Performance Analysis of Automotive Brakin System in Various Road Conditions

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Abstract. The world experiences continuous development from time to time which encourages progress in various fields of life, one of which is technology. Technology has developed significantly due to the influence of people's lives which are always changing dynamically. Various automotive industries that compete with each other to present dream vehicles that can support people's lives in every condition. Innovations developed by various automotive industries are based on the basic human need for safety and comfort which is the main goal so that all innovations are always a top priority because in an era that continues to develop everything is forced to always be done quickly. One of them is the Braking system which has a function to slow down and stop the speed of a vehicle which is analyzed using direct observation methods with systematics using flow charts to determine the effectiveness of the Potential Braking System on Isuzu Mux Cars Based on Braking Torque, Braking Time, and Braking Distance which are reviewed from various perspectives. The condition of the road surface, the type of material used, and the various levels of speed so as to determine the best braking potential possessed by the Isuzu Mux car to support safety in driving on the highway.

Keywords: Braking system · Effectiveness · Safety car

1 Introduction

The world experiences continuous development from time to time which encourages progress in various fields of life, one of which is technology [1]. Technology has developed significantly due to the influence of people's lives which are always changing dynamically. Dynamic changes in people's lives provide opportunities and opportunities for technology to always experience updates. Up-to-date technology can be seen easily from transportation facilities that come with various sophistications to make people's lives easier, especially helping mobility from one place to another so that the development and improvement of sustainable automotive technology continues [2].

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Innovations developed by various automotive industries are based on the basic human need for safety and comfort which is the main goal so that all innovations are always a top priority because in an era that continues to develop everything is forced to always be done quickly. In the field of transportation is also expected to apply in accordance with the developments that occur. For this reason, the quality of vehicle behavior have need of known in order to avoid unwanted impacts. Therefore, the braking system of a vehicle must also be further refined in accordance with the increase in the speed of the means of transportation because brake technology plays an important role in safety [3]. Increasing the safety factor is also one of the most main goals current technological developments. Many accidents occur due to errors or imperfections of the brake system [4]. In addition to avoiding accidents, the shorter the braking distance the better because a good system is to meet the requirements of fast, accurate, and synchronous braking [5].

The quality of a good braking system is braking that can prevent locking or locking of the wheels because in the upstate the adhesion coefficient between the wheels and the road will decrease so that the braking distance will be longer [6]. Not to mention if the ups do not occur simultaneously between the front and rear wheels (what is meant by the wheels on the middle and rear axles). If the front wheels are up first, the vehicle will lose control and if the rear wheels are locked first, the vehicle will lose stability and this situation is very dangerous. The occurrence of locks that are not simultaneously between the front and rear wheels is caused by the inappropriate distribution of the brake pressure given and required [7].

Basically the braking system is a system that is able to slow down and stop a rotation so that it must be considered carefully because if a braking system has a problem, a big problem will arise that will cause material and personnel losses, so knowledge about the most effective braking is needed on vehicles against various the type of terrain or road that will be passed in order to avoid various unwanted events. Vehicle braking performance must always prioritize passenger safety. For this reason, vehicle braking performance must always prioritize passenger safety [8].

2 Method

In the study of Vehicle Braking System Performance Analysis in Various Road Conditions using semi-qualitative research methods regarding Torque, Time, and Braking Distance combined with direct observation on the object of research, namely the Isuzu Mu-x Car at PT Asco Dwi Mobilindo as well as based on vehicle specification documents and results of interviews with experienced mechanics.

Step 1: Determining the research flow.

The stage of determining the research flow aims to design an activity plan that is carried out systematically and structured in order to determine the effectiveness of the braking system on various road surface conditions based on the research method used as following Fig. 1.

