan untuk setiap spesimen. Spesimen dicetak menggunakan tiga jenis parameter: kesan luas permukaan, kesan ketinggian, dan kesan sudut cetakan. Kemudian, spesimen menjalani ujian kekasaran permukaan untuk menentukan orientasi pencetakan yang terbaik untuk menghasilkan bingkai dron. Bagi sifat mekanikal bahan yang dicadangkan, eksperimen yang telah dilaksanakan ialah ujian hentaman dan ujian tegangan. Spesimen dilukis terlebih dahulu menggunakan Autodesk Fusion 360, dipandukan oleh American Society for Testing and Materials (ASTM), dan direka menggunakan mesin pencetak 3D Peleburan Laser Terpilih (SLM). Parameter untuk eksperimen ini ialah keadaan bahan serbuk keluli tahan karat (serbuk dara dan serbuk kitar semula), ketebalan spesimen, dan penyelarasian spesimen pada tapak pembinaan. Selepas selesai semua eksperimen fizikal, proses diteruskan ke eksperimen simulasi. Langkah pertama ialah dengan melakarkan lima reka bentuk bingkai dron. Reka bentuk yang dilakukannya dilukis menggunakan Autodesk Fusion 360 dan menjalani proses Reka Bentuk Generatif. Selepas proses itu, proses simulasi menggunakan kajian Tekanan Statik dalam Finite Element Analysis (FEA) dalam perisian Autodesk Fusion 360 untuk memilih hasil reka bentuk bingkai dron yang terbaik lalu meneruskan proses pembuatan. Reka bentuk terbaik yang dipilih daripada ujian simulasi FEA dihasilkan menggunakan kaedah Pembuatan Aditif iaitu mesin Pencetakan 3D Peleburan Laser Terpilih (SLM) dengan menggunakan serbuk keluli tahan karat (dara) sebagai bahan utama. Hasilnya, bingkai dron yang kukuh dan ringan berjaya direka dengan menggabungkan strategi reka bentuk yang inovatif dengan teknik pembuatan termaju. Kebolehlaksanaan menjana tujuan yang mencukupi daripada motor untuk mengangkat bingkai juga dinilai. Penyelidikan ini menawarkan penyelesaian praktikal kepada cabaran berat, kekuatan dan kerumitan dalam pembinaan rangka dron.

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