UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF DIFFERENT THICKNESS OF CHROME SPRAY ON THE EXHAUST PIPES

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

By

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FACULTY OF ENGINEERING TECHNOLOGY
2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **EFFECT OF DIFFERENT THICKNESS OF CHROME SPRAY ON THE EXHAUST PIPES**

SESI PENGAJIAN: **2017/18 Semester 1**

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APPROVAL

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

……..

(Project Supervisor)

EN KHAIRIL AMRI BIN KAMARUZZAMAN

ABSTRAK

Sistem ekzos dalam keadaan yang baik adalah penting untuk menjimat minyak kereta, untuk alam sekitar dan keselamatan penumpang. Fungsi sistem ekzos kereta adalah untuk menyalurkan apabila bahan api dan udara dibakar di dalam ruang pembakaran. Gas-gas ini berbahaya untuk manusia dan alam sekitar. Pemeriksaan sistem ekzos adalah penting untuk keselamatan kita dan keluarga kita. Kita harus memastikan tiada lubang dalam sistem ekzos atau di dalam petak penumpang di mana asap boleh masuk dan berbahaya untuk kita. Bukan sahaja masalah kakisan yang merosot akan memendekkan jangka hayat kenderaan ekzos. Kotoran, kelembapan, pasir dan objek asing juga boleh memberi kesan kepada paip ekzos dan jangka hayatnya. Objektif kajian ini adalah untuk menentukan lapisan krom yang paling minimum yang diperlukan untuk melindungi paip ekzos apabila eksoz melanggar bonggol atau batu di jalan. Objektif kedua adalah untuk menentukan kesan kepada ekzos paip apabila berat 1.25kg, 1.5kg dan 2.5kg dijatuhkan pada ekzos paip yang mempunyai enam lapisan krom yang berlainan. Ketebalan krom yang berbeza akan menjejaskan kadar kakisan pada paip ekzos. Sifat mekanikal paip ekzos merupakan tumpuan utama untuk mengkaji tentang kakisan terhadap paip ekzos. Kajian kinetik mengenai kadar kakisan paip ekzos akan dimasukkan ke dalam projek ini untuk mempelajari tentang kekuatan bahan-bahan untuk keselamatan dan juga pengurangan bunyi untuk pemandu kereta. Selain itu, paip ekzos telah menjalani ujian jatuh, ujian hentam dan ujian kesan untuk mempelajari tentang perubahan sifat-sifat dan struktur terhadap ekzos paip. Faktor-faktor luaran untuk kadar kakisan paip ekzos baru dan lama termasuk suasana persekitaran. Dari eksperimen, kajian mendapati bahawa 3 lapisan merupakan lapisan yang terbaik dan paling minimum untuk paip ekzos daripada menahan dari hentaman batu dan bonggol di jalan raya. Analisis untuk paip ekzos yang berkarat menunjukkan bahawa sifat mekanikal dan mikrostruktur yang telah berubah dan bertukar. Ekzos paip yang bersalut krom yang tebal dan baik telah membuktikan bahawa ia tahan lebih lama daripada kotoran, air, gas toksik dan tar di jalan raya. Paip ekzos dengan lapisan yang nipis tidak dapat bertahan lama berbanding dengan ekzos yang bersalut krom yang tebal.

ABSTRACT

Exhaust system in good working condition is vital for fuel mileage, the environment and the safety. The car's exhaust system carries away the gases created when the fuel and air are burned in the combustion chamber. These gases are harmful to humans and our environment. Frequent check of our exhaust system is a must to provide our safety and our family's safety. Make sure there are no holes in the exhaust system or in the passenger compartment where exhaust fumes could enter. The problem statement would be not only corrosion that deteriorates the lifespan of exhaust vehicles. Dirt, humidity, sand and foreign objects also can affect the condition of the exhaust pipes and its lifespan. The objectives of this study is to determine minimum layer of chrome coating needed to protect the exhaust pipes when it hits the bump or rocks on the road. The second objective is to investigate the effect of different sets of weights 1.25kg, 1.5kg and 2.5kg dropped on the six different layers of chrome coating thickness. The different thickness will affect the corrosion rate on the exhaust pipes. The factors that might affect the speed of corrosion are first, the layer of coating, the chemical reaction happening at the bottom of the vehicle. The mechanical properties of the exhaust pipes were the main focus to study the corrosion of exhaust pipes. Kinetic study of corrosion rate of the exhaust pipes will be included in this project in order to know the durability of materials for the safety and also noise reduction for the drivers of cars. Then, the exhaust pipes underwent, drop test dent test and scratch test to investigate the changes of the properties and structure. The external factors for corrosion rate of new and old exhaust pipes include surrounding environment. From experiment, 3 layers of coating are the best and minimum layer of coating for the exhaust pipes to withstand knocks from rocks and bumps on the road. The result for the old corroded exhaust pipe shows that the mechanical properties and its microstructure has been changed and altered. The coated chrome exhaust pipe by thick and good chrome material proved it lasts longer and more durable to dirt, water, gases and tar on the road. The exhaust pipe with thinner layer less lasting compared to thick and good material of chrome coating.

