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The Influence of the Water Level in the Brake Fluid on the Rate of Increase in Temperature and Boiling Point of the Brake Fluid

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***Abstract*—The study aims to determine the effect of the water level in brake fluid on the rate of increase in brake fluid temperature and the boiling point of brake fluid. The study used an experimental method to determine the performance of 5 brands of brake fluid. The brands of brake fluid used are Jumbo, Fuso, Prestone, Tiga Berlian and Toyota Motor Oil (TMO). In each experiment, the rate of increase in temperature and the boiling point of the variation of 5 brands of brake oil uses 60ml of brake fluid. Changes in brake fluid temperature were measured using an infrared thermometer. To increase the temperature of brake fluid using an electric stove, then the calculation of the rate of increase in brake fluid temperature is done. The water level in brake fluid greatly affects the rate of increase in brake fluid temperature and the boiling point of brake fluid. The higher the water level of brake fluid, the longer the rate of increase in brake fluid temperature is achieved and the lower the boiling point of brake fluid. The rate of increase in brake fluid temperature and the boiling point of brake fluid is the longest achieved by the Prestone brand brake fluid, while the fastest is achieved by Toyota Motor Oil (TMO) brand brake fluid.**

Keywords: brake, brake fluid, rate of increase in brake fluid temperature, boiling point of brake fluid

I. INTRODUCTION

Based on accident data from the police of the Republic of Indonesia [1], the second-largest accident is caused by a system failure or function on a vehicle such as brakes. The highest cause of accidents is caused by human factors. Throughout 2017, the victims killed by traffic accidents reached 25,859 people and those injured were 16,159. The main causes of motor vehicle accidents are human factors such as drowsiness when driving or motorists' inadequacy by 35%. While the quality factor of the vehicle such as the brake is not up to 31% [2].

The failure of the brake system can be caused by many factors as stated by Oduro [3], through the survey results related to the failure of the brake system and its effect on traffic accidents on the Kumasi Metropolis road in Ghana. From the survey results, it was stated that 40% of 485 vehicle users agreed that braking failure was caused by low or run out of brake fluid and 33% caused by excessive heat on the brake system. Besides, from the survey results, the majority of 40% of 485 respondents answered that the cause of braking ineffectiveness was caused by the presence of air in the hydraulic brake system. From the results of the study, it can be seen that running out of brake fluid is the dominant factor causing the failure of the brake system. Running out of brake fluid is usually caused by a leak in either the seal, hose or other brake components. Besides, the effect of temperature is quite significant in braking efficiency. Very high temperatures have the potential to cause brake fluid to evaporate so that air bubbles will emerge. Brake fluid has a level of 3% water which can reduce the boiling point to 60% from 205^0 C (DOT 3 Standard), if left unchecked, the water will turn into steam so it has the potential to break down.

In connection with the above, a study will be conducted on the effect of the water level in brake fluid on the rate of increase in temperature and the boiling point of brake fluid. The results of this study are expected to provide clear information to the public as well as companies in the selection of brake fluid and replacement of brake fluid. This research is also expected to reduce the number of traffic accidents due to the failure of the brake system.

II. THEORETICAL BASIS

A. Brake system

The purpose of installing the brakes on a vehicle is to obey the driver's willingness to reduce the speed of stopping or park the vehicle on a climbing road, in other words controlling the speed of the vehicle to avoid accidents and is a safety device that is useful for stopping the vehicle periodically. Therefore good or not the ability of the brakes directly becomes a very important problem for the driver when driving a vehicle (Chassis Lesson Material, Toyota Step 2: 4-1). Brakes are designed to reduce speed (slow

down) and stop the vehicle and to allow parking in a declining place. This equipment is very important as a safety tool and guarantees for safe motorists (New Step 1 Training).

Based on these definitions, it can be concluded that the brake system is a device used to slow down or stop the vehicle.

B. Brake fluid

Brake fluid is a very common term for all organic liquids that do not dissolve or mix with water. The Brake fluid in the vehicle functions as a lubricant. Every motorized vehicle will have a braking system to stop the vehicle. Various components in the system relate to each other. Brake fluid and brake lining are some of these components.

C. Classification of brake fluid

Brake fluid based on its boiling point is classified into four categories:

- DOT - 3
- DOT - 4
- DOT - 5.1
- DOT - 5

DOT stands for the Department of Transportation (USA). This Department of Transportation (USA) determines the classification level of brake fluid. The higher the number that follows, the higher the boiling point.

III. RESEARCH METHODS

This research method uses experimental research design can be seen in Fig. 1. According to Sugiyono [4], said: "experimental research methods can be interpreted as research methods used to find the effect of certain treatments on others in controlled conditions".

