International Journal of Automotive Technology, Vol. 21, No. 1, pp. 249−257 (2020)
DOI 10.1007/s12239−020−0024−9

pISSN 1229−9138/ eISSN 1976−3832

UNDERSTANDING OF THE SPARK EFFECT OF ELECTRON COLLISION BY A CAPACITIVE DISCHARGE IGNITION IN A CONSTANT VOLUME COMBUSTION CHAMBER

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(Received 14 August 2019; Revised 25 September 2019; Accepted 2 October 2019)

ABSTRACT−This work is to investigate the physical effect of plasma discharge in atmospheric air using a capacitive discharge ignition (CDI) system. Also, to specifically investigate the kernel effects of CDI system, this work represents the different characteristics including the spark ignition, electric current, integral energy, spark propagation, flame growth, and kernel distribution comparing with the conventional spark ignition. In the experimental setup, the system is composed of a constant volume combustion chamber (CVCC), spark plug, transformer, capacitor device, mass flow controllers, regulators, high-speed camera, and LabVIEW software and cDAQ. The experiment carried out a wide range as the following conditions: J type spark plug, central type electrode, 1.0 mm plug gap, atmospheric air of initial pressure, 292 K of room temperature, 0.75 ms of spark duration, 420 V of CDI voltage, and 12.5 V of initial transformer voltage. As a result, the spark flame kernel of 400V CDI is increased by MEHV comparing with the conventional spark and the improved effect can be seen in 50 μs. Consequently, the plasma effect of MEHV based on CDI system has a linear characteristic regarding spark kernel growth by capacitance energy comparing with the conventional spark.

KEY WORDS : Capacitive discharge ignition (CDI), Spark propagation, Flame growth, Kernel distribution, Constant volume combustion chamber (CVCC), Spark energy, Internal combustion engine (ICE), Plasma-assisted ignition (PAI)

1. INTRODUCTION

When it comes to the plasma discharge in an internal combustion engine, it is significantly important to induce the spark flame, formation, kernel, and ionized electron (Starikovskiy and Aleksandrov, 2013). Nowadays, in order to improve the unstable effect of the conventional combustion system, the plasma-assisted ignition is applied to the combustor in an internal combustion engine. The plasma-assisted ignition is an application technology to combine two different energies between electrodes of a spark plug. In the automotive technology, the spark ignition is essential to well-induce a magnetic field to a combustion chamber. The initial combustion is significantly affected by spark formations which were created between anode and cathode of a spark plug (Hwang *et al*., 2016). Therefore, a spark plug is required to carefully design the mechanical specifications including the shape, length, insulation, material, and grounding area. Two spark electrodes use three different materials such as a nickel (Ni), platinum (Pt), and iridium (lr) to obtain the effect of an electric magnetic for plasma sheath (Kim and Askari, 2019). The spark energy of the ignition system is ordinary to spend 80 mJ because the spark volume is reduced by the initial pressure increase inside a combustion chamber. In fact, spark energy cannot be calculated exactly due to having a lot of losses, i.e., self-loss, transfer-loss, signal-loss, and absorbing-loss in ignition system (Nakamura *et al*., 1985). To overcome the energy loss in the ignition system, the plasma-assisted ignition has used in the spark ignition system by adding a transformer and circuit device since 2005 (Yue and Reitz, 2018).

The spark ignition system applies to all of the power systems which include the gasoline engine, natural gas engine, LPG engine, aero engine, shipping engine, and ionized engine. In order to obtain the effect of higher performances using CDI system than the conventional ignition system, SI engine systems can be easily altered from the spark ignition to plasma-assisted ignition (Klimov *et al*., 2001). The plasma-assisted ignition has the following advantages: the kernel size, fuel efficiency, and high power, combustion pressure can be significantly improved, the flame velocity and combustion reaction can be efficiently increased, and the exhaust gases can be reduced except for NO_X.

The matching effect of high voltage (MEHV) is well-known for a technical method capable of inducing the

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