UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY OF FLUID FLOW IN JUNCTION OF CAR WASHER TUBE USING CFD SIMULATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology
(Automotive Technology) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Study of fluid flow in junction of car washer tube using CFD simulation” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor Degree of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

…….

(Pn. Najiyah Safwa Binti Khasi'ie)

ABSTRACT

Wiper system is one of the driving safety systems for a vehicle. Most wipers operate together with a fluid washer and a motor pumps that supplies water from a tank to the windscreen. Conventional nozzles are usually used, but some designs use a fluidic oscillator to disperse the fluid more effectively. These various types of washer tube that have been used in automotive are washer T-tube design for Mitsubishi and Y tube design for Proton and Toyota. The main objective of this thesis is to modify the design of existing washer tube hose for three different washer tube of cars and compare the fluid flow properties by using Computational Fluid Dynamics (CFD) simulation. In order to minimize the eddy formation at the junction of washer tube, the existing junction of washer tube is replaced by a curvature junction. Washer tube hose models are designed by using Computer Aided Design (CAD) while fluid flow analysis by using CFD simulation that can save a lot of time without doing the actual experiment. By the end of this project, the results showed that the curvature junction proved can release the eddy forming a Y-junction but not at T-junction tube.

ABSTRAK

Sistem pengelap cermin kereta adalah salah satu sistem keselamatan memandu untuk sesuatu kenderaan. Kebanyakan pengelap cermin kereta beroperasi bersama dengan cecair pembasuh dan pam motor yang membekalkan air dari tangki ke cermin depan. Muncung konvensional biasanya digunakan, tetapi beberapa reka bentuk menggunakan pengayun cecair pada cermin untuk menyuraikan cecair dengan lebih berkesan. Pelbagai jenis tiub pembasuh yang telah digunakan dalam automotif adalah pembasuh reka bentuk T-tiub digunakan pada Mitsubishi dan Y-tiub digunakan pada Proton dan Toyota. Objektif utama laporan ini adalah untuk mengubah suai reka bentuk yang sedia ada pada tiub pembasuh untuk tiga kereta berbeza dan membandingkan sifat-sifat aliran bendalir dengan menggunakan Rekabentuk Terbantu Komputer. Dalam usaha untuk mengurangkan pembentukan pusaran di persimpangan tiub pembasuh, simpang sedia ada tiub mesin basuh digantikan dengan persimpangan lengkungan. Hos tiub pembasuh direka dengan menggunakan Lukisan Terbantu Komputer (CAD) manakala analisis aliran bendalir dengan menggunakan simulasi CFD yang boleh menjimatkan banyak masa tanpa melakukan eksperimen yang sebenar. Pada akhir projek ini, keputusan menunjukkan bahawa persimpangan lengkungan terbukti boleh mengurangkan pusaran yang membentuk pada persimpangan Y tetapi tidak pada tiub persimpang T.

DEDICATIONS

I would like to dedicate this to my father, Abdullah B. Ahmad and my mother, Noraini Bt Bujang, my supervisor, Ms Najiyah Safwa Binti Khashi'ie, Sir Azwar Bin Azhari, Sir Khairum Bin Hamzah, Sir Afdal Bin Shamsudin and my friends for supporting me from the beginning until the end of this project.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CAD	-	Computer Aided Design
CATIA	-	Computer Aided Three-Dimensional Interactive Application
CFD	-	Computational Fluid Dynamics
$K-\varepsilon$	-	K-epsilon
K	-	Kelvin
m	-	metre
mm	-	millimetre
m/s	-	metre per second
Re	-	Reynold Number
SA	-	Sparlart-allmaras
SST	-	shear stress transport
Pa	-	Pascal
τ	-	shear stress
μ	-	absolute (dynamic) viscosity
$\frac{dV}{dy}$	-	time rate of strain
f	-	Darcy friction factor

CHAPTER 1
INTRODUCTION

1.0 Introduction

This section will introduce the study of fluid flow in junction car washer tube using CFD simulation. The first section will discuss the fluid flow, type of car washer pipe and CFD simulation. The second section is problem statement. The third section is objectives of study. Lastly, is about the scopes of study.

