DEVELOPMENT OF NEW SHOWER HEAD BASED ON WATER FLOW ANALYSIS

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This thesis is submitted in partial fulfilment of requirement for the completion Bachelor of Mechanical Engineering (Thermal-Fluids) with honours

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of

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DECLARATION

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

Signature: ....

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Special dedication to my mom and dad

Mr. Mustafa bin Abdul Wahab

Ms. Saadiah binti Harun

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ABSTRACT

This research was conducted on current shower head and new shower heads. There are several methods on reducing the water usage at home. The current shower head selected is due to being commonly used by consumers. With studies that have been made, findings show that a shower head is one of the home appliances that use most of water. Therefore, research has been done and found that size of the nozzle hole and shape of shower head affect the water flow of the shower head. In order to solve this problem, an approach based on the resizing the nozzle hole and changing the shape of the shower head. The current and new shower heads was compared by the effect of water flow and the shape of shower head. As a result of this study, new design (2) of shower head has the highest velocity which is 5.88 m/s compared to others. Thus, the optimum water flow required for shower obtained with consideration of water coverage on to user body.

ABSTRAK

Kajian ini telah dijalankan ke atas kepala pancuran mandi semasa dan kepala pancuran mandi baru. Terdapat beberapa kaedah untuk mengurangkan penggunaan air di rumah. Kepala pancuran mandi semasa yang dipilih adalah kerana ia biasa digunakan oleh pengguna. Dengan kajian yang telah dibuat, mendapati bahawa pancuran mandi adalah peralatan rumah yang menggunakan sebahagian besar daripada air. Oleh itu, kajian telah dilakukan dan mendapati bahawa saiz lubang muncung dan saiz kepala pancuran air memberi kesan aliran air kepala pancuran air. Untuk menyelesaikan masalah ini, pendekatan dibuat berdasarkan mengubah saiz lubang muncung dan mengubah bentuk kepala pancuran air. Kepala pancuran mandi semasa dan kepala pancuran mandi baru dibandingkan dari kesan aliran air dan bentuk kepala pancuran mandi. Hasil daripada kajian ini, rekabentuk baru 2 mempunyai kadar halaju yang paling tinggi iaitu 5.88 m/s berbanding rekabentuk lain. Jadi, aliran air yang optimum diperlukan untuk mandi dan dengan pertimbangan liputan air ke badan pengguna.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

NUM.	TITLE	PAGE
2.1	American Virgunia Stool Shower	5
2.2	Skin Pressure Measurement	8
2.3	Daily Peak Instantaneous Flow Rates, 12 Study Sites	10
2.4	Pressure Flow Relationship	11
2.5	Multiple Shower Head	12
2.6	Cascading Shower Head	13
2.7	Shower Panel	14
2.8	Rain System Shower Head	14
2.9	Body Spas System	15
2.10	Recirculating Shower Head	16
3.1	Project Flowchart	18
3.2	Vernier Calliper	19
3.3	Startup of SolidWorks	22
3.4	Balls	23
3.5	Model of Current Shower Head	24
3.6	Cross Section View of Current Shower Head	24
3.7	Model of New Design 1	25
3.8	Cross Section View of New Design 1	25
3.9	Model of New Design 2	26

LIST OF SYMBOLS

mm	=	Milimeter
m/s	=	Milimeter per second
Pa	=	Pascal
kPa	=	Kilopascal
psi	=	Pounds per square inch
GPD	=	Gallons Per Day Used For Showers
P	=	Population
SPD	=	Showers per person per day
f	=	Shower flow rate
t	=	Shower duration
$\frac{P}{\rho}$	=	Flow Energy
$\frac{V^2}{2}$	=	Kinetic Energy
gz	=	Potential Energy
V_{avg}	=	Average flow velocity (m/s)
D	=	Characteristic length of the geometry (diameter) (m)
$v = \frac{\rho}{\mu}$	=	Kinematic velocity of the fluid (/s)

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

People are using water around 150 litres per day. But, water is a precious resource that user should minimise from wasting it. If people use water wisely, it can help reducing the amount of water taken from rivers or underground water. One of the easiest way to make the most of potential benefits is to reduce the amount of water use at home.

