UNIVERSITI TEKNIKAL MALAYSIA MELAKA

WASTE ENGINE OIL INFLUENCE ON VISCOSITY AND RHEOLOGY PROPERTIES OF ASPHALT BINDER

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

By

MUHAMMAD NASIRUDDIN BIN MAZLAN

B071610684

941012-07-5443

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **WASTE ENGINE OIL INFLUENCE ON VISCOSITY AND RHEOLOGY PROPERTIES OF ASPHALT BINDER**

SESI PENGAJIAN: **2019/2020 SEMESTER 1**

Saya **MUHAMMAD NASIRUDDIN BIN MAZLAN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

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

Disahkan oleh:

Alamat Tetap:

No 8 Jalan SG 6/7

Taman Sri Gombak 68100

Batu Caves Selangor.

Cop Rasmi:

MOHD FARIDUDDIN BIN MUKHTAR
Pensyarah
Jabatan Teknologi Kejuruteraan Mekanikal
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Waste Engine Oil Influence on Viscosity and Rheology Properties of Asphalt Binder" is the result of my own research except as cited in references.

Signature : .....

Name : Muhammad Nasiruddin Bin Mazlan

Date : 15/1/2020

APPROVAL

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

Signature :.....

Supervisor : EN. MOHD FARIDUDDIN MUKHTAR

ABSTRAK

Bahan buangan seperti sisa minyak enjin merupakan bahan buangan yang memberikan kesan kepada pencemaran alam sekitar. Keadaan pencemaran persekitaran yang membimbangkan terutamanya melibatkan sisa buangan minyak enjin telah membawa kepada tercetusnya kaedah alternatif yang baru untuk mengatasi masalah ini. Kajian ini dijalankan untuk mengkaji pengaruh minyak enjin buangan (WEO) terhadap asfalt dari segi kelikatan dan sifat reologi. Dua jenis asphalt yang dicampur bersama WEO pada kepekatan 4% dan 8% telah diuji. Dalam kajian ini, terdapat dua peralatan asas yang digunakan iaitu Fourier Transform Infrared (FTIR) dan Kelikatan Putaran (RV). Hasil kajian mendapati kelikatan campuran WEO dan asfalt pada 4% dan 8% untuk sampel A dan B, tidak memberi perbezaan yang signifikan. Namun begitu, kesemua campuran menghasilkan kelikatan dibawah 3 Pa bersesuaian dengan kelikatan campuran asfalt untuk pembinaan jalan. Analisa FTIR pula menunjukkan terdapat perbezaan kumpulan fungsi di antara asfalt sampel A dan B. Manakala campuran WEO dan asfalt pada kepekatan 4% dan 8% menunjukkan kumpulan fungsi yang sama iaitu C-H group, alkane dan asid karboksilik. WEO diubahsuai dengan asfalt dapat membantu memperbaiki mengurangkan kelikatan pengubahsuaian dan seterusnya akan dapat mengurankan suhu pembinaan.

ABSTRACT

Waste material such as waste engine oil is vital to the environment as it will bring pollution to the environment. Worsening environmental condition due to waste engine oil has leads to ways to find new alternative method to overcome this problem. This research is conducted to investigate the influence of Waste Engine Oil (WEO) towards asphalt binder in terms of viscosity and rheology properties. Two type of Asphalt were mixed with the WEO at 4% and 8% concentration. For this research, two basic equipment were which were Fourier transform infrared (FTIR) and Rotational Viscosity (RV). Result showed that there was no significant difference in viscosity between asphalt A and asphalt B. However, all mixture samples showed viscosity below 3 Pa, suitable for asphalt viscosity for construction. FTIR analysis showed that there were difference in functional groups for asphalt A and B. Meanwhile the WEO and asphalt mixture at 4% and 8% concentration resulted with similar functional groups of C-H, alkanes and carboxylic acid. The WEO and asphalt mixture may help to improve the viscosity if the modifier and subsequently reduce the construction temperature. On top of that, the usage of WEO is environmental friendly and help to reduce pollution for sustainable environment.

DEDICATION

To my beloved family

Mazlan bin Abas

Jamaiyah binti Jamaluddin

Muhammad Zulfadhli bin Mazlan

Nurzafirah binti Mazlan

Muhammad Zulhusmi bin Mazlan

Nurayuni binti Mazlan

Nuraishah binti Mazlan

Muhammad Najmuddin bin Mazlan

Thank you for all of your support, prays, patient, sacrifices and ideas to share with me.

