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DESIGNING AND IMPLEMENTATING THE THROTTLE-BY-WIRE SIMULATOR ON MODERN VEHICLES

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Abstract

Automotive technology is increasingly developed by using electronic control, such as throttle by wire technology to improve conventional throttle system that has some disadvantages, which still using mechanical components, connected using sling cable, the pedal likely to jam or feel heavy because of dirt or crust, too many components, and complicated on maintenance. The research purpose is to make throttle by wire simulator without sling cable, more responsive in performance, easier maintenance, and can be teaching media. The simulator component consists a wire/cable, pedal sensor, minimum system, and servo motor as throttle driver. The experiment was conducted on simulators which designed and made. Research data were tested by correlation and regression test. The results showed that when the pedal stepped deeper, the output voltage of the pedal getting bigger, the throttle angle is balanced with the pedal movement, the greater angle of the throttle, the required current is greater. The speed response of the throttle towards the pedal is 0-0.11 seconds, so the simulator is very responsive and feasible to be used as a teaching aid.

Key Words: pedal, throttle angle, simulator, throttle by wire, teaching aid

NOMENCLATURE

Modern vehicles: The vehicle with EFI system

EFI: Electronic Fuel Injection

LCD: Liquid Crystal Display

1. INTRODUCTION

The problems often occur on a vehicle with conventional throttle system is often jammed or feels heavy, cause the conventional throttle system uses a mechanical component (sling cable) to connects the throttle towards the pedal, so that allows for dirt or crust. Beside that, the maintenance of conventional throttle is more complicated. Currently, some of the modern vehicles have been developed the throttle by wire system without sling cable, but using wire control system, but the price is still very expensive and in many automotive institutions have not

existed, so the students will not understand the material comprehensively. To solve the problem, a throttle by wire simulator was designed and conducted in this reseach, with the problem formulation as follows:

1. How to design and create throttle by wire opening mechanism?
2. How to make a connection between the pedal with the throttle without sling cable?
3. How does the effect of the angle variation of the pedal on the throttle?

The research purposes are:

1. To design and create throttle by wire mechanism.
2. To make a connection between the pedal with throttle without sling cable
3. To determine the effect of variation of the pedal angle towards the throttle.

1.1 Throttle By Wire

Throttle by wire is a technology that makes connections or systems on the pedal towards the throttle without sling cable, but rather using sensors, connected on a computer or Electronic Control Unit (ECU). Technically, the module which connected with the ECU will read the engine requirements of ignition and fuel supply, then compared with throttle angle and pedal pressure. When the car is running and the module reads that the engine does not require much fuel, even though the pedal is tramped deep, the fuel will be streamed as needed (Parsania, 2016: 3). The schematic concept of throttle by wire is showed as Figure 1.

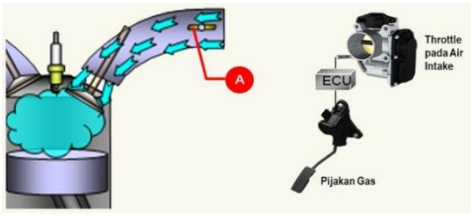


Figure 1. *Throttle by wire*

(Persania, 2016:3)

1.2 Throttle Body

Hermawan (2012: 12) said that the Throttle body is part of the air intake system that controls the amount of air intake into the engine. The throttle body is located between the water filter box and the intake manifold. The construction of throttle body as shown in Figure 2.

Figure 2. Construction of Throttle Body

(Hermawan, 2012:12)

1.2 Servo Motor

Servo motor is a motor with a closed feedback system in which the position of the motor will be informed back to the control circuit in the servo motor. Servo motors consist of a series of gears, and potentiometers. Potentiometer serves to determine the angle limit of servo rotation. While the angle of the servo motor axis is adjusted based on the width of the pulse sent through the signal foot of the motor cable (Sigit, 2007: 5).

