SPARK IGNITION TIMING USING ARDUINO CONTROLLER TO ACTUATE ARTIFICIAL KNOCKING CONDITION

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ABSTRACT

Modern vehicle are well equip with sensors to stabilize the engine during the running condition. Most sensors are located in different point of system, such as intake sensor to calculate the air fuel flow, oxygen sensor at the exhaust to identify oxygen quantity from the combustion and knocking sensor mounted on the engine block, nearest to the piston. Knocking sensor play an important role to stabilize the engine to avoid engine knocking. This condition will affect the engine badly if engine knocking happens. An Arduino micro controller is used to actuate artificial engine knocking condition. The artificial engine knocking is actuated to matched real life engine knocking condition. The signals are being observed and compared with other researches to verify the artificial knocking conditions.

Keywords: ignition timing, accelerometer, knocking.

1. Introduction

In modern world, engine control play a major role to run an engine smoothly (Spelina et al., 2014). A few sensors are located to the engine, to identify certain conditions. Such as oxygen sensor located to the exhaust system to identify amount of oxygen from the combustion to stabilize the engine system(Zaim et al., 2016). The signal then will send to the controller to suit the system normal condition.

The controller is designed to be efficient solution to an engine (Passenbrunner et al., 2014). The signals acquired from sensor will provide data to the controller. Therefore the data will suit the engine condition to be in efficient condition. In certain condition the controller are set to optimize threshold condition which are could be avoided (Peyton et al., 2013). In different condition engine is coded in various type based on the usage. Some users need the power of the engine in terms of torque and others need in high speed. However, these conditions are being adjusted to stabilize the engine system by identifying the usage of the user (Passenbrunner et al. 2014).

Spark plugs are the main part that ignites in the combustion chamber. Reinman et al(1997) suggested spark plugs can be manipulated to overcome the imbalance combustion. Due to different air fuel mixture, octane number of fuel and ion current supplied. These variables are the contribution to pollutants, but it can be solve by developing the multiple variable controller to actuate the right timing to the spark plugs by Laurain et al. (2015). This paper describes the design and study of Arduino microcontroller source to actuate the sequence of artificial knocking.

2. Methodology

Crank position sensor (CPS) is used to identify the frequency of engine timing. The frequency is used to design spark plug controller for the engine. Zaim et al.(2016) is manipulating fuel injector to actuate misfire condition. The signals from oxygen sensor are recorded to be analyze. Meanwhile in this project, an accelerometer is used to identify the misfire condition comparable to oxygen sensor signals. The accelerometer is mounted to the nearest position of the engine piston.

Figure 1 shows the project process flow. A controller is designed to initiate spark plug timing. It is to identify the ideal angle of spark plug timing based from the CPS signals. In other hand, the controller is used to actuate the misfire condition for further analysis.

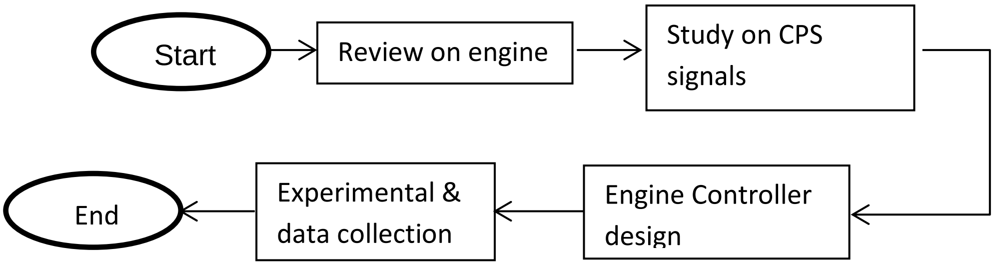


Figure 1. Project process flow

2.1. Experiment Setup

The experiment use an engine Yamaha LC 135, mounted to engine bench. An accelerometer is attached to the engine block nearest to the piston. To acquire signals a data acquisition (DAQ) is used. It is connected to a computer where Multi VirAnalyzer software is installed. The DAQ is used to record the signals. Whereas Arduino microcontroller is used to control the ignition timing for the engine. Table 1 shows the experiment equipment setup specification.