1.1 Background of the Study

Wiper is a component that used to clean the raindrops or any water at the windscreen. Wipers are made and designed to make driver sight clear and driver concentration during the driving to see the road at windscreen. Most of cars have one viper on the rear window, two wipers on the windscreen, and the other on each headlight (Hashim et al., 2013).

Nowadays, every vehicle is provided with a windshield washer device to spray windshield washer fluid on the windshield of the vehicle when operated by a driver for cleaning the windshield with the operation of one or two windshield wipers (Cited et al., 2003). Windshield wipers, nozzles, tubing, a pump, and a reservoir designed to contain water are equipped with a windshield washer system comprising to all vehicles (Lengsfeld et al., 2008). For the rear window, some vehicles are provide an additional jet nozzle and the associated tubing for spraying washer fluid on the back window (Cited et al., 2003).

A washer fluid pump for a window cleaning system of an engine vehicle may include a housing with an electromotive drive which is masterminded in the housing, a pump unit which can be driven by the electromotive drive, and a ventilation opening which is arranged in the housing, where in an opening which is arranged on the internal side of the housing is counterbalanced or slanted concerning the ventilation opening (Cited et al., 2003).

Wiper washer hose also known as washer tube is use to flow water from wiper motor and wiper tank to the nozzle hose to dispersed water to the windshield screen. Washer tube diameter bigger than motor hose and nozzle hose to easily connect and to avoid water flow out from the washer tube (Doyle et al., 2012).

1.2 Problem Statement

Wiper system is one of the driving safety systems for a passenger car. Most wipers operate together with a windshield washer; a windshield motor pumps that supplies water from a tank to the windscreen. The fluid is dispensed through small nozzles mounted on the hood. Conventional nozzles are usually used, but some designs use a fluidic oscillator to disperse the fluid more effectively. These various types of washer types of washer tube uses in automotive; type T, Y and L tubes. For example, Mitsubishi mirage used washer T tube while proton saga and Toyota AE101 use Y tube.

Current study suggested the installation of arc junction to replace the existing junction. The arc junction may avoid eddy forming in pipe junction when the water flow to the junction (Li et al., 2013) and decrease the pressure losses during the water flow passed into the junction.

1.3 Project Objective

a) To redraw a CAD model of washer tube in wiper hose system.
b) To design a new structure of washer tube in wiper hose system and compare with the existing washer tube.
c) To simulate and compare the fluid flow properties in the washer tube of wiper hose system for different car.

1.4 Scope of Project

a) Redrawing a CAD model for branch tube of wiper hose system for different car using CATIA.
b) Designing a new structure of washer tube and compare with the existing washer tube using CATIA.
c) Simulate and comparing the fluid flow properties in the branch tube of hose wiper system for different car using CFD simulation (SolidWorks).
d) Assume the inlet value and pressure for the different car is same.

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CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Pipe networks are very familiar in industries, where fluid or gases to be transported from one location to the other. The pressure loss may vary depending on the type of components coming across in the network, the fluid that is being transported through the network and pipe fitting (Hirani et al., 2013).

Besides the pipe, the network also consists of elbows, T-junctions, bends, contraction, expansion, valves, meters, pumps, turbines and many other components that will cause of pressure loss due to change in flow momentum due to friction and pipe components. This means that the inflow of energy change to heat due to friction or energy loss due to turbulence (Vasava, 2007).

Pipe flow, a branch of hydraulics and fluid mechanics, is a type of liquid flow within a closed conduit (conduit in the sense of a means of containment). The other type of flow within a conduit is open channel flow. These two types of flow are similar in many ways, but differ in one important aspect. Pipe flow does not have a free surface which is found in open-channel flow. Pipe flow, being confined within closed conduit, does not exert direct atmospheric pressure, but does exert hydraulic pressure on the conduit (Avila et al., 2011).

The behaviour of flow at the junction will changes, depending on the inflow and outflow directions (Vasava, 2007). Car washer tube have similarity with T-junction and Y-junction pipe that have inflow and outflow direction to allow the water flow inside the hose. Normally, the washer fluid is stored in a specified tank

inside the engine compartment and is supplied to the spray nozzle through a washer tube formed from a resin or a rubber elastomer (Doyle et al., 2012).

