UNIVERSITI TEKNOLOGI MARA

DATA CHARACTERIZATION AND MAPPING VALIDATION OF DEVELOPED MACROFLUIDIC DYNAMIC AIRFLOW SENSOR

MOHAMAD DZULHELMY BIN AMARI

PhD

Januari 2021

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Mohamad Dzulhelmy bin Amari
Student I.D. No.	:	2016832934
Programme	:	Doctor of Philosophy in Mechanical Engineering – EM950
Faculty	:	Mechanical Engineering
Thesis Title	:	Data Characterization and Mapping Validation of Developed Macrofluidic Dynamic Airflow Sensor
Signature of Student	:	...Mohamad Dzulhelmy Amari...........
Date	:	Januari 2021

ABSTRACT

Sensitive automated reaction from the sensory system is most important in fulfilling the requirement of the intelligent control system. Hence, there are many related studies regarding developing the hardware of the system. The effect of the fast detection of the sensor through the high sensitivity of the airflow sensor has enable the system to identify and analyse the behaviour of the user in higher accuracy compared to the conventional system. Within the scope of airflow sensitivity, the problem of the conventional airflow sensor is its narrow range of detection and the approach used for detection. The necessity and approach for dynamic airflow sensor is lacking because of the limited information and research that can be done in past research due to lack of technology such as analysis software. Hence, this research proposed a separation between two parts in the airflow sensor in altering the velocity impact that have been inquired in purpose, while a few investigations in relations to determine the pressure contour in the analysis. The analysis have been done by using Computational Fluid Dynamics (CFD) to explore the possible outcomes such as producing the simulation of the airflow, pressure streamline, deformation and performance of the new product. This simulation is performed in the ANSYS program software. Thus, this study consequently intends to focus on detection of the high sensitivity of the airflow movement by distinguishing the high and low velocity impact. The data of the airflow movement will be mapped accordingly in order to produce a prototype that is capable to detect the airflow with more than 90% high sensitivity performance. The approach in mapping need to be verified through series of testing in the wind tunnel to ensure the data collected can be categorized with the speed inside the wide tunnel. The flap structure has been divided into two main categories with a different purpose. The detection method is by using voltage divider rule in recording the converted voltage on the bending flap structure during the testing stage in the simulation and wind tunnel. The findings of the research shows that the detection was done by bending moment method to meet the requirement of the objectives stated in the research. Improvement on the design was done for the detection structure to increase the sensitivity and characterize the different speed of the airflow. Based on the pressure characterization analysis, the lower velocity gap (LG) and high velocity gap (HG) are in the range of 0.5 to 0.1 mm. While for the lower velocity flap thickness (LT) and high velocity flap thickness are maintained to the original design of 1 mm and 2mm respectively. As for bending moment analysis, the lower velocity flap thickness (LT), lower velocity gap (LG) and high velocity gap (HG) are remained constant with 0.4 mm, 0.5 mm and 1 mm respectively. The range of thickness for high velocity flap (HT) is between 2.00 mm and 3.04 mm. The best possible thickness that gave high total deformation (13.675mm) is 3.02 mm. The result also shows that the airflow has been mapped accordingly and justify the result in the simulation as required to achieve the objectives of this research. In testing stage, low velocity flap recorded the range from 11 b to 32 b for airflow speed from 0 km/h to 60 km/h. Meanwhile, high velocity flap recorded the range from -11.7 b to -7.9 b for airflow speed from 60 km/h to 110 km/h. Implications of the results and future research directions which the prototype was able to measure the airflow changes with high sensitivity airflow detection and broad range of speed after the characterization of the airflow speed had been achieved. The results presented in this study may facilitate improvements in the technology of the moving object by integrating the new sensor in achieving high sensitivity airflow detection while in motion.

ACKNOWLEDGEMENT

First of all, I am pleased to express my sincere gratitude to my faculty of Mechanical Engineering, Universiti Teknologi Mara for giving me the opportunity to do my research project. Special thanks to my supervisor, Dr. Sukarnur Che Abdullah and my co-supervisor Prof. Dr. Ir. Muhammad Azmi Ayub for aiding, guiding and supporting me all through this project. In fact, his presence was a major source of information, motivation and self-assurance during my project. It was a great experience by having them throughout the session.

Most of all not to forget my to my beloved wife, children, parents, siblings and entire family. They are my backbone in supporting me throughout my journey to complete this research through thick and thin with positive encouragement. In addition, the greatest gratitude of this success comes from the barakah Allah S.W.T. as in Holy Quran Chapter 11 Verse 88 that recites “My success is only by Allah S.W.T.”.

The chance that had been given to me to conduct this research is an advantage to me because I can learn, not limited to detail of the task but rather enable me to enhance my aptitude too. Finally, I would like to convey my affection and appreciation to my parents and you who have constantly given me the supports in whatever I have pursued. Also credits and gratitude to my companions for guided me throughout this project. Thank you for the friendship and the knowledge that has been shared.

TABLE OF CONTENTS