FLOW ANALYSIS ON DISEASED HUMAN AIRWAY IN FIRST AND SECOND GENERATION

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SUPERVISOR DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

Signature :…………………………

Name of Supervisor : MUHAMAD ZUHAIRI BIN SULAIMAN

Date : ……………………......

STUDENT'S DECLARATION

I hereby declare that the work in this project is the result of my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………

Name : MOHD ZULFADHLI BIN ABD WAHAB

Date : ……………………………..

For my beloved family

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ABSTRACT

The human respiratory system is a complex structure consisted of twenty – three generations of branching airways. The study is to analyze flow characteristic of asymmetrical human airway in normal and disease condition, disease like inflammation and reduction of bronchi diameter. The related diseases called Chronic Obstructive Pulmonary Disease (COPD). The result shown in alteration of flow and graph based result. In result validation, velocity contours at fem point streamlines location are measured, and compared with previous study. Due complexity of structure and lack lab equipment available, the study used CFD software for analysis medium, The results are significant in improving understanding of flow pattern visually, since the analysis simulating in 3D environment. The data, with improvement, liable to be used for medical purpose, like appropriate Reynolds number to be chose for disease human airway structure.

ABSTRAK

Sistem pernafasan manusia adalah kerangka yang rumit meliputi 23 cabang generasi kecil. Tumpuan pembelajaran ini ialah analisis bentuk aliran di dalam kerangka bentuk tidak sekata bagi sistem pernafasan manusia yang biasa dan yang berpenyakit, penyakit seperti ketumbuhan and pengecilan ukur lilit pada cabang generasi. Penyakit yang berkaitan di panggil *Chronic Obstructive Pulmonary Disease (COPD).* Keputusan kajian di papar dalam bentuk perubahan aliran garis bentuk dan grafik. Bagi pengesahan keputusan kajian, garis bentuk bagi halaju di beberapa lokasi di ambil kira, Dan di buat perbandingan dengan kajian terdahulu. Di sebabkan oleh kerangka yang rumit dan kekurangan peralatan makmal yang sesuai, pembelajaran ini menggunakan perisian *CFD* untuk analisis. Keputusan kajian adalah penting di dalam menambah kefahaman berkaitan perubahan garis bentuk aliran secara nyata, kerana perisian tersebut menganalisis model dalam ruang 3D (*3 – dimensional*). Data kajian, dengan penambahbaikan, boleh digunakan dalam aplikasi perubatan seperti kesesuaian memilih bilangan *Reynolds* yang sesuai bagi sistem penafasan manusia yang berpenyakit.

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LIST OF SYMBOLS

∇	Kinematics viscosity
u	Velocity of fluid (Navier – strokes)
P	Pressure (Navier – strokes)
u	Fluid density (Navier – strokes)
ρ	Density
µ	Dynamic viscosity
D	Diameter of pipe
V	Inlet fluid velocity
Q	Inlet fluid flow rate
A	Area of pipe

LIST OF ABBREVIATIONS

COPD	Chronic Obstructive Pulmonary Disease
CFD	Computational fluid dynamics
Re	Reynolds Number
3D	3 dimensional
2D	2 dimensional
Pa	Pascal (pressure)
K	Kelvin (temperature)

CHAPTER 1

INTRODUCTION

1.1 PROJECT SYNOPSIS

The project is to studies flow characteristic and behaviour inside lung brunches for diseased human airways. The related diseases called Chronic Obstructive Pulmonary Disease (COPD), cause by inflammation inside the structure either with narrowing or obstruction of the airways. One of diseases is Bronchitis, an inflammation of the Bronchi (air passages connecting trachea with the lung (alveoli)).

The study was designed in 3D and used CFD software as to analyze effect of disease in velocity, pressure drop and flow pattern in first and second generation of lung branches. Also to analyze the relation between the Reynolds number and overall flow characteristic.

1.2 PROBLEM STATEMENT

Chronic Obstructive Pulmonary Disease (COPD) is human airway disease, its cause by reduction in diameter of structure; obstruction with inflammation and etc. The studies are required to analyzing and understanding flow characteristics and its effect to the structure for human lung system.

Due to the complexity of the structure and lack of experimental equipment, the research utilize computational fluid dynamics (CFD) software in analyzing effect the respiratory flow of lung diameter to daughter branches. Parameter involves Reynolds number and lung diameter. The result shown from velocity, pressure drop and flow pattern inside the branches.

1.3 OBJECTIVES

The objectives are to design and model human airways structure of first and second generation in normal and diseased condition, and to analyze flow behaviour in asymmetrical human airways and its changes due reduction of diameter.

