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16. Abstract

Tests carried out in November 1981 on the stationary flap of STOL test planes at Kakuda Labs are described. Acoustic pressure, outer plate temperature of the fore flap, and acceleration, strain, and temperature of the outer plate of the main flap were measured. High load turbine inlet distortion experiments were also performed. Results of these experiments are discussed.

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Inaugural Address

I have recently been informed of my appointment as the successor to Mr. Kawasaki as the head of the National Aerospace Lab. I /1* would like to take this opportunity to give my inaugural address.

I am of the opinion that there will be rapid developments in the field of aerospace engineering in the future and that the leading countries of the world will put a great deal of effort into aerospace research and development. There are high expectations with regard to the field of aerospace engineering in Japan, which is following a path of state establishment based on technology. The National Aerospace Lab, which is the main aerospace research agency in Japan, will play a large role in this development. The head of the National Aerospace Lab will answer to these national and world-wide demands for development with progress in research and planning and construction of necessary facilities. In accordance with the recent extension of Japanese power, our country is working in cooperation with other countries from the aspects of development and practical usage in aerospace technology. Consequently, even more effort in the development of aerospace technology is anticipated. In answer to these national demands, and in order to support world-wide aerospace technology development, it will be necessary to put more effort into execution of research and experiments and construction of new facilities.

Test production of fan jet STOL is now being carried out as part of fan jet STOL research and development, which is the main project of the National Aerospace Lab at this time. Flight tests will probably begin in 1984. Many countries are now emphasizing STOL technology, with importance placed on jets, as the most important transport plane technology for the future. Therefore, the role that this lab will play in completion of the machine itself and flight tests will become even greater. FJR

*Numbers in margin indicate foreign pagination.

engine research and development, which has been carried out in cooperation with the Agency of Industrial Science and Technology, was recently completed. This may result in even more Japanese influence in development of STOL test plane engines and in international joint development. This lab has planned wind tunnel tests for aerodynamic tests in XY development, in which Japan is participating. However, more effort must be put into design simulations, economization of structure, reliability improvement, electronic control technology, as well as wind tunnel tests, for the recently anticipated YXX development, etc. The main research in this phase of space technology involves liquid oxygen and liquid hydrogen engines, upper motors, guided control systems, etc. for the H-1 rocket. Moreover, it seems that research in cooperation with space development /2 companies and strengthening of basic technology for satellite and space use in the future are necessary. While this research is in its final stages of practical use, basic and advanced studies will be necessary in the future and therefore, this lab will play a leading role in these studies. Moreover, it is necessary that solutions for problems such as deterioration of facilities, etc. be found quickly in order to carry out studies and operation tests, which is one of the main duties of this lab.

It has been almost 30 years since the National Aerospace Lab was established and it is now time to re-analyze the structure, personnel, plans, operations, etc. of this organization. The previous head, Mr. Kawasaki, realized this. However, more effort will need to be exerted toward making this even more effective as a national research agency. In order to achieve this goal, effort and cooperation of personnel and guidance and aid from other related organizations will be necessary.

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As head of the National Aerospace Lab, I would like to extend my thanks for this increasing effort and cooperation.

National Aerospace Lab Head
Takashi Takeda

Fan Jet STOL Plane Research
Acoustic Pressure, Acceleration, Strain, and Temperature Measurements of the Main Wing USB Flap

Tests were carried out in November, 1981 on the stationary flap of STOL test planes at Kakuda Labs (refer to Kogiken Nyusu No. 274, 1982/2). Adequacy of various set conditions was tested during the planning of the main wing USB flap.

Acoustic pressure above the wing surface, outer plate temperature of the fore flap, and acceleration, strain, and temperature of the outer plate of the main flap were measured at the locations /3 shown in Figure 1 during tests on the main wing USB flap construction. These measurements were taken with two vortex generators (V(standard) and V(small)) having different locations and shapes and without a vortex generator (V(none)).

