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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

PERFORMANCE OF J33-A-27 TURBOJET-ENGINE COMPRESSOR

III - OVER-ALL PERFORMANCE CHARACTERISTICS OF MODIFIED COMPRESSOR WITH WATER INJECTION AT DESIGN EQUIVALENT SPEED OF 11,800 RPM

By Joseph R. Withee, Jr., William L. Beede
and Ambrose Ginsburg

Lewis Flight Propulsion Laboratory
Cleveland, Ohio

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SUMMARY

An investigation was conducted to determine the effects of water injection on the over-all performance of a modified J33-A-27 turbojet-engine compressor at the design equivalent speed of 11,800 rpm. The water-air ratio by weight was 0.05.

With water injection the peak pressure ratio increased 9.0 percent, the maximum efficiency decreased 15 percent (actual numerical difference 0.12), and the maximum total weight flow increased 9.3 percent.

INTRODUCTION

An investigation to determine the performance characteristics of a series of J33 turbojet-engine compressors is being conducted at the NACA Lewis laboratory at the request of the Air Materiel Command, U. S. Air Force. The over-all performance characteristics of the modified J33-A-27 compressor with water injection are herein presented. Also shown are the characteristic curves for the compressor without water injection previously reported in reference 1.

The investigation with water injection was conducted at the design equivalent impeller speed of 11,800 rpm, an inlet pressure

of 14 inches mercury absolute, and ambient inlet temperature. The water-air ratio by weight was 0.05.

APPARATUS AND PROCEDURE

Apparatus. - The apparatus and instrumentation are the same as those described in reference 1 with the following additions: (1) water-alcohol spray nozzles were installed, (2) a rotometer was used to measure water flow, and (3) a wattmeter was used to measure power input to the variable-frequency induction motor.

Procedure. - The modified J33-A-27 compressor was operated at the design equivalent impeller speed of 11,800 rpm, an inlet pressure of 14 inches mercury absolute, and ambient inlet air temperature. These operating conditions are the same as those used in the investigation without water injection (reference 1) in order to permit direct comparison of data. The water-air ratio by weight was 0.05.

Computations. - The compressor efficiency with water injection is the ratio of the isentropic work, which was found by using the enthalpy rise for an isentropic process from the initial to the final pressure (determined by the method presented in reference 2), and the actual work determined by power-input measurements. The specific humidity of the inlet air was of the order of 0.008 pounds of water per pound air and its effect on the computed isentropic enthalpy rise was considered in this investigation.

The actual power absorbed by the compressor was determined by measuring the power input to the variable-frequency drive motor and allowing for losses in the motor, the gear box, and the assembly. The validity of this method was determined during the runs without water injection by comparing measured power with a computed power based on the compressor temperature rise and weight flow. The maximum variation of the powers determined by the two methods was less than 1.0 percent.

RESULTS AND DISCUSSION

Figure 1 presents the effect of water injection on the over-all performance characteristics of the modified J33-A-27 compressor. Total weight flow is defined as the equivalent weight of air flow plus the weight of water flow.

Representative changes in the performance variables are given in the following table:

Water injection	Maximum efficiency	Maximum equivalent air weight flow (lb/sec)	Maximum total weight flow (lb/sec)	Peak pressure ratio
Without	0.764	110.70	110.70	4.56
With	.647	115.25	121.00	4.97

With water injection the peak pressure ratio increased 9.0 percent and the maximum efficiency decreased 15 percent (actual numerical difference 0.12). The maximum equivalent air weight flow increased 4.1 percent, and the maximum total weight flow increased 9.3 percent.

The specific power required with and without water injection is presented in figure 2; the specific power is defined as the actual horsepower required divided by the actual total weight flow. With water injection, an increase in specific power was obtained over the flow range with a maximum increase of 3.5 percent occurring at the peak-pressure-ratio point.

SUMMARY OF RESULTS

1. With water injection the peak pressure ratio increased 9.0 percent and the maximum efficiency decreased 15 percent (actual numerical difference 0.12). The maximum equivalent air weight flow increased 4.1 percent and the maximum total weight flow increased 9.3 percent.

2. With water injection an increase in specific power was obtained over the flow range with a maximum increase of 3.5 percent occurring at the peak-pressure-ratio point.

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Joseph R. Withee, Jr.
Joseph R. Withee, Jr.,
Aeronautical Research Scientist.

William L. Beede
William L. Beede,
Aeronautical Research Scientist.

Ambrose Ginsburg
Ambrose Ginsburg,
Aeronautical Research Scientist.

Approved: Robert O. Bullock
Robert O. Bullock,
Aeronautical Research Scientist.

Oscar W. Schey
Oscar W. Schey,
Aeronautical Research Scientist.

