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Determination of Air Drag Coefficient of Mini Track

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Abstract:

The Labo car is used as a small truck in Central Asia, especially in Uzbekistan. The Labo car is available with an open trunk and a closed trunk. In both cases, it is well known that the air resistance to the car is different. An increase in air resistance affects fuel consumption. Especially when moving at high speeds, the resistance value increases even more. Even a small change in the body will cause a change in the value of the air resistance. In this article, the research work on the Labo car with the same front end but different trunk was carried out and the results were compared. The test was carried out on miniature models.

Key words: Car model, air resistance, air drag coefficient, air flow.

INTRODUCTION

At the time of the invention of the car, its aerodynamics were not so important. The first bodywork was simply to protect the driver and passengers from the discomfort of the external environment. Cars manufactured at the beginning of the 20th century were wagon-shaped bodies, and the coefficient of aerodynamic resistance of these cars was 0.7-0.8. In addition, the power of the engines installed on them was low. These two factors resisted the achievement of high speed. One of the main issues of that time was to start work on improving the aerodynamics of the car body before the development of engines.

Improving the aerodynamic characteristics of the car body and improving the construction improves safety, fuel efficiency, speed and dynamic characteristics, and ergonomics. Today, all tests are digitized. However, due to the complex shape of the car body, its aerodynamics is studied in special devices. Aerodynamic studies on full-size cars require aerodynamic tubes, which are very expensive. Only large car manufacturers have the opportunity to use such a device. The research carried out in this paper was carried out using scale models and in a small aerodynamic tube, and this methodology is recommended for use in the early stages of the design process.

LITERATURE SURVEY

Several studies have been conducted on scaled models. The position of elements in the car body has an effect on the force of air resistance. In [1], the experimental results of how the air resistance coefficients change depending on the position of the doors on the M1:36 scale car model are presented. [2] describes test work on a M1:15 scale vehicle. Another test on scaled models was performed by Pikula B. et al.[3]. Unlike [1] and [2], this experiment uses wind tunnels with an open working section. In [3], it can be seen that the value of the air resistance coefficient decreases when the speed of the car increases. An 18 times scaled-down car model was used for the experiment. Mohd Nizam Sudin [4] conducted research on reducing the drag flow generated at the rear of the car. Lee Good studied the relationship between road tests and aerodynamic tube results [5]. The article by W. H. Hucho and others covered in detail the work initially carried out to improve the aerodynamics of cars. In our previous works, researches on minivan and hatchback type models were carried out based on this method[9-10].

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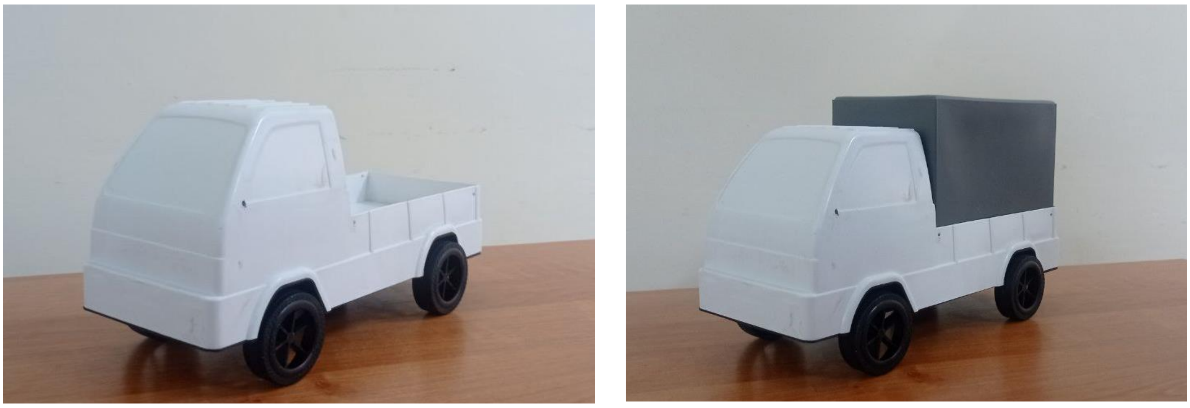
EXPERIMENTAL METHODOLOGY

How the air flow passes over the surface of the model can be determined using virtual testing programs. With the help of this method, it will be possible to see in which parts the cumulative air flow appears.

An experiment was conducted on the air flow movement in a test device with an open circuit and a closed working part. In the working part of this aerodynamic pipe, it is possible to move the air flow up to 18-20 m/s.

