INVESTIGATION STUDY OF VARIOUS CARRIER TYPE FOR AIR TUNNEL TRANSPORTATION

WANIS MUSTAFA EDUKALI SHIBANI

A thesis submitted in
fulfillment of the requirement for the award of the
Doctor of Philosophy

Faculty of Mechanical and Manufacturing Engineering
Universiti Tun Hussein Onn Malaysia

MAY 2018

specially dedicated to:

my Mother and my Wife,
Words cannot express everything you have done for me
Thank you for all of your love and support.
Brothers, sisters, friends and all those who have been
a great help in the completion of this thesis.

My love for you all remains forever…

ACKNOWLEDGEMENT

I would like to take his opportunity to express this heartfelt appreciation to my respectful supervisor, Dr Mohd Fadhli bin Zulkafli for his supervision, encouragement, contradictive ideas, patience, guidance and invaluable advice, enabling me to achieve the objectives of this thesis.

I would also like to extend my appreciation to the man who had supported me at the beginning of my PhD journey, the late Professor Ir Dr Hj Abas Bin Ab Wahab. Many thanks to all the lecturers and technicians in UTHM, and especially to Ir Dr Bambang Basuno who have contributed their efforts and knowledge for the completion of this thesis.

Finally, I wouldn't have been in this position if I hadn't had the support and prayers from my family, especially my mother and my wife. I owe everything to them.

ABSTRACT

This study highlights the influences of internal airflow on the motion of carrier in an air tunnel. The aim of this work is to study an alternative method of transporting goods from one place to another through an air tunnel. The development of such transport system can help to reduce traffic jams and deliver goods faster to its desired places. The analysis of carrier movement and the flow surrounding it was performed using FLUENT software version 16.1. The computational domain along the air tunnel was discretized using tetrahedron grids. The adopted numerical scheme was the time-averaged Navier-Stokes equation with $k - \varepsilon$ turbulence modeling and the scheme was solved using the SIMPLE algorithm. The air movement was created by the presence of pressure difference. The results indicate the possibility of defining a carrier, which has a particular geometry to float and move. This study was performed in three stages. The first stage started with the investigation of suitable geometry of the carrier. Four shapes were considered, i.e. box, ball, wedge A and wedge B shape. The wedge A and B had the same configurations and dimensions, but the only difference was the position of each shape, facing the inlet in the air tunnel. It was found that the wedge B and the box shape had the fastest speed compared to the other two shapes. Rectangular wings with a cross section of either FX63-137, NACA 0012 or NACA 4412 airfoil was selected for this study. In the second stage, a carrier in a box shape with three rectangular wings attached was investigated. In the last stage, the carrier in wedge B shape with wings attached was examined. The results indicate that the carrier equipped with the airfoil NACA0012 has better performance than the carrier that uses airfoil FX 63-137 or airfoil NACA 4412 at wind speed of 30.8 m/s. In the experimental testing, a carrier in a box shape with wings attached was assessed. The result reveals that the movement of the carrier (FX63-137) shows better performance at the wind speed of 19.6 m/s, and this result is consistent with the simulation result.

