FINAL PROJECT
ENERGY CONVERSION FIELD

EFFECT OF PYRAMID TAIL AS AN AERODYNAMIC DEVICE ON DRAG AND FUEL CONSUMPTION OF CONVENTIONAL TRUCK

A Final Project is submitted as Partial Fulfillment
of The Requirements for Degree of Bachelor

By:
NOVIANDY
NBP: 03 171 093

MECHANICAL ENGINEERING
ENGINEERING FACULTY- ANDALAS UNIVERSITY
PADANG, 2007

Abstract

Truck, as one of vital transportations, has achieved 4.2 billion units with growth of 27 percent each year in Indonesia (Ditjen Hubdat, 2004). This situation can cause the deficit of fuel resource soon or later since the fuel consumption is increased as well. Some efforts have been made to solve this problem globally such as by designing vehicle whose economical fuel consumption and researching some alternative fuels. Besides, there is also alternative effort that can minimize the consumption of fuel that is by modifying the vehicle becomes the aerodynamic one. Conventional trucks in Indonesia that seems to have no aerodynamic consideration can be modified by installing a pyramid tail. It is convinced that by installing this device, the aerodynamic drag can be reduced. In addition, fuel consumption can be reduced, too. It is because the power commonly used to overcome drag has been cut down. In order to investigate the further effect of this device to drag and fuel consumption, wind tunnel and coast down examination have been conducted. As the result of those examinations, it is found that pyramid tail is able to reduce the drag. Specifically, pyramid tail 28 mm gives reduction of drag 20.4% and pyramid tail 50 mm gives reduction of drag 32.2% at high Reynolds number. To obtain the reliable measurements of fuel consumption through coast down examination in a real vehicle is quite complicated. The main problem is the influence of the external factors such as weather and traffic-load. They are not repeatable. While the vehicle is being rebuilt to another configuration, the weather and traffic-load have been different. But fuel economy potential is still obvious in high speed where pyramid tail 50 cm gives fuel saving 27.6% and pyramid tail 86 cm gives fuel saving 3.6%.

CHAPTER 1
INTRODUCTION

1.1 Background

Oil crisis that has begun since 1970 does not show a better development so far. Now, oil price has achieved USS 78 per barrel. This condition absolutely makes developing countries suffered. In Indonesia, the condition seems to be worst because there is a high increasing of vehicle number especially heavy vehicle such as truck. Truck, as a vital transportation for moving many kinds of products and raw material, has achieved 4.2 billion units with growth of 27 percent each year (Ditjen Hubdat. 2004). This fact will bring us to deficit of fuel condition immediately because fuel consumption is increased.

Some efforts have been made to solve this problem globally such as by designing vehicle whose economical fuel consumption and researching some alternative fuels. But there is another effort that can minimize the consumption of fuel which is by designing a vehicle that has lower aerodynamic drag. The aerodynamic drag becomes significant factor because it will generate drag which gives force to backward when a vehicle moves forward. In doing so, the vehicle needs some energy to overcome the drag. For example, a modern truck which has weight over 36 ton has drag coefficient C_D=0.6. When the truck achieves velocity 70 miles per hour, 65% energy is used to against the drag (Rose Mc Gallen et al, 2000). Drag still has effect to energy in lower velocity since it has big frontal area. Consequently, the truck consumes fuel lavishly.

Figure 1 Condition of Conventional Truck in Indonesia

In fact, Indonesian chooses to buy conventional trucks because it is cheaper than other types of trucks. A common conventional truck that occurs commercially has not had a container. So, the owner of the trucks needs to add local containers made of wood (Figure 1). This design of container seems neglecting aerodynamic consideration. When a container applies to it, a truck which has higher aerodynamic drag will be generated. The container is higher than cabin and beams that support construction of container become obstacle for fluids which flow beside the truck.

The changing of the truck construction can be made in frontage, base and along side of the truck. In this research, the reconstruction is just only focused on the base of the truck by putting pyramid tail. By this changing, the drag would be reduced by reducing vacuum area behind the truck. To find out the quantity of fuel reduction, a road test or coast down needs to be done.

1.2 Objectives

The objectives of this experiment are:

1. To investigate the effect of pyramid tail's length to drag of truck.
2. To demonstrate the potential of pyramid tail in fuel savings

1.3 Benefits

The experiment will give potential benefits for some sectors:

a. Science and Technology;

   1. To generate an aerodynamic land vehicle by putting pyramid tail for reducing of fuel consumption.
   2. To provide guidance to industry in the reduction of aerodynamic drag of heavy truck vehicles.

b. Economy;

   1. To reduce an operational cost because of decreasing of fuel consumption.
   2. To provides job vacancy on truck industry by making pyramid tail for 30 million trucks in Indonesia.

c. Environment

By saving fuel consumption means to decrease of emitting gas, therefore glass house effect can be reduced.

1.4 Problem of The Research

The profile of truck which has square shape generally generates vacuum area at backside of the truck. This means high pressure drag is produced at high velocity. A pyramid tail as an aerodynamic device is expected to reduce the drag and fuel consumption. To find out the effect of this device to decreasing of drag and fuel consumption, wind tunnel and coast down examination need to be conducted respectively.

1.5 Scope of the Research

This final report is focused on shape changing at the backside of a conventional truck, Mitsubishi 135 Ps Truck, 2000 Production. This truck was chosen as a sample because its design has no aerodynamic consideration. Two kinds of pyramid tail which has different size would be put behind the truck in separate test to find out the effect of the length. To identify that there is decreasing of drag or fuel consumption, empiric analysis such as coast down or road test is needed respectively.

