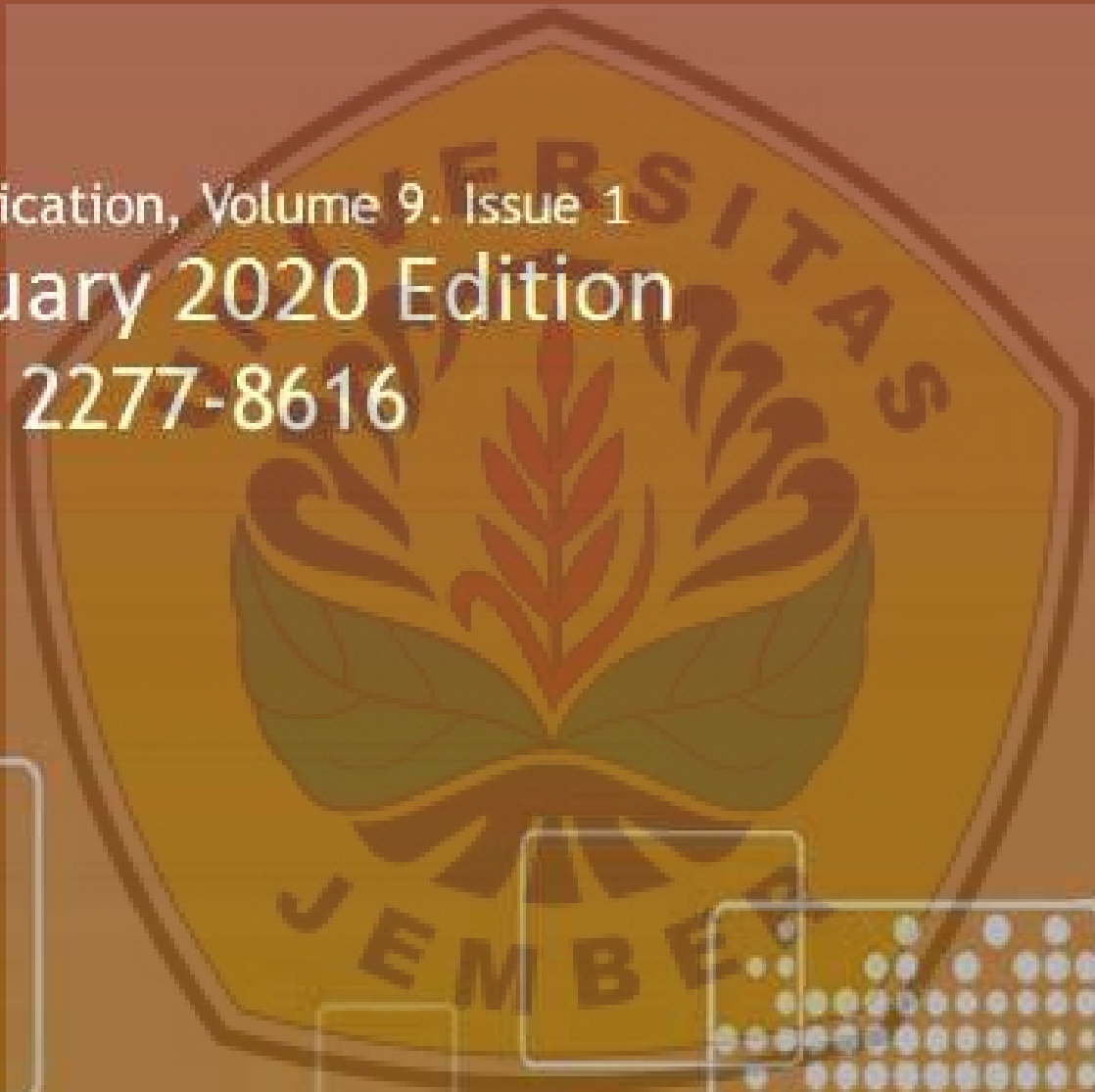


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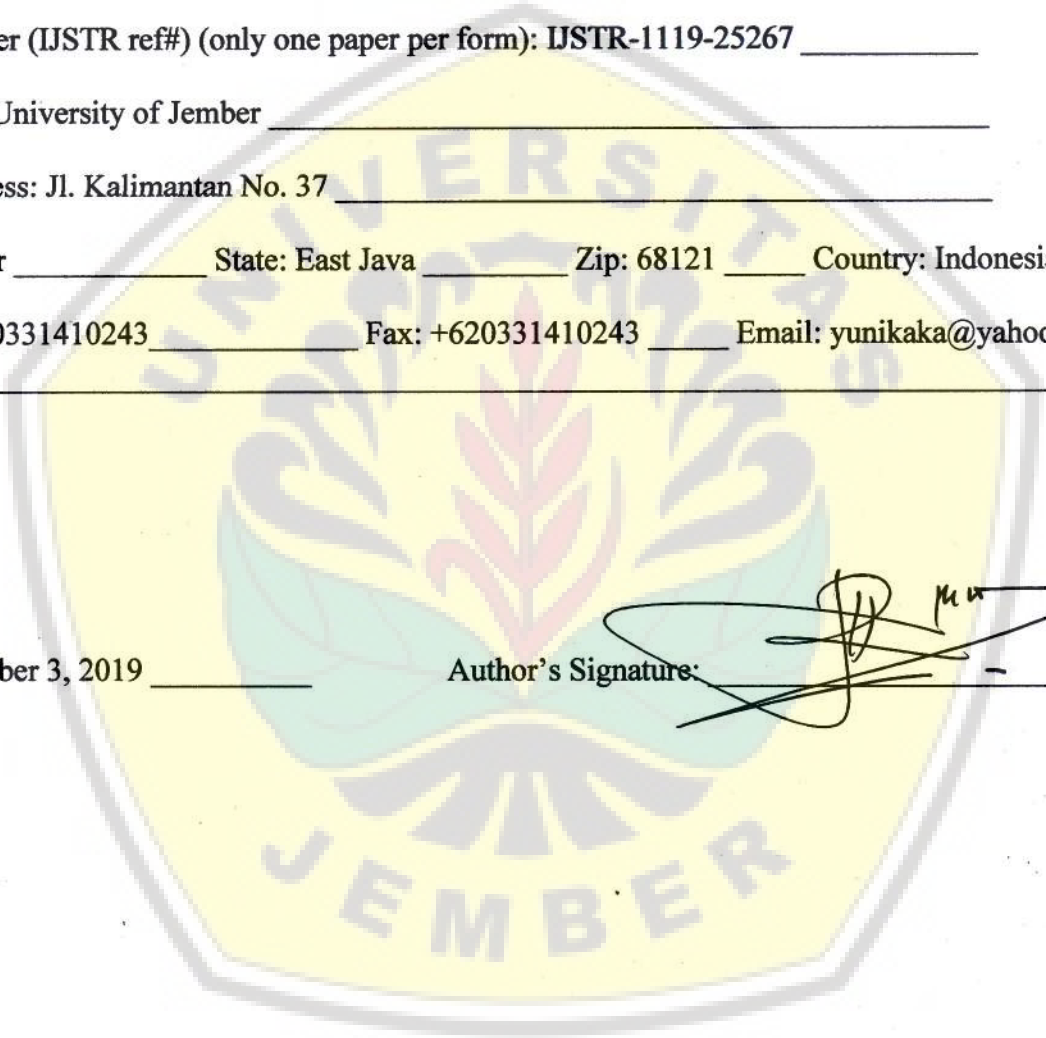
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# Contact Ball Bearing On Rolling Resistance

Yuni Hermawan, Santoso Mulyadi, Alex Tresa Elsyamba, Dwi Djumhariyanto, Ririn Endah Badriani

**Abstract:** The bearing is a machine element that influences the rolling resistance value, so a rolling resistance test tool needs to be designed to facilitate the testing process. In this study, testing was carried out using single row angular contact ball bearing types (7200, 7201) and double row angular contact ball bearings (5200, 5201), which were tested with variations of 290 rpm, 310 rpm, and 330 rpm. This study aims to determine the effect of flywheel loads and rotation variations on rolling resistance so that researchers can evaluate the effect of the type of bearing in accordance with the needs of the electric car to be studied. From the results obtained, the smallest rolling resistance force occurs in the type of single row angular contact ball bearing (7201) with 290 rpm rotation obtained by 0.6531 N and the largest rolling resistance force occurs in single row angular contact ball bearing (7200) with rotation 330 rpm of 1.2340 N. From the four types of bearings above that the influence of the contact area also affects the value of the rolling resistance force. The greater the contact area of the bearing, the value of the rolling resistance will increase. In the angular contact ball bearing type, the greatest rolling resistance force is obtained by the double row bearing type (5201). This is because the double row bearing type (5201) has a greater contact area than the single row bearing type (7200).

