PRESSURE MEASUREMENTS IN ROTATING DETONATION ENGINES

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The use of Rotating Detonation Engines (RDEs) is a promising way to efficiently convert the chemical energy of fuel into the mechanical energy for propulsion. The values of local pressure in the RDEs are the most important indicators of the operation process efficiency. Pressure sensors in RDEs are exposed to high temperatures ($\sim$ 3000 K) and pressures ($\sim$ 10 MPa), as well as mechanical vibrations. Therefore, the duration of test fires of RDEs with pressure sensors mounted directly in the RDE walls is usually very short (from tenths of a second to several seconds) to avoid sensors' destruction. During longer test fires of RDEs, pressure sensors are installed in the waveguide tubes or in the receivers at their end-walls (Fig. 1). On the one hand, it allows

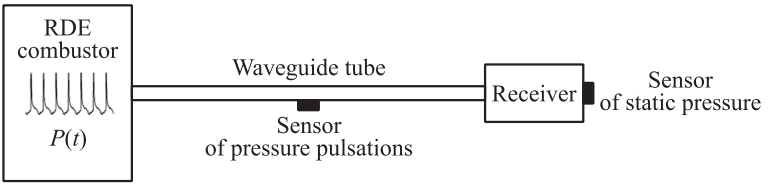

Figure 1 Schematic of pressure measurements in the RDE using sensors of pressure pulsations and static pressure mounted in a waveguide tube and in a receiver at the tube end-wall; $P(t)$ stands for the local pressure time history in the RDE

DOI: 10.30826/ICPCD12A28

protecting the sensors from high thermal and mechanical loads and, on the other hand, leads to distortions of sensors' signal characteristics due to wave phenomena in the system "waveguide tube – end-wall receiver."

The objective of this work is the three-dimensional computational study of the influence of the waveguide tubes and end-wall receivers on the amplitude and frequency response of signals arriving at remote sensors of pressure pulsations and static pressure. Three approaches are used, which are based on Euler, Navier–Stokes, and Reynolds equations. The situation is simulated when the operation process in the annular RDE combustor is accompanied with high-amplitude local pressure pulsations at a frequency of 1000 or 500 Hz caused by periodic arrivals of a detonation wave continuously rotating in the annular gap. The influence of the volume of the end-wall receiver and the frequency of pressure pulsations in the RDE on the "readings" of pressure sensors is analyzed. It is shown that the remote placement of static pressure sensors at the end-walls of waveguide tubes allows the time-averaged static pressure in the combustor to be recorded with an accuracy of $\sim 10\%$ (Fig. 2). The rotation frequency of detonation

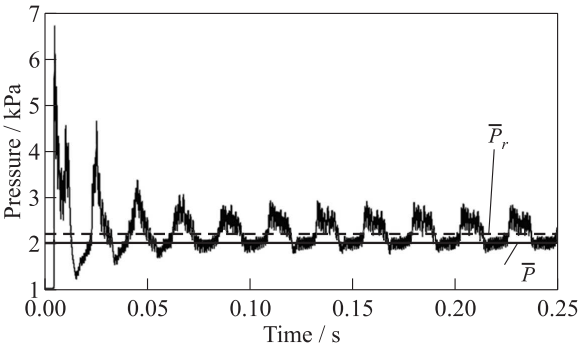

Figure 2 The calculated records of the static pressure sensor mounted in a receiver at the end-wall of a waveguide tube; receiver volume is 1 cm^3; waveguide tube diameter and length are 4 mm and 2 m, respectively; and the frequency of the operation process in RDE is 1000 Hz: $\overline{P}$ is the mean static pressure in the RDE; and $\overline{P}_r$ is the mean static pressure in the receiver

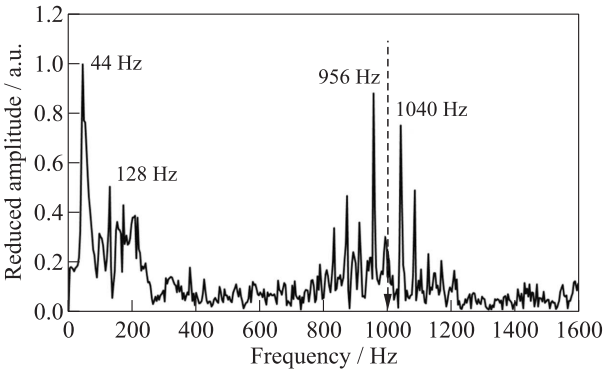

Figure 3 The FFT of the records of the sensor of pressure pulsations mounted at a lateral wall of a waveguide tube; the frequency of the operation process in RDE is 1000 Hz; the sensor is located in a long waveguide tube 4 mm in diameter at a distance of 0.8 m from the RDE

waves can be measured by sensors of pressure pulsations installed at the lateral wall of a waveguide tube with some uncertainty caused by wave interactions in the waveguide tube. Figure 3 shows the example of fast Fourier transform (FFT) of the corresponding signal.

Acknowledgments

The work was supported by the subsidy given to the N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences to implement the state assignment on the topic No. 0082-2016-0011 (Registration No. AAAA-A17-117040610346-5) and to the Scientific Research Institute for System Analysis of the Russian Academy of Sciences to implement the state assignment on the topic No. 0065-2019-0005 (Registration No. AAAA-A19-119011590092-6).