To my honoured supervisor

Encik Mohd Fariduddin bin Mukhtar

And my co-supervisor,

TS. Shikh Ismail Fairus bin Shikh Zakaria

All UTeM's lectures

Thank you for always giving me a guidance and persistent help to complete this project.

ACKNOWLEDGEMENT

All praise belong to ALLAH (SWT) the most beneficent and merciful. He gave strength, health body and perseverance to me to be able to complete this report and project. I've gave my effort to complete this project and work hard to finish this thesis. However, it would have not been possible without the kind support and help from each individuals. Especially the one that assist me in my project. They have inspire and giving full thought to me during this project. Firstly, I would like to express our gratitude to my supervisor Encik Mohd Fariduddin Bin Mukhtar that gave me moral support and guided in different matters regarding this project and thesis. I'm lucky to have a patient and supportive supervisor that helps me go through this semester. Without his supervision and persistent supports this project would not finish successfully. Besides that, I also want to express my gratitude towards my beloved parent and families especially my sister that help me a lot for the unceasing encouragement, blessing, and prays. They are my back bone to completing this project. Not to forget to my friends who gave encouragement and ideas in this project. In addition, I'm very indebted for those who give me a chance to ask general information regarding this project. And also my big appreciations to the people that directly or indirectly helped me finishing this project. Lastly, thank you so much from the bottom of my heart to be part of helping me in my final project.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATION

WEO	Waste Engine Oil
FTIR	Fourier Transform Infrared
RV	Rotational Viscosity
PAH	Polycyclic Aromatic Hydrocarbon
UMO	Used Motor Oil
HMA	Hot Mix Asphalt
RAP	Reclaimed Asphalt Pavement
Pa	Pascal
KM	Kilometre
μm	Micrometre
CRM	Crumb Rubber Modifier
WCO	Waste Cooking Oil
ASS	Atomic Absorption Spectrometry
ATR	Attenuated Total Reflection
cm^{-1}	Wavenumber
RPM	Rotational Per Minutes
ANOVA	Analysis of Variance

CHAPTER 1

INTRODUCTION

1.0 Research Background

Waste engine oil (WEO) is commonly an oil that has been used or contaminated by impurities in automotive such as cars, motorcycles, lorry and many more. Normally, all of WEO is received from the waste material, it can be taken up in any all sort of places such as workshop, manufacturer and also several other industries that are small, medium and large.

The properties of waste engine oil had been vanished and contaminated that led to unsuitable result because of the original properties that was altered. The properties and materials in WEO are type that is hard to extinguish. As for it, the oil is no longer appropriate for their intention and needed to change with the new virgin or refined oil (Xiaoyang Jia et al, 2013).

The waste engine oil contains non-degradable element that are difficult to be decomposed. Throughout engine process, heavy metal such as lead, zinc, calcium and magnesium slowly gather in engine. Estimated over 45 million tons per year waste engine oil is produce in world and 40% of oil is disposed properly and 8% is recycled to a new lubricant oil (Maceiras et al, 2016).

Content metal and other contaminant that remain in the additives substance example of phenols Polycyclic aromatic hydrocarbon (PAH) plus mixture consists of zinc, chlorine or phosphorous can danger and effect the human health (Fuentes et al, 2007). These metal are extremely toxic to the animals, plants and other organisms because of this lubrication additives. When the waste engine oil is burned down, the atmosphere will be polluted and can affect the greenhouse gas emission (Naima & Liazid, 2013).

Asphalt binder is anionic asphalt mixture that considered for patching, paving and coating process. Asphalt binder helps adhesion of bituminous concrete product and coating. Asphalt binder is highly well recognize and widely used in China for its excellent performance for its high viscosity asphalt modifier (Jun Cai et al, 2018). Asphalt is a

temperature sensitive material, basically applied in pavement industry as primary element for asphalt concrete (Pyeong Jun Yoo, 2018).

Throughout modification methods, using other material or unused materials to improve or promote the traditional asphalt modify are naturally approachable (Shengjie Liu et al, 2018). Rubber, bio-oil, recycle polyethylene, cooking oil, electronic waste material and waste engine oil are some of material that are waste material. Waste engine oil is a type of material that have similar properties as asphalt.

