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MICROCONTROLLER-BASED VEHICLE TESTING UNITS: ALTERNATIVE SPEED MEASUREMENT TOOLS IN SPEEDOMETER TESTING

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***ABSTRACT**: The use of the Speedometer Tester test equipment that is currently available has not been fully implemented in motorized vehicle testing units. One of the causes is the test equipment which is constrained due to damage caused by long-term use. This research discusses the design of microcontroller-based speed measuring devices as an alternative to the use of test equipment in speedometer testing when problems occur in the form of damage to the test equipment in the Motor Vehicle Testing Unit. This type of research is development or Research and Development (R&D) which aims to produce new products or improve existing products. Design of a Microcontroller-Based Speed Measuring Device consisting of an input, namely an Infared Proxlimity Sensor, then an Arduino process control with an LCD output connected to a Thermal Printer which can print measurement results. Based on the test results of the design tool for speed measuring devices on microcontroller-based motorized vehicle testing units, an average success rate of 97.9% was obtained, and an average deviation of 2.1%. The design performance of a microcontroller-based speed measuring device can function according to the program designed.*

KEYWORDS: *Vehicle Testing Unit, Speedometer Tester, Microcontroller, Infrared Proxlimity Sensor.*

I. INTRODUCTION

Speed is one of the important parameters that must be considered when driving. Speed is also a factor that supports safe driving on the road. Driving at high speed can trigger land traffic accidents. Many automotive industries produce superior products, both two-wheeled and four-wheeled vehicles, which are capable of creating power/ speed that can endanger the vehicle user and other road users [1], [2], [3].

Information obtained from the Central Statistics Agency (BPS) shows that the number of traffic accidents in Indonesia in 2021 is 103,645 cases, including 25,266 deaths, 10,553 serious injuries, 117,913 minor injuries [4]. One of the causes of accidents is a lack of traffic awareness, especially in regulating speed on the road without paying attention to the speed limit on the road. In obeying speed limits on the road, the driver must know what speed the vehicle he is driving is. The tool used by the driver when monitoring speed is the vehicle's speedometer [2], [5]. With a speedometer that has precise accuracy, the driver will be able to calculate the speed according to the conditions and speed limits in the area he is traveling through. The introduction contains the background, problem, problem solving plan and research objectives [6], [7].

Based on chapter 64 of Government Regulation Number 55 of 2012 concerning Vehicles, it is stated that every motorized vehicle operated on the road must meet roadworthy requirements. Roadworthy requirements are determined based on the minimum performance of motorized vehicles. One of the roadworthiness requirements in the Motor Vehicle Testing Unit is the accuracy of the speed indicator device. The accuracy of a speed indicator can be determined by measuring. Based on Article 72 of Government Regulation Number 55 of 2012 concerning Vehicles [11], it explains that the accuracy of speed indicating devices is measured using a speedometer test equipment at a certain speed which provides the same measurement results between the test equipment and the speed indicating device [13].

At this time, the speedometer test equipment available at the Motor Vehicle Testing Unit is still very expensive. Speedometer test equipment that uses a High Sensitive Proximity Sensor (Induction Sensor that has very high sensitivity) is very expensive. Apart from that, the implementation of speedometer testing has not been fully implemented in motor vehicle testing units. One of the causes is that testing equipment is hampered by damage which results in motor vehicle testing not being carried out properly.

Based on this, it is necessary to design a vehicle speedometer accuracy measuring device that is practical and efficient as an alternative to using test equipment for speedometer testing when problems occur in the form of damage to the test equipment at the Motor Vehicle Testing Unit . The design of the tool will use a microcontroller in the form of an Arduino Uno which is more affordable.

