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A Study of the Mechanism of Abnormal Ignition in H_2 Engine

Naoyoshi Matsubara[1] **Yoshinori Miyamoto**[1] **Shiro Tanno**[1] **Jun Miyagawa**[1] **Yuya Abe**[2]

Kazuki Kaneko[1] **Daishi Takahashi**[1] **Nozomi Yokoo**[1] **Koichi Nakata**[1]

1) TOYOTA MOTOR CORPORATION
1200, Misyuku, Susono-shi, Shizuoka, 410-1193, Japan
2) DENSO CORPORATION
1-1, Showa-cho, Kariya-shi, Aichi, 448-8661, Japan

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For the realization of Carbon Neutrality, hydrogen is considered to contribute to decarbonize various industries and being focused. In transportation sector, hydrogen engines are studied in addition to FCEVs. Since hydrogen has the property of being ignited more easily than gasoline, abnormal ignition is likely to occur. In this paper, the mechanism of abnormal ignitions peculiar to hydrogen are studied. 4 types of pre-ignition are confiremed in hydrogen engine and the mechanisms and countermeasures are examined.

(1) First pre-ignition is backfire type as shown in figure 1. It is likely to be occurred in Port Fuel Injection Engine. Backfire is a phenomenon in which the air-fuel mixture is heated and self-ignites when the premixed gas flow into the cylinder. One of the ignition sources is kown to be the high-temperature residual gas. It is shown that direct injection can be a countermeasure to avoid the influence of high temperature residual gas.

(2) Secound pre-ignition is Runaway type as shown in figure 2. It is comfirmed that the ignition source is high temperature material surface. It is measured and revealed that the ignition temperature of hydrogen case is around 200 celsius degree lower than the gasoline case. Therefore it is important to enhance cooling to suppress runaway type pre-ignition.

(3) Third pre-ignition is Sporadic type as shown in figure 3. The ignition source is analized and guessed as the high temperature residual gas that is remaining in flow stagnation area in some cycles when the mixing is not enough in that area. Therefore it is important to reduce residual gas temperature and decrease the volume of flow sporadic area to mitigate Sporadic type pre-ignition.

(4) Forth pre-ignition is eary ignition of H_2 injection. There are some kind of ignition source. One of the source is studied in this paper. It is supposed that small volume of hydrogen can back flow into intake port when overlapping of hydrogen injection duration and intake valeve open duration, flow into cylinder in next cycle, be ignited by high temperature residual gas like backfire, and those burned gas ignite H_2 injection. To avoid this assumed pre-ignition source, it is considered effective to adjust the relationship between intake valve and H_2 injection in the view point of time and space to avoid H_2 back flow into intake port.

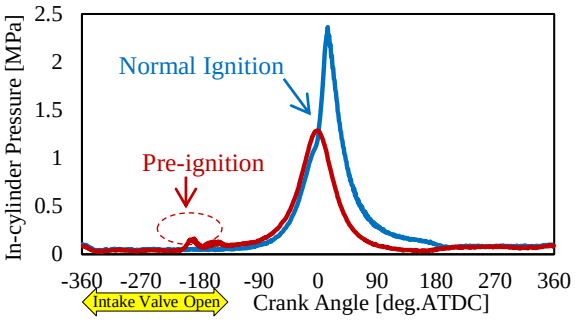

Figure 1 Backfire Type Pre-ignition

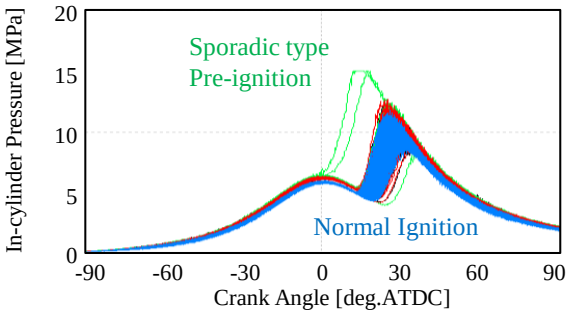

Figure 3 Sporadic Type Pre-ignition

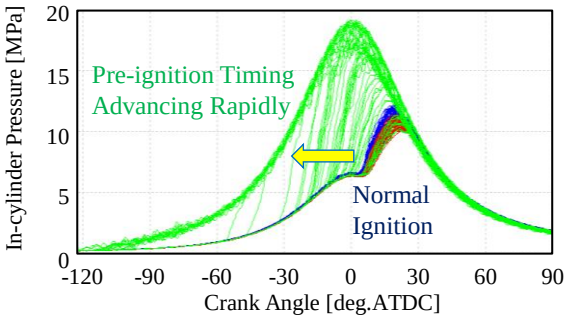

Figure 2 Runaway Type Pre-ignition

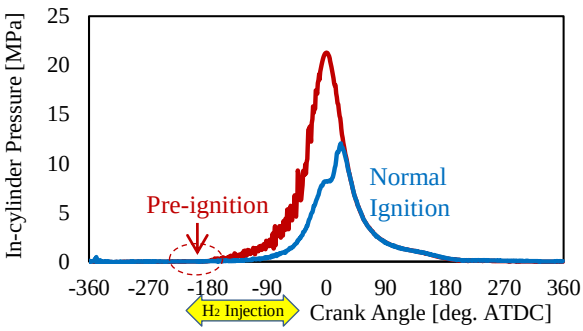

Figure 4 Pre-ignition of H2 Direct Injection