

UNIVERSITI TEKNOLOGI MARA

**AERODYNAMIC DESIGN
IMPROVEMENT OF THE
KENYALANG FUEL CELL
POWERED UNMANNED AIR
VEHICLE (UAV)**

NOOR IDAYU BT MOHD TAHIR

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Mechanical Engineering

December 2016

ABSTRACT

The research started with Kenyalang-1 as a fuel cell technology demonstrator back in year 2009. Kenyalang-1 UAV had flown successfully. However, detail calculations of the flight performance are yet to be done. It is necessary to have flight performance behavior in this project since there are a lot of rooms for future improvement. The previous Kenyalang-1 fuselage design is fabricated with a large, rectangular-shaped. The huge fuselage is used to fit propulsion system, hydrogen tank and avionics system. Nevertheless, this large fuselage increases the overall weight, which degrades the performance of the Kenyalang-1. Several alternatives and designs must be studied in order to improve the flight performance of Kenyalang-1.

The objectives of this project are to create alternative, improved aircraft aerodynamic designs, analyzing the best design's flight performance, and assess which design would be best for a new Kenyalang-2 fuel cell powered UAV.

The steps started with preliminary design, aerodynamic analysis using computational fluid dynamic (CFD) and aircraft performance analysis which are maximum speed, take off distance and rate of climb. Kenyalang-1 design used as the datum named model 1. Then the alternative designs have been created which are model 2, model 3 and model 4. The research continues with CFD analysis for model 1, model 2, model 3 and model 4. The CFD analysis results for all 3 models will compare with model 1 and ANSYS simulation data from other work [7] and also theoretical calculations. The comparison result between theoretical data and CFD analysis model 1 proved that the CFD data is valid. The next step is selecting best aerodynamic model based on C_L/C_D maximum. The best C_L/C_D maximum will proceed with flight performance analysis which are take off distance, stall speed, rate of climb and maximum altitude. The flight performance for best design will be the character for Kenyalang-2 model.

As a result, the maximum speed of alternative UAV Kenyalang-2 is 26 meter per second, and stall speed is 18.28 meter per second, take off distance is 178.19 meter while rate of climb is 4.16 m/s. The research objective has been achieved and the outcome is beneficial to the alternative energy, economy, society and knowledge.

ACKNOWLEDGEMENT

Alhamdulillah, in the name Allah Most Gracious and Most Merciful I am present thousands of thank you Allah for giving me the strength and ability to complete this master project. All perfect praises belong to Allah s.w.t lord of universe, may His bless upon the prophet Muhammad s.a.w and our group members of the family and companions.

I am using this opportunity to express my sincere and deepest gratitude to my project advisor, Prof.Dr.Ir Wahyu Kuntjoro, for the guidance and continuous encouragement, motivation, enthusiasm, for me keep the strength to finish the project. Prof Dr. Ir. Wahyu Kuntjoro is a very supportive lecturer I ever have. I would also like to honors him for his patience and kindness to assist me through completing this project. I learned too much from you and I really appreciate of what you have been giving to me throughout the process of finishing the project.

I express my warm thanks and appreciation to my husband Haji Umran Zahini Bin Abd Rahman for giving full support emotionally and financially. I would like to thank my family especially mother Puan Hajjah Halimah Bt Hj Husain and father Tuan Haji Mohd Tahir B Malaka and also my beloved daughter Damia Aylar & beloved son Muhammad Hadeef Aqil-Hud for continuously giving support, giving positive thinking and passion for completing this master project.

Thanks to all team member Nor Hisyam, Mohd Hadi Anuar, Firdaus B Mohamad, Zurriati, Niezam and Joerg Wiegl for the support and teamwork. Thanks for giving positive idea and passion to kept the project moving on.

Last but not least, I would also like to thank to my Co-supervisor Assoc Prof Dr Thomas Ward for giving me a continuous support for this project and also my friends who have contributed directly or indirectly in making this project become success.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENT	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xii
LIST OF ABBREVIATIONS	xiii
CHAPTER ONE: INTRODUCTION	
1.1 Background	1
1.2 Problem statement	4
1.3 Objectives of The Study	5
1.4 Scope of Study	5
1.5 Significant of study	6
CHAPTER TWO: LITERATURE REVIEW	
2.1 Introduction of UAV (Unmanned Vehicle)	9
2.2 Fuel cell Technology	10
2.2.1 History of Fuel Cell	10
2.2.2 Mechanism of Fuel cell	10
2.2.3 Advantage of Fuel Cell	13
2.3 UAV Fuel Cells	13
2.4 Research on Fuel Cell Aircraft Application	14
2.4.1 Georgia teach UAV	14
2.4.2 Aerosonde UAV	15

2.4.3	Korea Advanced Technology UAV	16
2.4	Aerodynamics	17
2.5	Computational Fluid Dynamic (CFD)	21
2.6	Element of Aircraft Performance	23
2.7	Kenyalang-1	26
2.7.1	Kenyalang 1 History	28

CHAPTER THREE: METHODOLOGY

3.1	Introduction	43
3.2	Summary Methodogy Approach	45
3.3	Steps of Methodology approach	46
3.3.1	Step 1 (Based Line Kenyalang 1)	46
3.3.2	Step 2 (Develop Alternative design)	46
3.3.3	Steps 3 (Analysis)	50
3.3.4	Steps 4 (Validation)	52
3.3.5	Steps 5 (Flight Performance)	56

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1	Introduction	57
4.2	Computational analysis (CFD Analysis)	58
4.2.1	Comparison C_L and C_D (Original design Kenyalang-1 with model 2)	58
4.2.2	Comparison C_L and C_D (Original design Kenyalang-1 with model 3)	60
4.2.3	Comparison C_L and C_D (Original design Kenyalang-1 with model 4)	62
4.3	Comparison of CFD analysis for 4 UAV Models	64
4.4	Research Result	69
4.5	Result of Calculations	69
4.6	Sample of Calculation	69
4.6.1	Calculation element of flight performance model 2	69
4.7	Discussion	75