FLOW MODELLING OF NASAL CAVITY WITH VARIOUS FLOW RATE

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)"

Signature	:	....
Supervisor	:	....
Date	:	....

DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature:	....
Author:	....
Date:	....

To my beloved family, my supervisor Ms Nur Hazwani Binti Mokhtar ,lecturers, technicians, friends and those whore are to my thesis, I thank you all for your kindness

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ABSTRACT

Nasal cavity is one of the organs in the human respiration system. Nasal cavity acts as the air flow passage for human ventilation and respiration. The unique geometry of nasal cavity can change the flow behaviour and the flow pattern of air throughout the nasal cavity. This project use to understand the effect and behaviour of air inside the nasal cavity. The project used three inhale breathing condition which is passive, moderate and active breathing. To get the simulation result, the study use an actual human 3D model of the nasal cavity and been added with several boundary conditions into the Engineering Fluid Dynamic (EFD) software. The mesh size that has been used in this study is 0.001m. Before the simulation and analyse process was started, the actual human 3D model of nasal cavity has been validated. The 3D model been compare with the previous study data to make sure that the data that have obtain are valid to use for further study. The results gained from this study are, the geometry have influence the value of velocity and pressure of air that flow inside the nasal cavity. For passive and moderate breathing the air inside the nasal cavity were at laminar state all the time. For active breathing the first half of the nasal cavity the air was at turbulent state, then for the last half of the nasal cavity the air was in the laminar state.

ABSTRAK

Rongga hidung adalah salah satu organ dalam sistem pernafasan manusia. Rongga hidung bertindak sebagai saluran aliran udara untuk pengudaraan dan pernafasan manusia. Geometri unik rongga hidung boleh mengubah kelakuan dan corak aliran udara semasa di dalam rongga hidung. Projek ini digunakan untuk memahami kesan dan tingkah laku udara di dalam rongga hidung. Projek ini menggunakan tiga cara pernafasan iaitu bernafas pasif, sederhana dan aktif. Untuk mendapatkan hasil simulasi, kajian menggunakan model 3D rongga hidung manusia sebenar dan ditambah dengan beberapa keadaan sempadan ke dalam *Engineering Fluid Dynamic* (EFD). Saiz jaringan yang telah digunakan dalam kajian ini adalah 0.001m. Sebelum simulasi dan menganalisis proses dimulakan, model sebenar manusia 3D rongga hidung telah disahkan. Model 3D bandingkan dengan data kajian yang sebelumnya untuk memastikan bahawa data yang mempunyai mendapatkan adalah sah digunakan untuk kajian selanjutnya. Keputusan yang diperoleh daripada kajian ini, geometri mempengaruhi nilai halaju dan tekanan udara yang mengalir di dalam rongga hidung. Untuk pernafasan pasif dan sederhana udara di dalam rongga hidung pada keadaan lamina sepanjang masa. Separuh pertama rongga hidung untuk bernafas aktif udara adalah pada keadaan gelora, maka bagi separuh akhir rongga hidung udara adalah dalam keadaan lamina

TABLE OF CONTENTS

CHAPTER	CONTENT			PAGE

LIST OF TABLE

LIST OF FIGURE

NO.	TITLE	PAGE

LIST OF SYMBOL

Re	=	Reynolds Number
ρ	=	Density, kg/m^3
µ	=	Dynamic viscosity, kg/ms
$\dot{V}$	=	Volume Flow Rate, lpm
Ma	=	March Number
v	=	Speed, m/s
T	=	Temperature, ºC

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Project Background Study

Nasal cavity is an important organ in the respiration system. The nasal cavity acts as an air flow passage for human ventilation and respiration. When airs enter nasal cavity, flow behaviour and flow pattern of air in nasal will change due the unique geometry inside the nasal cavity. To understand the effect of flow behaviour in nasal cavity, the numerical method is use.

To solve graphical simulation and analyse the air flow inside nasal cavity, this study use EFD software (SolidWork COSMOS Floworks 2008). To get the simulation result, several boundary conditions have been added into the Engineering Fluid Dynamic (EFD) software. Then EFD software was used to solve the Navier-Stroke equation to get the data that use for the analysing process.

There are several factors that can influence the air flow pattern inside the nasal cavity. First factor is the unique geometry inside the nasal cavity. The geometry can increase and decrease the velocity and pressure of the air flow inside the nasal cavity. Second factor is the pressure difference of the inlet and the outlet of the nasal cavity. The pressure difference can influence the airflow nasal cavity. The relation is the higher pressure difference of the inlet and outlet of nasal cavity, the higher the velocity of the air flow inside the nasal cavity.

