AERODYNAMIC ANALYSIS OF FLUSH-MOUNTED STATIC PORTS PLACEMENT ON THE COMMERCIAL TRANSPORT AIRCRAFT

Fang Yang1*, Sun Yifeng, Yang Shipu****
Shanghai Aircraft Design and Research Institute of Commercial Aircraft Corporation of China

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Abstract

Flush-mounted static pressure ports are widely used to sense ambient static pressure on modern commercial transport aircrafts. The flight altitude and flight speed of the aircraft are obtained through the air data computer by the static pressure measured. The fuselage static field is analyzed by computational fluid dynamics(CFD) in this paper. Combined with the used characteristics and design requirements of the static pressure ports ,we can obtain the layout position where the correction rule of the static pressure ports is simple. Through this ,we can laid a good theoretical basis for the design for pore pressure sensor in flight correction obtained high quality measurement accuracy.

1、Introduction

The static pressure sensor or the total static pressure sensor are used to measure static pressure of aircraft at an flight altitude. Relative to the total static pressure sensor, the static pressure measurement accuracy is high. Modern advanced civil aircraft and large civil aircraft are used the static pressure sensor measurement flow static pressure. Used the measured pressure value ,aircraft flight altitude and flight velocity is obtained through the air data computer, and displayed on the barometric altimeter and airspeed indicator. Static pressure sensor is showed on Figure1 .

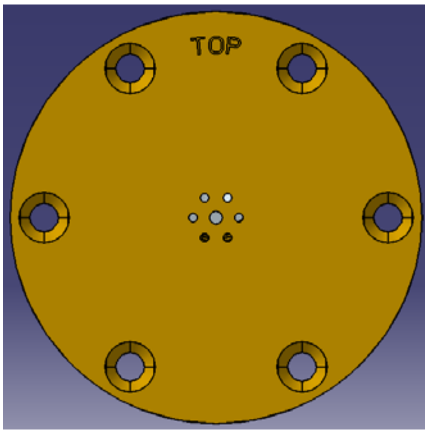

Figure. 1 static pressure sensor

Atmospheric pressure is defined as the static pressure in front of the plane at infinity. But due to the influence from the position of static pressure sensor on the aircraft, measuring equipment, mach number, angle of attack, sideslip angle, the static pressure measured by the sensor will always be some error. Under normal circumstances, the error can be divided into: position errors of installation of static pressure sensor, delay error and instrument error. The static pressure error is mainly determined by the position error. Thus, in order to reduce the static pressure error, we should to reduce the position error.

2、Design requirements analysis

The value that the static pressure sensor measured is the local static pressure. There is a certain error between this value and the static pressure of the flow, Which are affected by mach number, angle of attack, angle of sideslip, flap morphology and engine thrust. Mach number and angle of attack are critical factors .The relation curves between the static pressure and mach number, angle of attack are defined as Static Source Error Correction

(SSEC) curve. The SSEC curve can be obtained by the methods of CFD 、 wind tunnel test and flight test. The static pressure of the flow can be obtained by the SSEC curve.

In order to get the accurate flow static pressure values, the SSEC curve should be as simple as possible. Through this , the complexity of the process of revision can be reduced and the correction accuracy can be increased. Therefore, the main three design principles can be get of static pressure sensor layout design in the aerodynamic professional aspects.

a) The change law of static pressure with mach number should be simple, in order to reduce the complexity of the correction process;

b)Static pressure should remain unchanged with the change of angle of attack as far as possible, in order to reduce the error from low accuracy of the measurement of the angle of attack;

c) The static pressure is affected by the angle of sideslip as little as possible, in order to reduce the error caused by angle of sideslip.

3、Theoretical analysis of flow field

The static pressure sensor installed on the fuselage surface measures the static pressure of the fuselage surface. Based on the aerodynamic theory, the fuselage surface pressure field is related to four aerodynamics parameters, which are mach number, angle of attack, sideslip angle of sideslip and the Reynolds number . As the static ports usually located in the nose or forward fuselage, we can only consider the angle of attack and mach number in this field.

Because the influence which the other parts of the aircraft on the flow field can be ignored, wing-body configuration are research in the paper.

The characteristics of the flow field below 200 mm from the surface of the fuselage is focused. The unstructured grid are used to divide space flow field.

The flow region nearly body wall by prism grid to simulate boundary layer flow field and improve the spatial resolution along the direction normal to the wall surface of the local. The CFX software are used to calculate and the turbulence adopt SST model. The height of the first layer grid makes the y+ reach 100 magnitude, so it can choose the wall function method for solving boundary layer flow field in the CFX software.