Figure 3. Servo Motor

(Sigit, 2007:5)

1.3 Accelerator Pedal Position Sensor

The Accelerator Pedal Position Sensor (APPS) as Figure 4 is the sensor used to obtain the correct acceleration position. APPS on vehicles use angle positioning sensors with the help of potentiometer variables and generate analog output. APPS consists of two main signal sensors namely APPS MAIN and APPS SUB. APPS MAIN is used to monitor the throttle position, and APPS SUB is used to control the liveliness of the APPS sensor (Jadhav, 2016: 379).

Figure 4. Accelerator Pedal Position Sensor

(Jadhav, 2016:379)

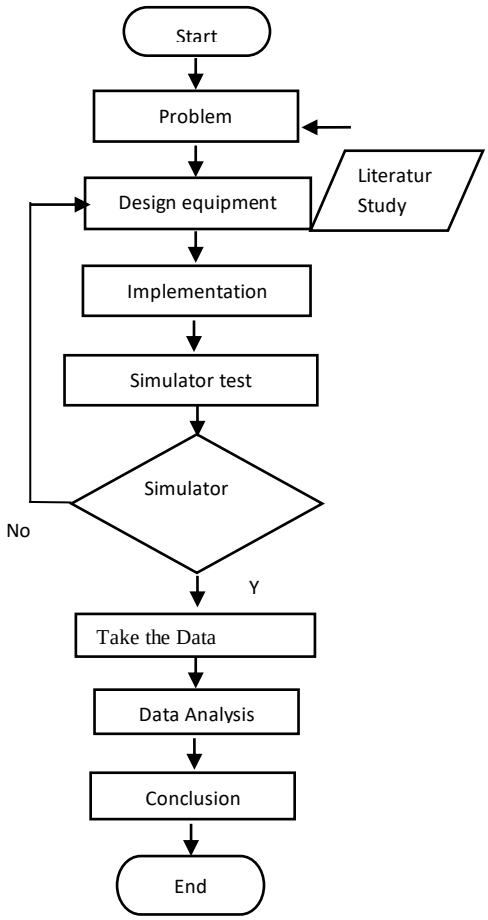
The pedal is connected to the accelerator pedal position sensor (APPS) as input, the APPS sends a signal to the microcontroller, which the microcontroller processes and processes the signal then commands the actuator (motor servo) to open the throttle.

2. THE RESEARCH CONCEPT

The pedal is connected to accelerator pedal position sensor (APPS) as an input, APPS wil send a signal to the microcontroller, and than the microcontroller will process the signal, than give command for actuator (servo motor) to open the throttle.

2.1 The Research Flow Diagram

The research flow diagram is showed as Figure 5.



This research is an experimental research, that is research which is used to find influence of certain treatment to other in controlled condition. In the design of this reseach there are independent variables that will be treated, and variable results/bound (dependent variable) to be observed (Zuriah, 2006: 64).

2.2 Reseach variabel

Variables used in this research are:
1. Free variable:
a) Angle of gas pedal (degree) 0 °, 5 °, 10 °, 15 °, 20 °, 25 °, 30 °.
b) Variation of output voltage of the pedal sensor (volts) 0.814, 1.322, 1.737, 2.180, 2.680, 3.120, 3.470.

2. Dependent variable:
a) Movement of servo motor or throttle angle (degree)
b) Response speed of throttle to the pedal (seconds).

The hypothesis of this reseach is determined as follows:
- H0: There is no significant influence between the angle of the pedal to the angle of the throttle and the current of servo motor
- H1: There is a significant influence between the angle of the pedal to the angle of the throttle and the current of servo motor

2.3 Simulator Design
The throttle by wire simulator is designed using mechanical and electronic components with a system block diagram as shown in Figure 6.

