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ANALYSIS OF LIGHTING INTENSITY AND ANGLE DUE TO LOAD CHANGES AND IMPACT ON VEHICLE SAFETY

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ABSTRACT

The lighting system on the vehicle has an important role in supporting driving comfort and safety, especially at night. The effectiveness of lighting is greatly influenced by two technical parameters, namely cut-off angle and horizontal angle, which determine how far and wide light is emitted and its impact on the driver's visibility without disturbing other road users. This study aims to analyze the effect of charging on the angle and intensity of lighting of motor vehicle lights. The method used is experimental, which is to provide treatment in the form of load variations and analyze its effect on lamp performance. The results showed that the increase in load was directly proportional to the increase in cut-off angles. Significant changes occurred during the switch from model 4 to model 5, with an increase in the left and right cut-off angles of 0.8º and 0.6º respectively. The highest values are achieved on the 5 model (driver + 420 kg load), which are 2,6º and 2,5º. At the horizontal angle, the model 5 produces the largest values of -5.7º and -5.3º, which indicate the expansion of the beam to the left side. The increase in illumination also occurs as the load increases, especially at the distance of 40 meters between the model 3 and the model 5, with the highest value being 9.79 lux on the model 5. These findings suggest that changes in vehicle load affect the direction and intensity of light of the lights, which has an impact on driving safety.

Keywords: illumination angle; lighting intensity; load change; vehicle safety

INTRODUCTION

The lighting system on vehicles plays an important role in providing comfort and safety in traffic, especially at night. One of the components of the lighting system in vehicles is the headlights. Headlights or often called head lights are lights placed at the front of the vehicle, functioning as street lighting at night (Esculenta & Febri, 2018). The light source coming from the lights of vehicles in the opposite direction has a high intensity, while the lighting on the highway is not optimal, even dark at certain points. This condition causes the eyes to adapt from low-intensity lighting to high-intensity lighting, causing a glare sensation in the eyes (Yehuda et al., 2024). From the aspect of the physical condition of the road, traffic accidents occur proportionally in both potholes and non-potholes in the environmental conditions. Meanwhile, judging from the lighting conditions, accidents occur more often in places with minimal/dark lighting conditions (Maulana, 2018).

Two technical aspects that greatly affect the effectiveness of vehicle light lighting are cut-off angles and horizontal angles (Cahyo et al., 2023). These two elements play an important role in determining how far and wide the light is emitted, as well as how it affects the driver's visibility without causing interference to other motorists (Hidayat et al., 2024). The use of lights with a good cut-off design can improve visibility without causing glare (Kusumo et al., 2018). In addition, horizontal angle adjustment also plays an important role in maintaining a balance between long viewing distance and wide light coverage (Rusko, 2022). Article 24 Government Regulation of the Republic of Indonesia Number 55 of 2012 concerning Vehicles Regarding vehicles, paragraph (1) is near main lights and far main lights as referred to in Article 23 other than Motorcycles must meet the following requirements:

a. Totaling 2 (two) pieces or multiples of them
b. Mounted on the front of the Motor Vehicle
c. Installed at a height not exceeding 1,500 (one thousand five hundred) millimeters from the road surface and not exceeding 400 (four hundred) millimeters from the side of the outermost part of the vehicle; and
d. It can emit light at least 40 (forty) meters forward for close main lights and 100 (one hundred) meters forward for far main lights.

In the above rules, there are no rules related to the limits of transmitting power and lighting angles caused by the loading of motor vehicles. Theoretically, this change in the angle of inclination directly changes the direction of the beam of the main lamp, both the low *beam* and the high *beam*. Too high a beam can glare the driver from the opposite direction and increase the risk of accidents. Therefore, the purpose of this study is to determine the effect of loading/loading on the transmitting power and angle of motor vehicle lights. It can also be a reference material for literature on the development of motor vehicle testing, especially the regulation of motor vehicle headlight testing in Indonesia.