1.1 Problem Statement

Due to the large number of active transportation by sea and land transport as well as the growth in traffic, Malaysia have produced 150 million litre of waste engine oil every year (Ruhana Hassan et al 2014). The environment is at threat due to industrialization and urbanization process and the sustainable management of natural resources has become completely challenging. Growth of transportation that we see in Malaysia not only will damage the environment and pollution, this is also harmful to the human body. Improper disposal of waste engine oil will drag Malaysia into greenhouse effect (Naima & Liazid, 2013).

During cold weather, engine will start easily and quickly as the thin oil decrease the friction in engine. As for the thick oil, the high temperature helps upholding film strength and oil pressure (Hanbey Hazar & Huseyin Sevinc, 2018). Besides that, due to oxidation and contamination, it will lead to growth of viscosity in waste engine oil. Throughout engine operation, oxidation can happen and develop corrosive oxidized product, deposit and varnish which lead to the growth in the viscosity (Ihsan Haamawand et al, 2013). With the increasing of temperature, the viscosity has to be stated for a specific temperature. This impact can cause damages to the road such as road cracking.

On top of that, the present of waste engine oil can lead to improvement of low temperature performance. This can be seen by using Fourier Transform Infrared Spectroscopy (FTIR) to characterize the change in functional group (Xiaoyang Xia, 2013).

Open burning of waste engine oil is one of the offense for disposal of waste material. The burning metal and other contaminant material in waste engine oil will result to pollution of air. This pollution can affect deeply into the human body and several major diseases such

as asthma, lung disease, coughing, and many more. Open burning also can cause and bring to depletion the ozone layer and can lead to global warming.

Therefore, the aim of this research is to study the influence of waste engine oil on the level of viscosity and rheological properties of asphalt binder. The characteristic of asphalt binder and waste engine oil was studied and compared because both of this product are petroleum refining and they have similar chemical.

1.2 Research Objective

The objective of this research were as follow:

I. To screen the spectrum of functional group in Asphalt Binder and Waste Engine Oil by using Fourier Transform Infrared Spectroscopy (FTIR).
II. To investigate the Rheological Properties of Asphalt Binder and Waste Engine Oil.

1.3 Scope of Research

This research is focused on the Waste Engine Oil's influence on viscosity and rheology properties towards asphalt binder. The functional groups of asphalt binder and Waste engine oil was evaluated based on FTIR spectrum. This can be a feasible way of recycling WEO towards sustainable environment.

1.4 Significant of Research

Research focused on waste engine oil mixed up with two types of asphalt binder. Waste engine oil is usually being disposed either by burning or with addition of additives. Thus, this research helps in sustaining the environment by mixing WEO with asphalt binder to be used in the construction field. Moreover, disposal of WEO to the environment can cause high cumulative of toxic and hazardous heavy metals contamination. The recycling of WEO has been reported in various literature as expensive and costly. Thus by making it as an added value to the asphalt binder, it helps to reduce the cost by using source from waste.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter aim on several topics of review on the waste engine oil, asphalt binder, importance of waste engine oil and asphalt binder, viscosity and rheology properties.

2.1 Waste Engine Oil (WEO)

According Ragab & Abdelrahman (2015) nearly every year 200,000,000 gallons of Used Motor oil (UMO) were incorrect disposed with the right ways. UMO is incapable of dissolving and posses' toxic chemical and heavy metals.

Engine oil is a petroleum filtering which is used to provide lubrication for engine component. After the engine oil is used, it gets tainted with heavy metals and toxic chemical. With the increasing use car lead to creation of waste engine oil has been increase in every years. In South Korea, about 370 million gallons of Waste Engine Oil (WEO) were produced in 2012. Figure 2.1 show the comparison between fresh engine oil and waste engine oil that was use during research. (Shoukat & Yoo, 2018).

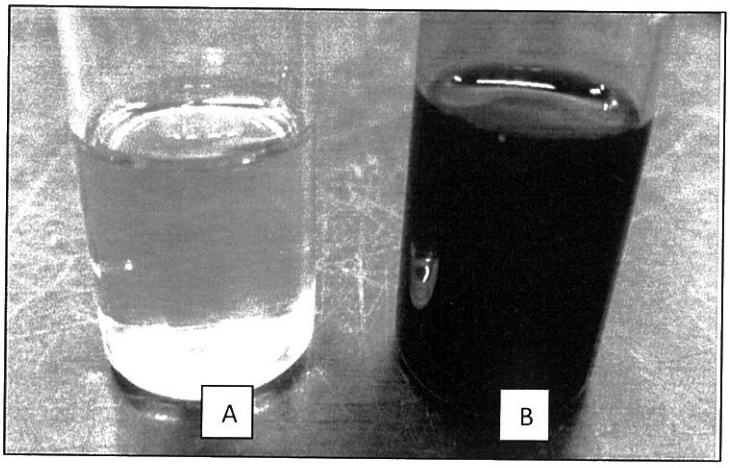

Figure 2.1: Engine Oil (A) and Waste Engine Oil (B). Adapted from Touqeer Shoukat and Pyeong Jun Yoo, 2018.