II. RELATED RESEARCH

A. LEGAL BASIS

Article 12 of Ministerial Regulation Number PM 19 of 2021 concerning Periodic Testing of Motorized Vehicles, explains that every motorized vehicle operated on the road must meet roadworthy requirements [10]. Roadworthy requirements are determined based on the minimum performance of a motorized vehicle which includes at least:

1. Exhaust gas emissions include exhaust gas smoke thickness, except for battery electric motorized vehicles
2. Noise level of horn and/or exhaust sound
3. Ultimate brake capability
4. Parking brake capability
5. Front wheel kinks
6. The transmitting ability and direction of the main light beam
7. Accuracy of speed indication devices
8. Tire tread depth
9. Light resistance of glass

Article 72 of Government Regulation Number 55 of 2012 concerning Vehicles [11], [12], explains that:

1. The accuracy of the speed indicating device is measured using a speed measuring device at a certain speed which provides the same measurement results between the test equipment and the speed indicating device.
2. In the event that the measurement results are not the same as the speed indicator, a tolerance limit can be given.
3. Further provisions regarding certain speeds and tolerance limits are regulated by ministerial regulations responsible for the field of traffic and road transportation facilities and infrastructure.
4. Further provisions regarding certain speeds and tolerance limits as intended in article 72 paragraph 3 are contained in Article 11 of the Decree of the Minister of Transportation Number 63 of 1993 concerning Roadworthiness Thresholds for Motorized Vehicles,
5. Trailer Trains, Attached Trains, Bodywork and Cargo Body and Components, which states that the deviation of speed indicating devices on motorized vehicles is determined at -10% to +15% under the measurement conditions. Deviation was measured at a speed of 40 kilometers per hour.

B. SPIN SPEED

Rotational speed is the speed of an object around a fixed point whose path is circular. An example of rotational speed is found in the wheels of a moving vehicle. In rotational speed there are the terms RPS (Revolutions Per Second) and RPM (Revolutions per Minute). These two terms are used to measure rotation speed [8] . Here's the equation formula:

$$RPS = \frac{n}{t} \quad \text{......} (1)$$

$$RPM = \frac{n}{t} x\ 60 \quad \text{......} (2)$$

$$RPM = RPS\ x\ 60 \quad \text{......} (3)$$

Information :
RPS : Revolutions Per Second
RPM : Revolutions Per Minute
n : Number of rounds
t : Time (s)
○

C. LINEAR SPEED

Linear Speed is the rate of change of position with a ratio between the distance moved and a certain time interval. In vehicles, speed is the distance traveled by the vehicle on a track in a certain unit of time [9]. The formula for linear speed is as follows:

$$v = \frac{s}{t} \quad \text{......} (4)$$

Information :
v : Speed (m/s)
s : Distance (m)
t : Time (s)

In circular motion, the path is the circumference of the circle whose magnitude is 2 πr. In one revolution of the wheel, the vehicle will cover a distance of 2 πr. The rotation speed is needed to determine the linear speed of the vehicle [1], [9]. The equation formula is as follows:

$v = 2\pi.r.(RPS)$	…………………………….. (5)
$v = \pi.d.(RPS)$	…………………………….. (6)

Information :
V : Speed (m/s)
RPS : Rotation per Second
RPM : Rotation per Minute
r : Radius of the circle
d : Diameter

How to change the unit V (m/s) to V (km/hour) and change the RPM unit to V(km/hour)

$$V(km/h) = \frac{3600}{1000} \times V(m/s) \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$V(km/h) = \frac{2\pi.r}{1000} \times RPM \times 60 \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

III. METHODOLOGY

This research uses the Research and Development (R&D) method. This research is also called development research. Researchers are developing designs for vehicle speed measuring devices using Infrared Proxlimity Sensors. This sensor functions as a detector/measures the speed and RPM produced by the rotation of the vehicle's wheels when rotating on the roller speedometer tester.