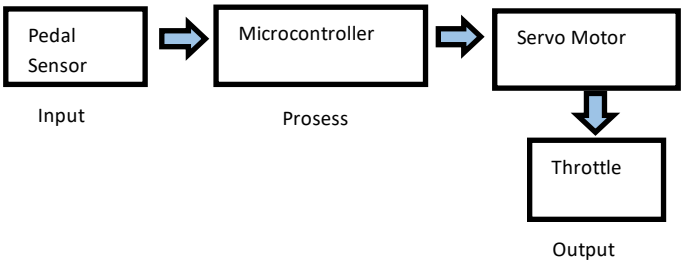
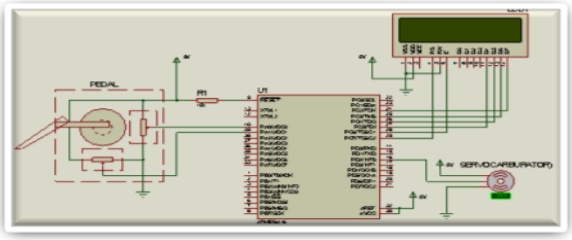


Figure 6. Block diagram of *throttle by wire* system

When the accelerator is pressed, the pedal sensor sends a signal to the microcontroller, the signal is processed by the microcontroller and the microcontroller gives the command to drive the servo motor as the throttle opening. So when the gas pedal in throttle stepped also move. The angle of the gas pedal and throttle aperture is displayed on the Liquid Chrysthal Display (LCD).

The throttle by wire simulator including an Electronic circuit consisting of microcontroller, LCD, servo motor and pedal sensor, as shown in Figure 7.

Figure 7. Simulator wiring diagram



2.4 Programming The Minimum System

Programming minimum system In order for the throttle by wire simulator to work as desired, it needs sequences of program codes that are embedded on the ATmega 16 microcontroller so that each circuit in the simulator can be set to work in accordance with its function. The programming in this simulator uses C ++ language.

2.5 The total wiring of simulator

The whole simulator circuit All mechanical and electronic components are subsequently assembled into simulators for use in learning media, as shown in Figure 8.

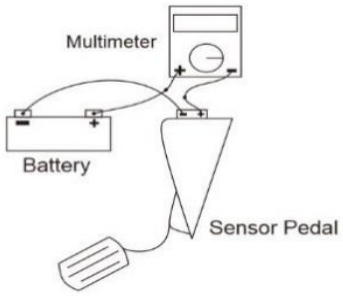


Figure 8. Throttle by wire **S**imulator

This simulator uses a microcontroller type ATmega 16 as a signal processor from the pedal sensor. The pedal sensor uses a potentiometer based accelerometer accelerometer. Servo motors use servo motors with 1.5 ms pulses in 2 ms wide period. 16x2-sized LCD is used for displaying PWM and pedal angles.

2.6 Simulator Testing

Simulator testing is done by testing each component of the system and testing the whole system

2.6.1 Pedal sensor testing

The aims of Pedal Sensor Testing is to determine whether there is a voltage / signal flowing and sent to the microcontrler. Testing is done by pressing the accelerator and measuring the output voltage with voltmeter. If the output voltage shown 0.8 Volt, the pedal sensor is in good condition.

The wiring of pedal sensor testing as shown in Figure 9.

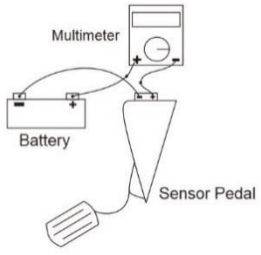


Figure 9. Pedal sensor testing

2.6.2 Servo Motor Testing

The aims of servo motor testing to determine if there is current flowing to the servo motor when the simulator is operated. If the servo motor is moving and the outflow 9.4 mA means the servo motor is in good condition. The servo motor testing circuit as Figure 10.

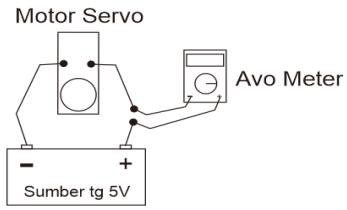


Figure 10. Servo motor testing

2.6.3 LCD Testing

LCD Testing LCD testing aims to determine whether the LCD can display text in the form of letters / numbers when the simulator is operated. LCD display letters / numbers, means it works well.

