Particulate number emissions during dynamic operating states of a hydrogen-fueled Turbulent Jet Ignition engine

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The dynamic operating states of an internal combustion engine significantly change the emission of toxic components of the exhaust gas, including the emission of the number of particulate matter [1, 2]. Controlling the operation of such an engine requires a number of systems that make it possible to change its dynamics while fully controlling the operating parameters [3–5].

The purpose of the work was to analyze the emission of exhaust components (including particulate number) during dynamic speed variation while keeping the initial operating parameters of the internal combustion engine mostly constant. The work was carried out with dynamic speed changes from n_1 = 1000 rpm to n_2 = 1800 rpm, and with the initial operating parameters of the engine:

- two values of the excess air coefficient λ = 2.0; 2.4
- the value of the center of combustion (AI50) determined at AI50 = 10 deg aTDC.

The study used a single-cylinder AVL5804 research engine with a two-stage combustion system equipped with a hydrogen injection system (P = 9 bar) into the intake channel (Fig. 1). The prechamber was equipped only with a spark plug (without gas supply).

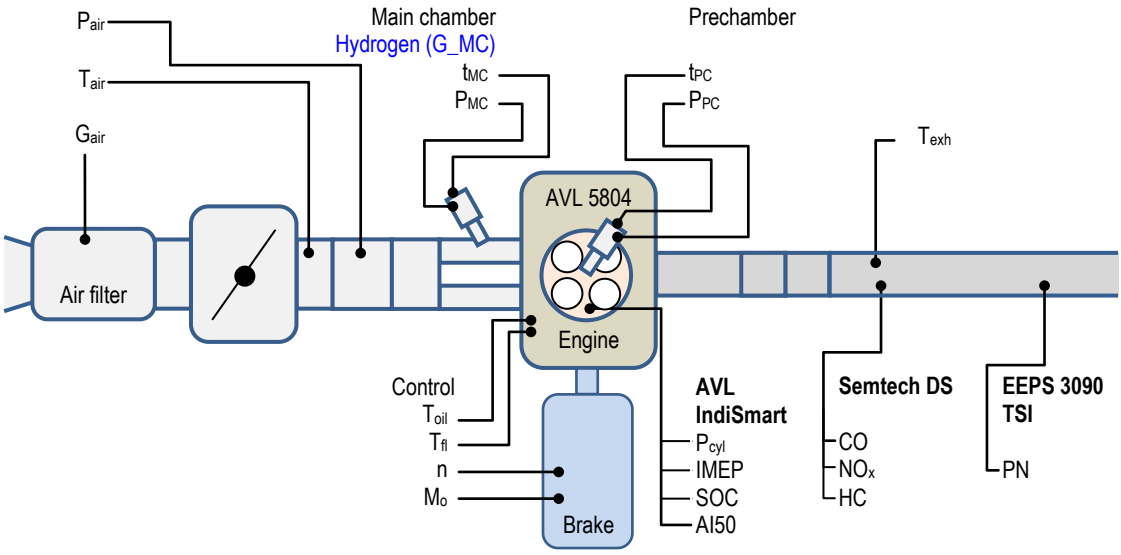

Fig. 1. Scheme of the test stand with measuring apparatus

The choice of initial conditions was dictated by the possibility of keeping many operating parameters (including ignition angle and maximum cylinder pressure angle) within the range of acceptable variations. The analysis was carried out with dynamic speed variation (Fig. 2a) at the initial IMEP setting. The resulting values of IMEP and AI50 increase slightly – with the larger values obtained at λ = 2.4 (Fig. 2b). At such a present rate of change, larger increases in NO_x concentration were noted during engine overdrive (the larger initial values are due to the higher engine load – Fig. 2c).