DEDICATION

Dedicated to my father, CHEAH YEW CHONG, my mother, TAN TECK SEOK and my two sisters, CHEAH WEN NEE and CHEAH ANN NEE. To my supervisor EN KHAIRIL AMRI BIN KAMARUZZAMAN, all the lecturers in UTeM and my friends for their help and their motivation for me to complete this report.

ACKNOWLEDGEMENT

Thanks god for His blessings and guidance, I have finally completed this project within my expectation even though there are many challenge and obstacle along the way. Though, I still managed to finish my part and I am very happy about it.

First of all, I would like to express my appreciation and deep respect to my supervisor, En Khairil Amri Bin Kamaruzzaman for his guidance and support during the time phase of this project. His constant guidance and support during my thesis writing is invaluable to me and continuous direction and opinion regarding the flow of the project has contribute a lot in achieving the objectives of the project.

Thanks to my family, who has been the constant advisor for giving me continuous support and inspiration throughout my campus life. Their supports meant so much for me to finish this report.

Last but not least, I would like to thank everyone who involved directly and indirectly in this project. The sacrifice and commitment given towards me earning my Bachelor's Degree are indescribable and without them, this PSM report will never be able to be completed in time.

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FTK	-	Fakulti Teknologi Kejuruteraan
mm	-	Millimeter
UTeM	-	Universiti Teknikal Malaysia Melaka
V8	-	Valve 8
SUH 409	-	Stainless Steel 409 (Grade H)
SUS 430	-	Stainless Steel Grade 430 (UNS S43000)
SKTM 11A	-	Carbon Seamless Pipe For Machine

CHAPTER 1
INTRODUCTION

1.0 Background

In the automotive industry, car manufacturers are dealing with corrosion almost every day. Corrosion is attacking their products of steel and metal parts and decreases the sales value. They create a hole on their product and rust over time. Anyone who owns a vehicle will face rust issue after some time. Rust usually happens when the paint job wears off and the body of the car in contact with the surrounding environment.

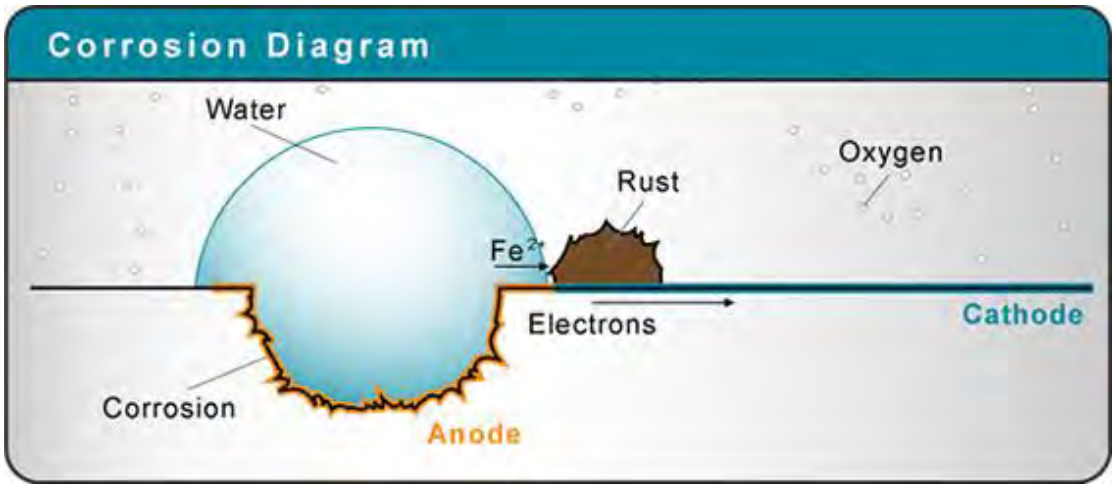

Figure 1.1: Corrosion chemical reaction diagram

Corrosion happens when the paint job finishes. From insects, dirt and bird droppings, as they inhabit the car body for a period of time. They stick to the body of the car and they are difficult to remove. A chemical reaction of rust is explained in Figure 1.1 When the paint of the car wears off over time, the car has a higher chance of facing corrosion (Silman, 1972). When the car passes the coast line of country every day, it has a higher chance of experiencing corrosion than in normal town drive. A scratch on the car body

