APPROVAL

'I hereby approve have read this thesis submitted to the senate of UTeM and have accepted this thesis as partial fulfillment of the requirement for the degree in Bachelor of Mechanical Engineering (Design and Innovation) '.

Signature	: …………………………….
Supervisor 1	: EN. MOHD HAIZAL BIN MOHD HUSIN
Date	:

STUDY OF EXTERNAL NOZZLE DESIGN

SYAUQI BIN MOHD HASHIM

This report is submitted in partial fulfillment of the requirement for the Bachelor of Mechanical Engineering (Design and Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2009

DECLARATION

"I hereby, declared this thesis entitled
STUDY OF EXTERNAL NOZZLE DESIGN
is the results of my own research except as cited in the references".

Signature : ....

Author's Name : SYAUQI BIN MOHD HASHIM

Date : ....

DEDICATION

To my beloved family and all my friends in UTeM

ACKNOWLEDGEMENT

First of all, I want to express my grateful to Allah S.W.T. for ease the way for me to finish this thesis with achievement and enjoyment. I thankful to Allah for the strength that keeps me standing and for the hope that keeps me believing the positive possibilities for my thesis. Also, I want to express my sincere gratitude to Mr. Mohd Haizal b. Mohd Husin, my supervisor, who have given his whelming support, guidance and consideration in helping me to finish this thesis.

Then, I would like to thank to my family who inspired, encouraged and fully supported me for every trails that comes. In giving me not just financial, but morally and spiritually. To my friends who willingly helped me to gather the necessary data's and information needed for this thesis.

Last but not least, I would like to thanks to all UTeM lectures and labratory technicians who give support and helping me throughout the fabricate process and finishing this thesis. I hope that this thesis can give much informations to all who needs.

ABSTRAK

Nozel penyembur jenis semburan kon penuh adalah nozel yang paling banyak digunakan di dalam industri seperti proses cucian dan bilasan, proses penyejukan di dalam kebuk pembakaran, pencegahan pembakaran sewaktu kecemasan dan sebagainya. Projek Sarjana Muda (PSM) ini melingkupi kajian berkenaan rekabentuk luaran nozel penyembur untuk mendapatkan bentuk semburan kon penuh yang terbaik. Kajian ini akan lebih menjurus kepada jenis nozel berpusar yang boleh menghasilkan bentuk semburan kon penuh dan masalah-masalah yang mengehadkan keupayaan nozel jenis ini. Penyelesaiannya, PSM ini akan mencangkupi proses rekabentuk konsep-konsep bagi nozel jenis berpusar, analisa simulasi aliran bendalir menggunakan *computational fluid dynamics* (CFD), proses fabrikasi nozel dengan menggunakan mesin *Fused Deposition Modelling* (FDM) dan ujikaji sebenar melibatkan prototaip nozel penyembur yang telah siap. Akhir sekali, diharapkan nozel penyembur yang boleh memberikan kriteria yang terbaik seperti bentuk semburan dan sudut taburan semburan akan dapat dipilih daripada 3 konsep nozel yang telah dicadang. Keperluan kepada penggunaan nozel penyembur semburan kon penuh dalam pasaran kini telah memaksa kepada keperluan untuk pembangunan produk nozel penyembur yang baru dan PSM ini adalah sebahagian daripadanya.

ABSTRACT

The spray nozzle with solid cone spray pattern are the most extensively used in industry such as for washing and rinsing process, cooling for combustion chamber, fire suppression and others. This thesis covers the study of the external design of spray nozzle to gets the best solid cone spray pattern. The study will focus on spiral nozzle type which distribute solid cone spray pattern and problems that limits the performance of this type of nozzle. In order to solve, this thesis comprise the designing process of the spiral nozzle concepts, analyze the fluid flow simulation using Computational-fluid dynamics (CFD) simulation, fabrication using Fused Deposition Modelling (FDM) machine and actual experimet with the prototype of spray nozzle. In the end, spray nozzle that can give the best criteria such spray pattern and spray angle distribution will been choose among the 3 spiral nozzle concepts. The needs in application of solid cone spray nozzle in today market, will force the consideration in development of the new product of spray nozzle and this thesis are part of it.

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LIST OF SYMBOLS

CAE	=	Computer-aided engineering
CFD	=	Computational fluid dynamics
FSI	=	Fluid structure interaction
CNC	=	Computer numerical control
CAD	=	Computational-aided design
3-D	=	Three dimensions
2-D	=	Two dimensions
gpm	=	Gallons per minute
lpm	=	Liter per minute
lbs/gallon	=	Pounds per gallons
C_1	=	Capacity
P_1	=	Pressure
VMD or $D_{v0.5}$	=	Volume Median Diameter
MMD	=	Mass Median Diameter
SMD or D_{32}	=	Sauter Mean Diameter
NMD.or.$D_{No.5}$	=	Number Median Diameter
μm	=	Micro meter
RSF	=	Relative Span Factor
Dmax	=	Maximum drop size
Dmin	=	Minimum drop size
SWIFT	=	SolidWorks Intelligent Feature Technology
FDM	=	Fused Deposition Modelling

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND STUDY

A nozzle is a mechanical device or orifice designed to control the characteristics of a fluid flow as it exits an enclosed chamber or pipe.

