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The Thermo-Gas-Dynamic Modeling of Afterburning Turbofan Engine for High Maneuverable Aircraft Combined with Its Automatics

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Abstract

The article considers modeling of aviation afterburning turbofan engine combined with its electrohydromechanical automatic control systems, supervision and diagnostics for high maneuverable aircraft. It describes an aviation engine and its automatic control system Dvig_Otladka2 developed based on Framework SAMCTO imitating simulation system. The designed imitation models sensors, regulators and actuating mechanism are described. A description of automatic control system action of one of modern aviation afterburning turbofan engine IV generation is presented; the change of main engine parameters by simulating of transient process of afterburner engagement and appearance on the augmented maximum rating are analyzed. The described technology of thermo-gas-dynamic simulation of aviation engines combined with its automatic control system allows selecting and optimizing the control and regulation programs considerably to accelerate fundamental phases of aviation engines design.

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Keywords: aviation engines; modeling aviation engines; automatic control systems; automatic aviation engine; engagement of afterburner; transient process; system imitation modeling; augmented rating

1. Introduction

At the first phase of aviation turbojet engine projecting there are produced different thermo-gas-dynamic calculations, as a result of them it is realized selection and optimization of scheme, of operation principle, of main engine parameters and geometrical dimensions of air-gas channel by basic altitude-velocity regimes. Exactly at this stage of projecting it is very important to work out the engine control and regulation laws in details, course of its

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dynamic processes. Only by such multiple-aspect interdisciplinary approach analysis, it is possible to design in short time final product with high characteristics of perfection, profitable behavior of operational description in the whole range of possible steady-state and transient processes [1]. It exists a number of software complexes for thermo-gas-dynamic simulation and they are efficiently used on different phases of product life cycle practically by all big manufacturers [2–4]. Much less of software complexes for nodal simulating of aviation engines in common with action of their automatic control system (ACS), with possibility of automatic switching from one regulation program to another. One of this software is Dvig_Otladka [5], developed with help of MetaCAE/Framework SAMCTO [6] on the base of system of imitating modeling (SIM) Dvigwp [7–9]. Dvig_Otladka allows simulating of aviation engines and power plants on their base of different scheme and operational principles of transient-free and transient processes. Automated regulation system is presented by one structural element (SE) «Regulator», by various installation-specific settings of which operation of different automatic types can be imitated [10, 11]. The topological model of afterburning turbofan engine with integral model of ACS is introduced on Fig. 1 [12].

Nomenclature

$F_{\text{nozzle throat}}$	area of nozzle throat
G_{fuel}	fuel consumption in afterburner
n_{HP}	rotating frequency of low-pressure rotor
n_{LP}	rotating frequency of high-pressure rotor
$n_{\max}$	maximum frequency of rotating
p_{K}	pressure after compressor
T_{H}	ambient air temperature
$T_{\max}$	peak temperature
$\alpha_{\text{control lever}}$	setting angle of control lever
π_{T}	pressure ratio of turbine

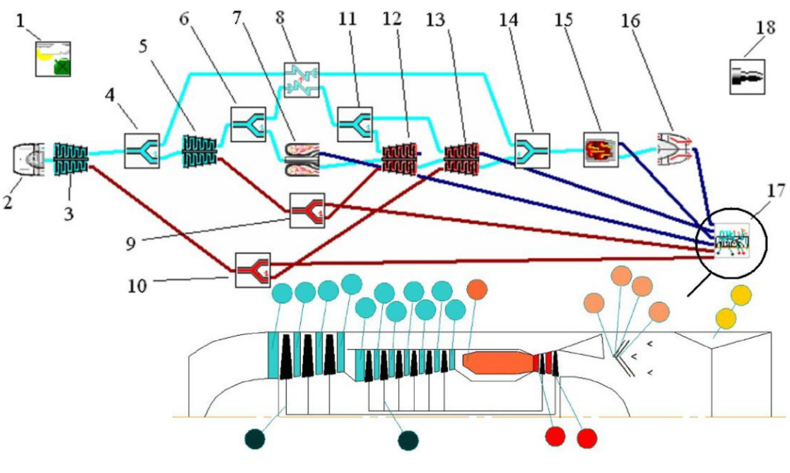

Fig. 1. Topological model of afterburning turbofan engine in SIM Dvig_Otladka, where 1 – ambient conditions; 2 – input device; 3 – low pressure compressor; 4 – gases selection; 5 – high pressure compressor; 6 – gases selection 2; 7 – combustor chamber; 8 – air-to-air heat exchanger; 9 – power selection; 10 – power selection 2; 11 – gases selection 3; 12 – high pressure turbine; 13 – low pressure turbine; 14 – flow mixer; 15 – afterburner; 16 – jet nozzle; 17 – regulator; 18 – total result.