can initiate the rust to starts and lead to corrosion. In terms of protecting the car body paint job, washing the car in a certain period of time can prevent those dirt, bird droppings and earth which contain a high amount of acid, water and oxygen from having a chance to start the corrosion process. As the layer of paint body is still available, it prevents contact with oxygen and air which are the main contributions to corrosion.

Figure 1.2: Corrosion on muffler leak

Apart from car body, corrosion does affects other car parts which are not visible to us until damages occur and give signs to the driver through sound or changes in driving experience. In Figure 1.2, we can see corrosion on muffler leak. Example parts of vehicle system which corrosion might attack and not visible from outside is electronic system, brake lines, fuel pumping and electrical wirings.

1.1 Problem Statement

In the 1950s, car manufacturers face corrosion mostly in the coastal and sea areas where a high amount of salt is available in the air (Lebozec & Thierry, 2010). However, in snow belt countries in the United states in the year 1970's, automotive industry faces a big problem from de-icing vehicles which produces a huge amount of cold temperature water and unable to evaporate due to cold water (Dosdat, Petitjean, Vietoris, & Clauzeau, 2011). As corrosion problems slowly affect the car automotive industry, car companies have made an effort to introduce anti-corrosion ways to prevent

corrosion from infiltrate our car body. Rust related damages which cost the locals in the United States every year are approximately $23.4 billion (Mizuno, Suzuki, Fujita, & Hara, 2014):

$14.46 billion — Vehicle damage by corrosion

$6.45 billion — Maintenance fees and corrosion repairs

$2.56 billion — Vehicle insulation and body finishes of new cars

1.2 Objective

In general, the objective of this experiment is to test the effect of different thickness of chrome layer on the exhaust pipes.

The specific objectives of this case study are as listed below:

- To identify the minimum number of chrome coating layer needed to protect from reaching the base.
- To test the effect of 1.25kg, 1.5kg and 2.5kg on six different thicknesses of chrome layer coating on the exhaust pipes.

1.3 Scope

These case study centres on optimizing the best protection layer or coating for the vehicle exhaust system. Hence, data collection will be limited to car exhaust pipe at the bottom of a normal car. As the car exhaust system consists of exhaust manifold, muffler, catalytic converter, exhaust tip and exhaust pipes (Muraki & Zhang, 2014). In addition, a single technique is used to develop an improved way of protection for the exhaust pipes. The technique used is the insulation which is applied on the elements with different percentage of thickness and time taken for each layer of specific material of coating. Moreover, this report is also limited to a single type of material of coating which is chrome, which is the standard material for car exhaust pipe coating. The variables of this experiment are the time taken and the thickness of layer.

1.4 Limitation

The case study on corrosion on car exhaust system begins with identification of the problem, objectives and scope of project as illustrates in Figure 1.1. Basically, the problem statement of this case study is to find the new method to prevent corrosion in exhaust pipe of a normal car on the road focusing on the joints and the most prominent part of the whole car exhaust system that is prone to corrosion, which is the bottom of the car that are exposed to water and dirt (Twigg, 2007).

Meanwhile, the objectives from this case study are to design a new method to protect our exhaust pipes from rust and corrosion effect. The specific objectives of this case study are to identify the best coating to be used in car exhaust system and also to design better and improved ways to prevent corrosion in car exhaust system. The scope of the case study is limited to the data contained in the electronegativity chart. Not much element can be experimented in this research as cost is concerned and the difficulty to find rare elements which is expensive (Polukarov, Safonov, Edigaryan, & Vykhodtseva, 2001). Chromium, nickel, copper and gold are the examples of elements used in electroplating.