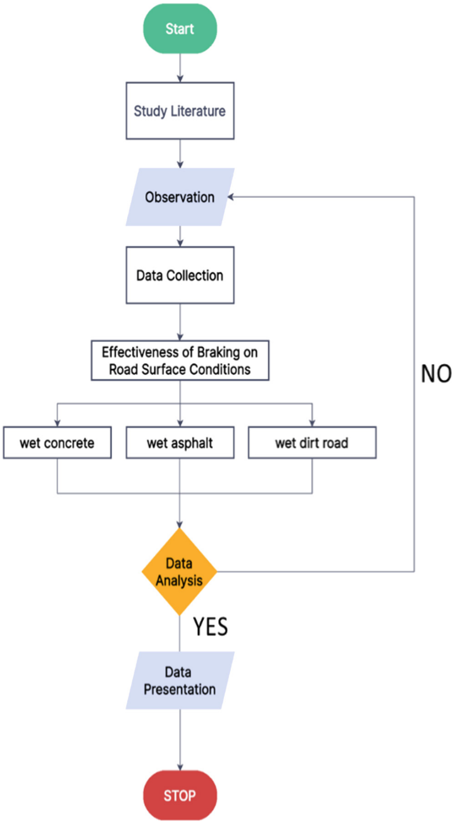

Fig. 1. Research systematic flowchart.

Step 2: Definition.

Defines the braking system and specifications owned by the Isuzu MU-X based on vehicle specification documents to provide general information such as vehicle size, vehicle capabilities, and others owned by the Isuzu MU-X so as to determine the potential of the braking system used.

2.1 Braking System Isuzu MU-X

The braking system is one system that is very important to make the car slow on various road surface conditions. One of them is the Isuzu MU-X car using Isuzu MU-X disc brakes on all four wheels with a more complete Safety system feature with ABS (Anti-Lock Brake System), EBD (Electronic Brake Distribution), BA (Break Assist), ESC (Electronic Stability Control), TCS (Traction Control System), as well as HSA (Hill Start Assist) and HDC (Hill Descent Control) which assist the driver by controlling the brakes to stay at low speeds when going downhill or passing through various road surface conditions so it is safe for driving. Downhill hydraulic pressure control linked to high resistance discs to provide fast and accurate response. More clarity about braking

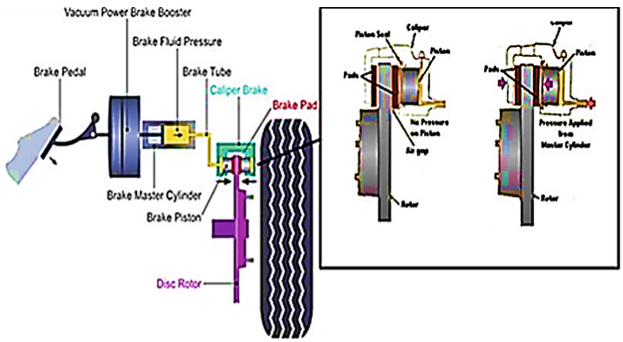

Fig. 2. Braking system.

Table 1. Machine Dimension Specification: *ISUZU MU-X Dimension*

Dimension Specification	
Length x width x height	4850 x 1870 x 1815 mm
Wheelbase	2855 mm
Distance Lowest To Ground	230 mm
Weight	2800 kg
Capacity Passenger	7 people

Table 2. Specifications of the engine frame

Frame Specification	
Frame	chassis high tensile strength steel
Front Suspension Type	Independent Coil Spring Suspension with Gas Shock Absorbers and Stabilizer Bar & 5-link Coil Suspension, Gas Shock Absorbers, Stabilizer Bar
Rear Suspension Type	Independent Coil Spring Suspension with Gas Shock Absorbers and Stabilizer Bar & 5-link Coil Suspension, Gas Shock Absorbers, Stabilizer Bar
Front Tire Size	255/65R17
Front Brake	Disc Brake 17″
Rear Brake	Disc Brake 17″

system can be seen on Fig. 2 and for specification of dimension, frame, and engine can be seen on Table 1 to Table 3.

