Prediction of Engine Oil Degradation Due To Temperature Effect by Using Optical Spectroscopy

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Abstract - **This paper presents the prediction of the engine oil degradation by using non distractive testing. The main objective of this project is to predict the worst condition of engine oil need to change based on its colour for maximum used. Two types of engine oil were used as samples in this project from grade SAE 10W40 and 20W50. A method have been used is heating the engine oil with inductance coil for 5 minute and then cool it about half an hour before continue heating for other 5 minute. This process repeat continuously until 100 minute and samples takes at every 10 minute after cooling process. The temperature of the engine oil is about 130°C. A spectrometer is used to measure the percentage reflectance of the samples. Data was arranged in the Microsoft excel and analyzed in order to predict the degradation of the engine oil.**

Keyword – engine oil, spectrometer, heating, reflectance

I. INTRODUCTION

Engine oils were used for lubrication of various internal combustion engines and to reduce the tear and wear of engine. It will reduce the friction between moving parts hence making the engine run smoothly and improves sealing and cooling the engine by carrying away from moving parts. Lubrication system provides oil as a film between the moving part of the engine to prevent wear from the friction and to keep the engine cool [1].

There are basically three types of engine oil, the mineral based oil, semi synthetic oil and the fully synthetic oil. Mineral oils are based on oil that comes directly from the rig, but that oil had been refined to be suitable to be used as engine oil. Synthetic oil in the other hand comes from the lab, it is formulated by chemist. Semi-synthetic is the mixture of the mineral based and synthetic oil. In this study the types of the engine oil used is 10W40 SAE and the 20W50 of MOTUL brand.

There are a lot number of research done on study the engine oil properties, quality and the lifetime prediction [1-5]. Unfortunately, none of them do not use colour as the main indicator to predict the degradation of the engine oil.

The method used to observe the changing of the engine oil colour is by direct heating with the inductance coil at temperature about 130°C. The main purpose of this project is to observe changing of the color of the engine oil. The colour changing is recognized by using the spectrometer. Spectrometer operates based on the reflectance of the light from the sample of engine oil surface. The light reflectance is refers to the visible light which is wavelength between 400nm to 780nm.

Reflectance is the proportion of light that a surface reflects compared to the amount of light falls on that surface. Dark, matt and/or textured surfaces absorb a lot of light and have low light reflectance values. Light, glossy and/or smooth surfaces reflect most of the light that falls on them and have high light reflectance values.

The objective of the study is to reduce the frequently changing engine oil by optimum interval used and will reduced the pollution due to oil.

II. METHODOLOGY

The process of determining oil degradation be simplified as below:

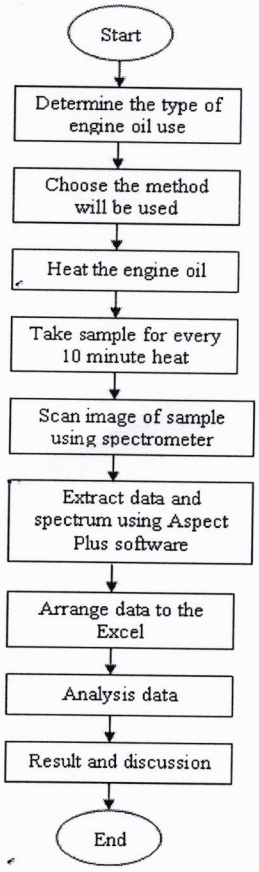

Fig.1: Flow chart

A Engine oil sample

The engine oil used was 10W40 and 20W50 from MOTUL brand. These oil was heating with inductance coil for 5 minute and then cool it about half an hour before continue heating for other 5 minute. This process is continues until 100 minutes. Sample of engine oil take at every 10 minute to observe the changing of it colour.

B Data scanning

The percentage light reflectances of the engine oil were obtained using spectrometer. The white background is choosing as a reference because it reflectance is nearly 100%. As colour become dark the percentage of light reflectance drops. The scanned light reflectance information was directly extracted using Aspect Plus software and then the data arranged to Microsoft Office Excel.

C Data analysis

To represent the percentage of the reflectance of the wavelength, graphical, tabulate, and test method were used. Statistic analysis method is used to predict the lifetime of engine oil.

III. RESULT AND DISCUSSION

As known, the engine oil will degrade its lubricating properties. After certain time, engine oil need to be change since it degrade properties and less protection of the engine. An analysis on the data has been done.

TABLE I represents result for the engine oil percentage light reflectance in 100 minutes and also in kilometers. As seen in the table, the percentage reflectance of engine oil grade SAE 10W40 by heating method at 100 minute almost same as percentage reflectance at 150km of the same grade. Degradation rate of engine oil grade 20W50 was less than the grade SAE 10W40.