METHOD

To obtain an actual research result regarding the measurement of the intensity and angle of the lamp with variations in the loading / loading of motor vehicles, the test starts from a planning of test equipment, testing and interpretation of test results. This research is carried out by an experimental method, namely by giving a treatment, then evaluating the influence caused on a research object. The object of the research in this case the headlights of category M motor vehicles, some of the variables given in the experimental research include variations in vehicle load values which refer to the standardization of ECE R48 related to loading conditions (The United Nations Economic Commission for Europe, 1988). This data collection was carried out at the motor vehicle testing and control laboratory at the Indonesian Land Transportation Polytechnic – STTD with a research time span from September to November 2024. The five loading conditions that differ from the ECE R48 reference will be used as a reference as a variation of loading in this test with the following categorization:

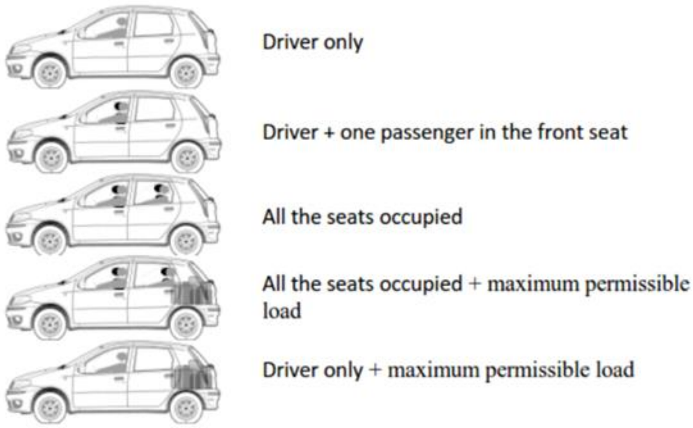

Figure 1. ECE R48, Specified loading conditions for category M1

Table 1.
Load Variations in Test Vehicles

Yes	Load Variation	Code
1	Driver	Model 1
2	Driver + passenger (driver side)	Model 2
3	Driver + 360 kg	Model 3
4	Driver + 360 kg + 50 kg baggage	Model 4
5	Driver + baggage 420 kg	Model 5

The stages of testing and data analysis are briefly described as follows:

1. Testing of vehicle headlight angles, namely cut off angles and horizontal angles, was carried out using a headlight tester with various load variations according to Table 1;
2. Furthermore, the test of the transmission power of vehicle light beams is measured based on the distance of 40 and 100 meters referring to the regulation of Government Regulation No. 55 of 2012 concerning vehicles;
3. Data collection and analysis of the significance of changes in transmitting power and lamp angle to load variations in vehicles. This is done by using tables or graphs to visualize the data.

RESULT AND DISCUSSION

The test was carried out with a load variation of model 1 to model 5 with a *cut-off* angle. The *cut-off* angle is a dividing line with a horizontal pattern between the light and dark areas of the vehicle's headlights that function as the focal point of the light beam. The cut-off point *of the cut-off* angle will be tested by sequentially assigning load variations as shown in Table 2.

Table 2.
Test results of load variation with cut-off angle

No	Load Variation	Cut-Off (º)	
		Kirishima	Kanan
1	Model 1	0,9	0,7
2	Model 2	1,1	0,9
3	Model 3	1,4	1,5
4	Model 4	1,8	1,9
5	Model 5	2,6	2,5

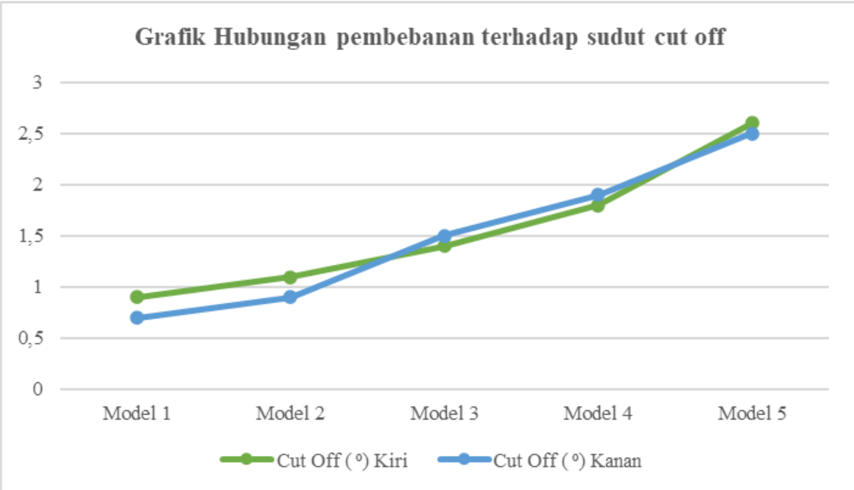

Figure 2. Graph of the relationship of the load to the *cut-off angle*

The horizontal angle of the vehicle's lights is the pattern of the distribution of light to the left and right. The following are the results of the test of the relationship between load variation and the horizontal angle of the vehicle lights in Table 3.

