A MATHEMATICAL MODEL OF AN AFTERBURNING TURBOFAN ENGINE FAN ON THE RAMJET MODES

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A promising power plant that allows supersonic transoceanic flights is an afterburning turbofan engine (ATFE), which can operate at ramjet mode with the blocked gas turbine duct at supersonic flight conditions [1].

The use of fixed geometry fan blades on the ATFE ramjet mode allows the fan to work only in the turbine mode, which decreases the total pressure and temperature in the ramjet duct. Moreover, the low value of the fan efficiency on the turbine mode intensifies the total pressure reduction due to the flow separation around the blade rows. These phenomena have a negative effect on the specific parameters of the ATFE on the ramjet mode. At the same time, the use of variable fan blades on the ramjet mode makes it possible to set the blade rows in the vane position, in which the flow around the fan blades is continuous, so it ensures the invariance of the total temperature and minimal losses of the total pressure at zero fan power (the maximum value of the total pressure recovery factor σ_F) [2].

To calculate σ_F in the fan with variable blades a development of mathematical model is needed.

For each fan blade row its geometric parameters, the value of the reduced velocity λ, the total pressure and the angle of attack i at the first blade row are known. It is necessary to assign λ_n, i_n and eventually the total pressure recovery factor of each blade row $\sigma_{BR.n}$. To determine σ_F a system consists of the following equations: balance equation of mass flow rates through blade rows and balance equations of mass flow rates through the fan and the nozzle; dependences of the flow deviation angle on the blade geometric angle and λ; dependences of σ on λ and i. So, the number of equations is equal to the number of unknowns and the system has one solution. The total pressure recovery factor σ_F is defined as the product of $\sigma_{BR.n}$.

The estimation of σ_F for the fan, both with fixed geometry of the blade rows and with variable blade rows, was carried out using this model at zero power mode. For a two-stage fan with variable blades, for the range of gas dynamic flow function $q(\lambda)_{in} = 0,4...0,6$, the total pressure recovery factor was $\sigma_F \approx 0,997...0,992$, which is significantly less than for a fan with fixed geometry of the blade rows $\sigma_F \approx 0,95...0,93$.

References:

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