**Index Terms:** bearings, rolling resistance, and ball bearings

## 1. INTRODUCTION

The development of technology in vehicles and the increasing popularity of vehicles will certainly attract the interest of the automotive industry to compete in developing vehicle technology. Energy-efficient car is a car that is specifically designed to produce a high level of efficiency. The vehicle is an electric car that is expected to consume as little fuel as possible but can travel long distances. According to Juhala [1], vehicles have different levels of efficiency because each vehicle has different design and technology applied. There are three basic factors that will affect the efficiency of a vehicle, namely vehicle weight (mass), aerodynamic resistance (aerodynamic resistance), and rolling resistance (rolling resistance). Based on data from the New European Driving Cycle (NEDC), every 10% increase in vehicle weight will increase 4% energy consumption, every 10% increase in aerodynamic resistance will increase 1.5% energy consumption and every 10% increase in the vehicle rolling resistance will increase 1.8% increase in energy consumption [2]. According to research conducted by K. Chatti [3], rolling resistance has a large impact on the use of vehicle fuel, which is between 7-10% of total vehicle energy consumption. A 10% reduction in rolling resistance will cause a 2-3% increase in fuel savings. Rolling resistance contributes to the total loss in vehicle fuel consumption. There are several factors that affect vehicle fuel consumption, namely losses incurred due to lost moments of inertia, the shape of the body, and wheels that are aerodynamic, rolling resistance. A bearing is a machine element that supports a loaded shaft, so that rotation or alternating motion can take place smoothly, safely, and long life. The bearing must be sturdy enough to allow the shaft and other engine elements to work properly. If the pads do not function properly, the performance of the whole system will decrease or not work properly. Mostafa Yakout [4], examines rolling bearing performance and dynamic characteristics of bearings. The analysis is performed on rolling bearings of the same size and type to measure their dynamic characteristics. The result is dynamic characteristics, and consequently, dynamic performance, scroll bearings are significantly affected by internal radial distances. Van-Canh Tong [5], researched about angular misalignment having an insignificant effect on the torque of running angular contact balls when the constant force load method was adopted. Furthermore, extensive simulations are carried out to test the effects of angular misalignment induced. The simulation results show that

angular misalignment induced by radial loads requires the addition of torque to the actual rotor-bearing system, especially when using constant displacement preloads. Lucian Tudose [6], examines a new systemic approach for calculating bearing loads and compressive forces that load ball bearings. The proposed method is based on the following theory: when static shaft balance is reached, the load and the moment transmitted from the shaft to the bearing must be reacted with the load and moment that arise due to the elastic deformation of the rolling element. Nikhil D. Londhea [7], examines fatigue life predictions for modern bearings that use modified life relationships very below the observed age predictions. Therefore there is a need to update the parameters of this equation using newer life data. The results of this study indicate that the exponential load life for ball bearings must be 4.1, not 3, and for roller bearings, it must be 5.5, not 3.33. The L10 age calculated using the corrected exponent value of life shows better agreement with the observed life. M. Yakout [8], examines the predicted fatigue life of rolling element bearings and discusses the technical aspects of each method. The statistical method is a method of calculating life based on statistical events. The result is that various sources cannot be easily traced. A useful output from the experimental method is to test the behavior and effects of various parameters on bearing life. Size accuracy affects the accuracy of bearing pairs. High accuracy provides appropriate leeway and reduces pair errors. This is the basis for determining bearing performance for remaining calm and long life. The accuracy of the shaft and bearing housing must also be adjusted to the accuracy of the bearing. To choose between "press plate," "switch plate", and "loose handle" the following factors must be examined, namely the forces acting on the bearing during operation, the rotating ring (inside or outside), the high-temperature rise, thick walls of bearing houses, separate rings or not [9, 10, 11]. From various previous studies that have been presented, that the bearing has an influence on rolling resistance. So it needs to be tried to raise bearing research in accordance with needs.