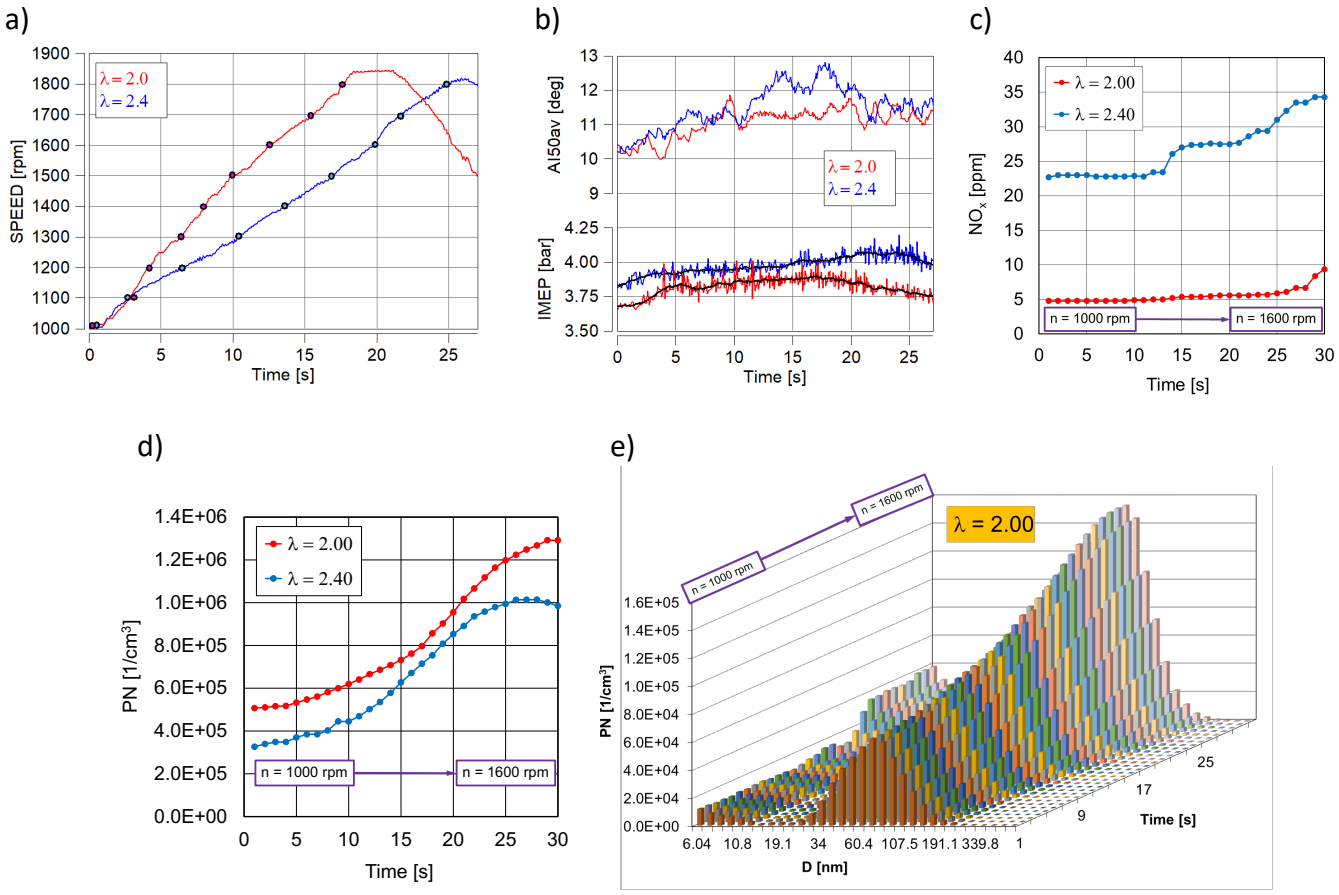

Fig. 2. Results of tests of exhaust gas components under different operating conditions of a hydrogen-powered engine: a) course of dynamic change of engine speed; b) conditions of change of engine operating indicators; c) concentration of nitrogen oxides; d) particle number at different values of excess air ratio λ; e) concentration histogram particle number under conditions of dynamic change of speed

Despite the lower load on the engine at λ = 2.0, the concentration of the particle number is about 100% higher with respect to its operating conditions at λ = 2.4 (Fig. 2d). Similar values can be observed during the final phase of increasing engine speed – regardless of the excess air coefficient, a twofold increase in particle number concentration is observed. The dynamic change of engine operating conditions indicates that the characteristic diameter value remains constant (in the range of 80–100 nm), but a proportional increase in the number of particles from the range of particle diameters over 100 nm is also observed (Fig. 2e).

[1] Z. Wang et al. *Int J Hydrogen Energ*, **2024**, 49, 968-979. doi: 10.1016/j.ijhydene.2023.09.279
[2] AP. Singh et al. *Int J Hydrogen Energ*, **2020**, 45, 18021-18031. doi: 10.1016/j.ijhydene.2020.05.005
[3] R. Payri et al. *Appl Therm Eng*, **2023**, 230, 120754. doi: 10.1016/j.applthermaleng.2023.120754
[4] E. Frasci et al. *Fuel*, **2023**, 345;128265. doi: 10.1016/j.fuel.2023.128265
[5] A. Thawko et al. *Int J Hydrogen Energ*, **2019**, 44;28342-28356. doi: 10.1016/j.ijhydene.2019.09.062