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RESEARCH MEMORANDUM

for the

Air Materiel Command, U.S. Air Force

PERFORMANCE OF J33-A-27 TURBOJET-ENGINE COMPRESSOR

I - OVER-ALL PERFORMANCE CHARACTERISTICS AT EQUIVALENT IMPELLER SPEEDS FROM 6100 TO 11,800 RPM

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

The J33-A-27 compressor was operated at an inlet pressure of 14 inches of mercury absolute and ambient inlet temperature over a range of equivalent impeller speeds from 6100 to 11,800 rpm.

At the design equivalent speed of 11,800 rpm, the J33-A-27 compressor had a peak pressure ratio of 4.40 at an equivalent weight flow of 105.7 pounds per second and a peak adiabatic temperature-rise efficiency of 0.745. The maximum equivalent weight flow at design speed was 113.5 pounds per second.

INTRODUCTION

At the request of the Air Materiel Command, U. S. Air Force, an investigation is being conducted at the NACA Lewis laboratory to determine the performance characteristics of a series of J33 turbojet-engine compressors. The over-all performance of a J33-A-27 compressor is presented. This compressor consists of a double-inlet centrifugal impeller in combination with a 14-vane diffuser. Runs were made over a range of equivalent impeller speeds from 6100 to 11,800 rpm with an inlet pressure of 14 inches of mercury absolute and ambient inlet temperature. Because alterations had been made to the inlet-ducting system and a larger plate orifice was required to cover the flow range of the J33-A-27 compressor, additional runs were made at an equivalent impeller speed of 8000 rpm to determine the effect of the new inlet ducting configurations on the accuracy of weight-flow measurements and to check the value of the flow coefficient for a larger plate orifice.

APPARATUS AND INSTRUMENTATION

The J33-A-27 compressor embodies some substantial changes from the earlier model J33 compressor designs (references 1 to 3). The inlet guide vanes were redesigned to improve air-flow distribution at the impeller inlet. The impeller assembly has been redesigned to include a deep inducer with parabolic blade curvature and a larger impeller-inlet tip diameter. The diffuser has been made in two parts so that all wetted surfaces can be fully machined to close tolerances. The number of impeller blades per side is 23 and the over-all diameter of the compressor is 48 inches, which is the same as the previous J33 compressors investigated.

Two alternative inlet systems (reference 4) were used. The system containing the submerged, flat-plate orifice was slightly altered to decrease the inlet-ducting pressure losses.

The remainder of the apparatus used for the J33-A-27 compressor investigation is the same as that described in reference 1.

The instrumentation is described in reference 1 with the exception that two submerged, flat-plate orifices were also used to measure the compressor weight flow.

SYMBOLS

The following symbols are used in this report:

N	impeller speed, rpm
P_1	inlet total pressure, inches mercury absolute
P_2	outlet total pressure, inches mercury absolute
Q	volume flow, cubic feet per second
T_1	inlet total temperature, $^{\circ}R$
W	weight flow, pounds per second
δ	ratio of inlet total pressure to NACA standard sea-level pressure
η_{ad}	adiabatic temperature-rise efficiency
θ	ratio of inlet total temperature to NACA standard sea-level temperature

PROCEDURE

Runs were made over a range of equivalent impeller speeds from 6100 to 11,800 rpm at an inlet pressure of 14 inches of mercury absolute. Additional runs were made at an equivalent impeller speed of 8000 rpm to determine the effect of the new inlet-ducting configurations on the accuracy of weight-flow measurements and to check the value of the flow coefficient for a larger plate orifice. All runs were made at ambient inlet temperature, which varied from 65° to 82° F.

Computations of adiabatic temperature-rise efficiency η_{ad} for the compressor were made in accordance with reference 5. The equivalent-weight-flow parameter $W\sqrt{\theta}/\delta$ and the equivalent-speed parameter $N/\sqrt{\theta}$ were computed according to the method of reference 6.

RESULTS AND DISCUSSION

The results of the calibration of the air-flow systems are presented in figure 1. The weight flow through the commercial adjustable orifice (reference 4) was used as the standard. The maximum deviation among the systems was 1.0 percent.

