Journal of Applied and Computational Science in Mechanics, Vol. 29, No. 2, 2018.

Simulation of the Secondary Combustion Chamber of Turbofan Engine in Off-design Point

S. Jafaripanah[1], F. Ommi[2*], S. Khezrpour[3]

1- Introduction

The main objective of this study is a parametric investigation of twin spool unmixed flow turbofan engines for 6-person light aircraft. Obtaining the engine performance curves and mathematical modeling of the off-design function of the engine by using the Serial Nested Loops method is studied. Despite the complexity of mathematical modeling, the performance of off-design turbofan engine is investigated and Twin Spool modeling of unmixed flow is presented. The design choices for specific fuel consumption and specific thrust are examined. The performance parameters of the turbofan engine with constant geometry contain thrust, specific fuel consumption, engine intake air, component efficiency, component pressure ratio, turbine inlet and outlet temperature. For cycles, the static or flight performance is analyzed and the performance matching of each engine component is determined.

2- Engine Modeling

To facilitate the simulation of the turbofan engine performance, the engine is numbered according to the location of the main components of the engine, Table 1.

Table 1. Marking number turbofan engine with a secondary combustion chamber

item	Number	Description
1	0	Free flow conditions
2	2	Inlet Air
3	13	Inlet Low Pressure Compressor
4	17	Inlet Fan
5	18	Outlet Fan
6	2.5	Inlet high Pressure Compressor
7	3	Inlet Combustion Chamber
8	4	Inlet high Pressure Turbine
9	4.5	Inlet Secondary Combustion Chamber
10	4.8	Inlet low Pressure Turbine
11	5	outlet low Pressure Turbine
12	7	Inlet nozzle engine core
13	8	outlet nozzle engine core

In Fig. 1, the numbering is related to the state of the engine without the secondary combustion chamber and according to Fig. 2; the secondary combustion chamber is located between the low and high pressure turbines. The air outlet from the high pressure turbine is heated up again and then enter to the low pressure turbine. This results an increase in the special output of the low pressure turbine, thus increase the specific thrust.

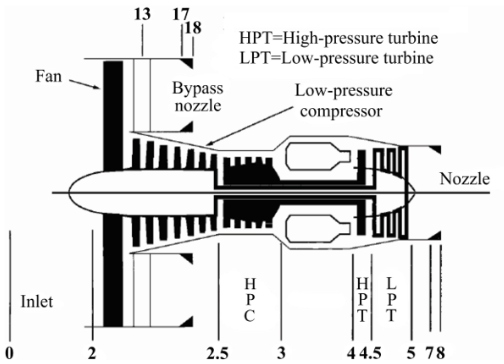

Fig. 1. Different stations turbofan engines without secondary combustion chamber.

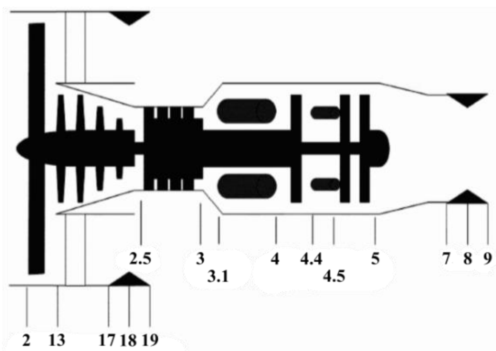

Fig. 2. Different stations turbofan engine with a secondary combustion chamber.

3- Discussion of Result

In Fig. 3, a simulated model and GSP (Gas Turbine Simulation Program) software is compared. As seen on the right side of figure, the matching error has a high error in the low period. However, as the RPM increases, the error is reduced until the error rate reaches less than 20% in over than 90% RPM. It indicates that the simulated model in the high RPM has an acceptable accuracy. At the design point, the error is minimum but as the RPM decreases or increases, the error increases which is due to the application of the scale method.

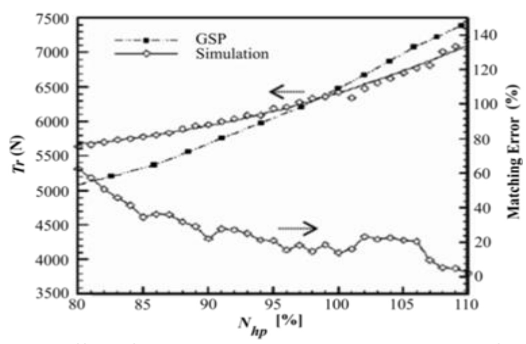

Fig. 3. The effect of Reynolds number on the distribution of time-averaged local Nusselt number.

[1]- Ph.D. student in Department of Aerospace Engineering, Tarbiat Modares University, Tehran, Iran.
[2]- Corresponding Author: Associate professor, Tarbiat Modares University, Tehran, Iran. fommi@modares.ac.ir
[3]- Master of Science in Department of Aerospace Engineering, Tarbiat Modares University, Tehran, Iran.

4- Conclusion

In this study, it is indicated that the cycles with intermediate-stage combustion chambers at higher speeds perform better than those of conventional cycles. In turbofan engine, the cycles with the secondary combustion chamber have a higher specific thrust and lower specific fuel consumption and lower pollution compared to ordinary cycles. By increasing their fan pressure ratio, the specific thrust ascends and specific fuel consumption descends. In fact, the cycles can support engines that have high bypass ratio and can increase their efficiency. Generally, the cycles with less input temperature in high pressure turbine can reduce the specific fuel consumption of the cycle. It is found that due to the unavailability of the curve of the engine's characteristics, using the scaling method is proper for estimating functional curves. In this method, constant coefficients of the design point of the engine are analyzed and the obtained curves are closer to each other and the error in simulation results is reduced.