1.6 Outline of the Report

This experiment report is arranged in systematic form as follow:

1. Chapter 1 Introduction contains the background, objectives, benefits and systematic of writing.
2. Chapter 2 Review on Related Studies, explains the theory of aerodynamic and another experiment that support this experiment.
3. Chapter 3 Methodology consists of parameters and procedure which is used in this experiment.
4. Chapter 4 Result and Discussion contains result of the examination and discussion about the result.
5. Chapter 5 Conclusion and Suggestion

CHAPTER 4
RESULT AND DISCUSSION

In this chapter will present the result and discussion of examination in different area; wind tunnel and coast down based on their purposes. The wind tunnel examination is conducted in order to find out the effect of pyramid tail to drag of a model, while coast down is carried out to know effect of this aero device to fuel consumption of conventional truck.

4.1 Wind tunnel examination

This section presents the result from three configurations of drag measurement. There are unmodified conventional truck model, model installed with pyramid tail 28 mm, and model with installed with pyramid tail 50 mm. Those results are depicted in figure 4.1 showing a correlation between Reynolds number and drag coefficient. Correlation between them shows positive correlations. This means increasing of Reynolds number will improve drag coefficient. But there is a little disturbance at Reynolds number around 80000. This phenomena was caused by transition stream.

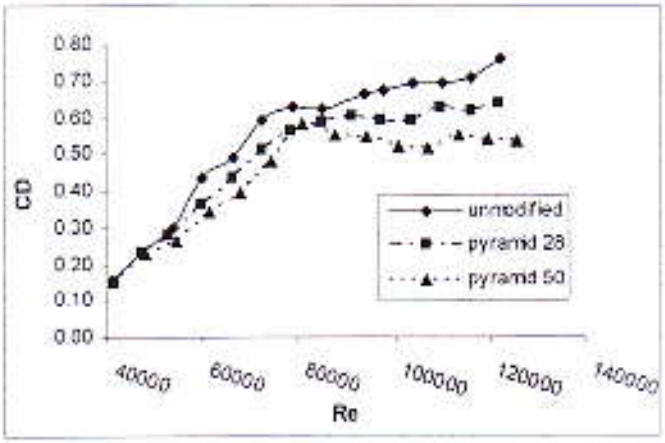

Figure 4.1 Correlation between Reynold number and drag coefficient

Examination by using pyramid tail 50 gives higher Reynolds number than others. It is caused by longer length will generate turbulence stream which much higher than others configuration.

CHAPTER 5
CONCLUSION AND SUGGESTION

5.1 Conclusion

The using of pyramid tail is examined to know effect to drag and fuel consumption of conventional truck. The examination is conducted in different types based on their purposes; wind tunnel and coast down. Some points that can be concluded from those examinations are:

1. The measurement of drag through wind tunnel examination shows that the increasing of Reynolds number will be followed by increasing of drag. By installing pyramid tail behind truck model, drag can be reduced where pyramid tail 28 mm gives reduction of drag 16% and pyramid tail 50 mm gives reduction of drag 27.8% at high Reynolds number.
2. Doing reliable measurements of fuel consumption through a coast down examination in a real vehicle is complicated. The main problem is that surrounding factors are not repeatable. While the vehicle is being rebuilt to another configuration, surrounding factors like weather and traffic-load change. But fuel economy potential is still obvious in high speed where pyramid tail 50 cm gives fuel saving 27.6% and pyramid tail 86 cm gives fuel saving 3.6%.

5.2 Suggestion

An alternative for further coast down examination is to use several vehicles at the same time, but still there are unwanted differences between the individual vehicles and drivers. How hard the driver accelerates and at which engine speeds gears are changed can influence fuel consumption by 5% [Sandberg, 2001]. Additionally, the differences between different vehicle configurations are usually very small, so it is necessary to drive in a long distances to ensure a certain difference.

BIBLIOGRAPHY

[1] Crouse, W. H dan Anglin, D.L., *Automotive Mechanics*, Mc Graw-Hill Book Company, New York, 1985.

[2] Gartner, M., *General Aerodynamics Principles*, http://Race Car Design Tips and Information – Aerodynamics.html, New York, 1999.

[3] Visser, K.D., *Tractor Trailer Drag Reductions*, www.K-Visser--Trailer Drag Reduction Project.html, New York, 2002.

[4] Daugherty, R.L, Franzini, J.B dan Finnemore, E.J. *Fluid Mechanics with Engineering Applications*, McGraw-Hill Book Company, Singapore, 1989.

[5] Blevins D. Robert., *Applied Fluid Dynamic Handbook*, Van Nostrand Reinhold Company Inc USA, 1984.

[6] University of Southern California ., *Systematic Approach to Analyzing and Reducing Aerodynamics Drag of Heavy Vehicle*, Los Angeles, 1996.

[7] Rutledge, W. H., McCallen, R., *DOE Truck Aerodynamics Project*, Summary, Sandia National Laboratory, USA, 1999.

[8] McCallen, Rose., *Aerodynamic of Heavy Vehicles (Class7-8): Simulation and Benchmarking*, NASA Ames Research Center USA, 1999.

[9] White F. M., *Mekanika Fluida*, Jilid 1, Erlangga, Jakarta, 1988.

[10] White F. M., *Mekanika Fluida*, Jilid 2, Erlangga, Jakarta, 1988.

[11] Munson, B.R, Young, D.F dan Okiishi, T.H., *Fundamentals of Fluid Mechanics*, Wiley, Toronto, 1990.

[12] Stroms, B. L, Heineck J. T., *Experimental Measurements of 1/8-Scale Ground Transportation System in the NASA Ames 7-by10-Ft Wind Tunnel*, USA, 1999

[13] Sandberg, Tony. *Heavy Truck Modeling for Fuel Consumption Simulations and Measurements*. Lingkoping University. 2001