## 2 MATERIALS AND METHOD

The bearings used for testing are single row angular types contact ball bearings (7200, 7201) and double row angular contact ball bearings (5200, 5201). This test is done without lubricating so that after each test, the bearings used must be cleaned. Rolling Resistance Bearing Test tool is a device used

to measure the rolling resistance force of a bearing, as in Figure 1. This tool is designed by combining the bearing testing tool according to the rolling resistance testing standard using the ISO 18164: 2005 standard [12, 13, 14, 15]. The clutch used is fixed coupling, as a successor to rotation and power from the driving shaft to the shaft that is driven with certainty (without slipping), where the two axes are located in a straight line or slightly different axis. The flywheel is used to store rotational power (inertia) in the engine. When engine power increases, rotation also increases, the excess power will be stored in the Flywheel. When the engine lacks power, Flywheel will supply the energy that has been stored previously. The result is that the engine can rotate in harmony and evenly, as a result of vibrations of power produced by Flywheel [15,16]. The tachometer is used to measure the rotational speed of an object, such as a gauge in a car that measures rotation per minute (RPM) of the engine crankshaft.



Figure 1. Rolling resistance test equipment

### 3 RESULT AND DISCUSSION

The results of tests carried out by rolling resistance tests on the bearing show that there is an influence of the rolling resistance value produced by different types of bearings. Calculation of rolling resistance of the drag force is influenced by the gravitational force on the flywheel. The flywheel is a device used to store energy in the form of the rotational motion on the shaft. Data is collected by giving a load on the bearing and given the specified bearing rotation variations, then see the time required for the taking to spin until it stops.

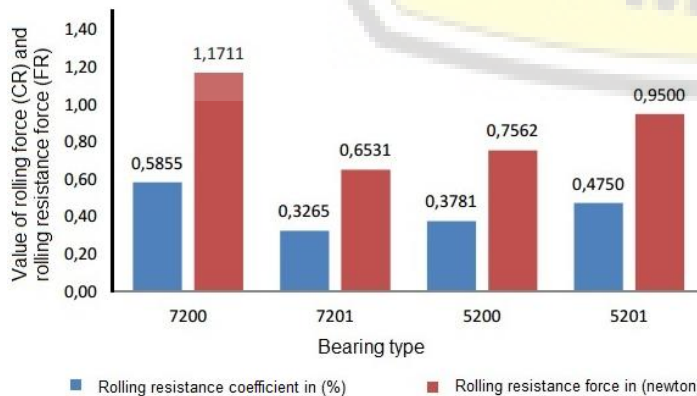


Figure 2. Graph of bearing type on rolling resistance force and coefficient bearing rotation 290 rpm

Figure 2 shows that there are differences in the value of the rolling resistance coefficient and the rolling resistance force in each bearing. For the rolling resistance coefficient with a bearing rotation of 290 rpm, the highest rolling resistance coefficient of single row angular contact ball bearing type is obtained type (7200), which is equal to 0.5855%. And the highest rolling resistance coefficient of double row angular contact ball bearing type is obtained by type (5201), which is equal to 0.475%. Furthermore, for the highest rolling resistance style, single row angular contact ball bearing type obtained type (7200) which is 1,1711 N. And the highest rolling resistance force type double row angular contact ball bearing type obtained is (5201) which is equal to 0,95 N In the type of single row angular contact ball bearing, the percentage decrease in rolling resistance force was 44.23%. And the type of double row angular contact ball bearing occurs the percentage increase in the rolling resistance coefficient by 25.63%.