Table 3.
Test results of load variation with horizontal angle

No	Load Variation	Horizontal (º)	
		Kirishima	Kanan
1	Model 1	-4,1	-4,6
2	Model 2	-4,5	-5
3	Model 3	-4,7	-5,1
4	Model 4	-4,7	-5,1
5	Model 5	-5,7	-5,3

Based on the results of the relationship between load variations and lamp angles above, then validation was carried out in the form of simulation of the glare level of near and far lights based on the predetermined load variation with testing based on distances of 40 and 100 meters. This refers to Article 24 of Government Regulation No.55 of 2012 concerning vehicles. For the height of the lux meter test device, it is assumed to follow the height of the driver's point of view of the M1 category car.

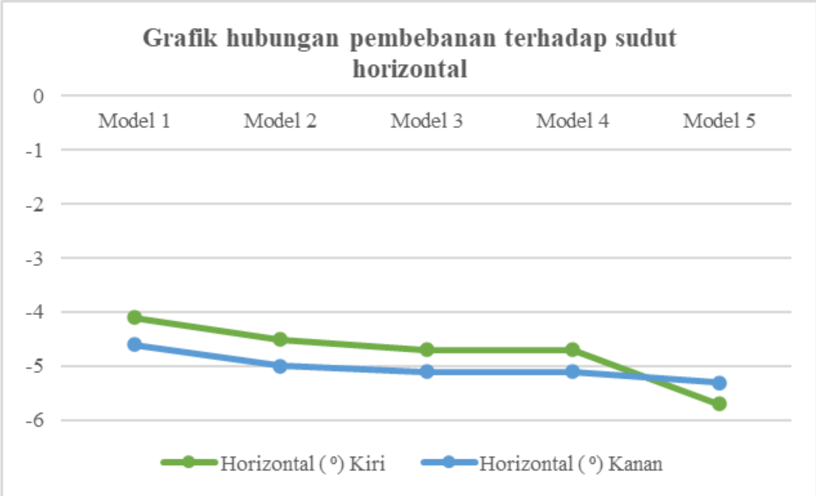

Figure 3. The Relationship of Load Variation to the Horizontal Angle of the Lamp

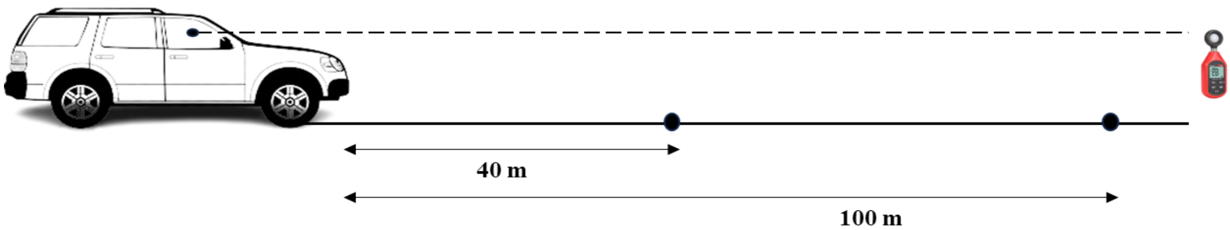

Figure 4. Simulation of lamp intensity and glare level testing based on load variations

Table 4.
Test Results of Load Variation with Measurement Distance

No	Load Variation	Iluminasi (luX)	
		Distance 40 m	Distance 100 m
1	Model 1	2.15	1.36
2	Model 2	2.04	1.08
3	Model 3	4.79	3.34
4	Model 4	8.21	6.89
5	Model 5	9.79	5.62

Figure 2. shows a graph of the relationship between load variation to the *cut-off* angle of the lamp. Based on the graph, it can be seen that the greater the load placed on the vehicle, the greater the degree of *cut-off angle*. The additional load is simulated with different weight points and in accordance with the construction of the vehicle's design. The value that can be seen to increase significantly is when the load position of model 4 to model 5 changes with an increase in the cut off angle of the left and right lights by 0.8^o and 0.6^o. The highest cut-off angle values obtained during the model 5 test, namely vehicles with a driver and a load of 420 kg of baggage, were 2.6^o and 2.5^o. This happens due to a change in the position of the load that rests on the rear trunk area of the vehicle.