3. RESULTS AND DISCUSSION

The research Data is shown as Table 1.
Table 1. Reseach Data

No	Sudut injakan pedal gas (derajat)	Tengangan output sensor pedal (Volt)	Sudut bukaan throttle (derajat)	Arus output motor servo (miliampere)	Kecepatan respon throttle terhadap pedal gas (detik)
1	0°	0,814 Volt	0°	9,4 mA	0
2	5°	1,322 Volt	15°	81,2 mA	0
3	10°	1,737 Volt	30°	98,3 mA	0
4	15°	2,180 Volt	50°	149,5 mA	0
5	20°	2,680 Volt	70°	180 mA	0
6	25°	3,120 Volt	86°	480 mA	0
7	30°	3,470 Volt	90°	580 mA	0,11

The data that has been obtained is then poured in the graph as Figure 11.

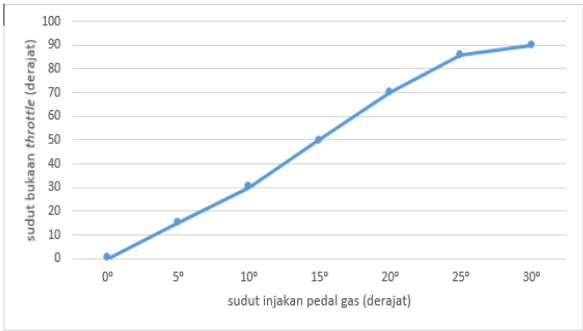


Figure 11. Correlation graphic between pedal angle and throttle angle

Based on the graph on Figure 11 it is seen that the throttle angle to the pedal is balanced, whereas when the accelerator is trampled by a small angle, the throttle also opens slightly and the larger the pedal stroke, the throttle opening angle also widened. The maximum pedal angle is 30° and the maximum throttle angle is 90°. The response speed of the throttle to the pedal is 0-0.11 seconds. This shows that the simulator is very responsive.
The graph of relation between the pedal angle with the current flowing to the servo motor as shown in Figure 12.

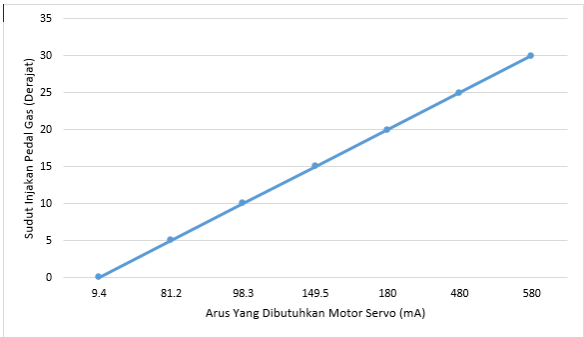


Figure 12. Graphic of correlation between pedal angle with the current of servo motor

The graph on Figure 12 shows that the current flowing to the servo motor increases linearly as the increasing of the accelerator pedal. If of the pedal stroke is bigger, the current flowing into the servo motor is getting bigger. It coused by the greater load received by the servo motor.

Correlation and regression test between pedal angle and throttle

The results of the correlation and regression test between the pedal angle and the throttle, as shown in Figures 13 and 14.

Results for: Worksheet 2

Correlations: sudut injakan; sudut bukaan

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Pearson correlation of sudut  injakan and sudut bukaan = 0,992
P-Value = 0,000
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Figure 13. Result of correlation test between pedal angle and throtlle

From the correlation test it can be seen that the value of pearson correlation value between the pedal angle and the throttle is 0.992, which means that the correlation between the angle of the accelerator and the throttle is very strong. A very strong correlation shows that the performance of the throttle by wire simulator is very good. Furthermore, the regression test with the results as shown in Figure 14.