TABLE I
RESULT OF ENGINE OIL ANALYSIS.

heating method			**mileage method**	
	Oil types			Oil types
	10W40	20W50		10W40
minute	%R	%R	km	%R
0	80.46372	78.60965	0	80.46372
10	75.93949	75.20334	60	66.82047
20	73.88763	75.27003	150	64.09545
30	73.82749	73.00116	360	63.06831
40	72.06995	72.37139	460	62.90444
50	72.08217	71.70235	2000	43.51646
60	69.67541	71.58519	-	-
70	68.97342	70.57325	-	-
80	67.70523	70.15541	-	-
90	66.6581	69.43327	-	-
100	64.968	68.7223	-	-

A) Line Plot

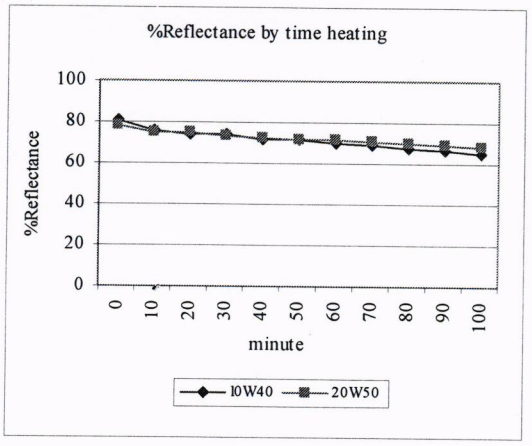

Fig. 2(a)

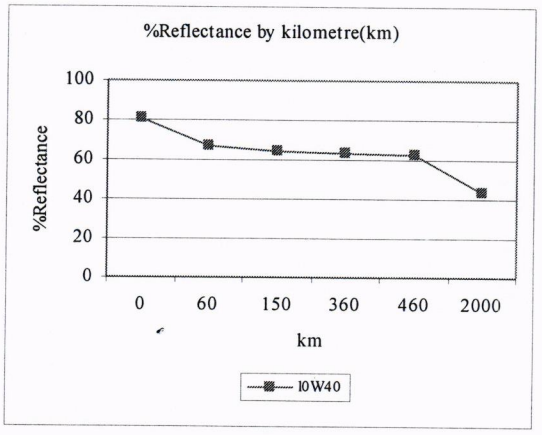

Fig. 2(b)

Result in the TABLE I was illustrate into line plot to show the degradation pattern of engine oil as in Fig. 2(a) and Fig. 2(b). Degradation of engine oil was measured by its percentage reflectance of the spectrum colour. From the Fig. 2(a) shown that there was no major different of percentage reflectance between the SAE 10W40 and 20W50 of engine oil. The value of percentage reflectance at 100 minute almost same with value percentage reflectance at 150 km as seen in Fig. 2(a) and Fig. 2(b) the line is linear. To prove the line is linear or not the testing of the usefulness if linear regression was done as in section C.

B) Original light reflectance intensity graph.

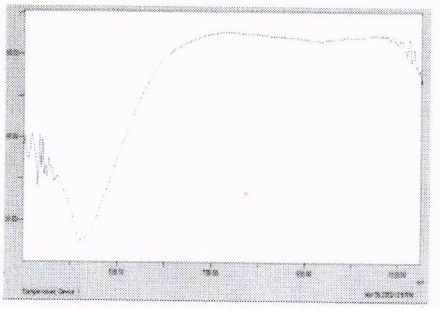

Fig. 3(a)

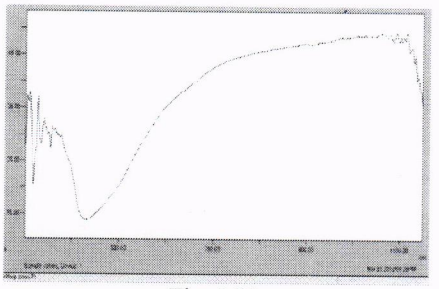

Fig. 3(b)

The light reflectance of the engine oil colour is in the visible spectrum or light spectrum. Light spectrum or the visible spectrum makes up a small portion of this electromagnetic spectrum, the portion from 400 nanometers to 780 nanometers in wavelength. From the figure illustrate in Fig. 3(a) shows that reflectance at particular wavelength which is around (580 -700) nm wavelength. Based on the visible spectrum it contains yellow, orange and red colour. Its true for the new engine oil is yellow colour. Fig. 3(b) show the percentage light reflectance decreased. It means that intensity of yellow is decrease and will turn to gray or black. Black colour means that the engine oil is degraded its properties and less protection to the engine.

C) Testing of usefulness of linear regression.

Null hypothesis:
Ho: There is no significant linear regression between time and %R

Alternative hypothesis:
Ha: There is a significant linear regression between time and %R.