Table 1. Specification of all equipment and devices used in the experiments.

Test engine	Engine Yamaha LC 135, liquid cooled 4 stroke, SOHC, Forward incline single cylinder, 560kPa (80psi) (5.6kgf/cm2) at 500rpm with electric starter, compression ratio 10.9:1, Bore; stroke (54.0;58.7 mm)(Ltd. 2005)
Accelerometer	Knock Sensor For KA24DE 2.4L SR20DE 2.0L VQ30DE 3.0L For Nissan /Altima /Infiniti I30
DAQ	Brand Name: INSTRUSTAR, Band Width: Less than 60MHz, Digital Channels: 2, Real Time Sampling Rate: 48MS/s, Model: ISDS205A Bandwidth: 20M, Sampling frequency: 48M, Function 1: USB virtual oscilloscope, Function 2: Spectrum Analyzer, Function 3: Data recorder
Controller	Arduino Mega, stack with protoshield.

Figure 2(a), shows the accelerometer is mounted to the engine block, red and black wire are being attached to the oscilloscope to record signals. There are few wires wrapped with a black tape. It contains charging circuit and CPS wire circuit. CPS wire circuit is attached to oscilloscope to identify the signals and the signal is used to intiate the spark timing. The CPS signal connected to the Arduino controller at port A0. The signals are identified by the Arduino controller (figure 2(b)) for the engine running in normal condition and the program are designed to actuate artificial knocking condition.

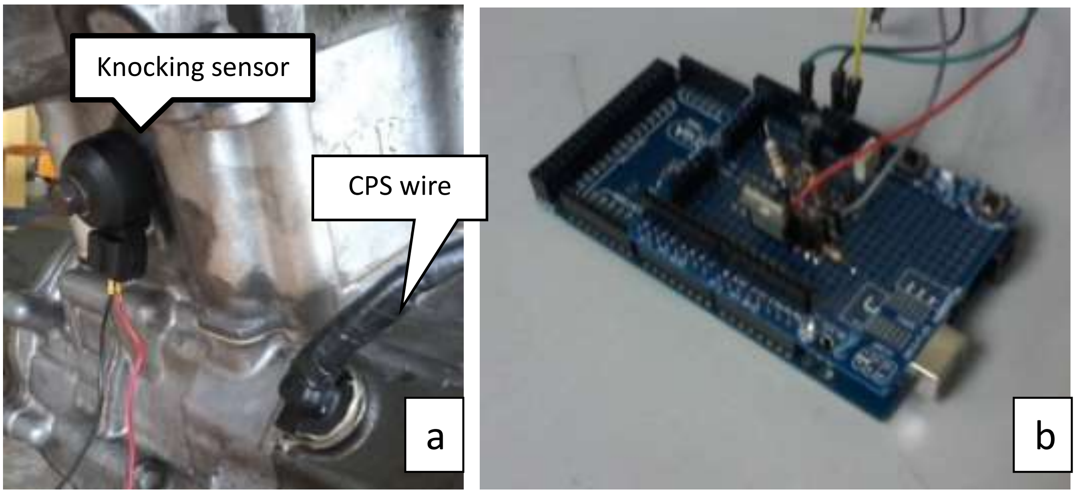


Figure 2. (a)Accelerometer attached to the engine and CPS wire for signals identification. (b) Arduino Mega with protoshield.

3. Result

The engine is tested for the knocking sensor response from the CPS signal. As Figure 3, showing the signal are set to 100milisecond to spark for 1 millisecond. The constant voltage at 5V dropped to 0V and it is switch off for 1 millisecond every 100 milliseconds alternately. It will produced at 600 rpm, and several knocking signal seem to be appear every 10 second alternately. This condition is to be simulated as artificial knocking condition. Figure 4 shows clearly the constant 1 millisecond spark and 100milisecond in between the spark to produce the artificial knocking condition. This condition is set by using arduino microcontroller and a mosfet circuit to actuate spark plug timing.

