

Multi-Time Ignition Concept of Four Stroke Gasoline Engine

Paramin Timtam and Jirawath Parnklang

Abstract—This article presents the design and fabrication of multiple time ignition flame of ignition plug in the 4 stroke internal combustion gasoline engine. The idea concept is to increase the number of controlled ignition voltage signals, so the ignition flame of the spark plug is igniting several times in one engine ignition cycle. Ensuring that the overall signal timing of the maximum ignition period is not over than the period of the engine piston in normal position from Before Top Dead Center (BTDC) to the Bottom Dead Center (BDC) at the maximum 8000 round per minute (*rpm*). Based on the usual gasoline engine ignition system, a complete driver circuit of ignition coil unit, it is found that the new idea of ignition pulse signal of the spark plug can be created up to 4 times while the output voltage of the sample ignition coil decrease not less than 10% compared to the normal ignition signal condition. The lowest accumulated charging time of ignition coil was 3.9ms.

Keywords—ignition spark plug, multi time ignition, pulse spark signal.

I. INTRODUCTION

The internal combustion gasoline engine has recently been developed to reduce engine pollution. The whole concept is to increasing output engine power, reducing the fuel consumption, pollution and also the engine sound. The development sometimes needs higher quality of gasoline fuel to produce higher output engine power, which causes higher pollution. The nature of the internal combustion gasoline engine is that when the fuel efficiency characteristic is improved, the other aspect such as the power efficiency is unavoidably reduced. The evolution of the internal combustion engine is slower than the expectations from the regulations of each country.

The single spark plug ignition coil unit (coil on plug) of the internal combustion gasoline engine is one of the development to example improve the engines an ignition cycle concept with low pollution emission. For example, the techniques of the spark plug ignition flame while the engine discharges the exhaust to reduce its severity before releasing outside the engine. Although the pollution (toxic gas) discharge from the engine is burned again for the second time and reduced the pollution rate. It does not increase the engine output power.

Paramin Timtam, Graduate Student, Department of Electronics Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand 10520, Email: mienimi20@gmail.com

Jirawath Parnklang, Associate Professor, Department of Electronics Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand 10520, Email: kpjirawa@kmitl.ac.th

Formerly, the development of the number of the spark plug ignition to increase the power is to add spark plugs in the one engine piston (only 2 plugs maximum). The problem on the appropriate position to install the several ignition spark plugs is being discussed as the spark plug position. The ideally is to install at the center of piston combustion chamber. This multi spark plug engine ignition is not satisfactorily enough fuel efficient. The resolution of this issue is to increase the electrode in spark plugs to be 2, 3 and maximum 4 electrodes (formerly there is only 1 electrode). And find the best possible position to install a plug for produce maximum output engine power with minimum pollution as possible. However, there is still a problem as the ignition plug only took place at only a suitable point in the combustion chamber. And there is only one electrode can spark because of that electrode gives the minimum electrical spark gap resistance. This development is therefore considered a solution for the case of hot electrode plug, after a long time use of spark electrode can no longer lifetime. The ignition flame occur at the another electrode sparkplugs which are still low electrical spark gap resistance. Furthermore, the development of spark plugs by using difference material such Iridium or Platinum at the spark electrode produces conduction efficient and reduces the degradation of the plugs. The ignition point is more accurate. It is the evolution of spark plugs that is currently used.

However, all of the spark plug ignition system development has been focused on single ignition per one ignition round due to the fact that there is the mechanical limitation of control unit (pick up coil in the distributor unit). Currently, there is a innovation that creating high voltage to eliminate the ambient air surrounding the spark plugs in the combustion chamber. This innovation is single spark plug per one ignition coil and one coil driver circuit. With the smaller power electronics device technology, the ignition coil and coil driver control unit is combined in the small single unit. A lower duty cycle time to ignite and responds to higher ignition frequency response. The sample of a complete coil on plug ignition circuit unit is illustrated in Figure 1.