The observed value of the test statistic is calculate as

$$t = \frac{b}{s} = b/\left(\sqrt{\frac{S^2}{SS_x}}\right) \quad (1)$$

$$b = \frac{SS_{xy}}{SS_x} \quad (2)$$

$$S^2 = \frac{SS_y - \left[\frac{(SS_{xy})^2}{SS_x}\right]}{n-2} \quad (3)$$

$$SS_x = \sum x^2 - \frac{(\sum x)^2}{n} \quad (4)$$

$$SS_y = \sum y^2 - \frac{(\sum y)^2}{n} \quad (5)$$

$$S_{xy} = \sum xy^2 - \frac{(\sum x)(\sum y)}{n} \quad (6)$$

Where:

t – Test statistic
x – Time (minutes)/ km
y - %R
n – Number of sample
n = 11 for minute sample
n = 6 for kilometer sample
S^2 – variance
SS_x – Sum of squire x
SS_y – Sum of squire y
S_{xy} – sum of x multiply y

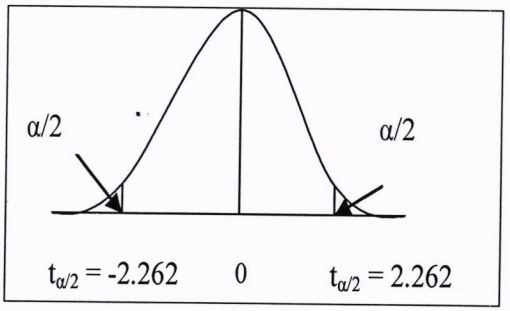

Fig. 4(a): t probabilities for n =11

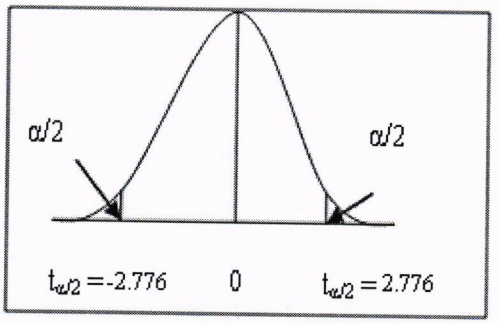

Fig. 4(b): t probabilities applet for n = 6

TABLE II
RESULT OF TEST LINEAR REGRATION

method	type	SSx	Ssy	Sxy	S^2	b	t
minute	10/40	11000	202.144	-1452.51	1.149	-0.132	-12.91
	20/50	11000	86.481	-935.83	0.762	-0.0851	-10.204
km	10/40	2837150	699.03	-40041.7	33.48	-0.0141	-4.107

TABLE II shows value of the test statistic for all measurement. Result shows that minute method, both value of test statistic t < -2.262 which are refer to the Fig. 4(a). With 95% CI Ho is rejected and there is significant linear regression between minute and %R. For the km method, value of t < - 2.776 which is refer to Fig. 4(b), with 95% CI Ho is rejected and there is significant linear regression between the km and %R. From this test, the linear equation can be developed.

D) Linear regression

To predict the times when engine oil lose it functionally a mathematical function to link x and y is developed.

$$y = a + bx \quad (7)$$

To find a:

$$a = \bar{y} - b\bar{x} \quad (8)$$

$$\bar{y} = \frac{\sum y}{n} \quad (9)$$

$$\bar{x} = \frac{\sum x}{n} \quad (10)$$

Where:

$\bar{y}$= mean of y
$\bar{x}$ = mean of x

TABLE III:
RESULT OF THE LINER EQUATION

method	type	$\bar{y}$	$\bar{x}$	b	a	y = a + bx
	10W40	71.47	50	-0.132	78.07	y = 78.07 - 0.132x
minute	20W50	72.42	50	-0.0851	76.67	y = 72.42 - 0.0851x
km	10W40	63.47	505	-0.0141	70.60	y = 70.60 - 0.0141x

The results are present in the TABLE III shows that the slope is negative because value of the b is negative as the %R is decreasing. From the result, the prediction of the time is build.

From equation that tabulated in the TABLE III, the prediction of the lifetime of the engine oil is obtained. The reference value of the %R of wear out engine oil is 10% represent the value of y. By manipulated equation y = 70.60 - 0.0141x, value of x can be obtained. Based on the calculation, the value of the x obtained was about 4000km.

For the heating method, it is difficult to convert from minute to mileage because the parameter change and degradation rate may be different to the actual combustion in the engine of the motorcycle compare to the heating outside the engine itself. Thus this will effect the changes of the colour. Degradation of engine oil due to temperature will change its viscosity, weight, and density. The actual temperature in the engine may differ with the experiment has been done and this cause the difference in the changes of its properties. With compare to mileage method, it gives information that the degradation of the engine oil by heating method has correlation with mileage. Based on that, the prediction of the degradation of the engine oil can be made and observe the rate of degradation.

IV. CONCLUSION

According to the study, it was found that the engine oil lubrication will lost after a certain time based on the observation of it colour changing. From the statistical analysis on the SAE 10W-40 and 20W-50 engine oil, engine oil will degrade around 4000 km and above depend on the type of riding. This study concludes that motorcycle engine must change oil according to the recommended oil change interval and these potential to reduce nationwide waste and recycled oil.

V. FUTURE RECOMMENDATION

In future, it recommended that more types of the engine oil should be used as sample for this research. In addition, more data need to take on the each one sample in order to have more accuracy and effectiveness of the research. The analysis by absorbent also recommended in order improving the research. Both reflectance and absorbent analysis also recommended providing more accuracy to the research.This study also can be guide to produce indicator based of colour light reflectance.

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