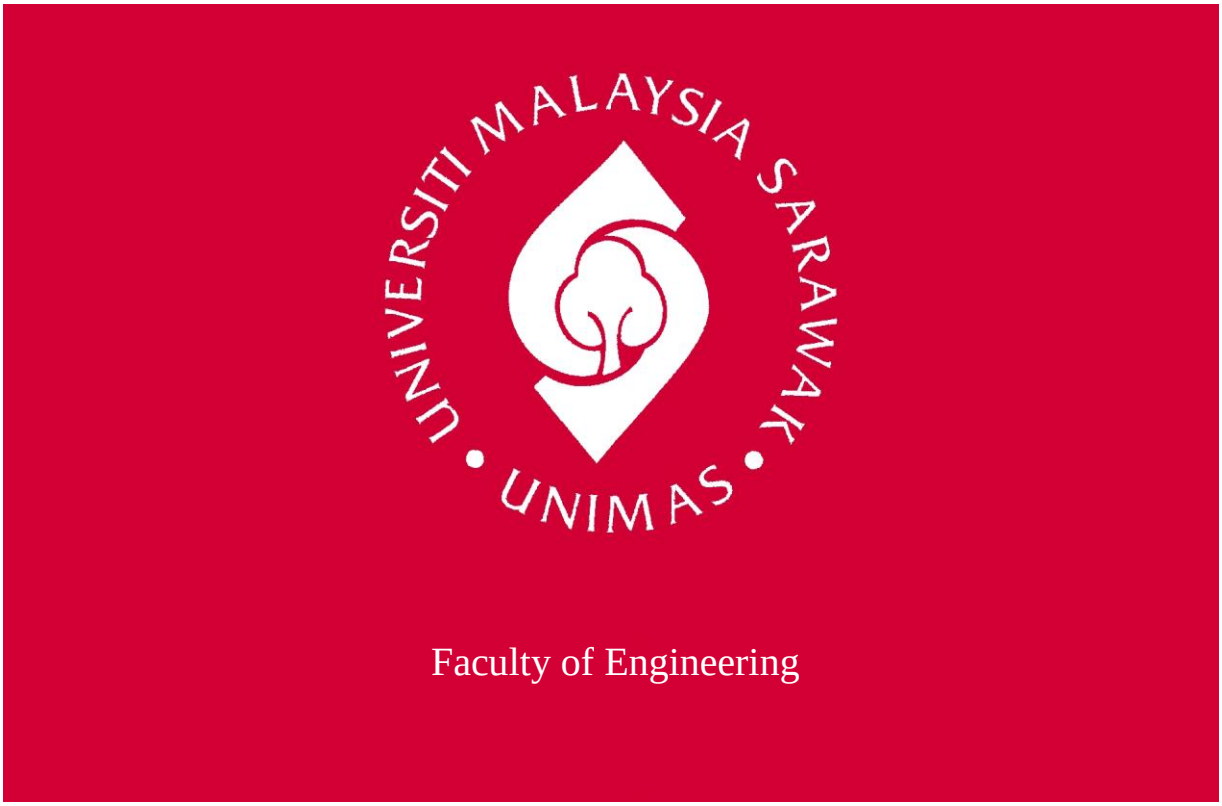

DESIGN AND FABRICATION OF METERED DOSE NASAL SPRAY

Gan Jameson

Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing System)
2008

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN STATUS TESIS

Judul: **DESIGN AND FABRICATION OF METERED DOSE NASAL SPRAY**

SESI PENGAJIAN: 2004 - 2008

Saya **GAN JAMESON**
(HURUF BESAR)

mengaku membenarkan tesis * ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sarawak.
2. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Membuat pendigitan untuk membangunkan Pangkalan Data Kandungan Tempatan.
4. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
5. ** Sila tandakan (✔) di kotak yang berkenaan

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan).
☑	TIDAK TERHAD	

Disahkan oleh

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat tetap: 33-G, LORONG 4,
JALAN LIM CHENG HOON,
TAMAN BUKIT SERINDIT,
75400 MELAKA.

PN. ERVINA JUNAIDI
(Nama Penyelia)

Tarikh: 21 APRIL 2008 Tarikh:

CATATAN
***** Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah, Sarjana dan Sarjana Muda.
****** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

Approval Sheet

The following final year project:

Title : Design and Fabrication of Metered Dose Nasal Spray

Author : Gan Jameson

Matrics No. : 13435

Is hereby read and approved by:

_____ _____

Pn. Ervina Junaidi Date

(Supervisor)

_____ _____

Ir. Dr. Andrew Ragai Rigit Date

(External Examiner)

DESIGN AND FABRICATION OF METERED DOSE NASAL SPRAY

GAN JAMESON

This project is submitted in partial fulfilment of
the requirements for the degree of Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing System)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2006

To my beloved

Family

And

Friends.

