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Thrust calibration method study during Engine powered simulation

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- Nacelle with TPS unit calibration method study
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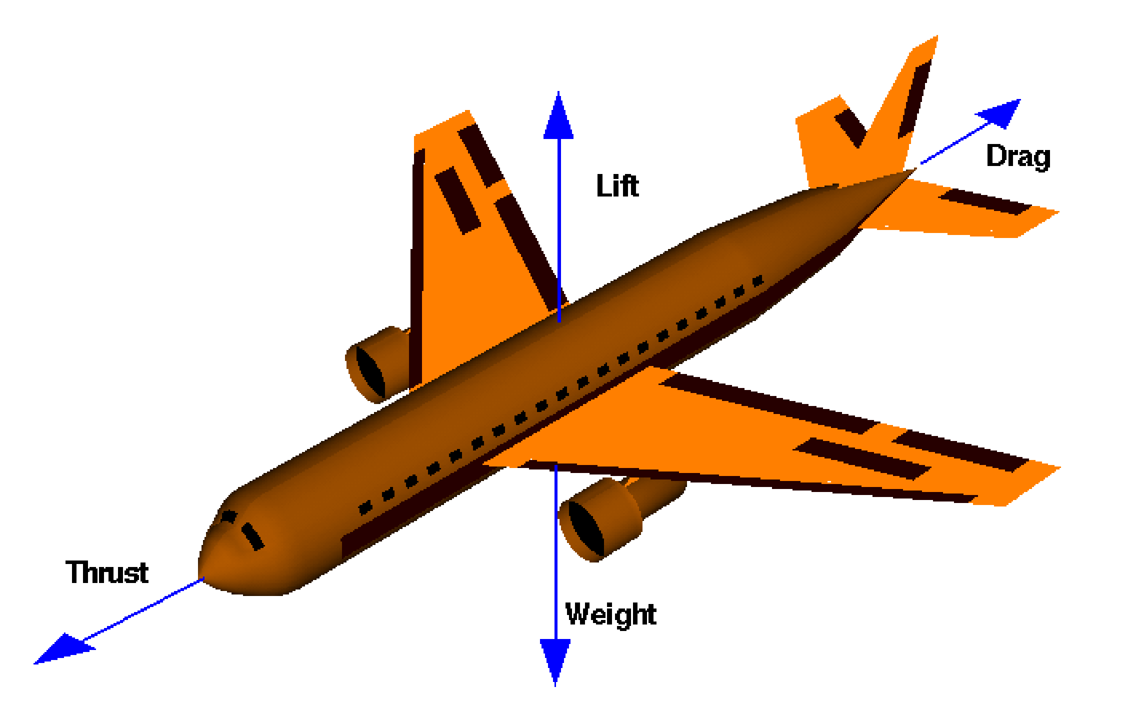
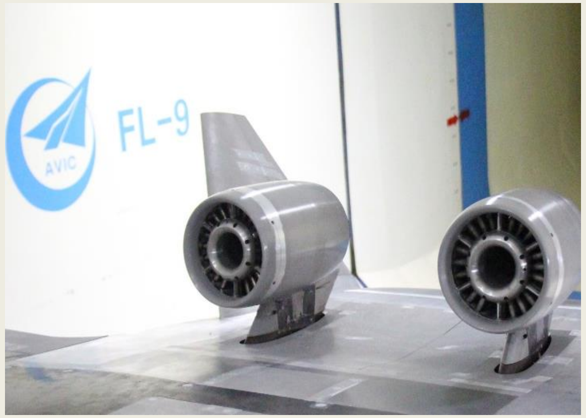
Introduction

Wind tunnel tests are needed to obtain aerodynamic characteristics of aircraft. In the conventional wind tunnel test, to measure the aerodynamic force of the aircraft, the through-flow model is generally adopted, without accounting for the influence of engine intake and exhaust on the aerodynamic force of the aircraft.



Introduction

The turbofan propulsion simulation test could simulate the intake and exhaust flow generated by the engine, consequently obtain the aerodynamic increment caused by the engine power disturbance, and the influence of the engine thrust reversal on the aircraft performance.



