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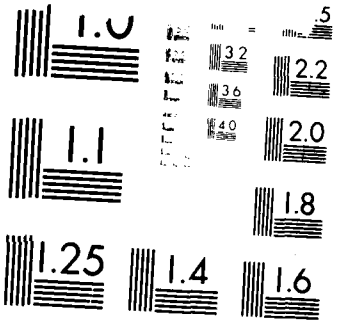
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FOREIGN TECHNOLOGY DIVISION

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An Introduction of the Power Engineering Research at Nanjing Aeronautical Institute

Department of Aeronautical Power Engineering
Nanjing Aeronautical Institute

INTRODUCTION

In order to improve the performance of aircraft, it is required that the power plant have good technical specifications such as high ratio of trust to weight, high efficiency, long service life, etc. Therefore new progress should be made in the research of power plant; that is, on the one hand, paying attention to improving the quality of parts and components and to improving the match between them; on the other hand, solving the technical problems of the systematic control of the power systems. In order to achieve these goals, the scope of research should delve further enlarged, and the content of research should be deepened into the fields of interdisciplinary science and technology.

Recently, the Department of Aeronautical Power Engineering, of Nanjing Aeronautical Institute, has carried out a series of theoretical and experimental studies in the above fields, especially in the fields of flow air inlet, stability of combustion, analysis of flow field, cooling technology of high temperature turbine blades, strength and

vibration of structure, system control, micro-computer technology, etc. New progress and results at certain levels were already obtained.

STUDIES OF AIR INLET

In order to obtain the required status of the flow field of the intake air under different working conditions, it is necessary to make systematic studies on the flow and the flow field in the air inlet channels. A research laboratory of air inlet channels was built in the 70s. In the past ten years, research work was carried out for improving the quality of the flow field in air inlet channels. First we carried out the experimental studies of stability of the flow field in the air inlet channels by using the simulating boards. This offered an effective simulation method for the matching of aircraft and power train. Afterwards, we carried out the study of the control of the attached surface layer by using vortex generators (blade- and air- vortex-type). It offered a useful design method for improving the quality of the flow field of the air inlet channels. We also carried out systematic studies of the mechanism of the unstable flow by the interactions between the shock waves and the attached surface layer. The British Royal Aeronautical Research

Institute (RAE) has made a special report about our results in this field. Recently, we are studying the mechanism of turbulent flow generator and its applications. Furthermore, In the field of subsonic pressure expanders we have studied the properties of the flow field of different surface types. This offered a reliable data base for the design of pressure expander. In the fields of calculation and experimental study of viscous compressible turbulence accompanied by a vortex flow field, we also have made progress, and this was paid attention to by foreign colleagues. British R. R. Company has used some of our data as references in evaluating the performance of their air inlet channels. Figure 1 shows the equipment of the experimental studies.

Fig. 1. The equipment for the experiment of viscous compressible all-turbulent flow accompanied by a vortex flow field

THE STUDIES OF THE FLOW IN TURBINE MACHINES

In order to obtain the optimum relation between the efficiency of an air compressor and its geometric parameters and weight, we carried out the study of the "series blades". Progress was made on choosing the geometrical parameters of the series blades and their relations with the characteristic parameters of the flow field. This offered some useful data and information for the design of serial blades. We made the calculation of the parameters of a three-dimensional flow field in the channel of a viscous large turning angle blade rotor. We have suggested that the method of solving the flow equations on the boundary of the curved surface can be applied to the calculation of the three-dimensional flow field. In the field of non-steady state flow, we studied the mechanism of the axial propagation of deformation and the influence of the geometrical parameters on the deformation. We also have analysed the possibility of applying the judgement criteria of the pulsed vibration and speed loss of the air compressor to real problems. This accelerated study of the performance of the whole compressor and its matching with the whole system. Figure 2 shows the test equipment for the performance of the whole compressor.

Fig. 2. The test equipment for the performance of the whole compressor

THE STUDIES OF STABILITY AND FLOW OF COMBUSTION

In order to obtain an accurate and reliable ignition of the combustion chamber and to obtain a stable, high efficient working performance, we have carried out systematic studies in the igniting technique, the stability of a combustion chamber, and the flow field in the returning flow zone. The results of catalytic ignition and an evaporation type stabilizer have reached the same level in foreign countries. In the field of the stability of combustion, we have carried out the performance study of a pre-combustion type stabilizer. This type stabilizer has shown its potential of decreasing the fuel consumption and improving

the stability in the testing of a model engine; and recently it also succeeded in a flying test. In the field of the calculation of the cold-state and hot-state flow field of the returning flow zone, we have developed the calculation method of the flow field in the rear returning flow zones of different type flame stabilizers in a cold state, and the calculation method of the flow field in the returning flow zone of a flame stabilizer in a hot state, by using a simple combustion model. We also obtained the method of calculating the expansion angle of a blunt flame. We have solved the calculation of the products of reaction and thermodynamical parameters at the chemical balance of hydrocarbon fuel, and some useful data have been obtained. Figure 3 shows the equipment for the model performance testing of different stabilizers.