4、Numerical calculation analysis

The CFD results are statistically processed in order to directly display the relationship between position error and angle of attack and mach number. Fixed angle of attack , variance is computed of different mach number at the same position. The variance can react to the influences of angle of attack to static pressure. Fixed mach number , variance is computed of different angle of attack at the same position. The variance can react to the influences of mach number to static pressure. The comprehensive CFD study is then carried out to investigate the static pressure dependencies on Mach number and angle of attack on a typical commercial transport aircrafts. The results are illustrated from Figure 1 to Figure4.

It can be seen from the Figure 2 that at a simple aerodynamics aspects , the deep blue zone is the ideal location for the placement of static pressure sensor. In this aero, the static pressure is very insensitive to the change of the angle of attack . On the contrary ,in the red zero, the static pressure is very sensitive to the change of the angle of attack. Figure 3 proves this conclusion. Obviously, it can be concluded that position S2 is more suitable for the installation of static pressure sensor. Figure 4 and Figure 5 show that Position 2 is more suitable for placement of static pressure sensor than position P1.

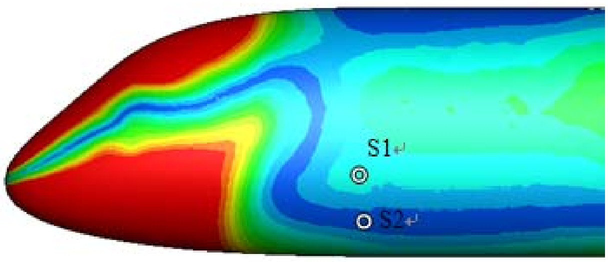

Figure 2. the influences of angle of attack to static pressure of the aircraft

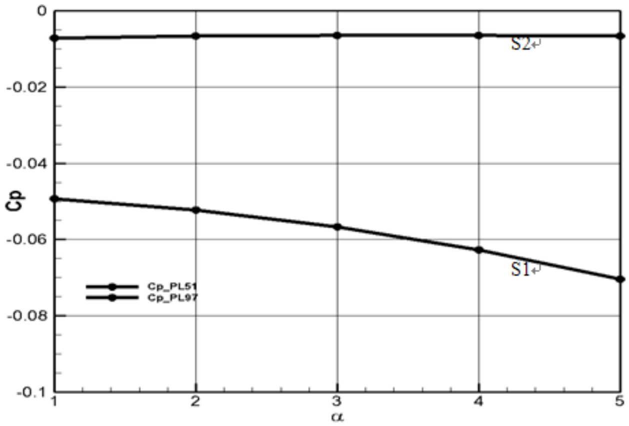

Figure 3. the influences of angle of attack to static pressure of the aircraft on position S1 and position S2

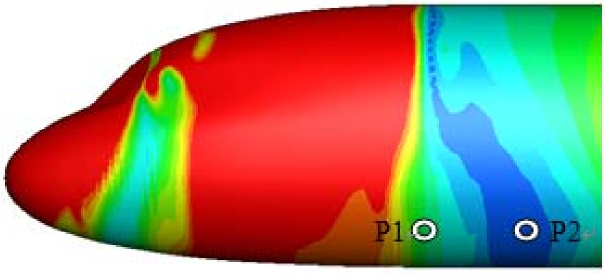

Figure 4. the influences of mach number to static pressure of the aircraft

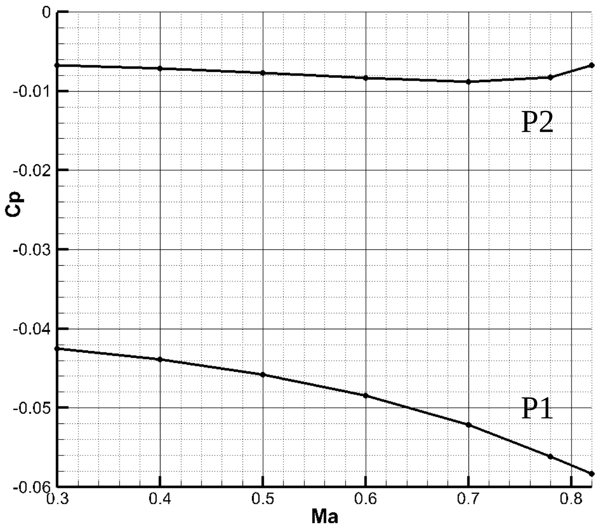

Figure 5 .the influences of mach number to static pressure of the aircraft on position P1 and position P2

5、Summary

In this paper , the aerodynamics characteristic are studied by the method of CFD and get the static pressure changes with the angle of attack and the mach number.

A region of insensitivity to angle of attack is discovered on the fuselage from statistically post-processing of the CFD results. Similarly, A region of insensitivity to mach number is can be discovered. Such this insensitive region is which the static pressure ports is suitable for placement of static pressure sensor.

6 Contact Author Email Address

My email address :fangyang@comac.cc

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