1.4 SCOPES

The scopes are to design and analyze model using CFD software (computational fluid dynamics), with analysis of flow behaviour in first and second generation of human airway system in normal, disease and full exercise condition.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is one of most disease nowadays; this may come from food, air pollution and etc. The disease known as respiratory disease includes asthma, emphysema & bronchitis. This study is to analyze diseased human airways in efficiency of transporting air particles toward lung.

The chapter explained various aspect by other researcher, consist of relate design, equation, material properties, boundary condition, software and clinical term which applied.

2.2 CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

The definition of Chronic Obstructive Pulmonary Disease (COPD), is a disorder in transferring air particle and characterized by reduced maximal expiratory flow. (American Thoracic Society, 2006).

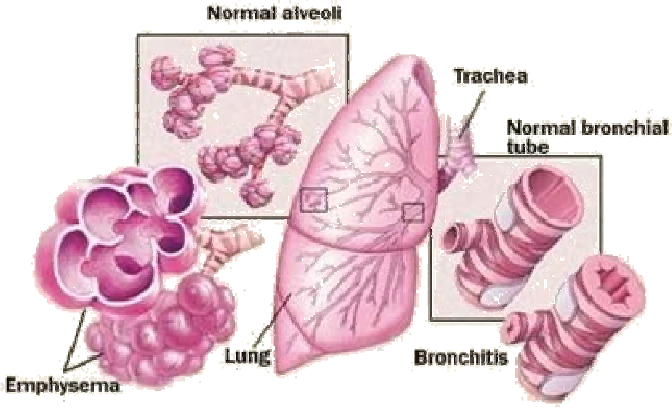

Figure 2.1: Normal and diseased human airway

Source: American Thoracic Society (2006).

Character of disease, reduce diameter, external low pressure, flow obstructed by inflammation or tumor and etc (Douglas J, 1998).

These diseases include chronic bronchitis, asthma, muscles in airways tighten, and emphysema (less efficient air sacs that are not able to handle the normal exchange of oxygen and carbon dioxide) (American Thoracic Society, 2006).

Signs and symptoms of emphysema include, mild cough, Loss of appetite, fatigue, breathlessness, coughing up blood, fainting among others.

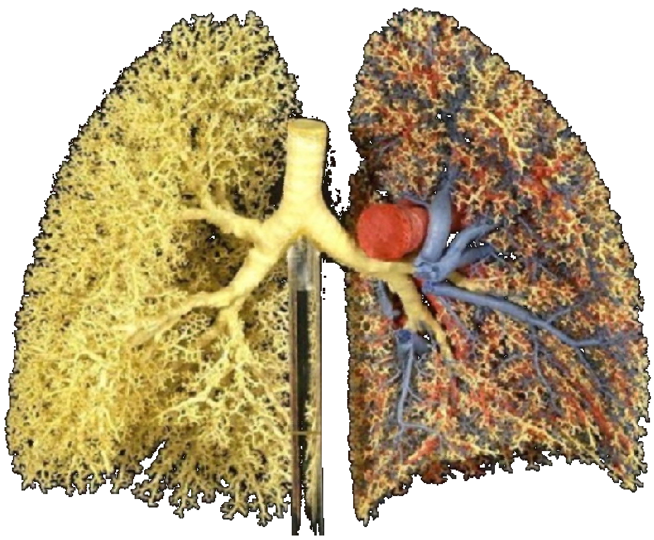

Figure 2.2: Left (airways structure), Right (airways, with arteries and veins).

Source: American Thoracic Society (2006).

2.3 SOFTWARE

The study used CFD software in analyzing effect of parameter involves to structure of human airway in first and second generation.

2.3.1 COSMOSFloWorks Software

COSMOSFloWorks is the Fluid flow simulation and thermal analysis program that is fully functioning with SolidWorks software.

The fluid flow simulation product fully integrated with SolidWorks. Unlike other fluid flow programs, COSMOSFloWorks allows users to immediately create designs and analyze without having to transfer the data to the analysis code. (R.M. Spencera, 2001).

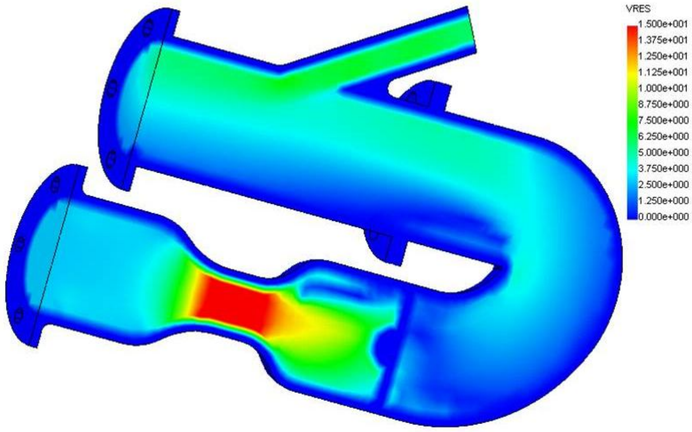

Figure 2.3: Application of software

Source: R.M. Spencera (2001)

2.4 FLUID FLOW EQUATIONS

2.4.1 Navier – Stoke Equations

Mathematical relationship governing fluid flow is the famous concept equation and Navier – strokes equation. The equation describe related between velocity, pressure, temperature and density of moving fluid.