2.1 Washer tube

Washer tube is an application that used in branched pipe design in wiper system. Washer tube is made from plastic, and their feature does not absorb water and drain the water directly to the wiper washer tube nozzle. The washer fluid is stored in a specified tank inside the engine compartment and is supplied to the spray nozzle through a washer tube formed from a resin or a rubber elastomer (Doyle et al., 2012). Figure 2.1 show the position of washer tube in wiper system that use on this days:

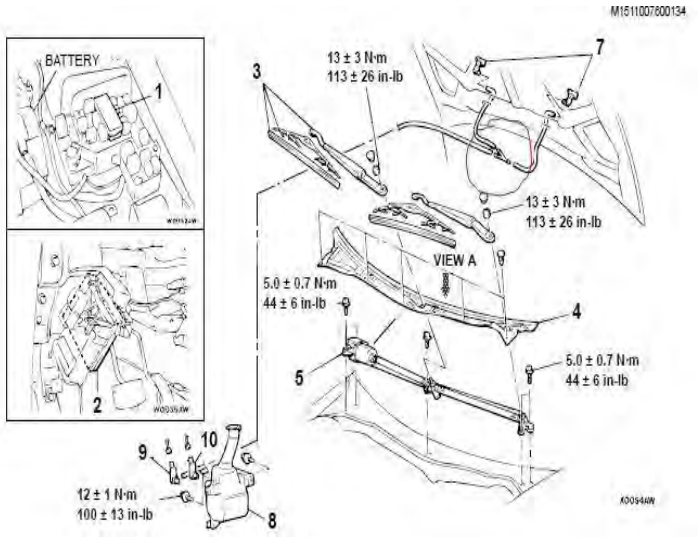

Figure 2.1: washer tube are located under the front bumper

(Source: https://www.ar15.com/archive/topic.html?b=1&f=134&t=1039177 5/11/2010)

Washer wiper tube has similarity with pipe concept. According to (Vasava, 2007), pipe network also consists of elbows, T-junctions, bends, contractions, expansions, valves, meters, pumps, turbines and many other components. Washer tube also have this type of shape that using in automotive industries. Washer wiper tube is used determined by the number of nozzle used on a vehicle. Figure 2.2, 2.3 and 2.4 shows T type and Y type are commonly used only to vehicles which has two wiper nozzles and elbow type only used to a vehicle with only one wiper nozzle.

Figure 2.2: T type of washer tube

Figure 2.3: Y type of washer tube

Figure 2.4: Elbow type of washer tube

2.2 Pipe

Nowadays, piping is a system of pipes used to deliver fluids such as liquids and gases from one location to another location in industry (Hirani et al., 2013). The type of components coming across in the network, material of the pipe, the fluid that is being transported through the network and pipe fitting are the factors that can occur the pressure losses (Hirani et al., 2013). Fittings are used in plumbing and pipe systems to connect tubing sections or straight pipe, to adapt to different shape or size, and for other purposes, for example for measuring or regulating fluid flow (Singh et al., 2013).

2.2.1 Type of pipe

Tee pipe are used to either dividing or combining a fluid flow. Most common are equal tees which have the junction diameter and equal body but there is also a wide range of decreasing tees where either the body or the junction are different diameter relative to each other (Smith, 2014).

According to (Vasava, 2007), tee pipe are used to unite flows from many pipes to a single major pipe and split the flow from main pipe to other junction of pipes . Depending on the inlet and outlet directions the behavior of flow at the junction definitely changes .The figure 2.5 below shows some potential of fluid exit and entering the junction.

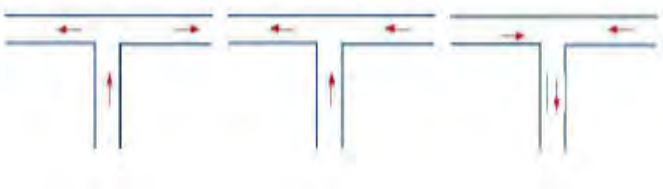

Figure 2.5: Example possibilities of fluid (liquids or gasses) flow inside and outside the junction (Vasava, 2007).