The performance of the J33-A-27 compressor over the range of equivalent speeds from 6100 to 11,800 rpm is shown in figure 2. Over a range of equivalent speeds from 6100 to 11,000 rpm, the peak adiabatic temperature-rise efficiency remained nearly constant at a value of 0.78, with the maximum efficiency of 0.786 occurring at an equivalent speed of 8000 rpm (fig. 2(b)). At the design equivalent speed of 11,800 rpm, the operating limits of the compressor are between the surge point (105.7 lb/sec) at which the peak pressure ratio of 4.40 and the adiabatic temperature-rise efficiency of 0.745 occur and the maximum equivalent weight flow of 113.5 pounds per second. At the maximum equivalent weight flow of 113.5 pounds per second, a pressure ratio of 4.04 and an adabatic temperature-rise efficiency of 0.701 were obtained.

At an equivalent speed of 8000 rpm, two audiable surge points were encountered (fig. 2). Surge occurred at the minimum obtainable equivalent weight flow of 29.75 pounds per second and again at an equivalent weight flow of 47.04 pounds per second but a high pressure level. Unstable compressor operation was encountered from an equivalent weight flow of approximately 44 pounds per second to the surge point at 47.04 pounds per second.

SUMMARY OF RESULTS

The following results were obtained from the over-all performance investigation of a J33-A-27 compressor:

1. At the design equivalent speed of 11,800 rpm, the compressor had a peak pressure ratio of 4.40 at an equivalent weight flow of 105.7 pounds per second and a peak adiabatic temperature-rise efficiency of 0.745. The maximum equivalent weight flow at this speed was 113.5 pounds per second at a pressure ratio of 4.04 and an adiabatic temperature-rise efficiency of 0.701.

2. Over a range of equivalent speeds from 6100 to 11,000 rpm, the peak adiabatic temperature-rise efficiency remained nearly constant at a value of 0.78.

Lewis Flight Propulsion Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio, June 28, 1949.

