Electronic and GUI Development of Roller Brake Tester

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Abstract. This paper discusses the development of electronic system and Graphical User Interface (GUI) for axle load and brake tester platform owned by UPTD PKB Dinas Perhubungan Kabupaten Banjar Kalimantan Selatan which has not been operated for about 10 years due to failure on its electronic system. The new electronic system is developed consisting of HX711 load cell amplifiers for A/D converter from axle and brake force load cells, ATMega328 microcontroller, relay driver and contactor. The GUI program is implemented using Delphi 7 for process monitoring, roller brake tester controller, printing the test results and saving the test results into the data base system. Based on the calibration tests, it was found that the results are very good with maximum percentage error of 2.22% for axle load meter, 1.47% for right brake force and 1.1% for left brake force.

1. Introduction

The braking system is one of the most active security equipments for vehicles to support driving safety. If the braking system fails, the vehicle will be difficult to handle and even to stop, hence it is very vulnerable to cause fatal accidents that endanger the lives of drivers, passengers, and other road users. Referring to Article 48 of the Republic of Indonesia Law Number 22 Year 2009 paragraph (1) which states that every motorized vehicle operated on the road must meet technical requirements and roadworthiness. In paragraph (3) the requirements for road worthiness as referred in paragraph (1) are determined by the minimum performance of motorized vehicles measured at least consisting of exhaust emissions, noise, efficiency of the main brake system, efficiency of the parking brake system, front wheel speed, sound horn, transmit power and direction of the main light beam, turning radius, accuracy of speed indicator device, suitability of wheel performance and tire conditions, and suitability of drive engine power to vehicle weight [1].

To ensure the safety of the vehicle braking system, it is necessary to periodically test the motorized vehicles, one of which is by testing the efficiency of the braking force. The infrastructure used in the Motor Vehicle Testing Unit is a motor vehicle braking system efficiency test for static models of a roller brake tester. Roller brake tester test equipment must be able to test the amount of brake force per vehicle axis, braking force efficiency and percentage imbalance between the right brake and left brake.

UPTD Pengujian Kendaraan Bermotor Dinas Perhubungan Kabupaten Banjar Kalimantan Selatan has an axle load meter and a roller brake tester that has not been used for 10 years because the electronic system failures. The main objective of this paper is to design, develop, calibrate and test a new
electronic system and Graphical User Interface (GUI) program for axle load and brake tester to replace the old and failure system.

2. Working principle of the roller brake tester

Main elements, rotating directions, and forces of the roller brake tester are shown in Figure 1. Axle load and roller brake tester platform are shown in Figure 2. The scheme in this Figure 1 is essential for understanding the brake tester working principle and for the determination of braking force.

![Figure 1. schematic diagram of roller brake tester [2]](image1)

![Figure 2. axle load and roller brake tester platform](image2)

Calculation of braking forces and the coefficient of adhesion is done by the following equations:

\[ z_1 = z_2 = z_3 \]  
\[ d_1 = d_2 = d \]  
\[ M_R = \frac{z_R}{z_V} \cdot \frac{d_w}{2} \cdot F \]  
\[ F_3 = \frac{M_R}{l} \]  
\[ F_3 = \frac{1}{l} \cdot \frac{z_R}{z_V} \cdot \frac{d_w}{2} \cdot F \]  
\[ F = 2 \cdot l \cdot \frac{z_V}{z_R d_w} \cdot F_3 \]  
\[ K = \frac{F_{L1} + F_{R,1} + F_{L2} + F_{R,2}}{m} \cdot 100 \]  
\[ R = \frac{F_2 - F_1}{F_2} \cdot 100 \]
where:

\(d\) – Roller diameter, m
\(d_1\) – Front roller diameter, m
\(d_2\) – Rear roller diameter, m
\(d_W\) – Vehicle wheel diameter, m
\(z_V\) – Number of roller gear teeth, -
\(z_1\) – Number of front roller gear teeth, -
\(z_2\) – Number of rear roller gear teeth, -
\(l\) – Length of torque lever, m
\(z_R\) – Number of torque lever gear teeth, -
\(F\) – Vehicle braking force (braking force of the wheel on the roller), kgf
\(M_R\) – Torque on the motor stator, kgm
\(F_3\) – Force on the force transducer, kgf
\(K\) – Coefficient of adhesion of the vehicle, %
\(R\) – Difference in braking force between the left and the right wheel, %
\(F_{L,1}\) – Braking force on the front left wheel, kgf
\(F_{R,1}\) – Braking force on the front right wheel, kgf
\(F_{L,2}\) – Braking force on the rear left wheel, kgf
\(F_{R,2}\) – Braking force on the rear right wheel, kgf
\(F_1\) – Weaker braking force, on the left or the right wheel, kgf
\(F_2\) – Stronger braking force, on the left or the right wheel, kgf
\(m\) – Mass of the vehicle, kg

Both rollers rotate at a constant speed \((\omega_{W1} = \omega_{W2})\) driven by a constant torque from the electromotor shaft. When braking force is applied, the wheel decelerates and a torque \(M_W\) is created. The torque lever connected to the electromotor body rotates in the opposite direction from that of the rollers, the electromotor rotor \((\omega_R)\), and the vehicle wheel \((\omega_W)\). The torque from the vehicle wheel \((M_W)\) is transmitted over roller sprockets and chain through the electromotor shaft to the electromotor body (lever). The lever that transmits the force \((F_3)\) to the force transducer is connected to the electromotor body. The force on the sensor is proportional to the braking force on the wheel [2].

3. **Design of electronics system for axle load meter and roller brake tester**

The design of electronic systems are shown in Figure 3. The system consists of two loadcells with a capacity of 10 tons each [3] for the axle load connected to the loadcell junction box then output from the junction box connected to the HX711 24-bit ADC [4] special function IC for weighing scale or loadcell.
Both the left and right roller have their independent loadcell for the braking force measurement, each loadcell has a capacity of 2 tons [3], the converted ADC data is read by the microcontroller [5] which then transmitted to the computer with RS232 serial interface. In addition, the measurements the microcontroller can control the start / stop electro motor to drive the roller and lift up / lift down the roller.

4. Graphical User Interface
The Graphical User Interface (GUI) of this system is implemented using Delphi 7. The front panel displays the measurements of axle loads, right brake force, left brake force, efficiency and unbalance brake force. The program is also equipped with a form of data input for vehicle owners and registration plate numbers.

For the measuring process, it requires one operator to run the program. At first the weigh the vehicle axle, waits until the result of measuring the axle is stable. When the axle load measurement has been stable, the start button for brake testing will appear. Then the wheel of the vehicle enters the roller. After that, the operator will press the start button, then the elevator will go down and the roller will start spinning. When the indicator on the screen is red, the vehicle is ordered to press the brake pedal, wait for a while, then the measurements of the right brake force, the left brake force, efficiency and unbalance will appear on the screen display. For the next axle measurement the operator presses the
next button and the steps are the same as that of the previous axle measurement. After the measurement is complete the operator presses the print button to print the measurement results. Measurement results are also stored in the database.

5. Calibration Method
The calibration method for the axle load meter is using a standard calibrated weighing stone as a weight reference. The calibration process is shown in Figure 5. Calibration is done by placing the weighing stone into the platform axle load then measuring the weighing stone and compared to the results of the display on the monitor display. Calibration results are shown in Figure 7. The brake force calibration has already been discussed in [6][7]. Calibration the brake force uses a static calibration bar, as shown in Figure 6. This calibration bar contains a loadcell that is connected to standard force measurement equipment having indicator display as the reference which will be compared to the brake force reading on the display monitor. The results of calibration of brake force readings are shown in Figure 8 and Figure 9.

![Figure 5. axle load calibration](image1)

![Figure 6. brake force calibration](image2)

![Figure 7. Axle Load calibration result](image3)
6. Conclusion
An electronic system and GUI for the axle load and brake tester have been successfully developed, tested and calibrated. Accurate results have been obtained with maximum error percentage of 2.22% for axle load meters, 1.47% for right brake force and 1.1% for left brake force.

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