Table 3. Engine specifications

Engine Specification	
Machine	RZ4E-TCIn-line 4-cylinder DOHC, 16 Valve featuring electronichigh pressure common-rail direct fuel injection withintercooled VGS (Variable Geometry System)
Fill Cylinder	1,898 cc
Diameter x Step	80 x 94.4 mm
Maximum power	150/3,600 PS/rpm
Maximum torque	35.7/1,800–2,600 Kgm/rpm
Lubricating oil capacity	2,5 L
Drive system	4WD - Shift On The Fly
Transmission	A/T 6 Speed Triptonic
Model	AWR6B45-II
Fuel system	Common Rail
Fuel Type	80 L

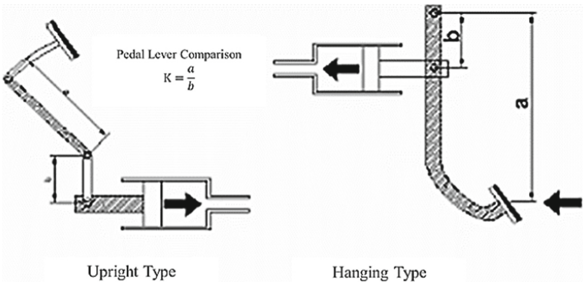

Fig. 3. Force on the braking system.

Step 3: Braking System Schematic.

The purpose of the explanation of the braking system scheme is to show the effectiveness of the braking system on various road surface conditions based on data obtained from a literature study on Torque, Time, and Braking Distance combined with direct observation on the object of research, namely the Isuzu Mu-x Car at PT Asco Dwi Mobilindo as following in Fig. 3. At the same time based on vehicle specification documents as well as the results of interviews with experienced mechanics.

In addition, it is also necessary to find the master cylinder pressure in the braking system which is described as follow Fig. 4.

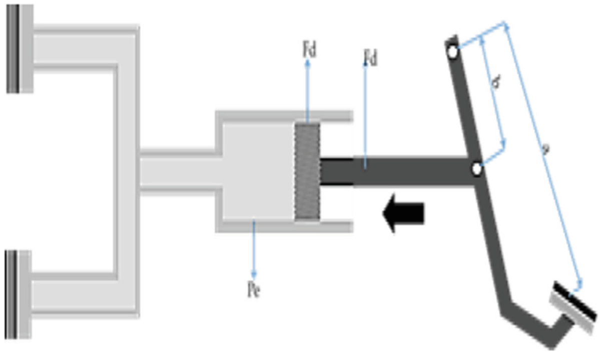

Fig. 4. Braking system on the pedal.

3 Results and Discussion

Referring to the Flowchart design in the design step and the design that has been made in the development step which is analyzed in the form of calculations, the amount of braking torque possessed by various types of materials is as following in Table 4.

Through the amount of torque, the calculation of braking time at various speed levels, namely 30 m/s, 60m/s, and 90m/s, is followed by calculating the braking distance to determine the distance to slow down or stop at 3 speed variations with 3 different types of road surface conditions. - speed differences ranging from 30 km/hour, 50 km/hour, and finally 90 km/hour including wet concrete, wet asphalt, and wet dirt roads to determine the effectiveness of the braking system on Isuzu Mux vehicles, the calculation analysis is carried out as follows.

3.1 Braking Time (te)

Braking time is the time it takes to stop the vehicle from a certain speed until the vehicle stops, so the calculation is carried out in such a way as to get the te value for three variations of speed, namely 30 m/s, 60 m/s, and 60 m/s, with the result obtained for a speed of 30 m/s is 3.82 s while at a speed of 60 m/s the result is 7.64 s then for a speed of 60 m/s the result is 11.47 s. All results are obtained from calculations that take into account the braking synchronous point with an e value of 0.5 – 0.8 and the influence of gravity when braking.

3.2 Braking Distance (d)

Braking distance is a condition where a vehicle brakes to slow down or stop the vehicle at a certain distance, the distance in this study is adjusted to 3 variations of speed and 3 variations of the road surface, starting from speeds of 30 km/hour, 60 km/hour, and the latter is 90 km/hour which is calculated in such a way by taking into account the adhesion coefficient in Table 5.

Table 4. Braking torque.