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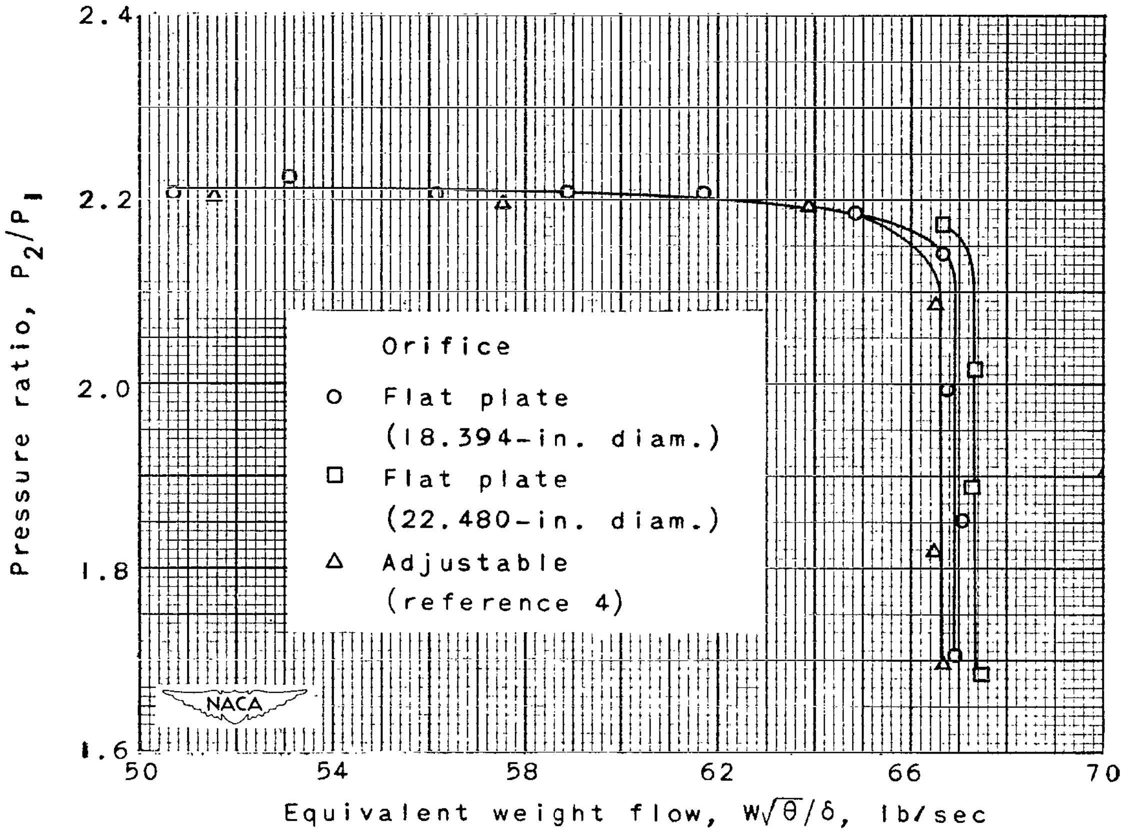
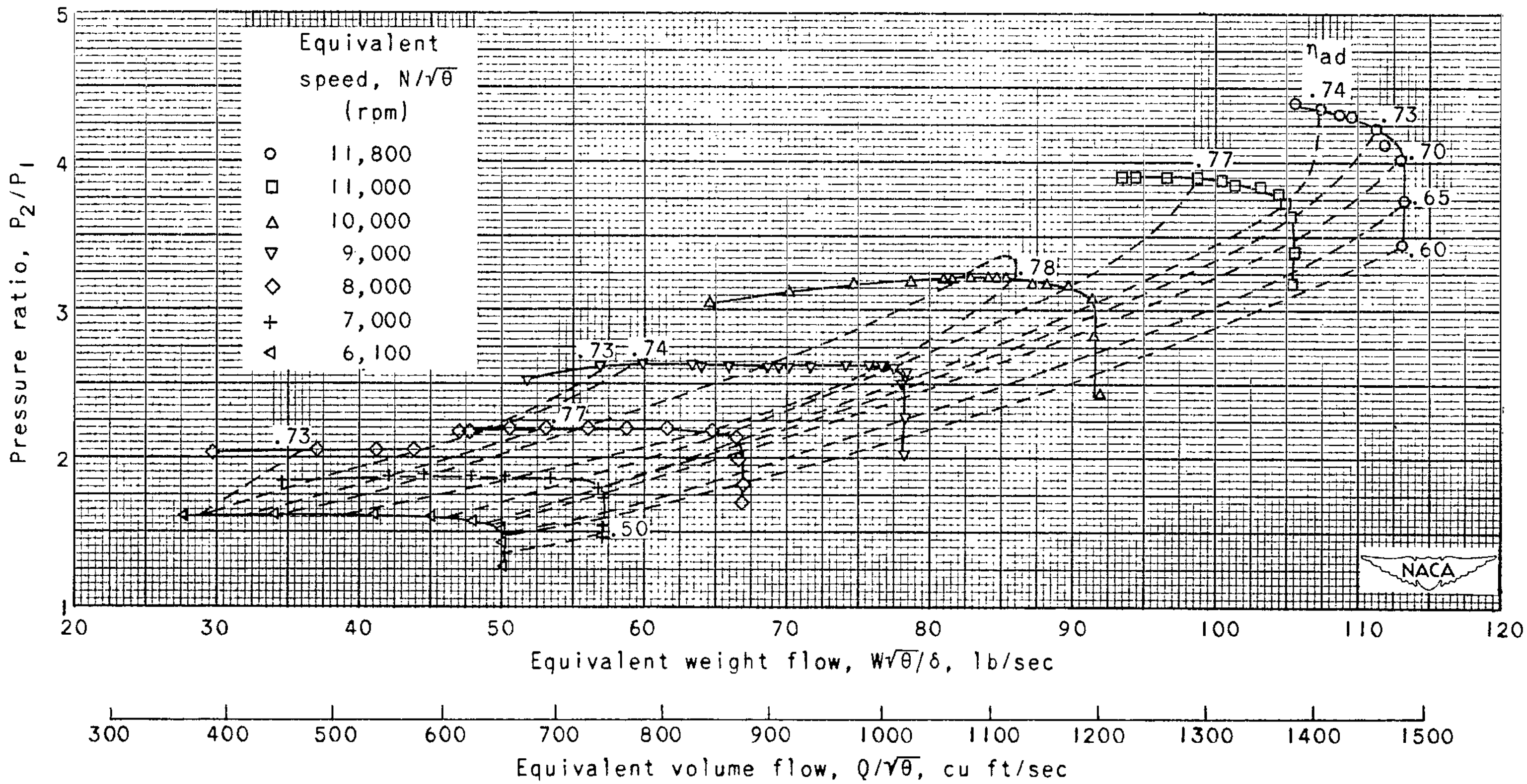
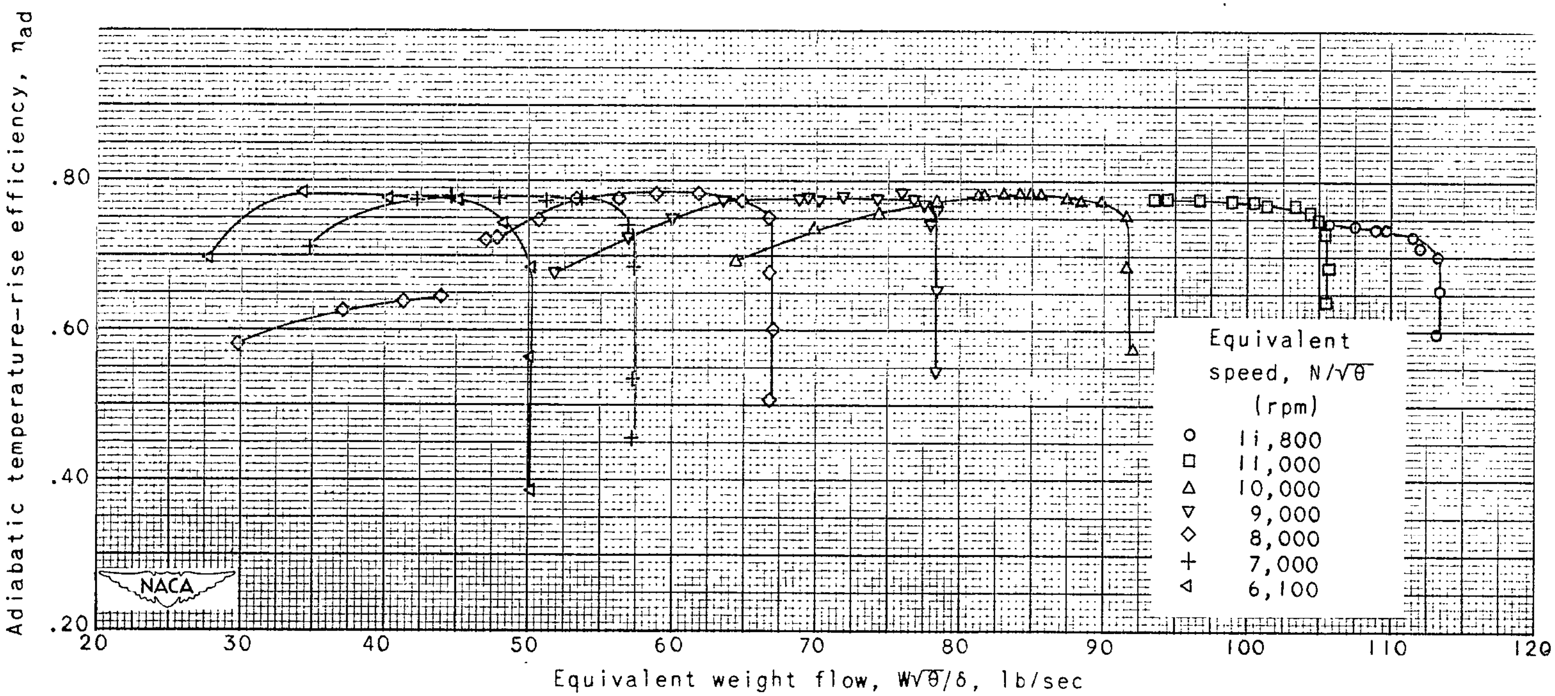


Figure 1. - Calibration of air-flow meters at equivalent speed of 8000 rpm at inlet pressure of 14 inches of mercury absolute and ambient inlet temperature.



(a) Pressure ratio.

Figure 2. - Performance of J33-A-27 compressor at inlet pressure of 14 inches of mercury absolute and ambient inlet temperature.



(b) Adiabatic temperature-rise efficiency.

Figure 2. - Concluded. Performance of J33-A-27 compressor at inlet pressure of 14 inches of mercury absolute and ambient inlet temperature.