ACKNOWLEDGEMENT

My acknowledgements go to several individual and institute for the support and help provided through out the research period. This dissertation would not come to completion without their support and participant.

First of all, I would like to convey my sincerest appreciation to my supervisor, Pn. Ervina Junaidi for her guidance, support, and motivation throughout the progress of the research ensuring the project is carried out successfully with least obstacles.

Secondly, special thank is forwarded to Ir. Dr Andrew Ragai Rigit for his knowledge and thoughtful idea throughout the process of designing and testing. His constructive inputs in technical and theoretical issues faced are very much appreciated.

Thirdly, I would like to thank QRT Technologies Sdn. Bhd., the fabricator the nasal spray prototype for his expert advice on fabrication and modification.

Last but not least, my sincere appreciation goes to my beloved family and friends for their morale support, help and advice.

ABSTRACT

Nasal sprays are used for the nasal delivery of drugs. These drugs generally are used to alleviate cold or allergy symptoms such as nasal congestion. Nasal sprays generally consist of four parts which is the container closure system, pump mechanism, bottle cap and the nozzle. Atomizer had been used in the applications of nasal spray for some time. Atomization is the process of converting a bulk liquid into a cluster of spray or mist. Axiomatic Design is used to identify the weaknesses associated with the existing nasal spray. A new design is proposed to improve the weaknesses and effectiveness. A pressure-swirl atomizer is utilized to create better atomization and mixing of drugs. Pressure-swirl atomizer creates a wider spray angle and mistier spray droplets. The pressure- swirl nozzle produces a solid cone spray and distributes the drug evenly in small liquid droplets. This will increase the rate of absorption into nasal moist wall. CATIA V4® software is used to create the design the component blueprint. Fabrication is done using CNC machine for better strength. Meanwhile, the COSMOSFloWorks® 2004 is used to simulate the flow inside the nozzle with a predetermined parameter. The pressure and inlet volume flow are also determined. Experiments are done to determine the spray pattern and angle of spray dispersion.

Keywords: nasal spray, atomization, pressure- swirl, CNC, Computer Aided Design

ABSTRAK

Nasal sprays berfungsi sebagai sebuah alat untuk menghantar ubat cecair melalui hidung. Kebiasaannya, ubat ini digunakan untuk meringgankan demam selsema, simptom alergi dan kesesakan nasal. *Nasal sprays* mempunyai empat komponen penting iaitu, *container closure system*, mekanisme pam, penutup botol dan *nozzle*. *Atomizer* telah lama digunakan dalam aplikasi *nasal spray*. *Atomization* ialah proses penghasilan semburan halus dari cecair. *Axiomatic Design* berfungsi untuk mengenal pasti kelemahan *nasal spray* yang ada di pasaran kini. Selepas kelemahan *nasal spray* diketehui, satu reka bentuk *nasal spray* baru yang lebih baik dicadangkan. Pengunaan *pressure-swirl atomizer* dicadangkan kerana ia menghasilkan penyemburan ubat yang lebih sekata. Peryemburan yang luas and halus juga dapat dihasilkan dengan adanya *atomizer* ini. Secara tidak langsung, kadar penyerapan cecair ubat ke dalam kulit lembap hidung dapat ditingkatkan. Projek ini melibatkan proses merekacipta, dan menganalisis nasal spray prototiap. Perisian CATIA V4® 2007 digunakan untuk merekabentuk mekanisma and komponen *nasal spray*. Dalam pada itu, perisian COSMOSFloWorks® 2004 diguna untuk mengkaji pengaliran cecair dalam *nozzle*. Ciri- ciri penyemburan *nasal spray* dikaji dalam kertas kerja ini.

TABLE OF CONTENTS

Page No.

Page No.

LIST OF TABLES

LIST OF FIGURES

LIST OF NOTATIONS

ΔP_L	Pressure Differential, Pa
d_0	Discharge Orifice Diameter, m
v_L	Kinematic Viscosity of liquid, m^2/s
U_L	Velocity, m/s
Re	Reynolds's Number
D_b	Breaking Distance, m
	Mass flow rate, kg/s
ρ	Density, kg/m^3
A	Area, m^2
V	Volume, m^3
L_1	Distance between nozzle and target, m

LIST OF ABBREVIATIONS

CCD	Coupled Charged Display
SMD	Sauter Mean Diameter, m
MMD	Mass Mean Diameter, m
CFD	Computational Fluid Dynamics
CAD	Computer Aided Design

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Nasal sprays are used for drugs delivery through the nasal canal. These drugs are generally used to alleviate cold or allergy symptoms such as nasal congestion. Delivery methods may vary with different type of drugs but most nasal sprays operate by instilling a fine mist into the nostril by the action of a hand-operated pump mechanism. Nasal spray contains drug substances that dissolved or suspended in solutions in non- pressurized dispenser that deliver a spray containing a metered dose of drugs [1].