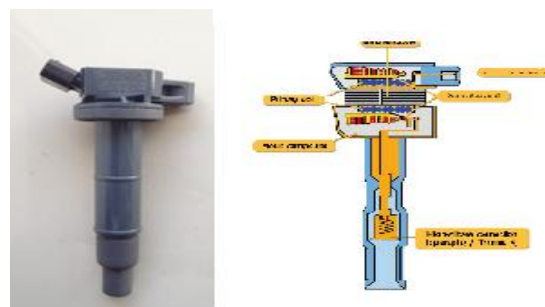


Fig. 1. The present single coil on plug

II. THEORY

With the internal combustion engine, gasoline ignited with a single spark plug presently is started during the engine piston compressing. The piston move to top dead end which refers as Before Top Dead Center (BTDC) and it occurrence at any suitable degrees depends on designing the gasoline engine and fuel combustion duration time. The fuel burn starts at the end point of the spark electrode plug and ignite overall the combustion chamber so that the fuel is thoroughly combusted. When the piston moves to the Top Dead Center (TDC), it descends to generate heat power to propel the automobile. The power of combustion attract to the top of the piston ended after the piston moves to the Bottom Dead Center (BDC). At this moment, the spark plug originates sparks from the time that the piston moves to the Bottom Dead Center. The timing period is researched to create duty cycle time spark signal for combustion at the spark plug electrode continually. The period time (T) is calculated from the equation (1):

$$T = \frac{D+180^\circ}{\frac{rpm}{60} \times 360} \text{second} \quad (1)$$

By D is combustion degree at Before Top Dead Center
 rpm is engine cycle in 1 min (round per minute)

Therefore, if we specify a maximum round per minute (rpm) of engine to be 8000 with 10 combustion degrees BTDC, the period to create the combustion signal is not over than 3.9ms. The problem in the system includes the method of combustion to originate the spark at the spark plug. So in this research mean that it cannot be calculate to find the period of cumulative load of combustion currently used coil. However, as a gasoline engine is combusted with single coil that has the coil propel system inside on single unit and a set of combustion ignition coil. This propels cycle is responsible for only a combustion piston. That is to say, the size of the combustion coil is made of copper wire with a small cross sectional area. It needs a low primary coil input current and high output secondary voltage. From studying the general period of load accumulation by considering the period of combustion signal derived from ECU (Engine Control Unit) controlled by general engine concept is 1.4ms. Hence, we begin the studying of timing of the newly generated signal to decrease from the signal period and experimenting signal creation with maximum combustion to the load at 3.9ms as specified above. The duration of the OFF state of each signal is equal to the duration of the ON of the calculated period.

Some former concept of dual ignition coil and dual spark plug ignition system of Alfa Romeos Twin Spark or Toyota Twin Plug Engine, a single spark plug ignition system is applied in present general vehicle to ignite engines with one power cycle. However, in recent decades, Alfa Romeo has conducted the experiment by adding another spark plug to the engine ignition system which means the dual spark plug ignition in one work cycle. The timing spark flame of the twin spark plugs are designed of suitability time. The experiment results indicated that the ignition of the dual spark plug in one power work cycle cause higher complete combustion, higher fuel efficiency and also lower amounts of engine exhaust pollution.

From the Alfa Romeo experiment, it is found that the dual or twin spark plug ignition system can provide fuel

combustion which higher than the single spark plug ignition system. Because of its more comprehensive ignition position, greater spark power, higher ignition fire by higher secondary voltage, and it causes more complete combustion fuel efficiency.

III. EXPERIMENT AND RESULTS

Designing a gasoline engine single spark ignition model system, and construction equipment for this concept of the ignition that multi times spark as mentioned above is fabricated. After that, conducted and experiment based on the concept by generating a control simulation of the ignition signal output from the general ECU of engine with 4 cylinder engine cycle's speeds of 2000rpm, 4000rpm, 6000rpm, and 8000rpm respectively. The ECU signal is stimulate into the fabricated new concept CPU of the experimental system and new ignition signals is created. The new multi time ignition signal is 1, 2, 3, and 4 times. Regardless of the number of ignition times that occurred, the sparking plug is terminated in a timely manner which is BTDC to the point where the engine piston position. This received such ignition point, reached to the BDC. Then the output voltage at the end of electrodes of the ignition spark plug is measured and compared with the ignition signal. The results of the experiment are shown from Figure 2 to Figure 8 and Table 1.

