HYDROGEN MIXING WITH AIR AND ITS COMBUSTION AT HIGH-PRESSURE INJECTION INTO THE COMBUSTION CHAMBER OF A SPARK IGNITION ENGINE

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Abstract: The results of numerical modeling of the processes of hydrogen mixing with air at direct high-pressure injection of hydrogen into the combustion chamber of an internal combustion engine and subsequent combustion at spark ignition are presented. Two formulations of the problem are considered. In the first formulation, the combustion chamber volume is constant and corresponds to the combustion chamber of a small-scale engine, i. e., when the piston is at the top dead center. In such a chamber, hydrogen is injected at a pressure of 700 atm through 6 slits with a total width of 1.8 mm. The mixing duration was about 25 ms and the combustion duration was 1 ms, while combustion incompleteness of hydrogen was equal to 9.5%. Within the framework of the second formulation, hydrogen is injected into the cylinder of an engine at the beginning of the compression stroke through a slit space of 1.6-millimeter width. The injection pressure was varied in the range from 20 to 140 atm. It is shown that mixing is realized most completely when relatively low pressures are used (less than 100 atm). The obtained quantitative estimations indicate the possible ways of optimization of the system of hydrogen direct injection into the cylinder of internal combustion engine.

Keywords: hydrogen; mixing; direct injection; spark ignition engine; numerical modeling

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Figure Captions

Figure 1 Problem setups: *1* — plane (*a*) or axis (*b*) of symmetry; *2* — wall with slits; *3* — combustion chamber (*a*) or cylinder (*b*); *4* — high-pressure chamber; *5* — spark position; *6* — bottom dead center; and *7* — top dead center

Figure 2 Tine history of the degree of homogeneity of hydrogen–air mixture in the combustion chamber for the case of hydrogen injection within the setup presented in Fig. 1*a* (*1*) and its linear approximation (*2*)

Figure 3 Fields of hydrogen molar fraction during combustion of hydrogen–air mixtures of different degrees of homogeneity at the time instant of ignition: (*a*) 100%; (*b*) 93.3%; and (*c*) 38.6%. The fields are presented at the time instants of 0.6 ms (*a*) and (*b*) and 0.8 ms (*c*) after the start of the spark discharge. White contour — isoline of temperature of 1000 K

Figure 4 Time histories of the degree of homogeneity of hydrogen–air mixture in the cylinder for the case of hydrogen injection within the setup presented in Fig. 1*b* at pressure of 20 (*1*), 60 (*2*), 100 (*3*), and 140 atm (*4*)

Figure 5 Fields of hydrogen molar fraction during its mixing with air under the moving piston on the compression stroke at the time instants corresponding to 2°, 60°, 120°, and 180° of crank angle. Injection pressure is equal to 20 (*a*) and 140 atm (*b*)

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