There are a lot of home appliances use water such as, toilet, shower head, laundry, dish washer and kitchen faucet. In general, to be known that almost 38% of daily water usage is came from shower (www.south-staffs-water.co.uk, 2010). Thus, this paper will focus on shower head.

Shower head is a perforated nozzle for spraying water on a bather taking a shower (TheFreeDictionary, 2014). The bather want to feel comfortable while taking shower. The water comes out from the shower should be comfort which means not hurting the user. There are a lot of aspects that should be considered in designing the shower head properly.

This study is comparing the water flow pattern from the new designs with current design of shower head. The time taken of user in the shower also affects the amount of water usage. Water-saving shower head is the most selected as it can reduce the water usage even though the bather shower at a longer time. The new design is supposedly to be more economic in water flow compared to the current design. The analysis will be based on the comparison of the water flow.

1.2 PROBLEM STATEMENT

There are factors that should be highlighted in order to produce a good product without having any problems. Today, a homeowner has many choices to choose hundreds of models of shower head available. At the beginning of the production of shower head must have many problems in satisfying customers demand. One choice that is not available, however, is complete control of the water flow: since 1992, by law, all shower head that are manufactured in the United States must restrict water flow to 2.5 gallons (9.5 liters) per minute or less. This is down from the prior level of 4.5 gallons (17 liters) of water per minute. As a result, many shower head developed since that time aerate the water flow in order to provide a fuller spray (Peter, 2006).

The invention relates to a shower head having a housing and a surface where jets exit the housing. The surface has numerous exit apertures. Various forms of shower heads of that type have long been known and inherently have numerous modes of system (Woolf, 2005).

1.3 OBJECTIVES

The objectives of this project are as follows:

a) To design new shower heads.

b) To analyse the flow analysis of shower heads.

c) To evaluate the comparison of the new shower heads with the current design.

1.4 SCOPE OF STUDY

The scopes of this project are as follows:

a) Design new shower heads.
Shower heads are designed by using SolidWorks software.

b) Analyse water flow of the new shower heads.
The water flow of the new designs of shower heads are analysed using Computational Fluid Dynamic (CFD).

c) Analysis to compare the water flow pattern of the new shower heads and the current one.
The water flow analysis of the new shower heads are compared with the current design which focusing on velocity and pressure of the outlet.

1.5 IMPORTANCE OF STUDY

The importance of this project is to develop good shower head and compare the water flow with the selected current design of shower head. The water flow of current and new shower heads have been analysed through ANSYS Software. The results have been compared and discussed. The new development of shower head should have optimum water flow velocity.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND STUDY

Water is a scarce resources around the world. Yet, human have numerous opportunities on the best way to save it. One of the opportunities is by water preservation is the shower (Kappel and Grechenig, 2009).

2.2 HISTORY OF SHOWER HEAD

One of the earliest models was called American Virgunia Stool Shower. Developed in 1830s, the all-wood unit was made of walnut and included a revolving seat, much like a piano stool. The machine was placed in a tub, and a hand-operated lever pumped water up to the batller's head and shoulders. A foot pedal controlled the scrub brush that could be worked up and down the user's back. This unit did not only clean away the dirt and grime, it provided an aerobic workout as well.

Figure 2.1: American Virgunia Stool Shower

(Source : Etindustries, 2015)

2.3 WATER VELOCITY OF PIPE

In order to avoid noise and damaging wear and tear of pipes and fittings, the fluid flow velocities of water should not exceed certain limits. Table 2.1 shows the different application will give different velocity.

Table 2.1: Maximum Velocity of Water on Different Application

(Source: Engineeringtoolbox, 2015)

Application	Maximum Velocity (m/s)
Tap water (low noise)	0.5 – 0.7
Tap water	1.0 – 2.5
Cooling water	1.5 – 2.5
Suction boiler feed water	0.5 – 1.0
Discharge boiler feed water	1.5 – 2.5
Condensate	1.0 – 2.0
Heating circulation	1.0 – 3.0

Other than the application of the water, the cross section area of the pipe also affects the velocity of the water. The cross section area is more or less depends on the diameter of the pipe. The larger the pipe size, the velocity of water is increasing. As a rule of thumb, the following velocities can be used in design of piping and pumping system for water as shown in Table 2.2.