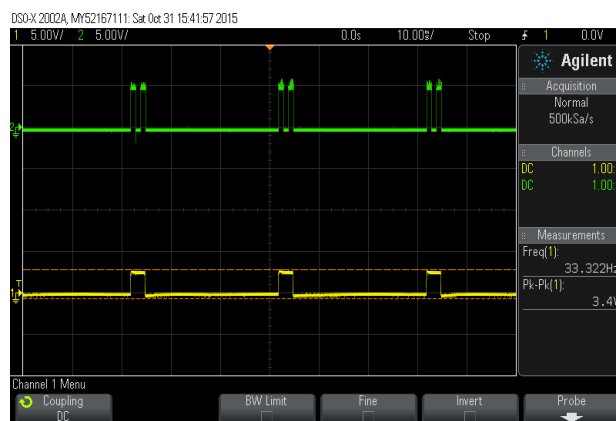


Fig. 2. Example of original ignition signal (below) and new ignition signal created (above)

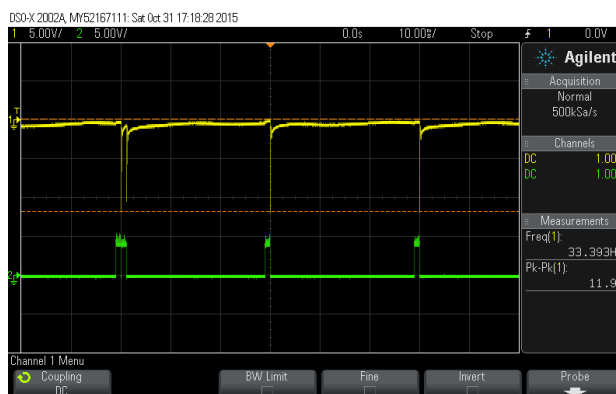


Fig. 3. Example of voltage levels record from electrode of the sparking plug's tip when experimenting ignition with default signal (above) and the new ignition default signal created (below)

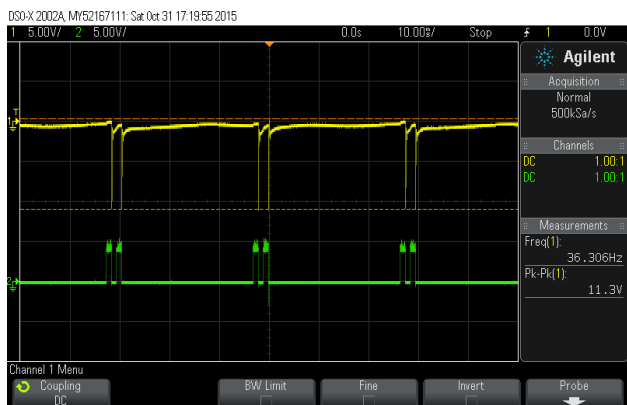


Fig. 4. Example of voltage levels record from electrode of the sparking plug's tip when experimenting ignition with signal 2 times (upper) and the new ignition signal created 2 times (lower)

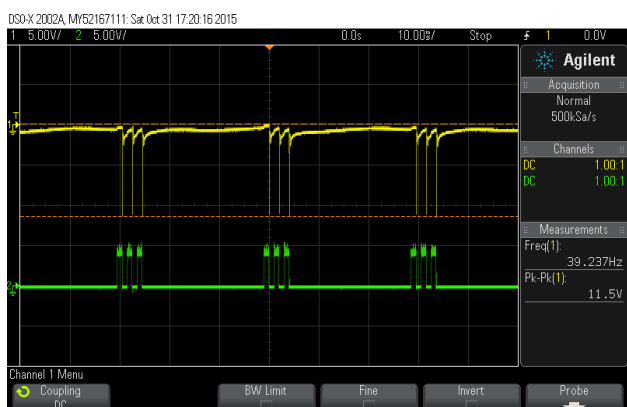


Fig. 5. Example of voltage levels recorded from electrode of the sparking plug's tip when experimenting ignition with signal 3 times (above) and the new ignition signal created 3 times (below)