A wye pipe is where the branch enters the body at an arc and is used to minimize the frictional losses and promote flow in the system. A wye pipe is where the branch is stabbed into the body at an angle (Smith, 2014).

Wye pipe fittings are with three openings and are used to create branch lines. A wye tee is where the branch is stabbed into the body at an angle usually 45 degrees and is usually used where the branch is a smaller diameter than the main pipe (Satyendra, 2015).

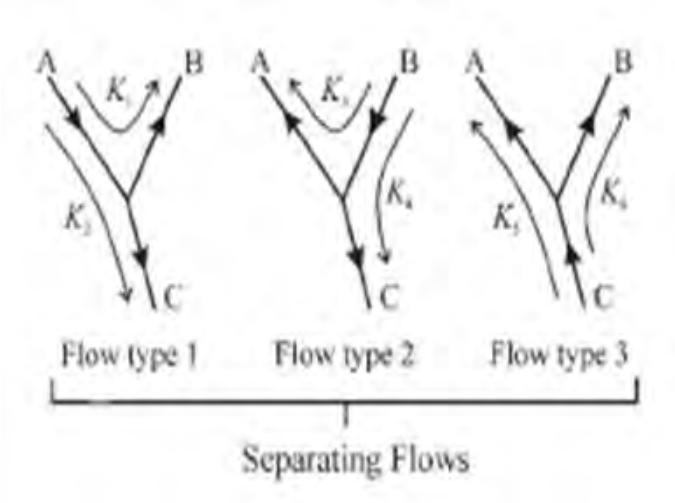

Figure 2.6: Possibilities of split fluid flow in the junction (Bassett, Winterbone and Pearson, 2001).

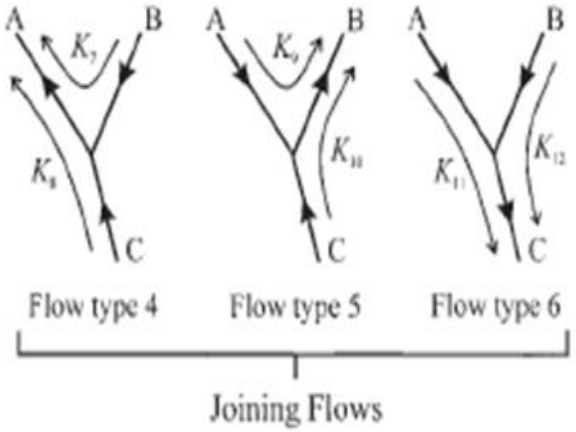

Figure 2.7: Possibilities of combining fluid flow in the junction (Bassett, Winterbone and Pearson, 2001).

2.3 Fluid properties

Fluids can be categorized as either gases or liquids. The most notable differences between the two states are that liquids are far denser than gases, and gases are highly compressible compared to liquids (liquids are relatively incompressible). The most important fluid properties taken into consideration in a water distribution simulation are specific weight, fluid viscosity, and (to a lesser degree) compressibility (Walski, 2001). Fluid flow is classified as external and internal, depending on whether the fluid is forced to flow over a surface or in a conduit. Internal and external flows exhibit very different characteristics (Page, 2004).

2.3.1 Viscosity

Fluid viscosity is the property that describes the ability of a fluid to resist deformation due to shear stress (Walski, 2001). For many fluids, most notably water, viscosity is a proportionality factor relating the velocity gradient to the shear stress, as described by Newton's Law of Viscosity at equation 2.1 below:

$$\tau = \mu \frac{dV}{dy} \qquad \text{Eq 2. 1}$$

Where τ = shear stress

μ = absolute (dynamic) viscosity

$\frac{dV}{dy}$ = Time rate of strain

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress. For fluids only, viscosity is "thickness" or "internal friction". Thus, water is "thin", having a lower viscosity, while honey is "thick", having a higher viscosity. Put simply, the less viscous the fluid is, the greater its ease of movement (fluidity) (Kotelnikov et al., 2000).