Nacelle with TPS unit calibration method study

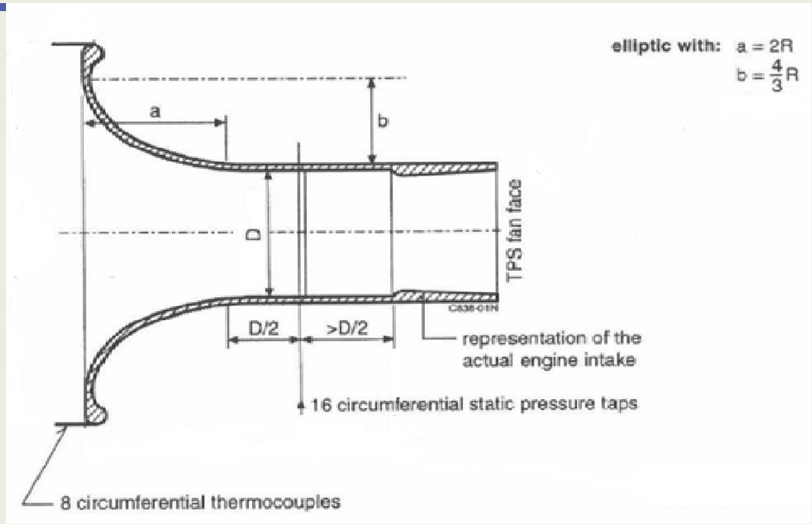
The main projective of the calibration of a nacelle with TPS in calibration tank are the discharge coefficient C_D and velocity coefficien C_V.

The TPS is mounted on the front plate of the calibration tank. During calibration tests, a pressing pressure (pressure different between the tank pressure and environmental pressure) is applied on TPS , which can work as equivalent Mach number M_{eq}. At this moment, no circulaton occurs in calibration tank around TPS.

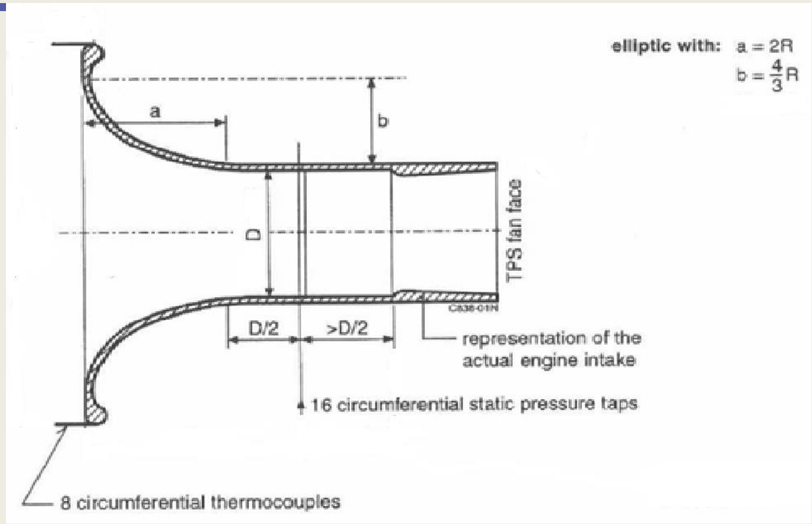
Generally the engine simulator used in wind tunnel is dependent upon a pre calibration. In other words, to find the relationship between measured pressure and temperature inside the nacelle with mass flow rate and thrust of the simulator.

BELL-MOUTH DESIGN AND RESISTANCE LOSS ESTIMATION IN THE THRUST SIMULATED NACELLE CALIBRATION PROCESS

There is a degree of differences between the wind tunnel test and the nacelle calibration test. Wind tunnel test would happen outflow, whereas nacelle calibration will not, just because of the calibration test utilizing the front and back pressure difference of nacelle to simulate the equivalent Mach number. Wind tunnel test adopts ternary nacelle lip, without bell mouth installed in front of nacelle, while calibration test needs to install it due to zero wind speed in front of nacelle and needs to deduct the friction resistance of bell mouth from the nacelle thrust by calculation. Moreover, the ternary nacelle lip is usually not axisymmetric and cannot well connected with the bell-mouth. Hence dualistic design is required to optimize the ternary nacelle lip.



BELL-MOUTH DESIGN AND RESISTANCE LOSS ESTIMATION IN THE THRUST SIMULATED NACELLE CALIBRATION PROCESS



Based on the analysis of the factors affecting the lip drag of the short nacelle inlet, the dualistic design method of the short lip is studied on the premise of ensuring the basic consistency of the drag.