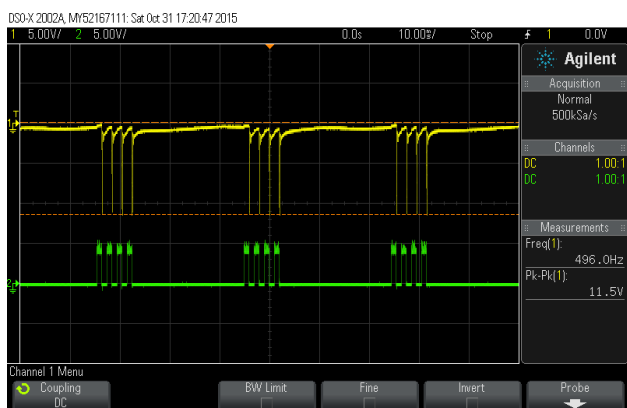


Fig. 6. Example of voltage levels recorded from electrode of the sparking plug's tip when experimenting ignition with signal 4 times (above) and the new ignition signal created 4 times (below)

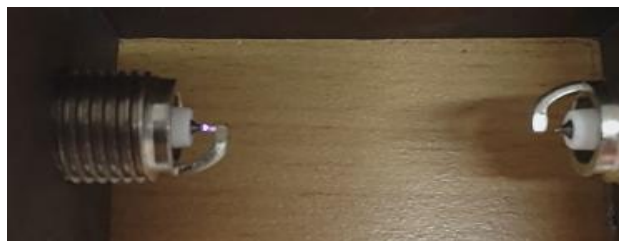


Fig. 7. Example of the nature of the flame obtained from the sparking plug ignited with normal signal



Fig. 8. Example of nature of flame obtained from the sparking plug ignited with multi pulse signal

TABLE I
THE RESULT OF OUTPUT VOLTAGE OF THE SPARK PLUG ELECTRODE

Number of Pulse Signal	Engine Cycle (rpm)	Ignition Timing (ms)	Sparking Plug Electrode Tip Output Voltage (V)
1	2000	15.83	11900
	4000	7.917	11100
	6000	5.28	11300
	8000	3.958	23100
2	2000	15.83	11500
	4000	7.917	10900
	6000	5.28	10300
	8000	3.958	10700
3	2000	15.83	11500
	4000	7.917	11300
	6000	5.28	10500
	8000	3.958	10700
4	2000	15.83	11500
	4000	7.917	11300
	6000	5.28	10300
	8000	3.958	11700

IV. CONCLUSION

Figure 7 and figure 8 show that this concept of the spark technique is better light intensity of the spark plug electrode tip than today general spark concept. And also from table 1 the experiment results by generating a signal with multi time pulse signal (maximum at 4 time) to the spark plug with different normal gasoline engine speeds (*rpm*) and measuring the output voltage from the spark plug electrode's tip shows that the efficiency of the detonation in different kinds of detonation signals and different *rpm* at the same detonating voltage. But the experimental results do not include the engine speed at 8000*rpm* which has a multi pulse signal 1 pulse that has a different voltage from the detonation and different from other *rpm* rates. The conclusion is that if the multi pulse signal 1 pulse is delivered to this type of coil on plug, the output voltage from the detonation at rate of 8000*rpm* has the highest voltage rate from the detonation. The next research is to change the sample of the coil on plug and find the maximum system frequency response or the minimum duty cycle time parameter of this idea ignition signal.

REFERENCES

- [1] J S Wijesinghe, G Hong, "Effect of Spark Assistance on Autoignition Combustion in a Small Two-Stroke Engine" School of Electrical, Mechanical and Mechatronic System, University of Technology, Sydney, New South Wales, Australia.
- [2] Thomas Kaiser, Alexander Flaig, Frank Mucklich "Design and Materials for Long-Life Spark Plugs" SAE paper no.2006-01-0617.
- [3] Ajay K.Singh, A.Rehman, "The Effect of Dual Spark Plug on Engine Performance Parameter in Two Stroke Gasoline Engine" Maulana Azad National Institute of Technology, Bhopal.