A. RESEARCH FLOW CHART

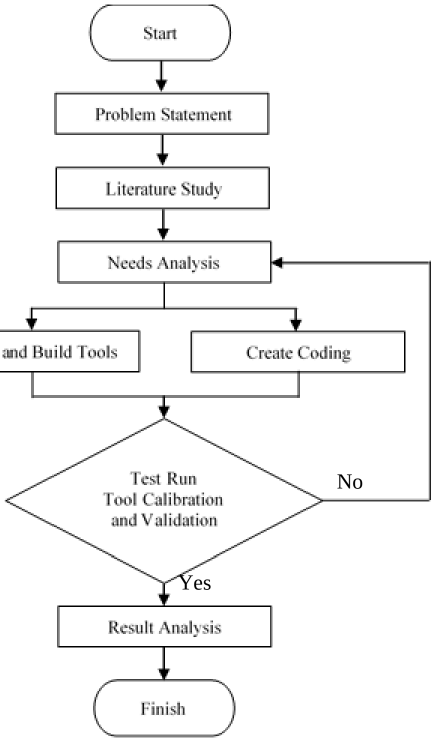

Fig 1. Research Flow Chart

B. TOOL DESIGN AND MANUFACTURING

In carrying out the design and manufacture of test equipment, it is generally divided into four phases. The first phase is designing a test equipment scheme using software in the form of Frtizing. The second phase is creating coding or system programming on the software, the software used is Ardunio IDE. The third phase creates a test tool design and a concept for how to test it using SketchUp software. The final phase (fourth phase) is assembling the test equipment with the specified tools and materials as well as inserting the program that has been created onto the Arduino board as a hardware system.

C. BLOCK DIAGRAMS

Block diagrams are used to explain the working principle of the tool to be made. Below is a block diagram that is used and applied in the system creation process.

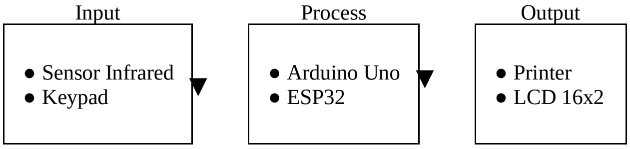

Fig. 2 Block Circuit Diagram

Explanations regarding components in the block diagram are as follows:

1. Infrared sensors are used as input sensors to measure vehicle speed and RPM.
2. The 4x4 Matrix Keypad is used as input as a remote control for operating the device.
3. Arduino UNO is used as a process in processing input data from infrared sensors and 4x4 matrix keypads.
4. LCD as output to display measurement results read by the sensor.
5. Thermal Printer as output to print measurement results in the form of sheets of paper.

D. ELECTRONIC CIRCUIT OF THE TOOL IN FRITZING SOFTWARE

The design of the electronic circuit of the tool in this research uses Fritzing Software which has features for digitally assembling microcontroller components and the components needed to assemble the tool.

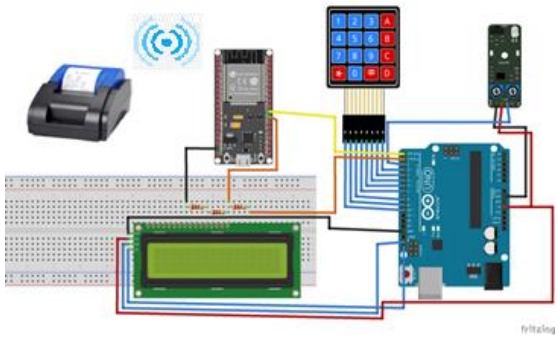

Fig 3. Electronic Device Circuits in Fritzing

E. PROGRAMMING WITH ARDUINO IDE

Coding or programming is made using Arduino IDE Software. This phase requires a detailed programming language according to the planned scheme.

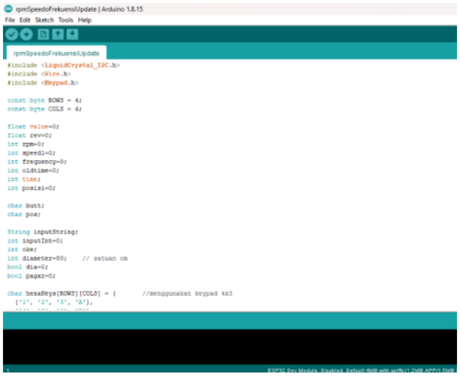

Fig 4. Ardunio Uno programming

F. TOOL DESIGN

In creating the test tool design, the author used the *SketchUp* 2021 application with 3-dimensional shapes.