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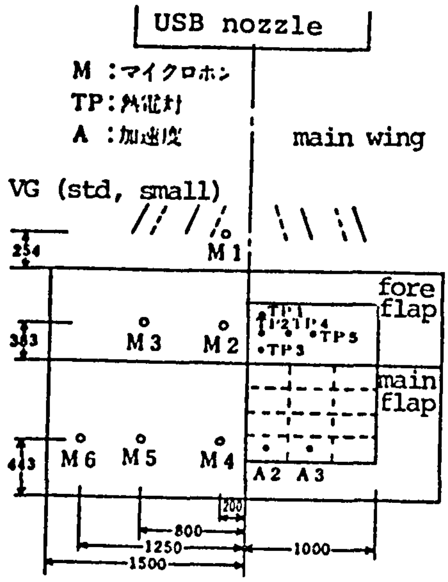

Figure 1 Sensor Locations

M: microphone TP: thermocouple A: acceleration

The correlation T/Tmax between parameters that express the total acoustic pressure and engine thrust is shown in Figure 2. When there is an increase in thrust, the M1 of VG(small) exceeds design conditions. This power spectrum density with T/Tmax=0.96 is shown in Figure 3. At 200-1000 Hz the measured values are larger than design conditions. This is due to the aforementioned reasons. Changes in acoustic pressure of VG(none) and VG(standard) by flap angle are shown in Figure 4. As is made clear from the figure, when a VG is used, the total acoustic pressure increases 4-5 db. Moreover, when the flap angle moves from 40° to 60° , the acoustic pressure with VG(none) rapidly decreases in comparison to VG (standard). However, this seems to be due to the reflected flow. In other words, the effects of VG(standard) are significant.

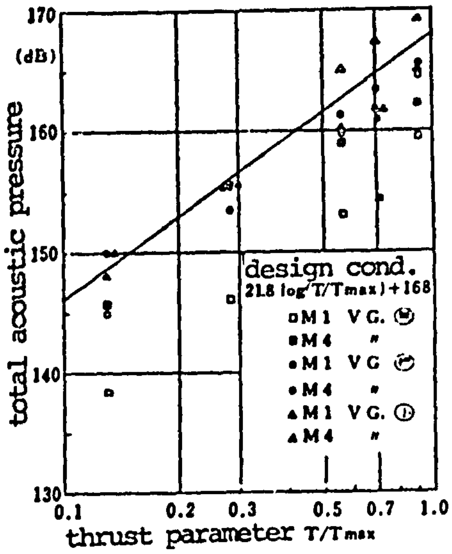

Figure 2 Correlation between Acoustic Pressure and Thrust

□ M1 V.G.(none) ○ M1 V.G.(standard)

Δ M1 V.G. (small)

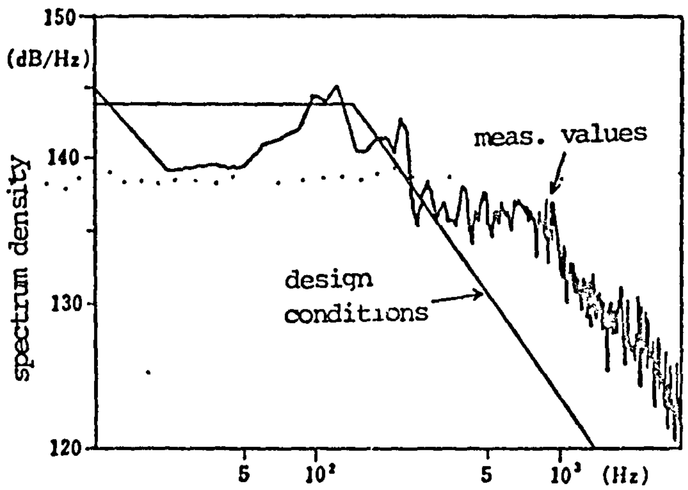

Figure 3 M1 Spectrum Density with VG(small) (T/Tmax=0.96)