The equation explains the flow of incompressible fluids together with the continuity equation. Where ∇ is kinematics viscosity, u is velocity of fluid, and P is pressure and u is fluid density.

$$\nabla . \mathrm{u} = 0 \qquad (2.1)$$

$$\frac{\partial u}{\partial t} + u\nabla \mathrm{u} = -\nabla P + \left(\frac{2\tau - 1}{6}\right)\nabla^2 u \qquad (2.2)$$

2.4.1.1 Continuity

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho\, u)}{\partial x} + \frac{\partial(\rho\, v)}{\partial y} = 0 \qquad (2.3)$$

2.4.1.2 Momentum

$$\frac{\partial(\rho v)}{\partial t} + \frac{\partial(\rho u v)}{\partial x} + \frac{\partial(\rho v^2 + p)}{\partial y} = \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} \qquad (2.4)$$

2.4.2 Reynolds Number

Reynolds Number defined as number of different situation of fluid moves relative to a surface. The equation include of fluid properties (air), density (ρ), and Dynamic viscosity (μ). For fluid flowing in pipe, diameter of pipe is included.

$$Re = \frac{\rho V D}{\mu} = \frac{V D}{v} = \frac{Q D}{v A} \qquad (2.5)$$

2.5 HUMAN AIRWAY MODELS

2.5.1 Review Current Design

Current study there was several of human respiratory geometry, either in symmetrical (D. Elad a et al, 1997) and (F.E Fresconi et al, 1998) or asymmetrical geometry (RK.Calay et al, 2001).

Previous studies approved, the bronchi are no longer Symmetric or regular asymmetric airways. (R.K. Calay et al, 2001). The flow characteristics of the asymmetric airway are totally different from the symmetric in structure and properties involved

Disease related as such inflammation and obstructions in airways could proportionally alter the air flow rate, flow pattern, velocity and pressure distribution inside the bifurcation toward the lung.

These parameters are sensitive to the tube diameter and bifurcation structure. And it’s called inflammation in human airway which leads to chronic obstructive pulmonary disease (COPD) (Y. Liua et al, 2001).

This study was used asymmetrical geometry as follow with current study and real human measurement of airway structure (RK.Calay et al, 2001) and (J. Russo et al, 2007).

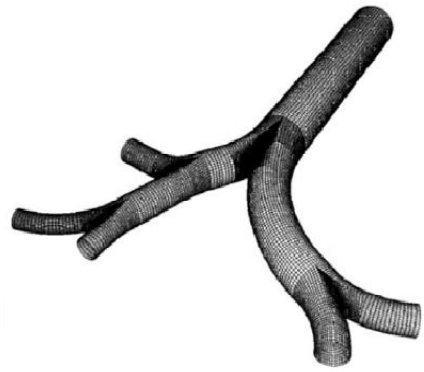

Figure 2.4 : Model of asymmetrical human airway structure

Source: RK.Calay et al (2001).

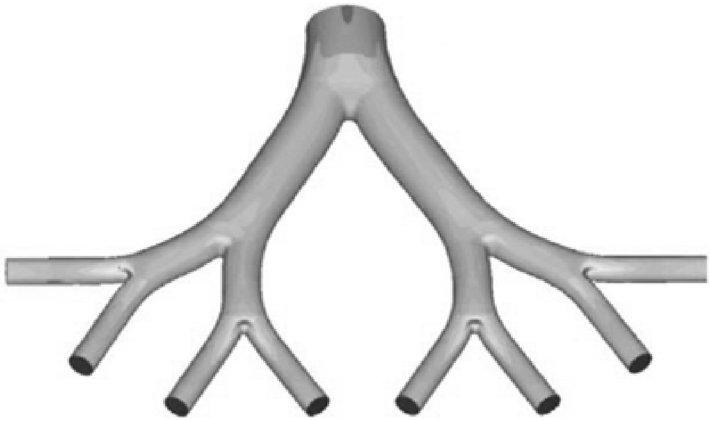

Figure 2.5 : Model of symmetrical human airway structure.

Source: Z. Zhanga et al (2004)