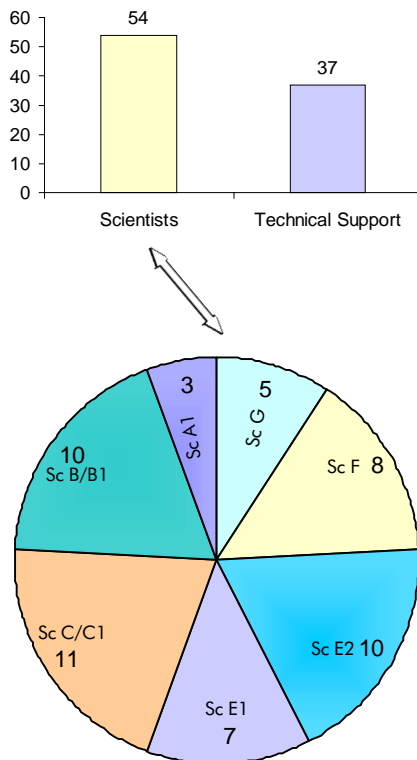


## PROPULSION DIVISION

### SUMMARY

**Dr B R Pai, Head**



The Propulsion Division is involved in applied research pertaining to turbomachinery, combustion and heat transfer, mechanical aspects of turbomachinery as well as design and development of entire propulsion and energy systems. The Division has continued giving R&D support to national institutions like GTRE, NSTL, ISRO, DRDL, HAL, BHEL besides taking up grant in aid projects from AR&DB.

The design of full scale combustion facilities for the development of advanced combustors for air breathing propulsion systems such as ramjets and scramjets, being considered by the ISRO, was an important activity in the Division. These facilities are slated to be ready by the end of 2002.

The International Symposium on Air Breathing Engines (ISABE), which was

held in Bangalore in September 2001 after 21 years, gave considerable global exposure to the activities of the Division. A number of agencies have shown interest in taking up collaborative and sponsored research in the Division and specific projects are under discussion.

International collaborative projects with the University of Cambridge, U.K., University of Aachen, Germany and the Carnegie Mellon University, USA have provided an exciting atmosphere and useful inputs to the Division.

### TURBOMACHINERY

Collaboration with the University of Cambridge has provided a good basis for taking up advanced computational problems in CFD of turbomachinery. Flow computation for entire multistage machines: three

### NAL-UNI Lecture Series on Rotor Dynamics and Vibrations

As a part of NAL-UNI Lecture Series, a course on *Rotor Dynamics and Vibrations* was held during 12 -14 December 2001, to benefit the participants from academic and R&D institutions with a view to propagate the importance of rotor dynamics and vibration reduction in rotating machinery. The course provided a comprehensive look at rotor dynamics in particular and vibration related topics in general. Several specific areas of rotor dynamics which were considered important from the point of view of practical applications, with special emphasis on gas turbines were addressed in this course. The 3-day course also featured lectures on related topics, case studies and visit to relevant facilities at NAL.

The course faculty included experts with wide experience in the areas of rotor dynamics and vibrations from NAL, GTRE and IIT Madras. 30 participants from academic as well as R&D organisations attended the course.

## XV International Symposium on Air Breathing Engines

The XVth International Symposium on Air Breathing Engines was organized in Bangalore during 2-7 September 2001. This Symposium is organized once in two years in various parts of the world with a view to bring together researchers in the area of air breathing engines and aerospace propulsion. It was last organized in India in the year 1981. India therefore played host to this Symposium for the second time after a gap of exactly two decades. The Symposium, in which NAL played a prominent role both in the organisation and the participation, attracted 10 special invited lectures and 222 contributed papers in 45 sessions. The highlights included special invited lectures by the Scientific Adviser to Raksha Mantri and Chairman, ISRO, respectively on the Indian Aeronautical Programme and the Indian Space Programme. There were 34 other contributions from India. Sessions included those on components, design, technology development, structural materials, vibration and aeromechanics of aerospace engines. Hypersonic propulsion, AJAX technologies and pulse detonation engines, being frontline areas of research, were an added attraction of the Symposium. 37 scientists from Propulsion Division, Experimental Aerodynamics Division, Computational and Theoretical Fluid Dynamics Division and Materials Science Division participated in

the Symposium. There were five papers presented by NAL scientists.

All the major aero-engine manufacturing companies participated in the Symposium and presented their perspective view of the industrial scenario that is envisaged and the research potential. There were presentations by General Electric, Rolls Royce, Pratt & Whitney, Snecma, MTU as well as NASA. 220 Indian delegates and 224 foreign delegates attended the Symposium.

There were visits to R&D establishments of GTRE, HAL, IISc and NAL arranged for the benefit of the delegates. More than 50 participants, all from institutions abroad, chose to visit NAL. From the keenness shown by the visitors, it is hoped that there is appreciation of work that is being carried on here and the prospect of collaborative work in the future.

On this occasion, the propulsion community chose to honour five distinguished professionals who contributed richly to technology development in India. These included Dr P A Paranjpe who headed NAL's Propulsion Division from December 1967 to July 1987.

stage and six stage transonic compressors has become feasible and the validation of such computations with in-house and other experimental data would give a strong base to the divisional activities. New areas such as investigation of tip-clearance flows are being envisaged.

Stall detection and control continue to be an important area of research. The use of strategically placed air jets provide yet another means of improving the stall margin and could now be considered for practical application.

### *COMBUSTION AND HEAT TRANSFER*

Studies on combustor development for high-speed vehicles such as ramjet and scramjet have been making good progress. The concept of thermal throttling to achieve supersonic combustion in a parallel-divergent duct has been convincingly demon-

strated using a series of smart cavities through which fuel is injected. This paves the way for the development of a dual mode combustor for such combustors.

### *MECHANICAL ASPECTS OF TURBOMACHINERY*

Two interesting studies have been carried out which would be useful to the aeronautical industry. One is the characterisation of several indigenously available high temperature elastomeric materials from the point of view of vibration damping properties. This database would give useful inputs for design of dampers for gas turbine and other applications. The other study relates to the design and fabrication of light weight and strong carbon fibre reinforced tubes for potential application to the tail rotor drive shaft of advanced helicopters. The experimental tubes developed have shown very good strength and

stiffness and weight saving over metallic tubes, and merit further investigations for specific application.

### *PROPULSION AND ENERGY SYSTEMS*

The design and development of a lightweight helicopter with weight shift control has progressed with the fabrication and setting up of a ground test rig. Most of the rotor components have been fabricated in-house and the rig tests are expected to validate the rotor design.

A unique power plant system, using methylene chloride as a working fluid, has been designed and fabricated for coupling to a solar pond for power generation using solar energy. The plant has been initially set up in the laboratory and successfully tested using an alternative heat source. It has since been dismantled, transported and re-erected at the solar

pond site at Pondicherry where it will be extensively tested.

As part of a consortium project, a

study was carried out on adoption of gas turbine technologies for power plants based on biomass fuels for decentralised power

generation in rural India. Based on these studies a demonstration plant would be considered in the next phase.