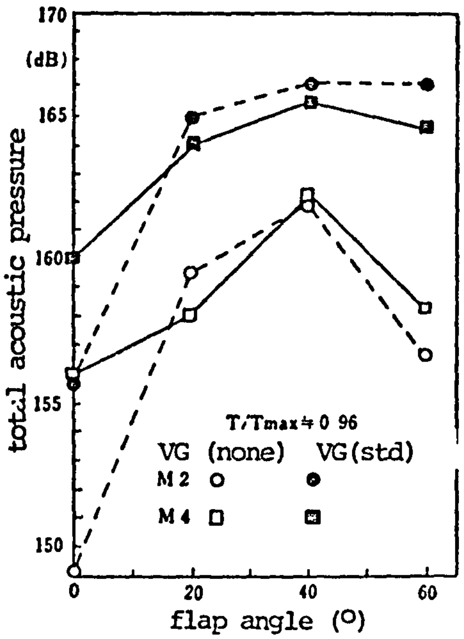

Figure 4 Correlation between Total Acoustic Pressure and Flap Angle

The total acoustic pressure in this test was 6-10 db higher in comparison to noise fatigue tests on the USB flap (refer to <u>Kogiken Nyusu</u> No. 262, 1981/2). Therefore, the acceleration and strain measurements were also 2-3 times those in the noise fatigue tests. The linear correlation between total acoustic pressure and acceleration and strain does not seem to be due to the unique phenomenon whereby the equilibrium point of thermal deformation fluctuates during flight because the temperature above the main flap can be reduced.

The temperature distribution in a chordwise direction and spanwise direction above the fore flap is shown in Figure 5. A maximum temperature of 70 °C was obtained with a VG(standard) at a flap angle of 60° . The temperature distribution above the main flap shows the same tendency as in this figure. The maximum temperature of VG(none), VG(standard), and VG(small) is, respectively, 45 °C, 100 °C, and 125 °C, which are lower than the maximum temperature of design conditions, 200 ° C.

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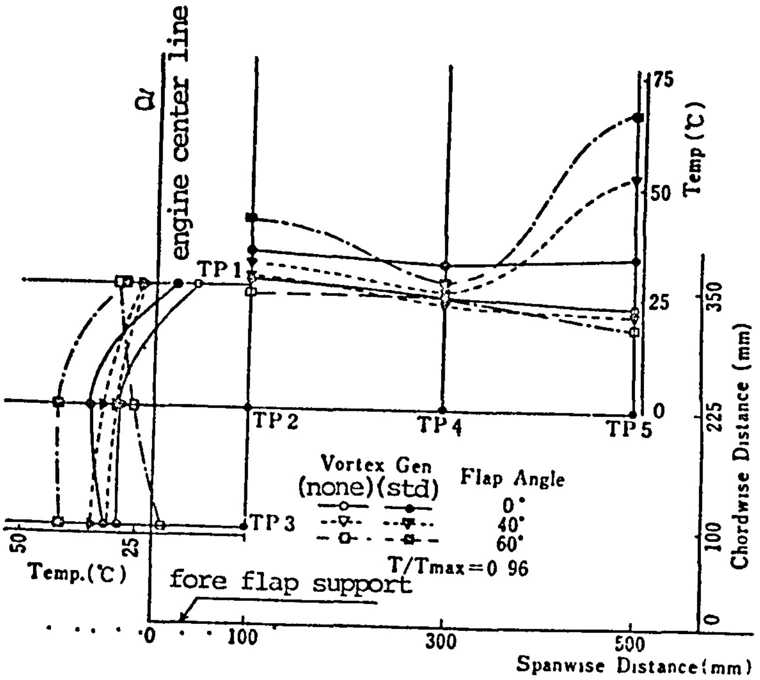

Figure 5 Fore Flap Temperature Distribution

According to these tests, although attention must be paid to noise fatigue of VG outer plates, the current design conditions seem to be suitable.

(STOL Project Department, Testing Development Lab, Structural Technology Development Team)

Research Plan for Trial Production of Cryogenic Wind Tunnel

Trial production of cryogenic wind tunnels as advanced /4 technology will be carried out in order to obtain basic information on three- dimensional wind tunnels with a high Reynolds number in the future. The background, details and future plans for these wind tunnels will be explained.

Cryogenic wind tunnels are wind tunnels on which tests are carried out at the stagnation temperature of 90 K. Vaporized liquid nitrogen is used as the gas. It is a known fact that the difference in gaseous dynamic properties, such as the specific heat ratio, etc., of low temperature nitrogen gas and normal temperature air has little effect. Moreover, low temperature nitrogen gas is used as the test gas and therefore, there are few problems.