Jia et al (2015) state that waste engine oil is naturally a petroleum made and frequently polluted by dirtiness and squalor throughout physical or chemical process. Result show primary purpose needed to change with the new virgin or re-refined oil for waste engine oil no longer suitable. Non-degradable element that contain in the waste engine oil is difficult to unravelled. This can lead to pollution that can harm permanent damage to the environment.

While Liu et al, (2018) stated that waste engine oil are production of petroleum purifying, for example rejected engine oil from the engine vehicle. It has the same properties as petroleum asphalt. With rising of transportation such as vehicle, motorcycle, lorry and buses, a countless volume of waste engine oil produce in worldwide.

2.1.1 Importance and usage of waste engine oil.

Addition UMO helps the binder to modify low molecular weight maltene structure as the role of the maltenes to provide consistency to the asphaltenes. The mixture of WEO and asphalt binder with the absence of Crum rubber modifier will lead to interruption of the asphalt molecular size built up and weakening of asphalt properties (Ragab& Abdelrahman, 2015).

According to Shoukat & Yoo, (2018) they stated that it is important for waste engine oil with the mixing asphalt will reduce the cost of Hot Mix Asphalt (HMA) or Reclaimed Asphalt Pavement (RAP). It also helps other rejuvenator from aging and fatigue that lead to cracking resistance. Research from Zaumanis et al (2014) appears that waste engine oil with 12% dose shows highly improve probability of RAP modify cracking at low temperature.

Study from Jia et al (2015) stated that waste engine oil had the same molecule structure as asphalt. This will give potential to waste engine oil as changer for asphalt. From the recycle perspective, waste engine oil helps RAP in paving mixture. Waste engine oil will act as a rejuvenating agent. This means that waste engine oil can improve performance asphalt mixture consist of RAP. Waste engine oil in reclaimed asphalt pavement normally reduce modify temperature. It also an alternative for modifier considering reduce the asphalt content.

Waste engine oil has the potential improve asphalt performance if waste engine oil can modify with asphalt and replace the binder in a supplier mixture. It also helps improve the environment worry and economic profit. Besides that, waste engine oil can increase the physical and chemical hardening asphalt. Waste engine oil also beneficial to softening and more flexibility to asphalt Liu et al, (2018).

2.1.2 Disposal of waste engine oil

Engine oil and asphalt binder had the same molecule structure. This means that waste engine oil was mostly expended as fuel or reselling after it has been screened out from industry (Shoukat & Yoo, 2018).

Jia et al (2015) studies that due to the hazard of heavy metal after engine operation, important procedure needed to be done to dispose waste engine oil by the right ways. A common ways to reycyle waste engine oil is to reuses it and makes it as fuel. DOE from the U.S. estimate 17% waste engine oil is recycle in total of 945 million gallons of recycle used oil.

2.1.3 Impact towards environment.

WEO produce toxic chemical and heavy metal that can lead harm to main sources, such as oil contamination to the watercourse and finally to sea. This pollution does not only harm the water sources but also to the human health, flora and fauna according to (Ragab & Abdelrahman 2015).

According to Shoukat & Yoo, (2018) the final product from engine oil transform to waste engine oil can harm and result to damaging the flora and fauna life if it were ditched without a correct solution to treat. As for it, a big demand had been requested from the pavement industries to recycle the waste material and reduce the uses of natural resources. Using fresh material will bring benefit to the pavement Industries to save a lot amount of good and save budget. This will helps the pavement industry to save budget compared to using new material

Waste Engine oil contain important amount of element during engine process this include zinc, calcium and magnesium. This element can verify that pollution can occur at soil and water permanently. This element also dangerous to the human body because of high percentage of aromatic hydrocarbon (PAHs) Jia et al (2015).