Although some nasal spray are similar in many features to other nasal spray products, some aspects such as drug formulation, container closure system, manufacturing, spraying characteristics desired, and stability may be unique. Therefore, in these aspects will be considered during the development [2]. There are three main types of nasal spray available which are antihistamines, corticosteroids, and topical decongestants.

Histamine is a chemical naturally produced by the body which creates an inflammatory effect to help the immune system remove foreign substances. Excessive histamine is the primary cause of allergic reactions in people. Antihistamines work by competing for receptor sites to block the function of histamine, thereby reducing the inflammatory effect. Steroidal nasal sprays are used to reduce swelling and congestion in the nasal passages and sinuses because of the anti-inflammatory effect of a corticosteroid. Topical decongestants nasal sprays such work to instantly open up nasal passages by constricting blood vessels in the lining of the nose [1].

Most of the nasal sprays are design and tested with the guidance by the Inhalation Drug Products Working Group of Chemistry, Manufacturing, and Controls Coordinating Committee in the Center for Drug Evaluation and Research (CDER) at the Food and Drug Administration (FDA) [2].

1.2 Introduction of Atomization technology

Atomizer had been used in the applications of nasal spray for some time. Atomization is the process of converting a bulk liquid into a cluster of spray or mist. It is often done by passing the liquid through a nozzle. When a liquid is dispersed as a stream of droplets (atomization), it is called a spray. One of the main purposes of atomization is to produce small drops of liquid spread over a defined angle.

Swirl atomizers are implemented in many applications ranging from producing sprays of tones per hour of heavy fuel in electric utility plant down to several ml per minute of various liquid used in an aerosol. The swirl atomizer

functions by introducing swirling liquid into a nozzle contraction. The liquid leaves the nozzle orifice as a high speed liquid film in a form of conical spray [3]. The swirl atomizer is capable of providing various spray characteristics depending on the allocation requirements. The atomization performance in the swirl atomizer is generally good.

Therefore, swirl atomizer has been chosen in this study of spray characteristic for the nasal spray. This is because swirl atomizer provides good atomization performance as well as the ability of providing various sprays characteristic. Thus, this will give a better mixing of liquid drug and reduced spraying discomfort in the nasal cavity.

1.3 Objectives

The objectives of this study are summarized as follows:

i. To investigate the spray characteristic of the nozzle of an existing nasal spray.
ii. To improve the spray characteristic onto a prototype.
iii. Design and fabricate a metered dose nasal spray.

The study of spray characteristics will be conducted by taking an existing nasal spray and render it to a CCD motion camera. The image taken will be studied according to the determined parameters such as spray solidarity, break up length, droplet size, and swirling effects.

The purpose of studying the spray characteristic is to introduce swirl atomizers into the applications of nasal spray. It is understood that atomization provide a larger surface area than the liquid itself. Thus giving a better dispersion of the drugs and controlled area coverage. With the implementation of the swirl atomization technology in the nasal spray will give a better mixing of drugs in the spray nozzle and controlled area of drug dispersion. Therefore, it will reduce the uncomfortable sensation of liquid dispersion inside the nasal cavity.

In order to create a better design, the guidance document on Nasal Spray and Inhalation Solution, Suspension, and Spray Drug Products- Chemistry Manufacturing and Control will be used. It is understood that there are parameters which need to be fulfilled when designing the nasal spray. The main parameters of the nasal sprays will be discussed in the following paragraph.

One of the important parameter in designing the nasal spray is metering and spray producing pump mechanisms. This includes the orifice, nozzle and other components that are used for producing delivery of liquid drug. This can be done by constructing parts of various designs that are accurately controlled in terms of dimension and composition.

The energy required for dispersing the drug through an atomizer is also taken into consideration in the designing stage. The general idea is to force the formulation of drug through the orifice or nozzle. Therefore, calculations on the amount of energy needed for the pump to force the liquid through the orifice have to be determined. Another important factor is the liquid properties and the container closure system such as the pump, closure, container, liquid density, liquid viscosity and packaging. The liquid properties are important because they affect the dosing performance and the spray characteristics. The design on the container closure system affects the ergonomics and the user friendliness of the products.