At the same time, this case study is only limited to a single type of coating material and only one method is used to solve the corrosion problem. After identifying the problem details, the technique and performance measure used are identified. Specifically, the chromium coating is to be applied to the exhaust pipes are investigated from the aspect of time taken and the thickness level to be experimented further. Then, data collection is conducted on the selected case study of chrome only. In this research the chrome has been selected as the case study material. Based on the data collected, experiment is conducted. The experiment includes development of a new layers based on the collected data. The improvised result is then compared to the existing layer used in the market and conclusion is drawn.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

As mentioned, automotive manufacturers began to place a stronger focus on corrosion protection during the 1970s (Woodman, Anderson, Jayne, & Kimble, 2009). This led to the increased use of an automotive metal finishing technique called electroplating. In simple terms, metal plating in Figure 2.1 entails the deposition of metal ions onto the surface of a metal part, which is known as the substrate. These metal ions are one component used to produce an electrolyte solution, commonly referred to as a plating bath. A DC electrical current is used to initiate a reaction that causes the deposition of the metal ions found in the plating bath onto the surface of the substrate, forming a thin, protective metal coating (Riegel, Neumann, & Wiedenmann, 2002).

Figure 2.1: Rust and Corrosion on Joint of Exhaust Pipe

Metal finishing for vehicles on the road are necessary to provide a protective coating against corrosion. For many years, companies and researchers have provided effective plating solutions that are widely used throughout the automotive industry. In addition to rust protection, automotive plating can be performed to brighten the finish

on metal or non-metal parts and even metallize plastic parts to improve sturdiness. There are a number of metals that are used when implementing electroplating as an automotive metal finishing technique.

2.2 Exhaust System

An exhaust system is usually piping used to guide reaction exhaust gases away from a controlled combustion inside an engine or stove. The entire system conveys burnt gases from the engine and includes one or more exhaust pipes. Depending on the overall system design as in Figure 2.2, the exhaust gas may flow through one or more of cylinder head and exhaust manifold, a turbocharger to increase engine power, a catalytic converter to reduce air pollution and a muffler known in North America or silencer known in UK or India functions to reduce noise created by the constant emission of end product of engine combustion in a single car engine (Benajes, Reyes, Bermudez, & Serrano, 2008).

Figure 2.2: Exhaust system of the Opel Corsa B 1.2 petrol

2.2.1 Exhaust Design Criteria

An exhaust pipe must be carefully designed to carry toxic and noxious gases away from the drivers of the cars and also trucks. Indoor cabin space and environment can quickly fill an enclosed space with poisonous exhaust gases such as hydrocarbons, carbon monoxide and nitrogen oxides, if they are not properly vented to the outdoors. Also, the gases from most types of vehicles are very hot. Therefore the pipe must be heat-resistant, and it must not pass through or near anything that can burn or can be damaged by heat.

A chimney serves as an exhaust pipe in a stationary structure. For the internal combustion engine it is important to have the exhaust system tuned or also known as tuned exhaust system for optimal efficiency. Also this should meet the regulation norms maintained in each country. In China, the regulation number for exhaust emission is China 5. In European countries, the regulation number is EURO 5 and in India is BS-4 (Rego, Hanriot, Oliveira, Brito, & Rego, 2014).

2.2.2 Tailpipe of Exhaust

With trucks, sometimes the silencer is crossways under the front of the cab and its tailpipe blows sideways to the offside, right side if driving on the left, left side if driving on the right. The side of a passenger car on which the exhaust exits beneath the rear bumper usually indicates the market for which the vehicle was designed. Japanese and some older British vehicles have exhausts on the right so they are furthest from the curb in countries which drive on the left, while European vehicles have exhausts on the left (Muraki & Zhang, 2000).

The end of the final length of exhaust pipe where it vents to open air, generally the only visible part of the exhaust system part on a vehicle, often ends with just a straight or angled cut, but may include a fancy tip. The tip is sometimes chromed. It is often of larger pipe than the rest of the exhaust system. This produces a final reduction in pressure, and sometimes used to enhance the appearance of the car.

In the late 1950s in the United States manufacturers had a fashion in car styling to form the rear bumper with a hole at each end through which the exhaust would pass (Mizuno et al., 2014). Two outlets symbolized V-8 power, and only the most expensive cars such as Cadillac, Lincoln, Imperial, Packard were fitted with this design (Jaaskelainen, 2007). One justification for this was that luxury cars in those days had such a long rear overhang that the exhaust pipe scraped the ground when the car traversed ramps. The fashion disappeared after customers noted that the rear end of the car, being a low-pressure area, collected soot from the

exhaust and its acidic content ate into the chrome-plated rear bumper.