There are several distinguishing features of cryogenic wind tunnels. For instance, cryogenic wind tunnels are characterized by the fact that the driving power is small and the Reynolds number is high. The fact that there are no changes in dynamic pressure, the driving power is proportional to the square root of the absolute temperature, and the Reynolds number is inversely proportional to the temperature raised to the 1.4 power can be mentioned as the effects of temperature with a fixed Mach number and fixed stagnation pressure with special wind tunnels. Consequently, when the same Reynolds number is obtained and the temperature is reduced, there is a remarkable decrease in dynamic pressure.

The necessity of tests with high Reynolds numbers has been displayed. However, normal temperature tests will probably be difficult from the point of model strength due to an increase in driving energy and aerodynamic load. It seems that the problem of driving energy may be solved with the use of intermittent wind tunnels. However, because only about 1/5 the necessary data is produced in this case, intermittent wind tunnels are not really appropriate when we consider the increase in the amount of time needed to test aircraft that have been recently developed. Both intermittent and continuous flow cryogenic wind tunnels are useful. However, attention must be given to techniques that will solve the many problems of driving energy aerodynamic load, data productivity, etc.

Operation of the 2.5 m x 2.5 m cryogenic transonic wind tunnel (National Transonic Facility) in the U.S. is forecast for this year. Several European countries have designed a 1.95 m x 1.65 m cryogenic transonic wind tunnel (European Transonic Wind Tunnel). Research and studies on test technology using small cryogenic wind tunnels have been carried out by the U.S., France, England, Germany, etc. in order to develop these large wind tunnels. An 0.1 m x 0.1 m cryogenic low speed wind tunnel is now being operated at Tsukuba University in Japan and an 0.5 m x 0.5 m cryogenic low speed wind tunnel is being constructed.

The cryogenic wind tunnel trial produced in Japan is the continuous circular stream wind tunnel shown in Figure 1. Transonic tests can be carried out in this wind tunnel. Trial production plans were divided into 3 stages because of budget problems and technological development. The first stage is the current stage and only normal temperature low speed operations are possible. The 2nd stage involves installing the liquid nitrogen supply and cooling systems and makes cryogenic low speed operations possible. In the final stage transonic tests will be carried out using the power of electric motors. Therefore, the fan should be able to produce the necessary pressure ratio of 1.14 (at -173 C) in transonic tests. The following conditions will be established when this final stage is completed.

test section: 0.1 m x 0.1 m
stagnation temperature: more than 90 K
pressure: 200 KPa
Mach number: 0 ~ 1.0

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An outside insulating system is used in this type of small wind tunnel because it is diffuclt to use an internal insulating system where insulating materials are placed inside the wind tunnel (the wind tunnel may be made with iron and steel materials for use at normal temperatures; NTF employed). The wind tunnel has a welded composition with aluminum alloy A5052 that can be used at low temperatures as the main substance.

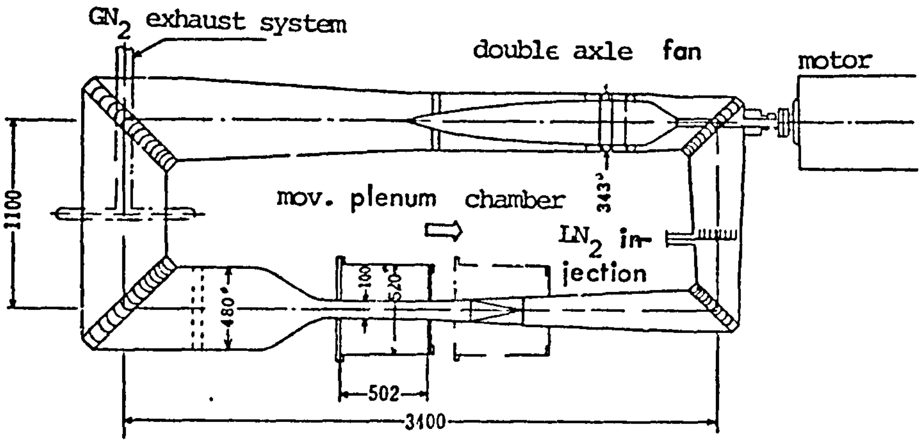

Figure 1 Cryogenic Wind Tunnel Being Trial Manufactured

The purpose of this wind tunnel is to understand the problems of cryogenic operations, and once these have been determined, to cut down on rectifying screens, model support devices, etc. necessary for flow disruption, model testing, etc.
Moreover, as there are no essential cooling devices in circular flow wind tunnels, LN_2 is continuously introduced to the wind tunnel during air flow using the vaporization latent heat of the liquid nitrogen and nitrogen gas inside the tunnel is continuously emitted outside the tunnel in order to maintain a constant internal pressure. The nitrogen gas that has been emitted is not recovered.