Research object

The M1:10 scale model of the Labo car was chosen as the research object. Tests were carried out with the rear trunk open (1) and closed (2). The front area of the models are S1=0.0208m2, S2=0.0189m2.



(a) (b)

Figure 1. A scaled model of the Labo car. (a) with an open trunk (b) with a closed trunk

Aerodynamic drag measurment

To determine the value of air resistance, a tensometric dynamometer is installed on the working part of the aerodynamic pipe. Installation is done in different ways. Three methods of installing aerodynamic dynamometers are described in [7]. Singh P.K. also presented a unique method of installing an aerodynamic dynamometer [8]. In our study, the tested object was placed directly on the strainometric sensor of the dynamometer.

Air speed measurment

Anemometers are used to determine the speed of the air. Nowadays, digital anemometers are common. Modern anemometers are equipped with sensors for measuring air temperature. This provides an opportunity to obtain information about the flow rate and temperature at the same time.

Description of the anemometer used in the aerodynamic pipe:

The range of temperature measurement is -10 .... +50^{0}C, measurement error - ±0.5^{0}C, measurement frequency 0.5 sec.

Speed measurement range 0.4... 20 m/s, measurement error 0.2 m/s.

Experimental method

A miniaturized model of the Labo car, first with an open trunk and then with a closed trunk, is placed in the working part of the aerodynamic tube. It is necessary to pay attention to the fact that the model touches the tensometric scale. Then air is sent to the working part. When the selected

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speed range is reached, the dynamometer reading is recorded. The coefficient of aerodynamic resistance is calculated based on the value of the aerodynamic resistance force, the front surface of the model, and the speed of the air flow in the working part. The number of experiments is 30.

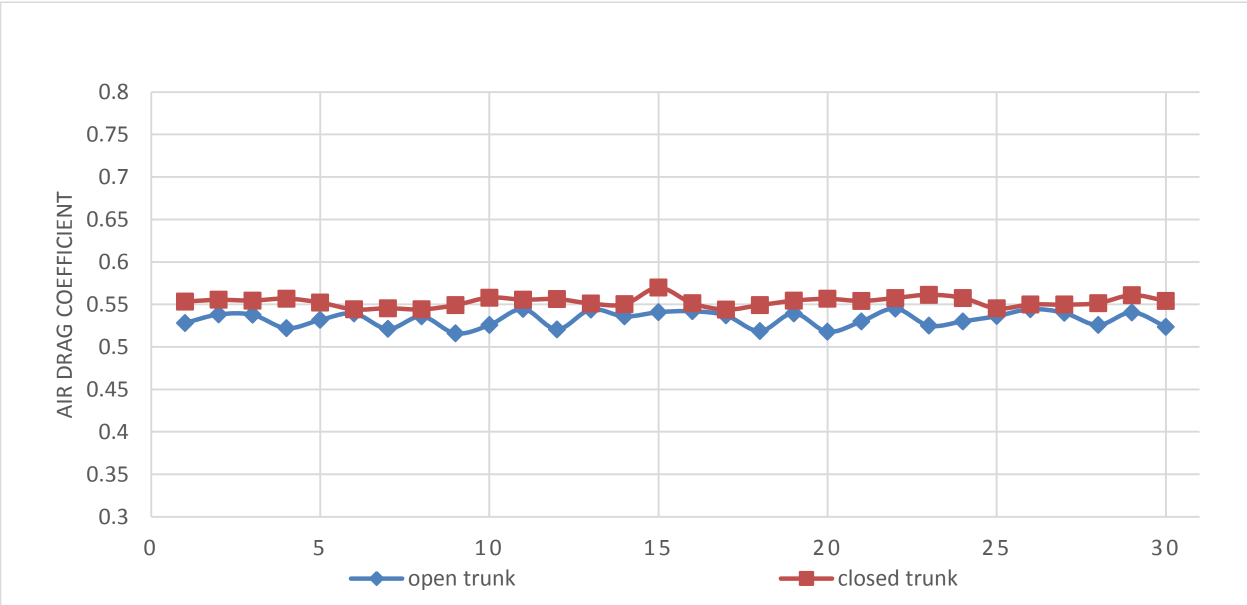
RESULTS

Experiments were conducted at an air flow speed of 7.3 m/s. Air resistance was recorded differently. The minimum value was 0.316N and the maximum value was 0.334N. In the closed trunk model, the minimum value was found to be 0.367N and the maximum value was 0.385N. Accordingly, aerodynamic resistance coefficients were calculated. The calculation was made based on the following formula:

$$C_d = F\frac{2}{pSv^2}$$

Type of model		Air resistance force, N	Air drag coefficient
Open trunk	min	0,316	0,51
	max	0,334	0,54
Closed trunk	min	0,367	0,54
	max	0,385	0,56

The results of 30 experiments can be seen in the diagram below:



How air flows through the model was examined in virtual test programs. The results are presented in Figures 2 and 3.

