Numerical Study of Turboprop Engine Performance at Off-design Condition


ABSTRACT

In the present study, performance simulation of a turboprop engine which equipped by Clark-Y 5068-R9 propeller is studied at off-design condition. In order to obtain the performance of the propeller, the power and thrust coefficients and also efficiency of the mentioned propeller are calculated using a FORTRAN code. At off-design condition, the object of cycle analysis is to determine estimate of engine's performance over its operating envelope. Finally, the thermodynamic cycle of a turboprop engine improved in order to thrust augmentation. The results show that in a specified altitude and at sea level to increasing flight Mach number, the compressor pressure ratio will be altered and the specific thrust will be decrease. As a result of increasing flight Mach number and in a given elevation, the specific fuel consumption (SFC) will be increase. Also, reducing the temperature of air by entry to a turboprop engine will increase the specific thrust.

Field of Research: Mechanical Engineering

Keywords: Turboprop Engine, Off-design Condition, Mach number, thrust augmentation.

INTRODUCTION

Many of today's airplanes are powered by turboprop engines. These engines are quite reliable, providing years of trouble-free service. Because of the rarity of turboprop engine malfunctions, and the limitations of simulating these malfunctions, many flight crews have felt unprepared to diagnose the engine malfunctions that have been occurred. However, the simulation of aircraft is probably one of the most complicated yet exciting fields in the engineering world today. Shu-cheng (2009) studied the preliminary design and off-design performance analysis of axial flow turbines, a pair of intermediate level-of-fidelity computer codes, TD2-2 and AXOD in case of using in turbine design and performance estimate of the modern high performance aircraft engine. He used a method which resolved only the flows in the annulus region of the turbine, while modeling the impact introduced by the presence of the turbine blade rows.

He proved that the design and the off-design codes (TD2-2 and AXOD) are fundamentally consistent and compatible to each other, and the methodologies applied are mathematically and physically sound. Also he demonstrated that these two codes can serve as a pair of companion pieces, to be used in the subsonic to transonic, axial flow turbine designs and off-design performance predictions for the modern aircraft engine. Binder, Carmoneau, and Chassaigne (2009) did some research to obtain simple information from an existing or predesigned machine, for both operational and geometric off-design conditions. He proved that the slope of the pressure ratio lines is significantly influenced by the pressure ratio and a dimension parameter for characterizing the stator. Koch (1998) used experimental data from the Langley low-turbulence pressure tunnel to design study of a propeller for a vehicle capable of subsonic flight in Earth’s stratosphere. He proved that propeller efficiency predicted by ADPAC was within 1.3 % of that calculated with the strip theory methods at the design point while ADPAC predictions of thrust, power, and torque coefficients were approximately 5% lower than the strip theory results. Ziemianski and Whitley Jr (1988) developed a program named NASA advance turboprop (ATP) in order to address the key technologies required for these new thin, sweep-blade propeller concepts. They were assembled to develop and validate applicable new design codes and also they proved by ground and flight test the validity of these new propeller concepts. Douglas (1986) developed a digital computer program called TURBOCAL which simulate the on-design, off-design and transient performance of arbitrary gas turbine configuration. This program performed also rig-test analysis of three engines. In order to obtain numerical solution of the dynamic equations for the transient performance simulations, the modified Euler method was used. The digital computer program called DYNGEN was improved by Seldner, milhalow, and bluth (1972). They used modified Euler method, which model the dynamics of the engine, to simulate the steady state and dynamic performance of a turbojet and turbofan engines. Glassman (1995) used computer codes and did some research for air-breathing propulsion system to determine the design geometry and to predict the design / off-design performance of