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Probe positioning for the exhaust emissions measurements

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Abstract

Emission of harmful compounds in the exhaust gases depends on the operating conditions of the engine and its technical condition. Therefore, the legislative activity is focused on the introduction of new diagnostic and research procedures. The preferred method is using probes with plurality of holes for multi-gas sampling from the entire cross-section of exhaust stream. This method appears to vitiated by an error caused by averaging dilution and sampling gas from the very beginning of the measurement path. The results of measurements contained in the article are related to changes in the concentration of harmful substances in exhaust gases depending on the distance from the axis of the jet. In the article the disadvantages of this the methods were highlighted and the single-point measurement method was proposed.

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Keywords: Turbine engine; exhaust emissions; probe positioning.

1. Introduction

Many factors indicate a continuous and long-term dominance of internal combustion engines in aviation. This situation will continue to be maintained because of the lack of an alternative drive solution. In subsequent years, one of the most serious human issues will be energy problems and environmental. The intensity of the negative impact of transport depends mainly on the number of vehicles. That is why many initiatives can be seen in order to minimize negative impact of transport on the environment. One of the key ways to impact is the introduction of more stringent limit values for toxic emissions from internal combustion engines. The current limits necessitate joint efforts of manufacturers of aircraft engines to search for new ways to reduce emissions of harmful compounds. These activities

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are conducted within the framework of the implementation of joint programs such as the European Union NEWAC program, which involves the reduction of CO_2 emissions by 6% and NO_x by 16%. This program is in line with the general assumptions of Advisory Council for Aeronautics Research and Innovation in Europe (ACARE), which involve environmental protection to reduce CO_2 emissions by 50% and NO_x by 80% and reducing noise by 50% by 2020, compared to the emission limit values in 2001 [1,3,4,5,6]. The European Union is also implemented a program CLEAN CLEAN SKY and the SKY 2. These programs are a joint initiative of technology, the aim of which is to support activities related to the development and implementation of new technologies in the field of aviation. Number of diagnostic methods and procedures for the determination of exhaust emissions were developed. Issues included in the testing procedures [7] also apply to method of sampling the exhaust gas. The preferred method assume usage of special multi-hole probes, characterized by a gas intake of the entire cross-section of the gas stream. This method of sampling is not accurate enough because of dilution the exhaust gas at very beginning of the path measurement. Therefore, studies were carried out related to the assessment of changes in the concentration of the compounds in the section of the turbine engine exhaust gas stream.

2. Methodology

2.1. Object of the research

The Pratt & Whitney engine, F100-PW-229 (Fig. 1) is a drive of fighter aircraft F-16. Its maximum values of thrust are 79.13 kN – without the use of afterburner, and 128.91 kN with afterburner. It is a turbofan, twin-shaft engine with hydraulically adjustable nozzle. It is equipped with three-stage low pressure compressor and a ten-stage high pressure compressor. The combustion chamber is annular.

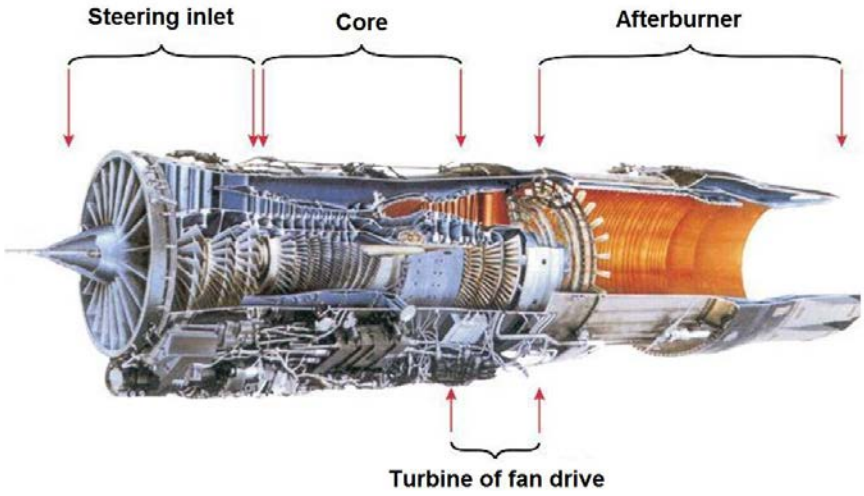

Fig. 1. Cross section of the engine Pratt & Whitney F100-PW-229 [1].

Technical parameters of the engine are as follows:

- Maximum diameter: 1080 mm,
- Length: 4855 mm,
- Engine weight: 1370 kg,
- Specific fuel consumption: 0.693 kg/(kG h),
- Specific fuel consumption with afterburner: up to 2.6 kg/(kG h).