A window is set up near the test section and LN_2 inlet in order to observe drops of LN_2. Frosting of windows, etc. often makes the windows nontransparent and therefore, steps should be taken to avoid these effects.

Many items should be tested with cryogenic wind tunnels. In addition to the pros and cons of testing in a cryogenic atmosphere, condensation of the gas, driving power, LN_2 introduction, pressure and temperature control, insulation, operation, measurements, safety maintenance, etc. should be analyzed. The most important points with this wind tunnel are the establishment of operation techniques and simultaneous safety maintenance. In addition to respiratory difficulties due to nitrogen exhaust, there is also the problem of fire prevention. This risk of fire damage may be due to the fact that at low temperature the small layer of air between the insulating materials (petroleum product) and the outer walls of the wind tunnel becomes highly concentrated with oxygen.

Special knowledge and experience in various fields will be necessary to solve the problems related to test production of wind tunnels. Therefore, it seems that there will have to be cooperation among these various fields of science in the future.

(Aerodynamic 2nd Division, Ichimei Takashima)

High Load Turbine Inlet Distortion Experiments

The Motor Division of this lab has been carrying out "Research and Development of Jet Engines for Aircraft" with the Large Industrial and Technological Research and Development System (alias "Dai Buro") of the Ministry of International Trade and Industry Agency of Industrial Science and Technology. Various tests have been carried out to study the improvement of turbire properties [1] , as part of the Essential Research Team's "Research Pertaining to Inlet Distortion, etc.." Tests were carried out on turbine inlet gas conditions during irregular situations as the final tests. In general, turbine aerodynamic property tests are often carried out with uniform inlet gas flow. However, these tests were carried out in order to elucidate the effects of irregularity of the outlet pressure and speed distribution of the engine combustion apparatus on turbine properties and to obtain data that will improve these properties. That is,

(1) when the flow turns at the cascade, an irregular speed distribution

is produced at the cascade inlet (generally from the boundary layer and cascade back flow, etc.) and therefore, a two-dimensional flow having a speed component perpendicular to the main flow is produced. A control vortex system has been designed to control the loss of two-dimensional flow as much as possible. However, a system for cases when the inlet flow is very irregular has not been developed. Moreover, 2) a flow boundary line method is now being used, but this method does not take into consideration the interference and mixing that occur at this flow boundary line. Consequently, it is necessary to study the adequency of design methods, property assessment methods, etc. and then to improve these conventional systems.

A cross section of the aerodynamic testing device is shown in Figure 1. Two types of irregular distributions in a radial direction, turbine (IGV) inlet pressure and speed, are made with the net (Photograph 1, case A or B), which is set up at the upward flow of the inlet guiding vane (IGV). In case A pressure and speed loss occur around the outside of the vane and in case B pressure and speed loss occur around the inside of the vane. An example of the total pressure distribution of the IGV inlet, which was obtained from these results, is shown in Figure 2. In both cases the IGV inlet distortion standard value ($ID=(P_{t,max}-P_{t,min})/\bar{P}_t$) is about 4%.