aap

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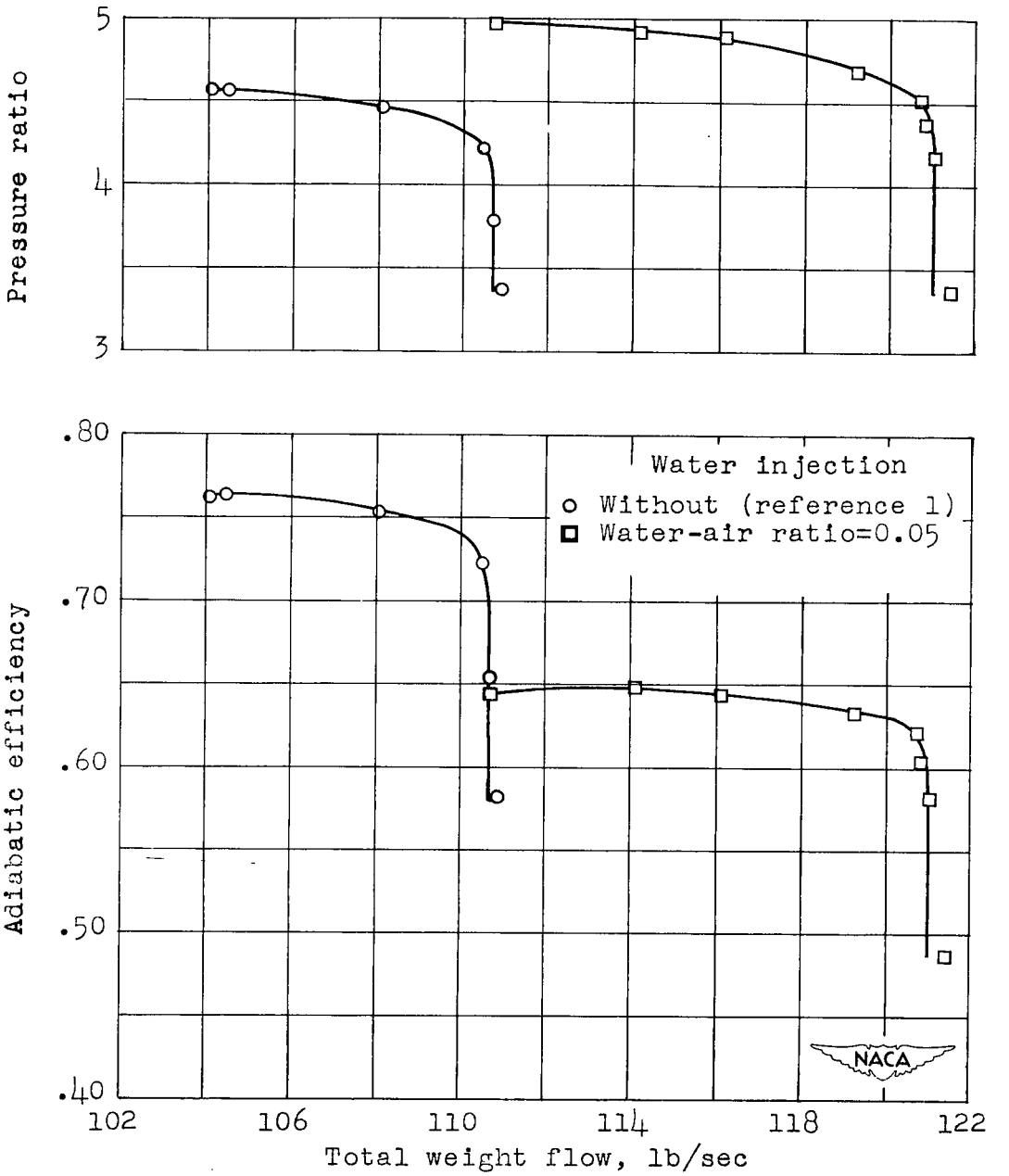

Figure 1. - Performance of modified J33-A-27 compressor with and without water injection at equivalent impeller design speed of 11,800 rpm.

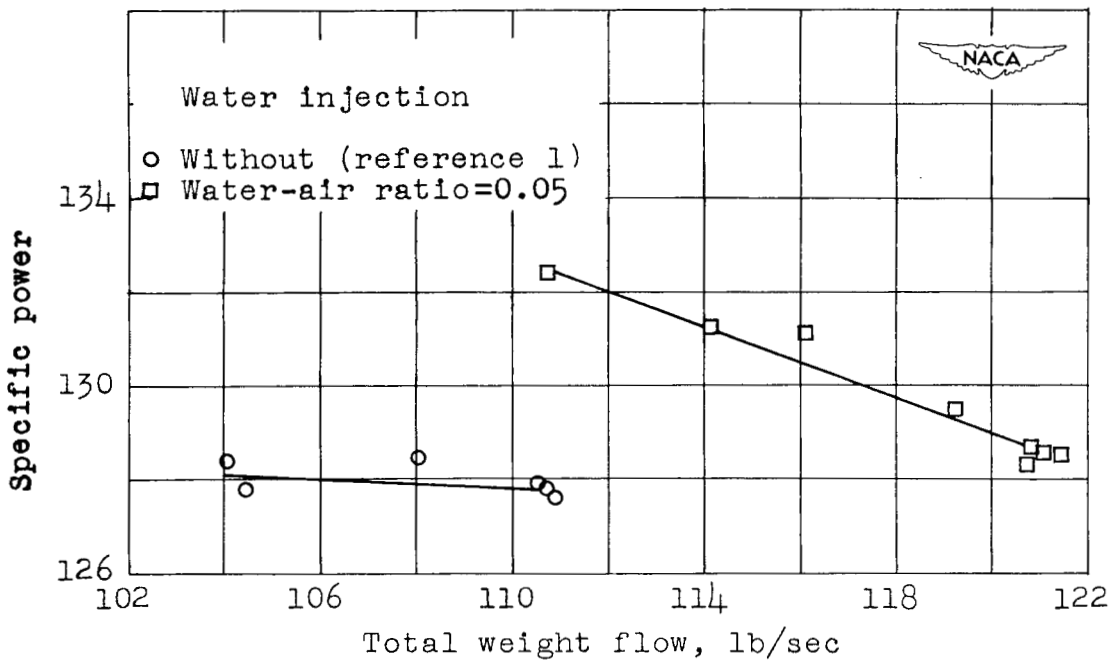

Figure 2. - Specific power of modified J33-A-27 compressor with and without water injection at equivalent impeller design speed of 11,800 rpm.