Results for: Worksheet 2

Correlations: sudut injakan; sudut bukaan

Pearson correlation of sudut injakan and sudut bukaan = 0,992
P-Value = 0,000

Regression Analysis: sudut bukaan versus sudut injakan

The regression equation is
sudut bukaan = 0,29 + 3,23 sudut injakan

Predictor	Coef	SE Coef	T	P
Constant	0,286	3,237	0,09	0,933
sudut injakan	3,2286	0,1796	17,98	0,000

S = 4,75094 R-Sq = 98,5% R-Sq(adj) = 98,2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	7296,6	7296,6	323,27	0,000
Residual Error	5	112,9	22,6		
Total	6	7409,4			

Figure 14 Result of rgression tes between pedal angle and throttle angle

The regression test on Figure 14 obtained p value = 0.000. For p> 0.05, then H0 is accepted and H1 is rejected, while p value <0,05 then H0 is rejected or H1 accepted. Based on regeresion analysis obtained p <0.05, then H0 rejected and H1 accepted. This means that there is a significant influence between the angle of the gas pedal on the angle of the throttle opening.

Correlation and Regression Test between Pedal Angle and Current of Servo Motor

The results of correlation and regression test between the pedal angle and the current flowing to the servo motor as shown in Figures 15 and 16.

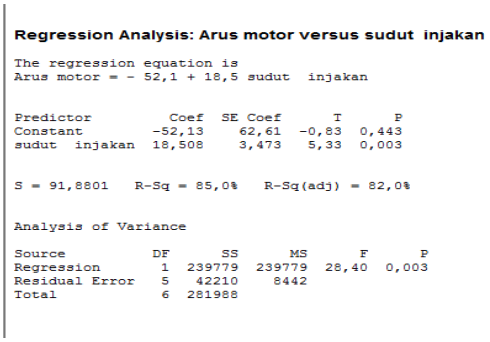
Probability Plot of sudut injakan

Correlations: sudut injakan; Arus motor

Pearson correlation of sudut injakan and Arus motor = 0,922
P-Value = 0,003

Figure 16. Result of correlation tes between pedal angle and servo motor

From the correlation test it can be seen that the value of pearson correlation between the pedal angle and the current of servo motor is 0.922, which means that the correlation between the accelerator pedal angle and the current of servo motor is very strong. Very strong correlation is pointed to the performance of throttle by wire simulator is very good.
Furthermore, the regression test of the relationship between the pedal angle and the current of servo motor, with the result as shown in Figure 16



Regression Analysis: Arus motor versus sudut injakan

The regression equation is
Arus motor = - 52,1 + 18,5 sudut injakan

Predictor	Coef	SE Coef	T	P
Constant	-52,13	62,61	-0,83	0,443
sudut injakan	18,508	3,473	5,33	0,003

S = 91,8801 R-Sq = 85,0% R-Sq(adj) = 82,0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	239779	239779	28,40	0,003
Residual Error	5	42210	8442		
Total	6	281988			

Figure 16 Result of regression tes between pedal angle and servo motor

The regression test obtained value p = 0,003. For p> 0.05, then H0 is accepted and H1 is rejected, while p value <0.05, then H0 is rejected and H1 is accepted. Based on regeresion analysis, obtained p <0.05, then H0 rejected and H1 accepted. This means that there is a significant influence between the pedal angle to the current.of servo motor

CONCLUSION

From the whole details research process, it can be concluded that:

1. The throttle mechanism on throttle by wire simulator using servo motor.
2. To make the pedal gas linkage with the throttle without sling cable, used control system consisting pedal sensor, microcontroller, servo motor and LCD. The pedal sensor sends a signal to the microcontrler, then the microcontroller orders the servo motor to drive the throttle.
3. If the variation of an accelerator pedal angle is great, it can affects linearly to the throttle, where the angle of the accelerator is responsively received by the servo motor to move or open the throttle at a speed of 0 - 0.11 second.

ACKNOWLEDGEMENT

SUGGESTION

For further research the following suggestions are given: 1. Need to use the pedal sensor on the real car, or provide appropriate spring on the accelerator, so that the pedal movement can return itself perfectly when stepped on. 2. Need to use servo motors with better quality / more responsive for throttle opening speed is not too late.

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