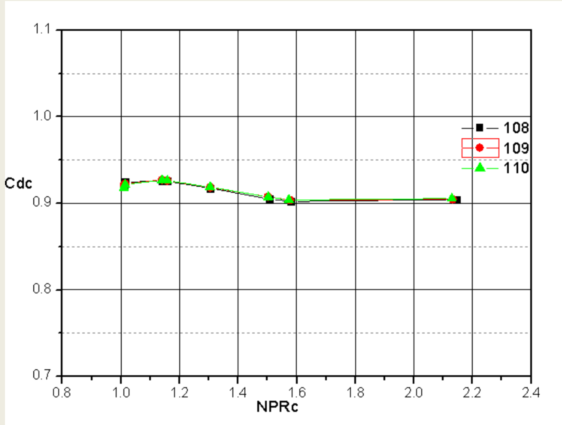
At One-dimensional pipe flow, the pressure loss can be calculated by corresponding formulas:

$$F_{bm} = \Delta p * \frac{\pi d^2}{4} = \lambda \frac{l}{d} * (P_a - P_{b-}) * \frac{\pi d^2}{4} = \frac{1}{4} \lambda \pi d l * (P_a - P_{b-})$$

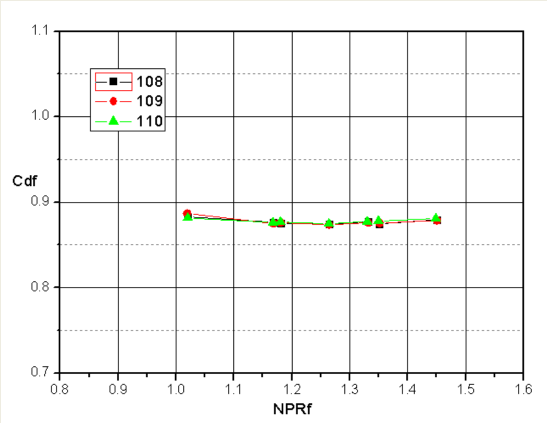
$$\Delta p = \rho h_f = \rho \lambda \frac{l}{d} \frac{v^2}{2} = \lambda \frac{l}{d} * \frac{\rho v^2}{2} = \lambda \frac{l}{d} * (P_a - P_{b-})$$

$$h_f = \lambda \frac{l}{d} \frac{v^2}{2}$$

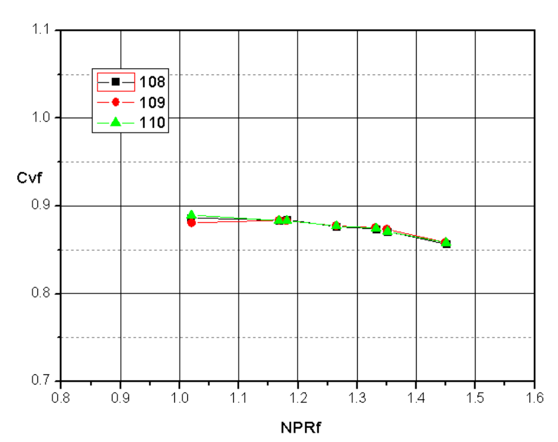
BELL-MOUTH DESIGN AND RESISTANCE LOSS ESTIMATION IN THE THRUST SIMULATED NACELLE CALIBRATION PROCESS