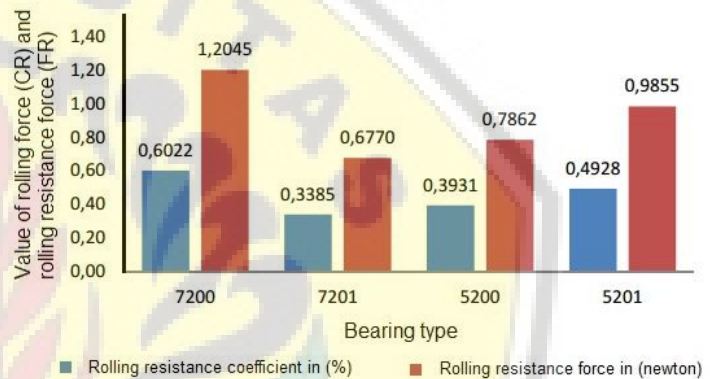
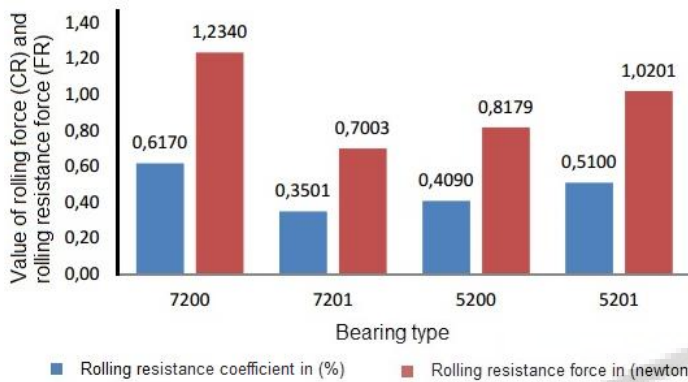


Figure 3. Graph of bearing type on rolling resistance force and coefficient bearing rotation 310 rpm

In Figure 3, we can see a rolling bearing rotation resistance of 310 rpm. The highest rolling resistance coefficient of single row angular contact ball bearing type is obtained type (7200), which is equal to 0.6022%. And the highest rolling resistance coefficient of double row angular contact ball bearing type is obtained type (5201), which is equal to 0.4928%. Furthermore, for the highest rolling resistance style, single row angular contact ball bearing type obtained type (7200) which is 1,2045 N. And the highest rolling resistance style of double row angular contact ball bearing type obtained is type (5201) which is 0,9855 N In the single row angular contact ball bearing type, there was a decrease in the rolling resistance force by 43.79%. And the type of double row angular contact ball bearing occurs a percentage increase in rolling resistance force of 25.36%.





**Figure 4.** Graph of bearing type on rolling resistance force and coefficient bearing rotation 330 rpm

Figure 4 shows the rolling resistance coefficient of bearing rotation of 330 rpm, the highest rolling resistance coefficient of single row angular contact ball bearing type is obtained type (7200), which is equal to 0.617%. And the highest rolling resistance coefficient of double row angular contact ball bearing type is obtained type (5201), which is equal to 0.409%. Furthermore, for the highest rolling resistance style the type of single row angular contact ball bearing type is obtained (7200) that is equal to 1.234 N. And the highest rolling resistance style of the double row angular contact ball bearing type is obtained type (5201) which is equal to 1.0201 N. type of single row angular contact ball bearing occurs a decrease in the rolling resistance force by 43.25%. And the type of double row angular contact ball bearing occurs the percentage increase in rolling resistance force of 24.72%.

#### 4 CONCLUSION

From the research results obtained, the following conclusions can be drawn:

1. From the research that has been done that the rolling resistance will increase when the bearing rotation at 330 rpm. So that every increase in bearing rotation will increase the value of rolling resistance in the type of single and double row angular contact ball bearings. The type of bearing that has the smallest rolling resistance force in the type of single row angular contact ball bearing with a rotation of 290 rpm is obtained at 0.6531 N while for the double row angular contact ball bearing type the rolling resistance style is at 0.7562 N.
2. The difference in inner and outer diameters affects the rolling resistance value. The influence of the inner and outer diameter of this bearing will affect the value of the moment of inertia. Single row angular contact ball bearing type (7201) has an inner diameter of 12 mm and an outer diameter of 32 mm has the smallest rolling resistance value compared to the single type angular contact ball bearing (7200) with an inner diameter of 10 mm and an outer diameter of 30 mm. This is because the inner diameter (RD) is inversely proportional to the value of the rolling resistance coefficient (CR).
3. The effect of contact area also affects the value of rolling resistance. The higher the contact area of the bearing, the value of the rolling resistance will increase. In the double row angular contact ball bearing type (5200, 5201), the largest contact area in the double row bearing type (5201) is obtained so that the smallest rolling resistance force

value is obtained in the type of double row angular contact ball bearing (5200) bearings.

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