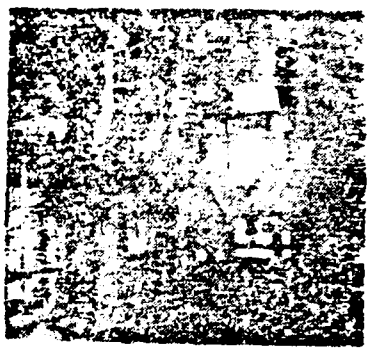

Fig. 3. The testing equipment for different models of stabilizers

THE STUDIES OF THE COOLING TECHNIQUES OF HIGH TEMPERATURE TURBINE BLADES

Since the middle of the 70s, we have carried out a series of studies of the cooling techniques of high temperature turbine blades. For example, good results have been obtained in the basic studies of the shock cooling of simulating turbine blades, the shock cooling of multi-column jet-holes, the heat transfer properties of shock cooling at limited zones, with the circle jet-flow jetted along the inside concave surface of the semi-cylinder, with or without air films, and shock and air film combined cooling. Some results were already used in the design of new type power engines. In the 7th International Heat Transfer Conference (7th IHTC), we published a paper with a title of "An Experimental Study of the Characteristics of Heat Transfer of Single- and Three-Column Jet-Flow in the Concave Surface of Semi-Cylinders." This paper was paid attention to by the attendants. Recently we are preparing to pursue a systematic study of some new cooling methods.

THE STUDIES OF STRUCTURE STRENGTH AND VIBRATION

In order to determine the fatigue lifetime of blades under real loading, we have automatized the fatigue testing

under conditions of constant amplitude and constant frequency, using the YZD-2 type automatic controller made by ourselves. This has improved the accuracy of the experimental result and reduced the working burden of the testing personnel. Now we are preparing the computer software, according to the real loading spectrum under flying conditions, to control the fatigue testing of blades. In this way we can obtain the (P-S-N) characteristic curves and fatigue lifetime. We have also carried out the studies of determining the (P-S-N) curves and fatigue lifetime of real blades by testing the simulation blades. We also made some progress in the fast evaluation of the blades' lifetime and the residual lifetime of old blades by using the accelerated fatigue theory.

Because force distribution of an aircraft box is very complicated, there are difficulties in the structural design. In order to solve this problem we have carried out the studies of the strength and rigidity of an aircraft box under complicated loading situations. We determined the distribution of stress in the aircraft box under loading both theoretically and experimentally. We have also studied the temperature field and stress field of an aircraft box, and the high temperature slipping and low circulation fatigue lifetime of a rectangular plate with holes, under pulsed single direction pulling. The results obtained are good.

In order to solve the matching problem of the parameters of the rotor and its wheel base, we used the impedance analytical method of sub-system to study the parameter matching between rotor and the elastic supporting base. We have suggested a method of "propagating matrix-impedance coupling" to analyze the dynamic characteristics of the rotor system, and built the relation between the critical speed of rotation of the rotor sub-system and the impedance of the supporting base.

In modern power engines, the vibration characteristics of blades depend on the rigidity and damping coefficient of the wheel. Therefore we should pay attention to the study of the coupled vibration of the blades and wheel. We have developed a set of calculation methods and programs for the intrinsic characteristics of real blades and wheels by using the advanced limited element analysis technique. We developed principles of simulating test and method of measurement, by using the methods of multi-point vibrating activation and hammer impact, to measure the vibration characteristics of the blades and wheel complex. We have carried out testing and measurement for the blade-wheel complex of an air compressor and good results were obtained. We have basically obtained rules of blade-wheel coupled vibration through the analysis of the typical model components. This offered a data base for further decreasing

the vibration level and removing deficiencies. Figure 4 shows the testing equipment of the blade-wheel coupled vibration.

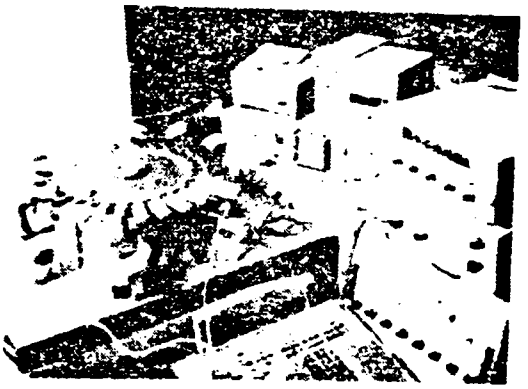

Fig. 4. The testing equipment for the blade-wheel coupled vibration.

THE STUDIES OF CONTROL TECHNOLOGY OF POWER APPARATUS

The performance of aeronautical power apparatus is closely related to the performance of the control system; and the control system has a close relationship with the applications of control theory, determination of control pattern, the choice of control method, and the performance of the control devices. It is necessary to combine the modern theory of control, electronics, computer technology, and hydraulic and pneumatic transmission in the control

systems. In this way we can improve the performance of the control system. In recent years we carried out studies of applying the optimum control theory to the control of aircraft power apparatus. Based on the building of the mathematical model of the device under control, we have obtained the program package for solving the optimum control problems of definite- and random-types under different performance standards. Thus we can obtain fast control of the digital computer-step motor system. We have obtained the time optimization, $u^*(t)$ control, and connected the step-motor system and the connecter to the semi-physical simulation platform to perform the simulation experiment. A batch of experimental data has been obtained.

For the worm-type power engines of helicopters, we studied the mathematical models of power transmission system of single-, double-, and triple-engine parallel systems. The results have already been applied in the performance calculation of some types of helicopters. In order to study the mechanism and design method of the flow field of the air-core pump, we have carried out some experimental studies and theoretical calculation on the home-made air-core pump testing platform. Some useful results were obtained and this will help future research and design work.

THE EXPANSION OF THE RESEARCH SCOPE

In order to fully use the resources of science and technology to aid in the development of the national economy, in recent years we began many new research projects in the fields of commercial wind turbines, commercial pumps, synthesized utilization of thermal energy, energy conservation, the measure and automatization of thermal dynamics, heavy oil and coal combustion, microcomputer applications in production and experiments, etc. In some of these projects initial results have already been obtained.

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