Liu et al, (2018) stated that waste engine oil is able to threaten the environment and even human health if proper dispose is neglected. Over period of waste engine oil is tough to reuses it to make a new engine oil. In 2006, Department of Energy in U.S. stated the majority of waste engine oil is recycled as fuel. The burning of waste engine oil to the air can lead a serious threat to human.

2.2 Asphalt Binder

Yoo (2018) said that asphalt is a temperature sensitive material, and basically used in roadway industry for example primary element for asphalt concrete. The most important element of asphalt is their viscosity that is to describe its workability which is blending and compaction of asphalt concrete. By changing the asphalt binder with the appropriate polymeric material, the viscosity can be control. Especially cracking of flexible pavement is vital problem which is clearer in cold places. The roadway construction inclined to contract under low temperature circumstances. As for this asphalt modification is needed to eliminate this reduction without losing combination with aggregates.

Dokandari et al (2017) said that due to the rapid developing of eco-friendly consciousness and limited resources, researcher are looking for a different and another technique and technologies to assure the conservation, effectiveness and less greenhouse effect in asphalt industry. In recent years, recycle of material has been on the vital of a new of recycle the asphalt pavement (RAP) in hot bituminous mixture can to improvise the critical used of natural resources and typically can harm less damage to the environment.

Fernandes et al (2017) express that there is growing apprehension to recycle waste material and to protect or reduce the use of natural resources in road paving. Waste material and the gradually reduction of oil reserve has paved the ways to searching the new waste material that may partially change the bitumen used in road pavement industry.

Asphalt binder is regularly applied to hot mix asphalt (HMA) for binding the aggregates mass. Nevertheless, the international used of asphalt as binder lead to high cost. This bring to increase development because of the demand of paved road lead to improve properties of asphalt, particularly to eliminate rutting and cracking. Therefore asphalt modification is necessary as fundamentally effect for properties of bituminous mixture (Shoukat &Yoo, 2018).

Mamun & Wahabb (2018) stated that a remarkable performance from the asphalt paving industry with the recycle use of receding asphalt pavement in the early twenties. The effectiveness outline of reclaimed asphalt pavement (RAP) on road construction reduce the total of virgin asphalt and aggregate that were desired and then made the paving industry operates extra maintainable.

2.2.1 Importance and usage of asphalt binder

Asphalt binder that had been modified with the mixture of used lubrication oil helps improve the low temperature of performance grading (PG). Modification an old asphalt with 4% waste cooking oil reduced the viscosity to its new form. Asphalt binder with mixture of modification waste engine oil decrease the stiff of binder at low temperature. From the X-Ray fluorescence spectroscopy of asphalt modify with waste engine oil shows the reduction of strain tolerance and physical hardening of asphalt binder (Yoo, 2018).

With the use of recycle material, the possible of saving raw material can be managed and also can help contribute in saving of energy and emission of hazardous gases through the air. With the saving of raw material such as aggregates, bitumen and energy in asphalt industry, it help achieve environment friendly and financially. It give more benefit by recycling with the used of recycling material. This is the main vital goal for all the effort to make 100% recycling of pavement material possible. (Dokandari et al, 2017).

Fernandes et al (2017) had study of new asphalt binder that partially including wastes is important to reduce the use of bitumen achieve from the oil bases, which is more vital for the upgrading of road paving construction. Some studies state this to non-petroleum bonding and synthetic binders made up of used oil, resins and polymers. As example, bitumen substitute or asphalt rejuvenator that has been studied lately is Bio-oil. Achievement of Bio-oil at the central and high temperature is comparable to the conventional bitumen but it is too competitive and quite hard at low temperature. Combination of asphalt mixture in waste engine oil is being verified to avoid aging due to the low viscosity which result to low mixing and compaction temperature.

Mamun & Wahabb (2018) stated that the vital tasks of used RAP in road construction are the stiffness of RAP. Used of the original RAP can bring the mixture stiffness and hard to pack. This lead to the result initial failure to pavement. Better stiffness is importance because gradually oxidation which transform the element of asphalt and then destroys the viscoelastic goods. So, the missing properties of oxidized asphalt needed to recover using a possible rejuvenation method to be able to used RAP on the road construction.

2.2.2 Impact towards environment

Yang et al (2014) stated that the making of asphalt binder causes biggest environmental impact out of all the raw material in the material production stage.

Mamun & Wahabb (2018) express that recycle RAP by used waste product can bring to sustainable and environmental friendly pavement rehabilitation and recovering program. Excess material in asphalt pavement can be categorized following their causes, such as industrial waste, municipal waste and mining waste.