Material type	Braking torque
cast iron	176,9303 N
wood	309,628025 N
sintered alloy	442,32575 N

Table 5. Coefficient of adhesion

No	Road Surface	Coefficient adhesion highest	Coefficient wheel adhesion lock
1	Asphalt and concrete (dry)	0,85	0,75
2	Asphalt (wet)	0,6	0,58
3	Concrete (wet)	0,8	0,7
4	Gravel	0,6	0,55
5	dirt road (dry)	0,68	0,65
6	dirt road (wet)	0,55	0,45
7	Snow	0,2	0,15
8	Ice	0,1	0,07

Table 6. Braking Distance (d)

Surface Conditions	Speed Level Road (Km/h)	Speed Level Road (m/s)	Braking Distance
Wet concrete	30 km/h	(8,33 m/s)	4,42 m
			12,27 m
			39,82 m
Wet asphalt	60 km/h	(13,88 m/s)	5,89 m
			16,36 m
			53,09 m
Wet dirt road	90 km/h	(25 m/s)	6,43 m
			17,85 m
			57,92 m

From the calculations that have been carried out with 3 variations of speed and 3 variations of the road surface, starting from the speed of 30 km/h, 60 km/h, and finally 90 km/h, the braking distance is obtained as follows in Table 6.

Table 7. Calculation of braking time (te) and braking distance (d)

Speed Level Road	Braking Time	Braking Distance	Surface Conditions
30 km/h (8,33 m/s)	3,82 s	4,42 m	Wet concrete
		12,27 m	
		39,82 m	
60 km/h (13,88 m/s)	7,64 s	5,89 m	Wet asphalt
		16,36 m	
		53,09 m	
90 km/h (25 m/s)	11,47 s	6,43 m	Wet dirt road
		17,85 m	
		57,92 m	

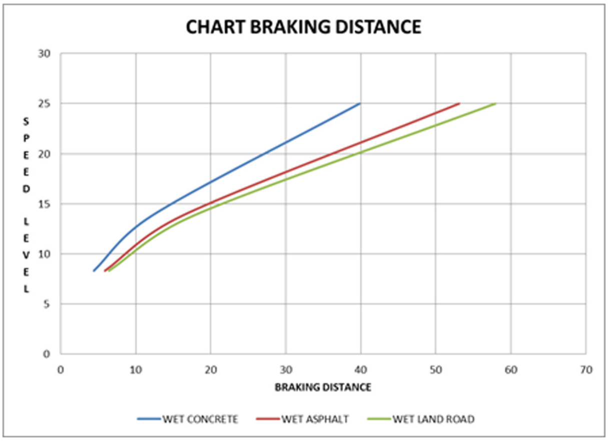

Fig. 5. Graph of braking distance at speed

Through the analysis of the calculation of the calculation of braking time at various levels of speed and braking distance with 3 variations of speed with 3 different types of road surface conditions, the following results are obtained as shown Table 7 and Fig. 5.

The braking system must be controlled with the vehicle speed determined by braking acceleration in reducing linear speed at low speeds, immediately after the first brake pressure modulation [9]. Based on this, a calculation analysis was carried out that compared the vehicle braking system in passing through various variations of the road with the results it is known that the braking effectiveness of the Isuzu MU-X vehicle is best when passing through wet concrete roads because it is able to produce very large friction between the road surface and the wheels supported by braking torque. Large so that the front wheel brake pressure gets a greater dynamic load than the rear wheel which causes the vehicle's stopping distance to be shorter with a short braking time. In accordance with the function the braking system must be able to provide sufficient braking force to fully lock the wheels at the end of the specified speed. It also shows that the coefficient of adhesion also affects the braking distance.

4 Conclusions

The potential for the braking system on Isuzu mux vehicles is most effective when passing through wet concrete roads because it is able to produce relatively shorter braking distances in a short time supported by high braking torque so as to provide security certainty to the driver when traveling while reducing the risk of traffic accidents, especially when passing through concrete roads. Wet is also able to provide an overview to vehicle users when passing through various road surface conditions to estimate braking time with the aim of the vehicle being able to stop quickly in a short distance to avoid various unexpected risks.

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