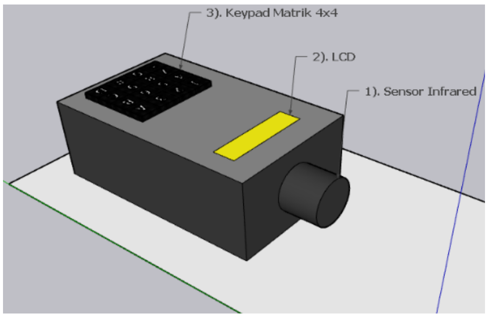

Fig 5. *Tool design*

Figure 5 is a tool planning design that is made with the location of the keypad and the sensor components that will be installed.

G. TOOL DESCRIPTION

An explanation of the tool starting from sensors to keypad functions is as follows:

1. Infrared Sensor used detect rotational motion.
2. LCD 16x4 for display the measurement results.
3. The 4x4 Metric Membrane Keypad.

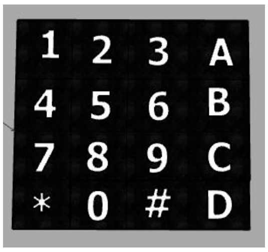

Fig 6. Keypad Buttons

Figure 6 is a keypad used on a tool whose function is explained as follows :

a. Button (D) to input roller diameter.
b. Number buttons (0-9), to enter the roller diameter.
c. Press the (#) button to enter the diameter of the tool.
d. Button (A) to read the RPM measurement.
e. Button (B) to read the Speed measurement.
f. Button (C) to read RPS measurements.
g. Button (*) to stop measurement reading and save measurement results.
h. Button (D) performs the print command to print the measurement results.

H. CONCEPT OF HOW TOOLS WORK

Creating a concept for how to operate the tool during testing needs to be done so that later the operator will have an idea when operating the tool. To find out how the tool works, it can be explained by making a 3 (three) dimensional drawing and flowchart which can be seen below:

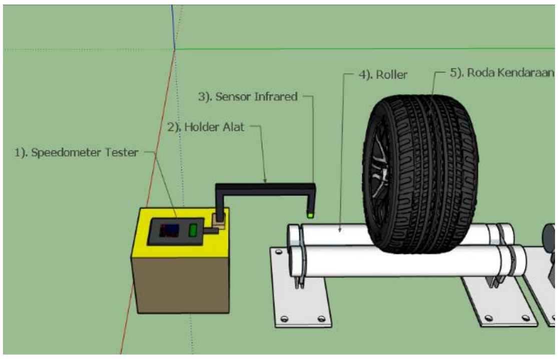

Fig 7. Test Scheme (3 Dimensions)

In figure 7 is the speedometer tester test scheme, first the vehicle enters the testing building then the tire is positioned on top of the speedometer tester then the speedometer tester measuring tool is placed next to the tire and the sensor position is placed on the speedometer tester roller to measure the rotation of the roller, because of the rotation speed roller is equal to the speed of the vehicle's wheels.

I. TOOL TESTING FLOWCHART

The flow of explanation of how the tool works is as follows:

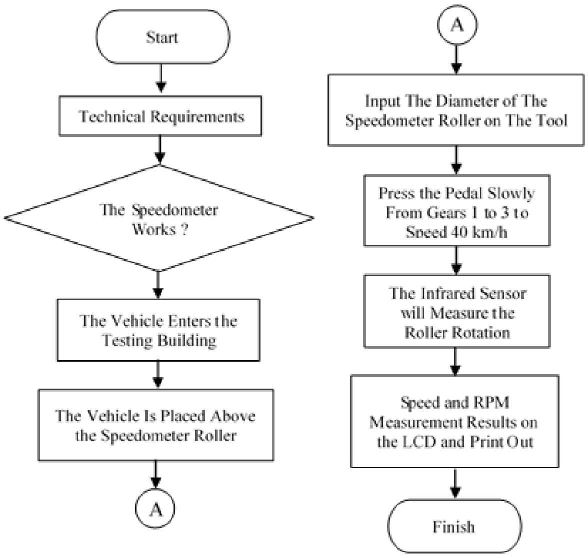

Fig 8. Tool testing flowchart

IV. RESULTS AND DISCUSSION

A. TOOL COMPONENT ASSEMBLY

The process of assembling tool components is assembling components, both installation wairing and mechanics directly, where this process combines one component with other components which are connected to each other according to the design or design of the tool. The component assembly process includes:

1. Preparation of Tools and Materials

In preparing tools and materials, researchers prepared input, output and processor components. The input component consists of an infrared *proximity sensor* and a 4x4 metric *keypad* , while the output component consists of an LCD and *thermal printer* , and the processor component uses Arduino Uno and ESP32.

Fig 9. Tool Components

B. CONTAINER ASSEMBLY

When assembling the container, researchers use rectangular acrylic, then a block will be formed which is used as a component holder and input/output path. Then mark and make holes in the container in certain parts, such as for the Infared sensor, LCD I2C cable input output button, and USB on the Arduino according to the tool design concept.

Fig 10. Container Assembly

C. INSTALLATION OF ELECTRONIC CIRCUITS IN THE INTERIOR OF THE CONTAINER

Assembled components then installed in a container that has been made according to the design plan. At this stage, components that are not visible from the outside (interior) are placed inside the container and attached to the base of the container so that they stick firmly.

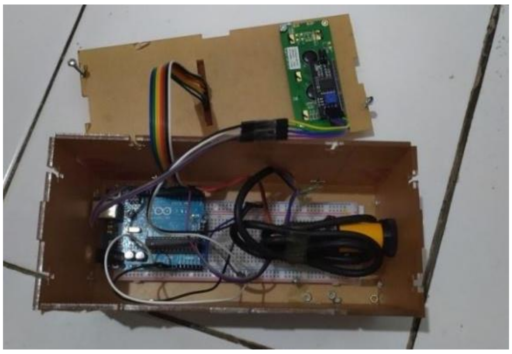

Fig 11. Installation of tool components in the container

D. FINAL RESULT OF TOOL DESIGN

After carrying out several stages of component assembly and assembling the container then forms a tool that is ready to be entered into the program to be created. Below is the finished form of the tool design and to the right is the thermal printer which is connected to the tool design via Bluetooth ESP32 which is attached to the tool body to print the measurement results listed on the LCD.

(a)

(b) (c) (d)

Fig 12. Microcontroller based speed measurement tool (a) side view, (b) front view, (c) top view, (d) back view

E. TOOL DESIGN TRIAL

Trials This tool aims to determine the level of accuracy of infrared sensor readings in reading rotation. The speed used for each sample vehicle is 40 km/hour under constant conditions. Before measuring the object to be observed, there are several stages that must be carried out, including the following:

1. Function Check
   a. Check the condition of the power supply cable in good condition and connected to the electricity source.
   b. Rotate the roller and check the function of the indicator showing the rotation speed value.

c. Make sure the indicator shows zero when the roller is at rest without the influence of any force.
d. If all the elements of a functional check are fulfilled then the design of the tool is ready to carry out measurements.


Fig 13. Tool function check

2. Measurement
   a. Measure the circumference of the roller (k) in units (cm) using a measuring tape and string or other medium that can measure well, then find the diameter.


Fig 14. Roller Circumference Measurement

   b. Determine a measuring point on the edge of the roller that is safe to attach to the measuring point using stickers or other media that can be read by the design of the tool.


