Research and development in aircraft gas turbines at the Gas Turbine Research Establishment

Arun Prasad

The Gas Turbine Research Establishment (GTRE) of the Defence Research Development Organization (DRDO) was started nearly three decades ago to design and develop aero engines principally for military aviation, and to establish the required test and research facilities for component and full scale engine development and to execute research and development connected with new designs.

In essence, this charter was the cornerstone of applied research and associated development in many aspects of gas turbine technology. To name a few areas. aerothermodynamics and internal flows in turbomachinery, combustion of liquid fuels and combustion chamber development including afterburners, rotor dynamics, vibration, stress analysis using finite element methods, experimental stress analysis, heat transfer in air cooled turbine blades, structural integrity and mechanical behaviour of engine components.

R&D work in the field of gas turbines demands availability of a continuous large air mass flow around 30 kgs^{-1} at reasonably high pressures (6 to 15 atm.). The air would cater for aerothermodynamic studies on engine components such as turbines, combustors, afterburners, propelling nozzles and for heat transfer studies in full size turbine blades and vanes. The compressors, on the other hand, need a large shaft power (around 8000 kW) for testing them at their design speed which is normally above 10,000 rpm. As part of its charter, GTRE settled on an unique way of providing such a facility at relatively low cost. The method was to expand the exhaust energy, obtained by running a grounded aircraft's gas turbine engine, through a free (i.e. unconnected) power turbine which provided shaft power in two modes—(i) to a plant compressor of the centrifugal type for high-pressure air supply or (ii) to the research compressor undergoing development.

The efforts on aerothermodynamic experimental investigations have to be matched with facilities that allow investigation of structural integrity and life of components before a prototype engine is tested on its test stand. Thus, specialized rigs have been established for fatigue testing of titanium compressor blades, cyclic spin testing and overspeed burst testing of titanium compressor rotor drums and super alloy turbine discs, and torsional fatigue testing of shafts.

An aircraft gas turbine engine has to deliver its rated thrust and performance at various flight conditions. Thus, the engine has to be tested in a facility that can simulate the normally aspirated engine inlet condition, as also that at high forward speeds of the aircraft at both high and low altitudes. The high Mach No. test facility (Figure 1) caters for testing of engines corresponding to a high inlet temperature and pressure as is prevalent on a hot day at high forward speeds.

In summary, the basic infrastructure for the design and development and associated research on full-scale gas turbine engine components has been established at GTRE. Over the years, technology demonstrator projects have been successfully completed. An engine development programme for the light combat aircraft (LCA) has now commenced. In the course of this work, some interesting technical concepts have been made use of. These are highlighted below.

Technical innovations

High-performance cooled turbine blade

To be able to operate effectively at the high gas temperature of 1650–1700 K, the high pressure turbine vane (stator) and turbine rotor blade are designed with internal cooling passages through which air tapped from the compressor of the engine is passed. The hottest parts of the blade are the leading edge and the trailing edge. The leading edge is cooled by impinging the cooling air passing through the blade in a metered manner to cope with the external gas temperature profile. Also, the cooling air cools the root of the blade through a multipass (serpentine) zigzag route

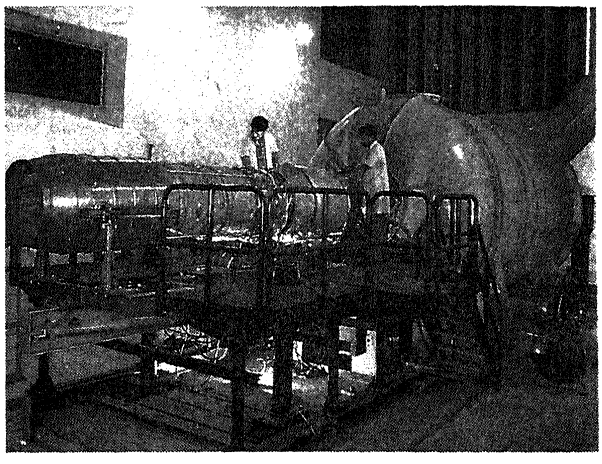

Figure 1. Simulated full scale engine test facility.