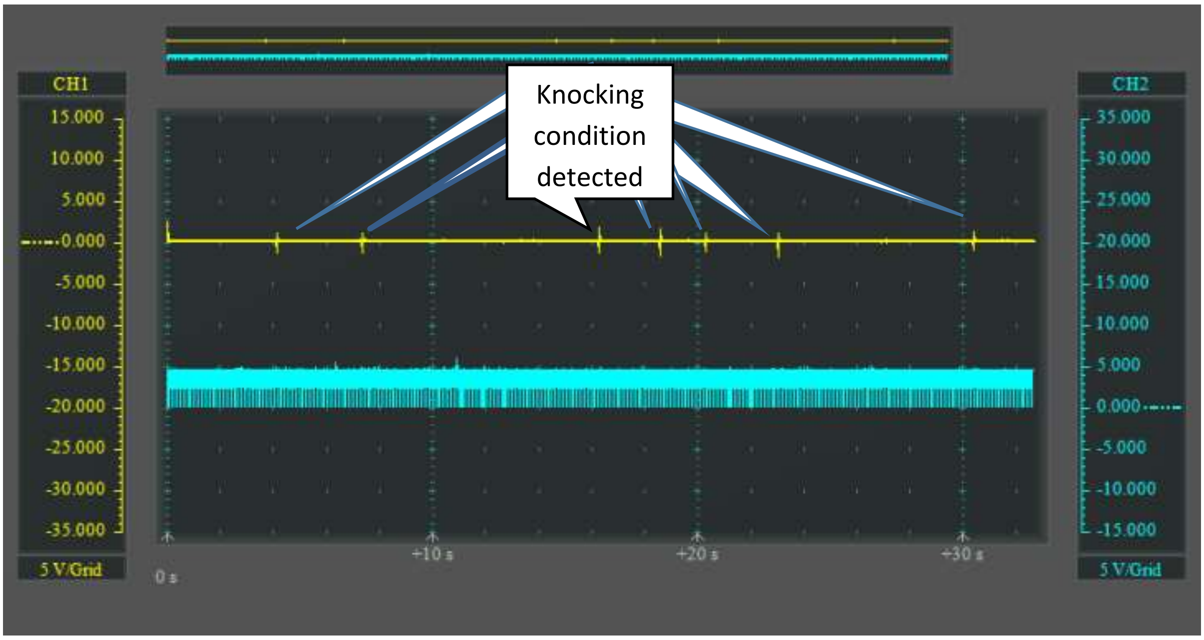


Figure 3. Ignition timing (blue) and knocking sensor(yellow)