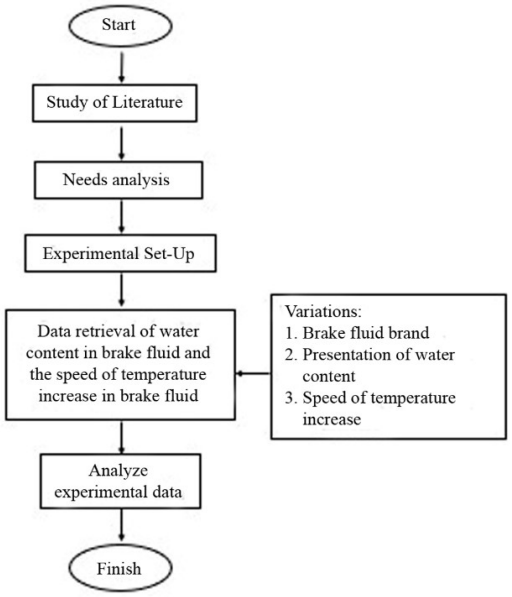

Fig. 1. Flowchart Research Methods.

This study uses an experimental method to determine the rate of increase in temperature of 5 brands of brake fluid. The experiment was carried out with the same amount of brake fluid in each experiment which was 60mL. The definitions of each variable from this study are as follows:

1. The brands of brake fluid used are 5 brands of brake fluid, namely Jumbo, Fuso, Prestone, Tiga Berlian, and Toyota Motor Oil (TMO).
2. The water level in brake fluid is the moisture level in the brake fluid measured using Brake Fluid Tester. In this study, the moisture level of brake fluid was varied into 4 moisture levels in brake fluid namely 1%, 2%, 3% and 4% which can be seen in the indicator light of Brake Fluid Tester.
3. Brake fluid temperature is the brake fluid temperature measured using the Infrared Thermometer at 34ºC. While the temperature of the electric stove is the temperature of the electric stove measured using the Infrared Thermometer which is at a temperature of 70ºC then measured the rate of increase in temperature by heating the brake fluid on the electric stove until it reaches a temperature of 80, 90 100, 110 and 120^{0}C.
4. The rate of increase in brake fluid temperature is the achievement of brake fluid temperature at a certain time.

IV. RESEARCH RESULT

The results of retrieval of the temperature rise rate data of 5 brands of brake fluid carried out through 3x experiments can be seen in TABLE I.

TABLE I. RESEARCH RESULT FROM BRAKE FLUID TEMPERATURE INCREASE WITH 1% MOISTURE

Oil type	Temperature Increase (s) with 1% Moisture				
	80^{0}C	90^{0}C	100^{0}C	110^{0}C	120^{0}C
Jumbo	01.29.22	01.48.37	02.11.04	02.33.47	02.57.52
Fuso	01.38.46	02.03.14	02.23.02	02.51.13	03.06.16
Prestone	02.00.26	02.29.06	02.58.19	03.26.41	04.10.48
Tiga Berlian	01.32.06	01.56.19	02.17.00	02.38.17	02.56.30
Toyota Motor Oil	01.27.22	01.46.56	02.03.48	02.31.03	02.56.48

From the table, it can be seen that the rate of increase in brake fluid temperature with 1% moisture level is the longest taken by Prestone brake oil with a time of 4 minutes 10 seconds to reach 120ºC, with a temperature variation of 80ºC, 90ºC, 100ºC, 110ºC, and 120ºC. Meanwhile, Toyota Motor Oil (TMO) brake fluid shows a faster time than other brake oils (Jumbo, Fuso, Prestone and Tiga Berlian), which is 2 minutes 56 seconds to reach 120 ºC. From the results of the trial of the rate of increase in brake fluid temperature with variations in temperature and variations in brake fluid, it was found that the higher the temperature of brake fluid, the longer the brake fluid takes in reaching that temperature.

The results of Fig. 2 were obtained from the update of the best brake fluid prices on the Prestone brand brake fluid

because it has a better average temperature increase compared to other brands. While Toyota Motor Oil (TMO) brand brake oil has the lowest or fastest average price increase (see TABLE II).

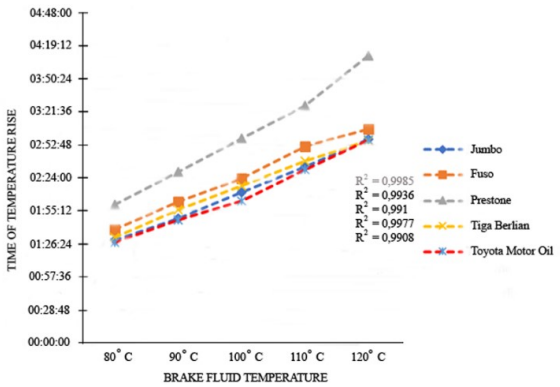

Fig. 2. The rate of increase in brake fluid temperature with 1% moisture level.