This study will simulate and analyse the air flow behaviours during inhalation with various breathing condition. The various breathing state is in three states, first is at passive condition such as sleeping and resting where the flow rate of air is at 5 lpm, second is at moderate condition such as studying and driving where the flow rate of air is at 12 lpm and third is at active condition such as exercising and doing sport activity where the flow rate of air is at 40 lpm.

1.2 Problem Statement

Currently, the studies in medical and engineering field are closely related to each other to provide comfort and better health to the public. The understanding of the flow rate effect on nasal cavity are improving by the continuing advances technology and increasing technology in numerical simulation. Therefore many researchers were interested to study the flow behaviour in nasal cavity.

The Nasal cavity acts as an air flow passage for human ventilation and respiration. Within the nasal cavity, air is warmed and filtered before joining the throat and trachea. Knowledge of the airflow field in nasal cavities is essential to understand the basic functions of the nose, such as air transportation and odorant sensation. This study will simulate and analyse the air flow behaviours during inhalation with various breathing condition.

1.3 Project Objective

The objective of this study is to simulate and analyses the air flow pattern in nasal cavity during inhalation with various breathing condition

1.4 Project Scope

The scopes of this project are:

1. Simulate the air flow pattern during inhalation by various breathing condition by using EFD software (SolidWork Cosmos Floworks 2008) and MATLAB 2008.

2. Analyze the flow pattern and characteristic in nasal cavity by using EFD software (SolidWork Cosmos Floworks 2008) and MATLAB 2008.

CHAPTER II

LITERATURE REVIEW

2.1 Nasal Cavity

Nasal cavity is a physical structure that located in a human nose that consist a tunnel that use during the reparation process and contain organs for smell. It has an opening from the face to an opening on top of the throat for a passage for airflow. In the nasal cavity, the air is warm up or cools down to within 1 degree Celsius of the body temperature, air will be humidified and particles like dust are removing by cilia [1]. In the nasal cavity there are several parts such as nasal valve, turbinates, nasopharynx and olfactory region as show in Figure 2.1.

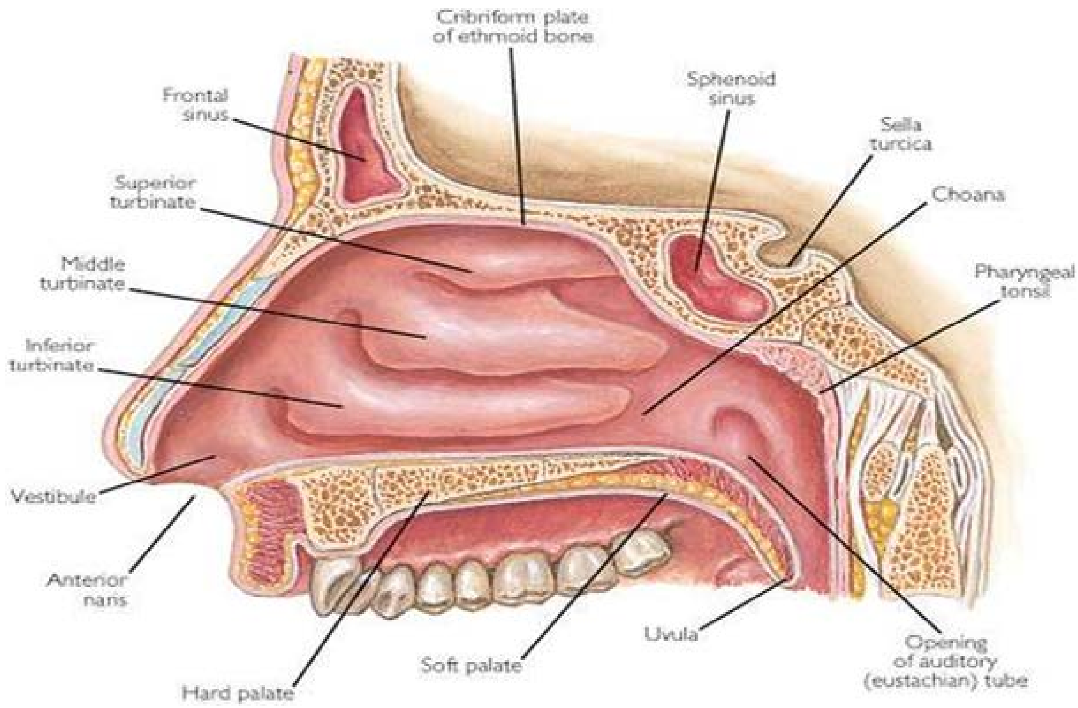

Figure 2.1: The overview of the nasal cavity area

2.1.1 Nasal Valve

Nasal valve is like the entrance of the nasal cavity for air to enter during the respiration process. It can be divided into four segments which are external valve, internal valve and septal valve [2]. This segment use to make the air is smooth and turbulent before it continues into other part of the nasal cavity. The smooth airflow will provides air movement toward the lower respiratory tract and the turbulent airflow will causes eddied currents within the nostril. This will allows the air distribution column across to a larger surface area for conditioning and for the air to reach the olfactory area.