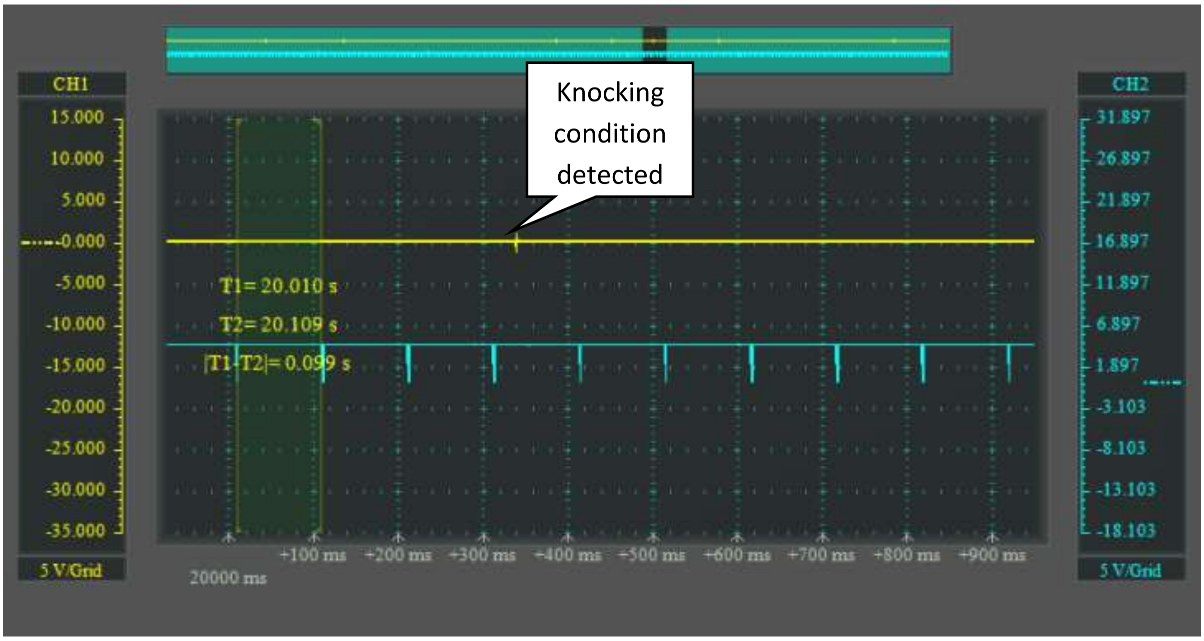
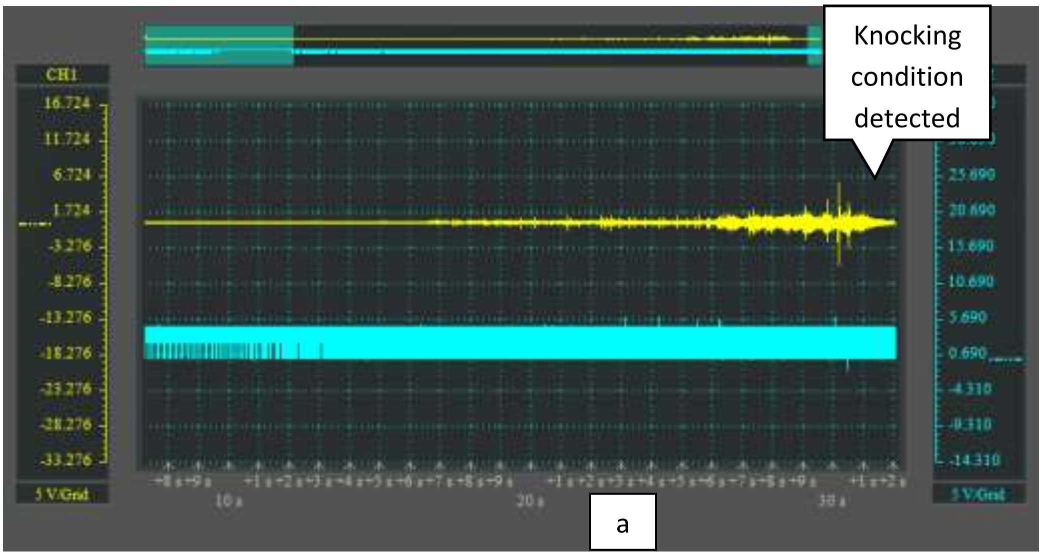


Figure 4. Iignition timing 100ms.

Figure 5(a) show signals from CPS was recorded to identify knocking condition. The signals indicate an acceleration from 1000 RPM to 8000 RPM. The fluctuations show it produced alternate current, constantly within 5V. It show the speed of the engine, whether it is on idling condition at low speed, acceleration from low speed to high speed or constantly in high speed condition. Different signals recorded for engine idling condition. Figure 5(b) show, where idling is the condition of the engine run at low speed constantly. There no signal at the knocking sensor occurs. Furthermore, Figure 5(c) shows signal at high speed, about 4000RPM. Ignition timing signals show constant signals voltage but different width of peak to peak. The engine starts to vibrate, the signals show about 1 v from knocking sensor occurs.