TABLE II. RESEARCH RESULT FROM BRAKE FLUID TEMPERATURE INCREASE WITH WATER LEVEL OF 2%

Oil type	Temperature Increase (s) with 2% Moisture				
	80⁰C	90⁰C	100⁰C	110⁰C	120⁰C
Jumbo	01.28.31	01.48.01	02.11.23	02.40.11	03.10.09
Fuso	01.38.17	01.55.18	02.14.47	02.45.17	03.10.47
Prestone	01.49.21	02.17.54	02.41.29	03.14.04	03.43.25
Tiga Berlian	01.34.28	02.02.18	02.26.04		
Toyota Motor Oil	01.21.43	01.43.42	02.08.29	02.29.47	

From the table, it can be seen that the rate of increase in brake fluid temperature with 2% moisture level is the longest taken by Prestone brake oil with a time of 3 minutes 42 seconds to reach 120ºC, with variations in temperature of 80ºC, 90ºC, 100ºC, 110ºC, and 120ºC. Meanwhile, Tiga Berlian brake oil shows a faster time than other brake oils (Jumbo, Fuso, Prestone, and Toyota Motor Oil (TMO)) which is 2 minutes 26 seconds to reach 120 ºC. From the results of the trial of the rate of increase in brake fluid temperature with variations in temperature and variations in brake fluid, it was found that the higher the temperature of brake fluid, the longer the brake fluid takes in reaching that temperature.

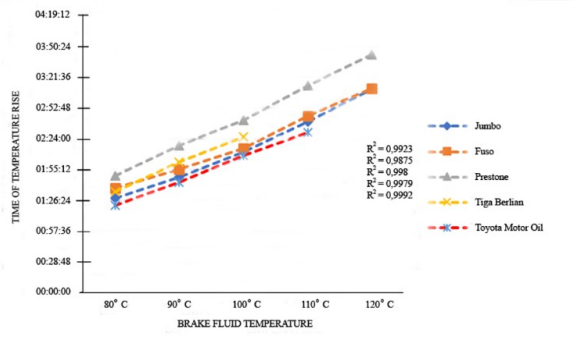

Fig. 3. The rate of increase in brake fluid temperature with a moisture level of 2%.

The results of Fig. 3 indicate the best rate of increase in brake fluid temperature in the Prestone brand brake fluid because it has an average temperature increase that is better than other brands. While Tiga Berlian brand brake oil has the lowest or fastest average temperature rise.

TABLE III. RESEARCH RESULT FROM BRAKE OIL TEMPERATURE INCREASE WITH WATER LEVEL OF 3%

Oil type	Temperature Increase (s) with 3% Moisture				
	80⁰C	90⁰C	100⁰C	110⁰C	120⁰C
Jumbo	01.35.31	01.50.17	02.13.19	02.42.06	03.06.53
Fuso	01.40.15	02.03.00	02.31.53	02.40.18	02.55.14
Prestone	01.49.40	02.21.21	02.45.50	03.27.21	04.06.15
Tiga Berlian	01.28.39	01.53.42	02.13.08		
Toyota Motor Oil	01.17.07	01.36.25	02.02.24		

From TABLE III, it can be seen that the rate of increase in brake fluid temperature with 2% moisture level is the longest taken by Prestone brake oil with a time of 4 minutes 6 seconds to reach 120ºC, with variations in temperature of 80ºC, 90ºC, 100ºC, 110ºC, and 120ºC. Meanwhile, Toyota Motor Oil (TMO) brake fluid shows a faster time than other brake oils (Jumbo, Fuso, Prestone, and Tiga Berlian) which is 2 minutes 2 seconds to reach a temperature of 100 ºC. From the results of the trial of the rate of increase in brake fluid temperature with variations in temperature and variations in brake fluid, it was found that the higher the temperature of brake fluid, the longer the brake fluid takes in reaching that temperature.

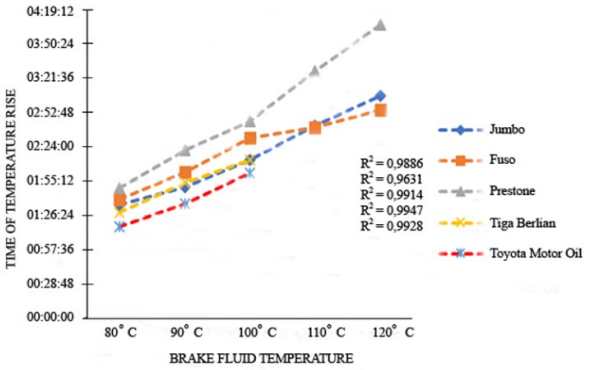

Fig. 4. The rate of increase in brake fluid temperature with a moisture level of 3%.