2.1.2 Turbinates

Turbinate is a curve, thin and bony plate that starts from the walls of nasal cavity and go through to the respirator passageways. The turbinate can be divided into 3 parts which is superior turbinates, middle turbinates and inferior turbinates as show in Figure 2.2.

From the three parts the turbinate superior turbinates is the smallest and inferior turbinates is the largest of the 3 part of the turbinates. In the turbinates, the air are prepare before it enter the lungs and help to feed the perceive airflow to the lung. In the turbinates they are mucous tissues that have a combine of capillary vessels, olfactory nerve, nerve terminals and gland cell that use to smell and breath. From this, when it cold the mucous tissues will enlarge and narrow the nasal airways to heat up the air. The process calls nasal obstruction [2]. The dimensions of the turbinates in the nasal are about 40 mm high, 1-3 mm wide, and approximately 60 mm deep.

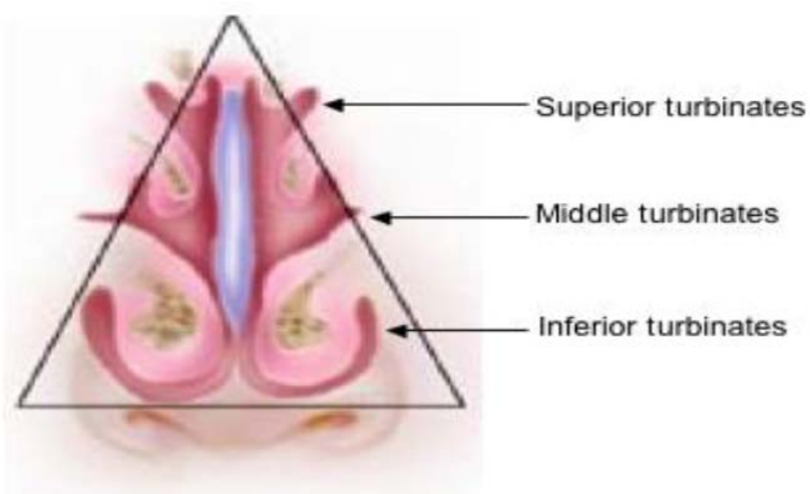

Figure 2.2: Turbinates part in nasal cavity area

2.1.3 Nasopharynx

Figure 2.3 shows the location of nasopharynx. The nasopharynx is the last part of nasal passage ways that located at top part of the throat or pharynx. It provides a passage way to airflow to other pharynx component and trough to the lungs. The nasopharynx is also coordinating the airflow during the eating. This will not let any food or drinks will enter the respiration line. It also uses to trap and kills bacteria that have in the surround air [3].

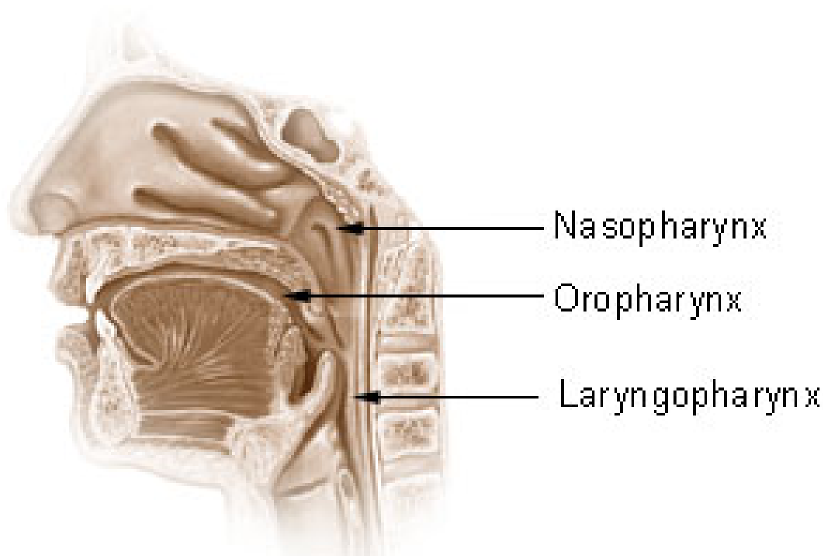

Figure 2.3: Location of nasopharynx