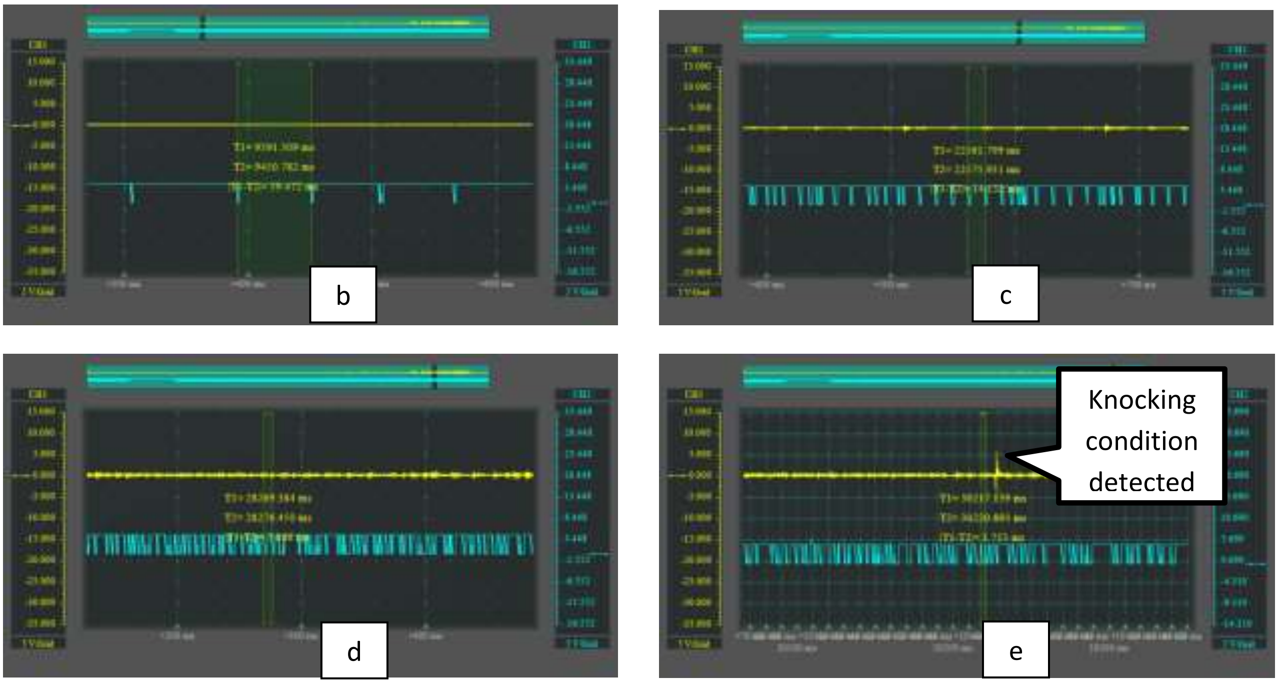


Figure 5. (a)knocking vs ignition timing signals range 1000-8000 RPM, (b)knocking vs ignition timing signals range 1000RPM, (c) knocking vs ignition timing signals range 4000RPM, (d) knocking vs ignition timing signals range 6000RPM, (e) knocking vs ignition timing signals range 8000RPM

Figure 5(d), the engine speed increases to 6000RPM. The knocking sensor detected almost 2 V of vibration. Whereas figure 5(e), the is a large voltage detected from the knocking sensor. About 5V of knocking sensor are recorded.

4. Discussion

From the signals recorded, artificial knocking condition is actuated from the Arduino Microcontroller. The knocking is identified from the highest peak from the knocking sensor signal. Figure 3 and figure 5(e) show similarity of knocking conditions. Knocking conditions should be avoided cause it may damage the engine. The condition may effected moving part in the engine, such piston, cylinder block and others (Dahl, 2015).

Furthermore, figure 4(a) show the uncertainty of the engine controller to stabilize the engine ignition timing. Between 6000 to 8000 RPM, the speed of the engine could not be verified clearly cause of the mistiming by the engine controller.

5. Conclusion

Based on the analyzed knocking signal form the engine actuated by the Arduino microcontroller, the artificial knocking condition could be actuate and identify. The signal shows the sudden and highest peak from the knocking sensor. Knocking condition only happens due to mistiming of the spark plug. For further investigation the artificial knocking condition is to be test to identify the knocking signals in specific speed.

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