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji penggunaan terowong udara sebagai kaedah alternatif mengangkut barangan dan manusia dari satu tempat ke tempat yang lain. Pembangunan sistem pengangkutan seperti ini adalah penting kerana ia dapat membantu mengurangkan kesesakan lalu lintas dan pencemaran udara, selain dapat menghantar barangan ke tempat yang dituju dengan pantas. Pergerakan pengangkutan dan aliran sekeliling ketika ia sedang bergerak dianalisis menggunakan perisian FLUENT versi 16.1. Domain pengkomputeran terowong udara dibina menggunakan grid tetrahedron. Skim berangka yang digunakan ialah persamaan purata masa Navier-Stokes dengan permodelan pergolakan $k - \varepsilon$. Skim ini diselesaikan menggunakan algoritma SIMPLE. Gerakan udara dibentuk melalui kehadiran perbezaan tekanan di antara keadaan aliran masuk dan keluar terowong udara. Kajian ini dijalankan di dalam tiga peringkat. Peringkat pertama melibatkan penyelidikan berkaitan geometri pengangkutan. Empat bentuk pengangkutan dikaji iaitu bentuk kiub, bola, baji A dan baji B. Dapatan kajian menunjukkan bentuk baji B dan kiub mempunyai kelajuan terpantas berbanding bentuk bola dan baji A. Satu sayap berbentuk segiempat tepat yang mempunyai bahagian bersilang, dilengkapi samada dengan airfoil FX63-137, NACA 0012 atau NACA 4412, telah dipilih untuk kajian ini. Di peringkat kedua, pengangkutan berbentuk kiub yang dipasangkan tiga sayap berbentuk segi empat tepat telah dikaji. Di peringkat akhir, pengangkutan berbentuk baji B yang dipasangkan satu sayap berbentuk segi empat tepat telah dikaji. Hasil kajian menunjukkan pengangkutan yang dilengkapkan dengan airfoil NACA0012 menunjukkan prestasi yang lebih baik berbanding pengangkutan yang dilengkapi dengan airfoil FX 63-137 atau airfoil NACA 4412 pada kelajuan angin 30.8 m/s. Di dalam eksperimen yang dijalankan, pengangkutan berbentuk kiub yang dipasangkan sayap berbentuk segi empat tepat diuji. Dapatan kajian menunjukkan pergerakan pengangkutan (FX63-137) adalah lebih baik pada kelajuan angin 19.6 m/s dan ini selaras dengan keputusan simulasi.

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LIST OF SYMBOLS AND ABBREVIATIONS

2D	-	Two-dimensional
3D	-	Three-dimensional
α	-	Angle of attack
α_{trim}	-	Trim angle
C_m	-	Pitching moment coefficient
C_l	-	Lift coefficient
C_d	-	Drag coefficient
M	-	Pitching moment
L	-	Lift force
D	-	Drag force
c	-	Chord length
A	-	Wing area
S	-	Full area of the carrier
u	-	The velocity in X-direction
v	-	The velocity in Y-direction
w	-	The velocity in Z-direction
v	-	Flow velocity
γ	-	Specific weight
g	-	Acceleration of gravity
h	-	Elevation height
ρ	-	Density
F	-	Force
N	-	Newton
ms	-	Millisecond
Hz	-	Hertz
μ	-	Molecular viscosity
Δ	-	Vector operator

$\bar{p}$	-	Time-averaged pressure
p	-	Static pressure
$\bar{u}, \bar{v}, \bar{w}$	-	Time-averaged velocity components
u', v', w'	-	Fluctuating velocity components
v_x, v_y, v_z	-	Velocity components
v_c	-	Total velocity
u_i	-	Instantaneous velocity
U_i	-	Mean velocity
τ_{ij}	-	Reynolds stress tensors
μ_T	-	eddy viscosity
k	-	Turbulent kinetic energy
ε	-	Dissipation rate
Ω	-	specific dissipation rate
∂	-	Partial derivative
Pa	-	Pascal, N/m^2
T	-	Time
M	-	Meter
S	-	Second
min	-	Minute
V15	-	Version 2015
V16.1	-	Version 2016
UTHM	-	Universiti Tun Hussein Onn Malaysia
Fps	-	Frame per second
CPU	-	Central Processing Unit
SDOF	-	Six degree of freedom
RANS	-	Reynolds Averaged Navier-Stokes
PDEs	-	Partial Differential Equations
CFD	-	Computational Fluid Dynamic
EMS	-	Electromagnetic Suspension
EDS	-	Electrodynamic Suspension
HEMS	-	Hybrid Electromagnetic Suspension

PMG	-	Postmaster General
Maglev	-	Magnetic levitation
WIG	-	Wing-In-Ground
DGE	-	Dynamic Ground Effect
PCP	-	Pneumatic Capsule Pipeline
PTC	-	Pneumatic Tube Capsule
PTS	-	Pneumatic Tube Systems
GmbH	-	Gesellschaft mit beschränkter Haftung (company with limited liability)
HMSO	-	Her Majesty's Stationery Office
FVM	-	Finite Volume Method
SIMPLE	-	Semi-Implicit Method for Pressure-Linked Equations
NACA	-	National Advisory Committee for Aeronautics
PLA	-	Polylactic Acid
PIV	-	Particle Image Velocimetry
DGE	-	Dynamic Ground Effect

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A. Journal papers:

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