Table 2.2 : Water Velocity in Different Pipe Diameter
(Source: Engineeringtoolbox, 2015)

Pipe diameter (mm)	Water velocity (m/s)
25	1
50	1.1
75	1.15
100	1.25
150	1.5
200	1.75
250	2
300	2.65

2.4 THE BERNOULLI EQUATION

The Bernoulli equation is an approximate relation between pressure, velocity and elevation. It is valid in regions of stead, incompressible flow where net frictional force are negligible (A. Cengel and M. Cimbala, 2010). The pressure and velocity is inversely proportional. It means, high pressure will have low velocity and vice versa. Equation 1 shows the steady and incompressible flow in Bernoulli.

Steady, incompressible flow: $$\frac{P_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2} + gz_2 \qquad (1)$$

Where:

$\frac{P}{\rho}$ = flow energy

$\frac{V^2}{2}$ = kinetic energy

gz = potential energy

2.5 LAMINAR AND TURBULENT FLOW

The transition from laminar to turbulent flow depends on the geometry, surface roughness, flow velocity, surface temperature and the of fluid. After exhaustive experiments in the 1880s, Osborne Reynolds discovered that the flow regime depends mainly on the ratio of inertial forces in the fluid. This ratio is called as Reynolds number. It can be express for internal flow as in Equation 2 below.

$$\text{Re} = \frac{Inertial\ forces}{Viscous\ forces} = \frac{V_{avg}D}{v} = \frac{\rho V_{avg}D}{\mu} \qquad (2)$$

Where:

V_{avg} = Average flow velocity (m/s)

D = Characteristic length of the geometry (diameter) (m)

$v = \frac{\rho}{\mu}$ = Kinematic velocity of the fluid (/s)

Laminar flow generally happens when dealing with low flow velocity. Meanwhile, the turbulent flow happens at high flow velocity and larger pipe size or larger space. In turbulent, vortices, eddies and wakes make the flow is unpredictabe (A. Cengel and M. Cimbala, 2010).

2.6 DIAMETER OF NOZZLE HOLE

Often shower head performance is only judged by visuals of the spray profile. It will be shown that it is possible to maintain a good spray profile at lower flow rates, maximising water coverage on the body, by reducing the size of the holes in the spray head. Reducing the size of the holes will also shown that water temperatures on the body are only slightly lower using small holes with low flow rates than large holes with high flow rates. The spray profile is also more likely to collapse resulting in collision of droplet streams with large holes. It will be shown that atomiser sprays result in greater temperature loss in transit to the body, well understood in practice, due to the smaller droplet sizes and are therefore not an efficient means of delivery. It will also be shown that surface pressure is extremely difficult to assess (Woolf et al., 2006).

2.7 SKIN PRESSURE

The pressure applied by a shower on the skin of the consumer has been assessed (Woolf et al., 2006) at around 50 Pa, or around 5 mm water gauge. Pressure of this request can be measured utilizing the effect of a shower on a microbalance (British Standards, 1983) however this procedure is troublesome to use except for vertical impact and just to be used in laboratory.

In the present work we have utilized a method indicated as in Figure 2.2. A thin rubber diaphragm is fixed on to a plastic funnel, and connected with a thin plastic funnel to an electronic manometer with a 2000 Pa full scale and 0.1 Pa resolution (Alkhaddar et al., 2007).

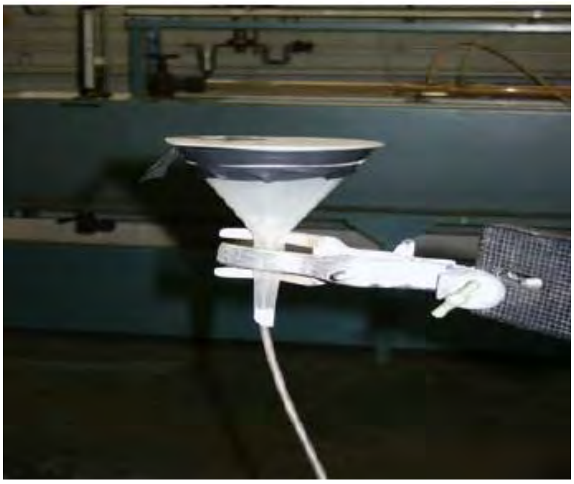

Figure 2.2: Skin Pressure Measurement

(Sources: Alkhaddar et al., 2007)