A nozzle is often a pipe or tube of varying cross sectional area and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and the pressure of the stream that emerges from them.

A type of nozzle that we want to consider in this study is Spray Nozzle. A spray nozzle is a device that facilitates the formation of spray. When a liquid is dispersed as a stream of droplets (atomization), it is called a spray. Spray nozzles are used to achieve two primary functions: increase liquid surface area to enhance evaporation, or distribute a liquid over an area. Spray nozzles are designed to perform under various spraying conditions.

The spray pattern of the nozzle gives us different patterns such as Solid Cone, Hollow Cone and Flat Spray. The spray pattern that we want to study for this project is the solid cone spray pattern.

Solid cone nozzles will form complete spray coverage in a round, oval or square shaped area. Usually the liquid is swirled within the nozzle and mixed with non-spinning liquid that bypasses an internal vane. Liquid then exits through an orifice forming a conical pattern. Spray angle and liquid distribution within the cone pattern depend on the vane design and location relative to the exit orifice. The exit orifice design and the relative geometric proportions also affect the spray angle and distribution.

Based on the solid cone spray nozzle that are already in market, an analysis will be made based on this nozzle from its spray pattern and fluid flow simulation. With the use of computer-aided design (CAD) software and computational fluid dynamics (CFD), a research will be conducted to make sure that the nozzle model that we design achieved high specification in its categories.

1.2 PROBLEM STATEMENT

Based on the past research and study on the solid cone spray nozzle, show that many applications can be performed by this spray nozzle in a daily life and industry. There are many things to be considered in order to get the best solid cone spray. Some of the problems that occur due to improper design of solid cone spray nozzle such as non-uniform coverage of the spray in period of time, the lifecycle of the nozzle are not durable compared with the time usage. This will cost more for the consumer for the maintenance.

The external design and internal design can give big problems if it not been fully analyzed. Different internal design of the nozzle can give different spray angles which means different in spray coverage. More, the common components of many spray materials, could wear out the orifices in the nozzles on our sprayers. Water is abrasive, and the materials we mix into it are even more abrasive. To such an extent, that a brass nozzle's orifice will begin to wear after only 10 hours of use at 100 pounds pressure.

Nozzle wear means that the orifice of the tip, so carefully engineered to produce an optimum spray pattern becomes deformed, which distorts the spray pattern, producing droplets that are larger than intended, uneven band application and, of course, higher volumes of material per acre.

Many things to be considered in order to get the best solid cone spray of the spray nozzle especially *spiral nozzle*. Many users don't have enough information and guidance when it comes to choose the right spiral nozzle. They were uncertain about the wide application of spiral nozzle in industry especially in washing process. The spiral nozzle can also been considered for dish wash application because of its good properties in spray distribution.

Hope that this study will help to discover, design, and analyze the common problem of spray nozzle application and able to propose the better nozzle especially the spiral nozzle type. This study will focus more on the external design of the nozzle rather than the internal. In the end, the main usage of the nozzle that been studied will be useful for the dish wash spray application.

1.3 OBJECTIVE

The objective of this project is to design and fabricate a solid cone spray pattern nozzle by using the SolidWorks 2007 to generate the detail design and Fused Deposition Modelling (FDM) machine to fabricate the nozzle. The spray pattern of the spray nozzle will be analyzed first by using COSMOS FloWorks to generate the fluid flow and spray pattern simulation.

1.4 SCOPE

The scope of this project will cover:-

1. Designing - Study the external design of the solid cone spray pattern nozzle. Generate design concept for nozzle which will give the best solid cone spray pattern. Applied the design through Computer-Aided-Design software (Solidwork 2007 are recommended).

2. Analyzing – Develop a Computational Fluid Dynamics (CFD) model. By using the COSMOS FloWorks software, simulate the fluid flow through the nozzle to get the solid cone spray pattern. Analyze the collected data to verify the best solid-cone spray pattern that we can get.

3. Fabrication – Fabricate the concept design of the nozzles by using Rapid Prototyping.

4. Testing – Test with the actual spray nozzle that been produced by rapid prototyping process so that it can be applied for dish wash spray application.

1.5 CONTENT OVERVIEW

Chapter One describes the project objectives and its scope of study. In Chapter Two, there is a complete literature study of spray nozzle with the solid cone spray pattern. Recent applications of the solid cone spray nozzle. Chapter Three explain thoroughly about the method used to analyze the spray pattern, 3 concepts of spray nozzle that been finalize and also the method use for nozzle fabrication by using FDM machine. Also, COSMOSFloWorks step by step method. In Chapter Four, the result and data of the fluid flow simulation by using CFD software are been shown. Also include, the result for actual experiment with the used of finish product of spray nozzle which been fabricate by rapid prototyping. Lastly in Chapter Five, conclude the findings of the best criteria of the spray nozzle among the 3 concepts with the best reason. Also the recommendations for this thesis for future study.