TABLE IV. RESEARCH RESULT FROM BRAKE OIL TEMPERATURE INCREASE WITH 4% MOISTURE LEVEL

Oil type	Temperature Increase (s) with 4% Moisture				
	80⁰C	90⁰C	100⁰C	110⁰C	120⁰C
Jumbo	01.58.38	02.19.11	02.44.04	02.45.30	
Fuso	01.44.48	02.18.58	02.53.20		
Prestone	01.52.44	02.24.15	03.09.46	02.53.35	03.17.33
Tiga Berlian	01.29.26				
Toyota Motor Oil	01.27.19				

The results of Fig. 4 show the best rate of increase in brake fluid temperature in the Prestone brand brake fluid because it has an average temperature increase that is better than other brands. While Toyota Motor Oil (TMO) brand brake fluid has the lowest or fastest average temperature rise.

From TABLE IV, it can be seen that the rate of increase in brake fluid temperature with 4% moisture level is the longest taken by Prestone brake oil with a time of 3 minutes 17 seconds to reach a temperature of 120^0C, with a temperature variation of 80^0C, 90^0C, 100^0C, 110^0C, and 120^0C . Meanwhile, Toyota Motor Oil (TMO) brake fluid shows a faster time than other brake oils (Jumbo, Fuso, Prestone, and Tiga Berlian) which is 1 minute 27 seconds to reach 80^0C. From the results of the trial of the rate of increase in brake fluid temperature with variations in temperature and variations in brake fluid, it was found that the higher the temperature of brake fluid, the longer the brake fluid takes in reaching that temperature.

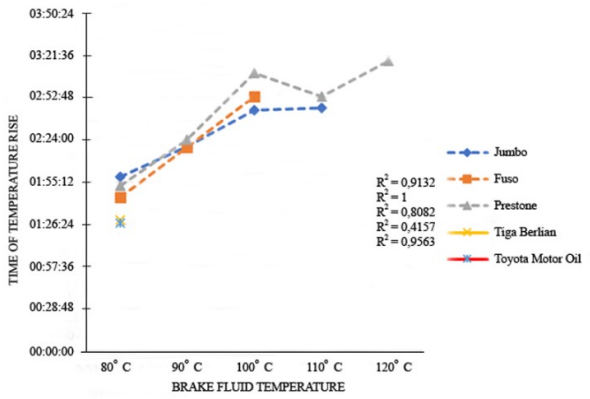

Fig. 5. The rate of increase in brake fluid temperature with 4% moisture level.

The results of Fig. 5 obtained the best rate of increase in brake fluid temperature in the Prestone brand brake fluid because it has an average temperature increase that is better than other brands. While Toyota Motor Oil (TMO) brand brake fluid has the lowest or fastest average temperature rise.

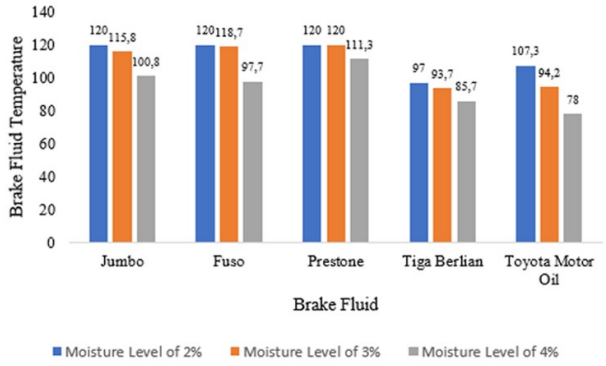

Fig. 6. Brake boiling point with a moisture level of 2%, 3% and 4%.

From the Fig. 6 can be seen that at the level of 2% brake fluid for Jumbo, Fuso and Prestone brands has a boiling point of 120°C, while the brake oil for Toyota Motor Oil (TMO) has a boiling point of 107.3°C, and brake fluid brand Tiga Berian has the lowest boiling point of 97. At 3% the Prestone brand brake oil has the highest boiling point of 120°C, and Tiga Berlian brand brake oil has the lowest boiling point of 93.7°C. At 4% the Prestone brand brake oil has the highest boiling point of 111.3°C and Toyota Motor Oil (TMO) brand brake fluid has the lowest boiling point of 78°C.

V. CONCLUSIONS

The moisture level of brake fluid affects the rate of increase in brake fluid temperature and the boiling point of brake fluid. The higher the water level of brake fluid, the lower the brake fluid temperature is achieved and the lower the boiling point of brake fluid. Different levels of water in the brand of brake fluid affect the rate of increase in the temperature of brake fluid and the boiling point of brake fluid. Prestone brake fluid brands have the longest increase in brake fluid temperature and boiling point temperature, while Toyota Motor Oil (TMO) brand brake fluid has the fastest brake fluid temperature and brake fluid boiling rate.

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