（a） the discharge coefficient of the core



（b） the discharge coefficient of the fan

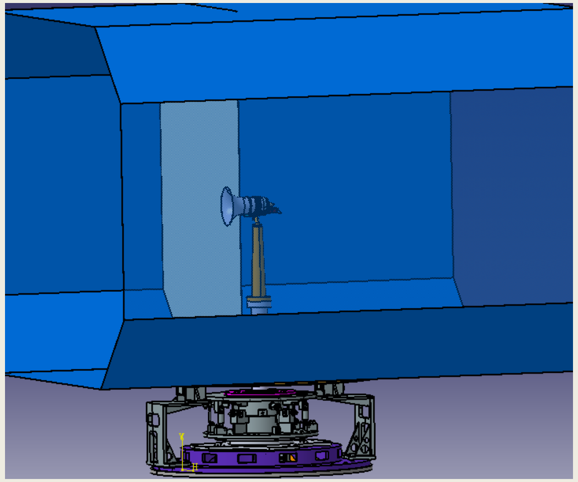


（c） the velocity coefficient of the fan

CALIBRATION METHOD OF THE NACELLE WITH REVERSER

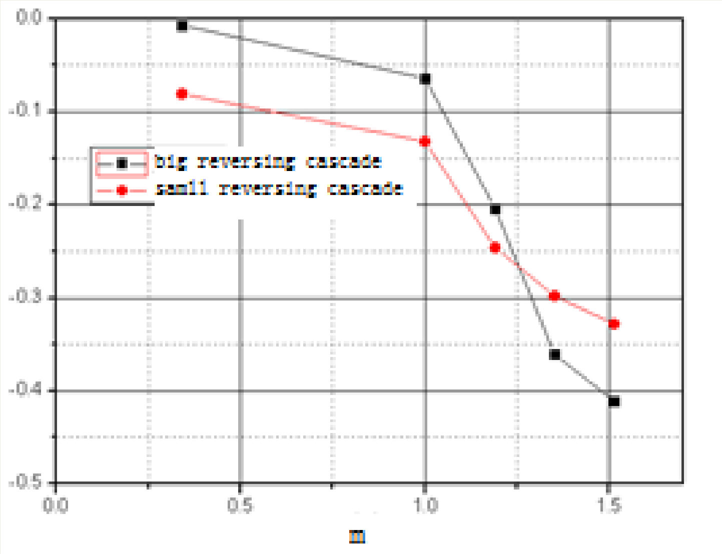
During the calibration process, to adjust the nacelle outlet pressure ratio, control the internal airflow supply by regulating the flow control device. When the nacelle outlet pressure ratio reached the standard, collect the external balance, temperature, pressure, and other data. Process these data to calculate the discharge coefficient and velocity coefficient of the core and fan. By continuously changing the airflow supply, produce the changing curve of the two coefficients with the outlet pressure ratio.

In the calibration test, perform the forward thrust nacelle calibration test first, until completed, then the reverse thrust nacelle calibration test. Process the experimental data in the two situations, finally, obtain the reverse efficiency of the nacelle.

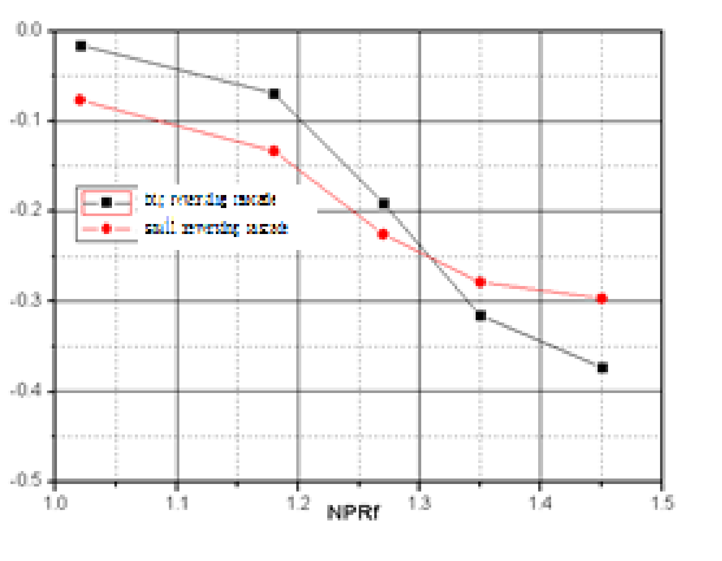


CALIBRATION METHOD OF THE NACELLE WITH REVERSER

By processing the test results of the engine with/without reverser, the reverser efficiency can be obtained. The reverser efficiency of the two reversing cascades are. The variation rule of the reverser efficiency with fan mass flow rate and fan pressure ratio. It indicates that the different configuration of the reversing cascade did lead to different reverser efficiency.



(a) reverse efficiency with flow change



b) reverse efficiency with NPR

CONCLUSIONS

The nacelle calibration tests are key steps before performing the powered simulation tests of an aircraft in wind tunnel. The precision and accuracy of the calibration test directly affects the whole aircraft model aerodynamics test. In this paper, the calibration method of TPS nacelle in calibration tank and nacelle with reverser calibrated in FL-9 was introduced along with the data processing method. During the calibration tests, the discharge coefficient of the engine, the discharge coefficient and velocity coefficient of the fan, and the reverser efficiency can be obtained. It is able to calculate the net thrust during wind tunnel tests and deducted from the readings of the balance. The accuracy of test data has reached the international advanced level. The reverser tests can provide technological support to the design of the reversing cascade.

Thank you!