In figure 3. shows a graph of the relationship between load variations to the horizontal angle of the lamp. From the graph, it can be seen that the greater the load placed by the vehicle, the greater the degree of horizontal angle. The additional load is simulated with different weight points and in accordance with the construction of the vehicle's design. In this horizontal angle examination, the min value (-) is interpreted as the expansion of the beam angle to the left side of the lamp. The more the load is added and based on the variation in the placement of the load to the rear of the vehicle cabin, feeding will make the horizontal angle of the lamp more inclined to the left. The value that can be seen to increase significantly is when the load position of model

4 to model 5 changes with an increase in the horizontal angle of the left light by 1º. The largest horizontal angle values obtained during the model 5 test, namely vehicles with a driver and a load of 420 kg of baggage, were -5.7º and -5.3º.

Based on the results of measuring lamps close to the variation in load to the distance of 40 and 100 meters from the table above, several fluctuating illumination values were obtained from several load variations. From model 1 - model 2, there is no increase in illumination value because there is only an increase in the load of passengers next to the driver. The increase in illumination value occurred in model 3 - model 5 at a distance of 40 meters. Conversely, in the measurement of the distance of 100 meters, there was an increase in model 3 - model 4, but there was a decrease in the illumination value of model 5 at a distance of 100 meters.

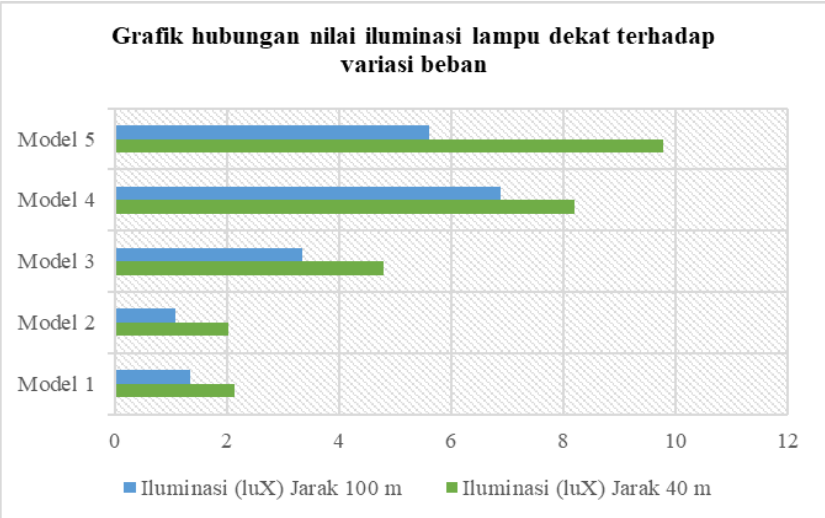

Figure 5. The Relationship of Near-Light Illumination Value to Load Variation

Based on the results of the analysis, the effect of load variation on the angle *cut-off* and the horizontal angle of the vehicle's headlights, there are several findings that are in line with previous research. Research by Kusuma (2018) In "Planning Automatic Lamp Height Adjustment Based on Vehicle Load" it is shown that the addition of load on the vehicle can cause a change in the beam angle of the lamp. In the study, a load of 650 kg led to a 12 cm decrease in the height of the rear of the vehicle, which resulted in an increase in the height of the headlights by 12 cm. This suggests that the load placed at the rear of the vehicle can affect the beam angle of the lamp, which is in line with the finding that increased load leads to an increase in cut-off angle and a shift in the horizontal angle to the left (Kurniawan & Purnawan, 2021).

CONCLUSION

From the results of testing the transmitting power and the illumination angle of the vehicle's headlights due to load variations, it can be concluded *that the cut-off angle* tends to increase as the load increases. The horizontal angle tends to increase to the left of the vehicle's headlight angle. In the test of transmitting power based on distances of 40 and 100 meters, there was an increase in illumination values at the measurement of a distance of 40 meters. This makes the relationship between *cut-off* angle and headlight emission power with increasing load variations have strong relevance to driving conditions on the road, especially at night. It is necessary to conduct a follow-up study that is more in-depth and more related in terms of road safety aspects.

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