When a bus, truck or tractor or excavator has a vertical exhaust pipe called stacks or pipes behind the cab, sometimes the end is curved, or has a hinged cover flap which the gas flow blows out of the way, to try to prevent foreign objects including droppings from a bird perching on the exhaust pipe when the vehicle is not being used) getting inside the exhaust pipe (Moos et al., 2002).

In some trucks, when the silencer is front-to-back under the chassis, the end of the tailpipe turns 90° and blows downwards (Sprouse & Depcik, 2013). That protects anyone near a stationary truck from getting a direct blast of the exhaust gas, but often raises dust when the truck is driving on a dry dusty unmade surface such as on a building site (Fu, Chuang, Li, & Yang, 2004).

2.2.3 Exhaust Pipe Material

Exhaust systems are developed to control emissions and to attenuate noise vibration and harshness to meet the regulatory requirements. The exhaust system components are manifold, close coupled and under body catalytic converters, flexible bellow, muffler, resonator, connecting pipes, flanges, and tailpipe. The part of the exhaust system containing the manifold, converter and the flex joint is named as hot end since this part of the system is relatively hot due to the hot exhaust gas passing through these components.

The part consists of intermediate pipe, resonator and the muffler is named as cold end since the gas tends to cool down from the exit of the flex tube. The temperature of the hot end of the gasoline operated vehicle can be as high as 1050°C while the highest temperature of the cold end is about 650°C (Yang, Yuan, & Lin, 2003). Material selection of an exhaust system depends on several parameters like usage temperature, geographical region and application. Depending upon the vehicle application, the material selection differs. The materials mostly used in exhaust systems are cast iron, stainless steel, mild steel or carbon steel (Karri & Helenbrook, 2007).

Recent trends towards light weight concepts, cost reduction and better performance, designers are progressing towards sheet metals. Nowadays, stainless steels are used in flexible bellows, catalytic converter, resonators, mufflers, pipes. Mild steel or carbon steel is used for flanges, pipes, and mufflers. The addition of elements plays an important role in deciding the performance, manufacturability and self-life (Davies, 2003). Examples such as carbon increase the hardness, hardenability while reducing the ductility. Silicon increases the ductility, strength and corrosion resistance.

The manganese helps in increasing the ductility, weld ability. Sulphur and phosphorous addition reduces the ductility and increases the brittleness. Molybdenum addition increases the hardenability, hardness, strength, corrosion resistance. Chromium, nickel and titanium enhance the corrosion resistance (Miller et al., 2000).

Figure 2.3: Muffler Assembly

Muffler assembly is responsible for noise, vibration and harshness reduction. Figure 2.3 shows the muffler assembly. The muffler assembly consists of end plates, baffle plates, perforated and non-perforated pipes, absorption material of glass wool and shell. A representative muffler assembly is shown in Figure 8.

The materials used must provide good strength, corrosion resistance. The materials used for absorption material are mostly glass fibre mat, molded fibre glass mat with binder, glass fibre bulky wool (E1, E2) (Li, Zhang, Huang, Wang, & Bi, 2014). The materials used

for these components are SUH 409L, SUS 436LM, SUS 439L, SUS 436L, SA1D, STKM 11A, SKTM 12A, SUS 436J1L, SUS 432L, SUS 429LM, SUS 441L and SUS 430J1L (Li et al., 2014).

Figure 2.4: Intermediate Pipe

The intermediate pipes are used for connecting the exhaust system components. The function of intermediate pipe as in Figure 2.4 is to help the flow of the gas and also provide thermal management. The pipes should provide good ductility, weld ability. The materials used for the pipes in the hot end should provide good thermal requirements and corrosion resistance. The pipes used for cold end should provide good corrosion resistance. The materials normally used are SUH 409 L, SUS 430, SUS 436LM, SUS 439L, SUS 304, SUS 441 L, SKTM 11A, STZC30, STZC 52 and SUS 436L (Li et al., 2014).

2.3 Electroplating

Electroplating is a process that uses electric current to reduce dissolved metal cations so that they form a thin coherent metal coating on an electrode (Lou & Huang, 2006). The term is also used for electrical oxidation of anions onto a solid substrate, as in the formation silver chloride on silver wire to make silver or silver-chloride electrodes (Almeida & Morcillo, 2000). Electroplating is primarily used to change the surface properties of an object. For an example, abrasion and wear resistance, corrosion protection, lubricity, aesthetic qualities, but may also be used to build up thickness on undersized parts or to form objects by electroforming.