2.8 BASELINE WATER AND ENERGY CONSUMPTION

The baseline water use for showers in the United States can be used to put the water and energy savings potential into perspective. The calculations below show that showers consume 3.7 billion gallons, or approximately 9,000 acre-feet, of water every day in the United States (Peter, 2006).

$$GPD = P \cdot SPD \cdot f \cdot t \qquad (3)$$

Where:

GPD = gallons per day used for showers
P = Population = 290 million
SPD = Showers per person per day = 0.70
f = Shower flow rate = 2.2 gpm
t = Shower duration = 8.2 minutes

2.9 WATER CONSUMPTION

At the end of the information collection of The Residential End Uses of Water Study (REUWS), 28,015 complete days of data (as known as "logged days") were collected from the 1,188 participating study homes. Frequency distributions of the peak instantaneous flow rate observed during each of the logged days for each one study house were created. The frequency distribution, indicated in Figure 2.3 shows that the observed peak instantaneous flow regardless of water use classification (indoor and outside) (Peter and William, 1999).

Normally the highest flows in the single-family setting happen during irrigation and lawn watering or when re-filling a swimming pool. The peak flow required, only have been observed for a solitary 10-second interval to be included in these analyses. The majority (more than 85%) of water meters utilized as a part of this study were 5/8 inch or ¾ inch in size. The peak flow limit of a 5/8 inch meter is approximately 25 gpm and the peak flow capacity of a ¾ inch meter is more or less

35 gpm. The largest water size meter utilized as a part of this study was a 1 ½ inch meter (a bit unordinary in the single-family sector).

More than 90% of the recorded peak instantaneous flows were less than or equivalent to 15 gpm (Peter and William, 1999).

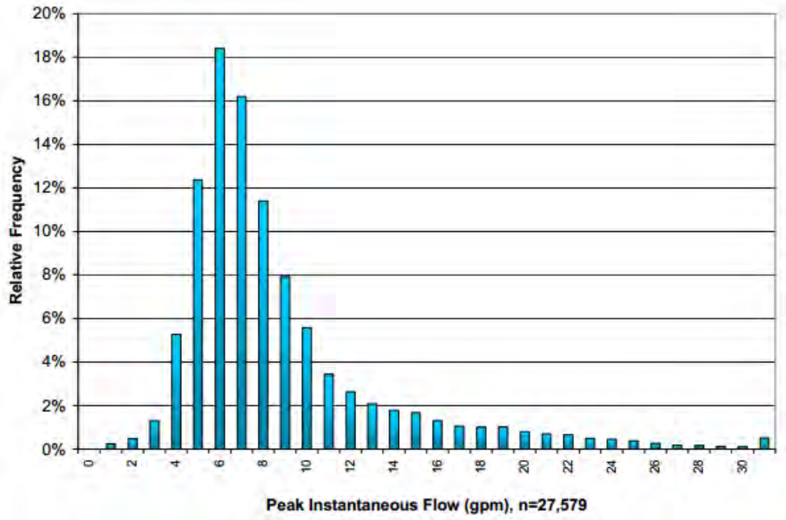

Figure 2.3: Daily Peak Instantaneous Flow Rates, 12 Study Sites.
(Sources: Peter and William, 1999)

Current national energy policy act (EPAct) standards mandate that all showerheads manufactured in the U.S. have a maximum flow rate of 2.5 gpm (9.5 lpm). Showerheads are also available at flow rates of 0.75 gpm (2.8 lpm), 1 gpm (3.8 lpm), 1.5 gpm (5.7 lpm), 1.75 gpm (6.6 lpm), and 2 gpm (7.6 lpm), although they may be harder to find at flow rates below 2.5 gpm (9.5 lpm). Before 1980, many showerheads exceeded 5 gpm (18.9 lpm) (Home-water-works.org, 2014).