Fig 15. Installation of measuring points (stickers)

   c. Use a motorized vehicle that must be tested while testing to rotate *the roller* to a predetermined rotation speed.


Fig 16. Speed Measurement

   d. Step on the gas pedal until the vehicle wheels can rotate the rollers until the vehicle's *speedometer indicator* reaches a speed of km/h up to 40 km/h.

Fig 17 .Vehicle Speedometer

   e. Pay attention to the measurement results listed in the Test Equipment Design in the Testing Building.

Fig 18. Measurement Results

In figure 18 the sensor reads rotation roller rotation at a speed of 40 km/hour. On the tool and on the speedometer tester screen show the same number.

   f. Data from Experimental Results of Tool Testing with KBWU

At this stage the researcher carried out a comparative trial of the measurement results of existing test equipment in motor vehicle testing with the design of the equipment. The following is the test data for the tool with KBWU (Motorized Vehicles Must Test):

Tbl 2. Test Equipment at a Vehicle Speed of 40 km/h

No	Speedometer Tester		Difference	Accuracy
	Test Equipment	Prototype		
1	39.6	39.8	0.5 %	99.5 %
2	38.7	39.4	1.5 %	98.5 %
3	40.4	40.0	1.0 %	99.0 %
4	39.8	41.6	4.5 %	95.5 %

5	41.1	42.1	2.4 %	97.6 %
6	40.2	40.1	0.2 %	99.8 %
7	42.4	41.2	2.9 %	97.1 %
8	38.4	40.2	4.6 %	95.4 %
9	41.2	42.4	2.9 %	97.1 %
10	38.8	39.9	2.8 %	97.2 %
11	40.3	39.5	1.9 %	98.1 %
12	39.4	41.0	4.0 %	96.0 %
13	40.3	40.1	0.4 %	99.6 %
14	40.5	39.3	2.9 %	97.1 %
15	39.4	39.8	1.0 %	99.0 %
16	40.6	39.9	1.7 %	98.3 %
17	41.8	41.6	0.2 %	99.8 %
18	39.3	40.2	2.2 %	97.8 %
19	40.9	39.7	2.9 %	97.1 %
20	40.2	40.1	0.2 %	99.8 %
Average			2.1 %	97.9 %

From the table 2 above with 20 samples of vehicles that were tested for the accuracy of the speed indicator, it can be explained that the measurement results with the roller speedometer tester measuring object at a speed of 40 km/h, on average have a deviation difference of 2.1% or equal to 0.85 km/h. This is influenced by several factors, for example the type of vehicle, the way the vehicle is operated, the calibration period of the test equipment, inaccuracies in measurements and other things that can change the vehicle speed measurement value, but technically the tool is functioning well. The tool can display measurement results either via LCD or display measurement results in the form of a print out via a Thermal Printer.

CONCLUSION

Based on the description of the design, manufacture and testing as well as discussion of the results regarding the Design and Construction of Vehicle Speed Measuring Devices in the Microcontroller Based Motor Vehicle Testing Unit, it can be concluded, among others:

a. Design a vehicle speed measuring device The microcontroller-based motor vehicle testing unit consists of input in the form of an infrared proximity sensor, then process control in the form of an Arduino and output in the form of an LCD, as well as the process of printing test results/print outs via a thermal printer connected by an ESP32 bluetooth module with Tool Design.
b. Design Performance of a microcontroller-based speed measuring device for measuring the level of accuracy of vehicle speedometers in the Motor Vehicle Testing Unit can function according to the designed program. Based on trials using 20 samples of motorized vehicles required to be tested, the test results showed an average success rate of 97.9% and an average deviation of 2.1%.
c. The use of a speed measuring device can be applied in critical situations, as an alternative option that can be used as a replacement for a speedometer tester in motor vehicle testing units when the test equipment experiences damage/problems.
d. It can be developed as a speedometer accuracy measuring tool on mobile testing cars because currently there are no speedometer testers on mobile testing cars.

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