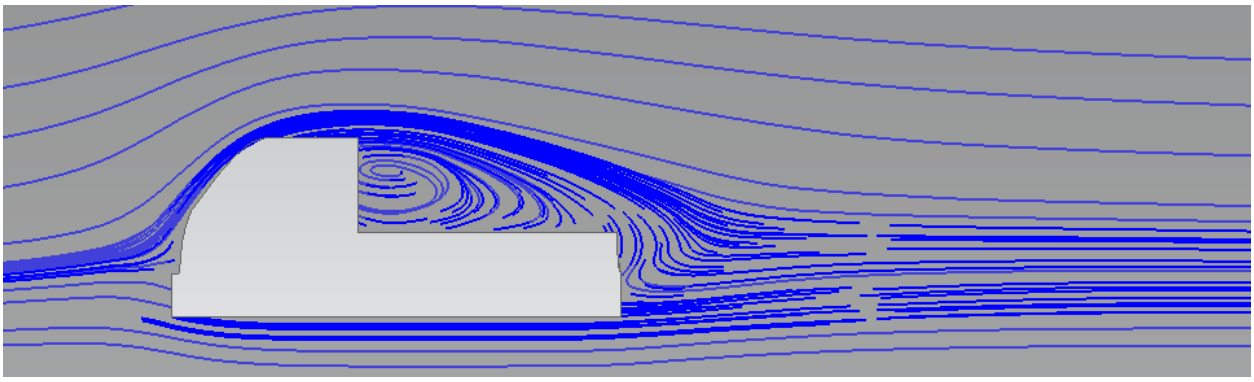


Figure 2. Air flow from the model with an open trunk

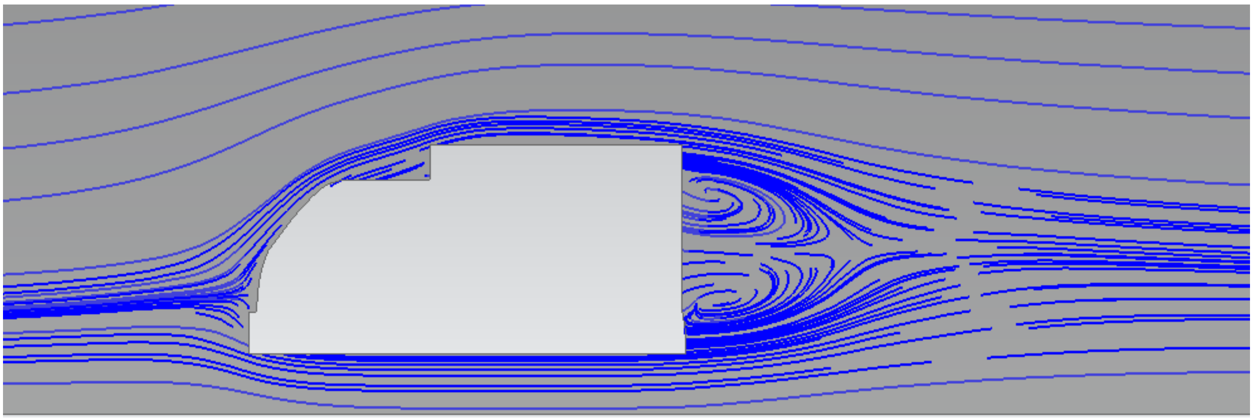


Figure 3. Air flow from the model with an closed trunk

CONCLUSION

The increase in the front surface of the car definitely affects the value of the air resistance. Among the factors affecting the air resistance, there is also the resistance coefficient, and it was determined by experiment that not only the front surface, but also the amount of the coefficient is different in the open and closed trunk types of the Labo car. Such a difference is also visible in a sphere and a cylinder with the same diameter. This method can be used to determine the drag force and drag coefficient. Using this method in the early stages of designing a new car model has several economic benefits.

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