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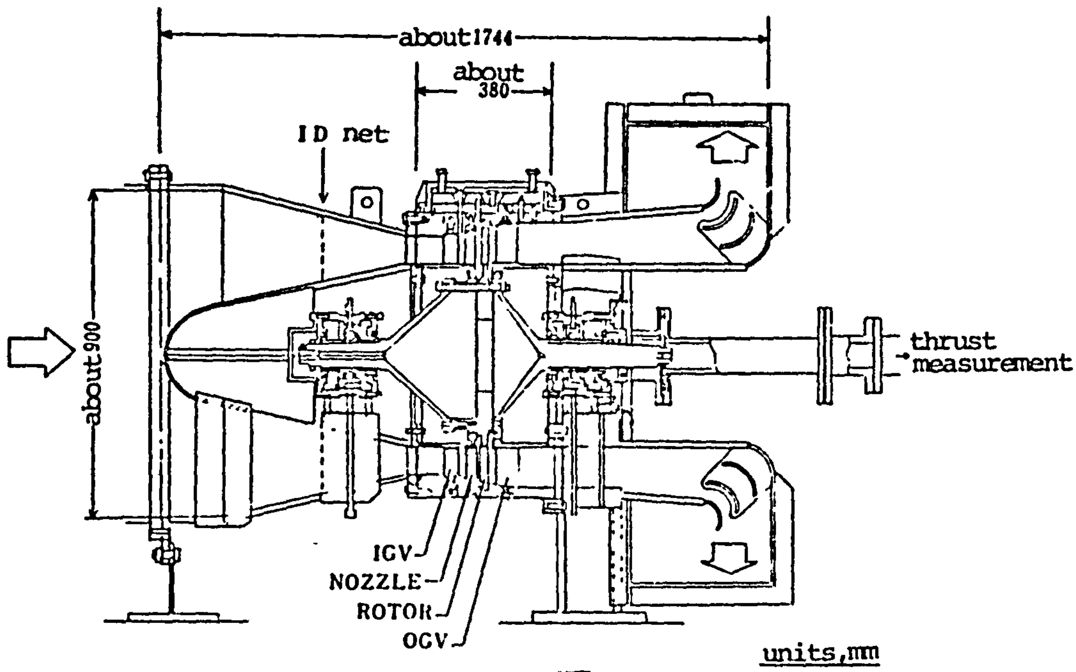

Figure 1 High Load Turbine Aerodynamic Test Outline

Photograph 1 Inlet Distortion Production Net (infront of the top half)

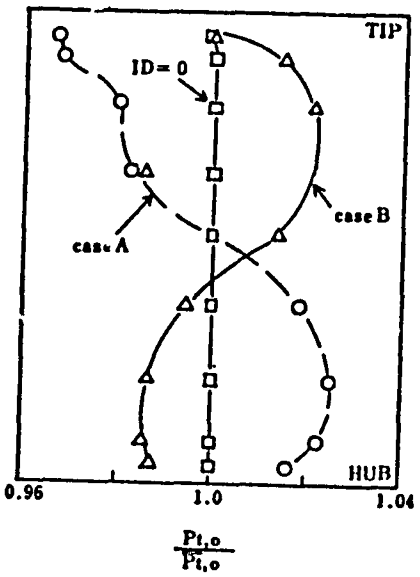

Figure 2 Inlet Total Pressure Distribution
(A,0-3=1.36)

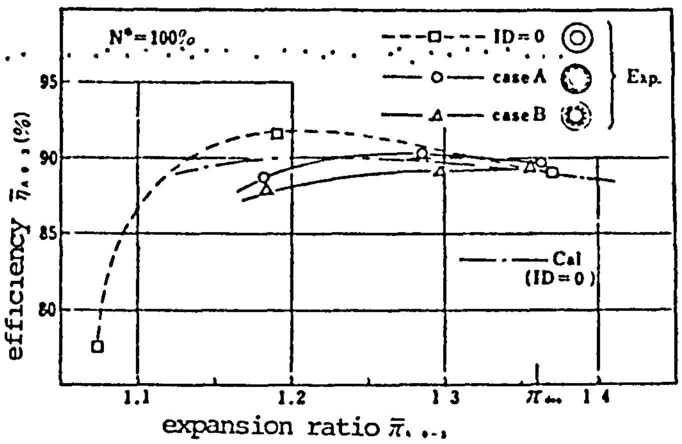

Figure 3 Turbine Efficiency Properties

Figure 3 shows a comparison of the efficiency properties of the turbine with a set r.p.m. and the case where the inlet flow is regular (ID=0). According to this figure, there is a decrease of 0-3% in efficiency (ID~4) with these tests. This reduction is not near the design point and is as high as the partial load. Moreover, the fact that this tendency is great when there is a loss of internal pressure and speed (case B) is very significant. Uniform property improvement will be carried out in the future by closer analysis of these results.

1 Kogiken Nyusu, 1979, No. 3, No. 238

(Motor Division, Heat Transmission Research Lab, Turbine Research Lab, Aerodynamic Lab)

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