THE INFLUENCE OF THE ANGLE OF ATTACK ALPHA ON THE PRESSURE RECOVERY AT AERODYNAMICS INTERFACE PLANE INVESTIGATION (PENYELIDIKAN PENGARUH SUDUT SERANG ALFA PADA PEMULIHAN TEKANAN DI AERODINAMIKA ANTARMUKA PESAWAT)

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ABSTRACT

In the process of design of an aircraft to know the performance and stability requires testing in a wind tunnel. Similarly, the selection of engines for aircraft design embedded on conducted tests in a wind tunnel model air intake with some variations of the angle of attack. This paper examines the effect of the high angle of attack alpha testing aircraft air intake with a position of beta 0° on the subsonic regime with wind speed of 65 meter persecond. A combat aircraft is flying with an unexpected manoeuvre to avoid enemy attack or to defense against missiles. Often the aircraft must fly to the position of a very high angle of attack. The theoretical value of the pressure recovery is approaching value of one in order to make the machine pinned can work optimally. Experimental observations of pressure recovery are plotted against the variations of the angle of attack alpha. The observations show that the performance design of aircraft engine inlet on the high angle of attack alpha can still give adequate pressure recovery.

Keywords: *angle of attack, aircraft, pressure recovery, engine inlet*

ABSTRAK

Dalam proses desain sebuah pesawat untuk mengetahui kinerja dan stabilitas memerlukan pengujian di terowongan angin. Demikian pula, pemilihan mesin untuk desain pesawat yang tertanam dilakukan tes di terowongan angin model penyedia udara dengan beberapa variasi sudut serang. Makalah ini mengkaji pengaruh sudut serang alfa tinggi pada pengujian model penyedia udara pesawat dengan posisi sudut samping beta 0° pada rezim subsonik dengan kecepatan angin 65 meter perdetik. Pesawat terbang dengan manuver tak terduga untuk menghindari serangan musuh tempur atau melakukan pertahanan terhadap rudal. Seringkali pesawat harus terbang ke posisi sudut serang sangat tinggi. Nilai teoritis pemulihan tekanan mendekati nilai satu untuk membuat mesin yang disematkan dapat bekerja secara maksimal. Pengamatan eksperimental tekanan pemulihan dipetakan terhadap variasi dari sudut serang alfa. Pengamatan menunjukkan kinerja desain pesawat inlet mesin pada sudut serang alfa besar masih dapat memberikan pemulihan tekanan yang memadai.

Kata kunci: *sudut serang, pesawat, pemulihan tekanan, inlet mesin*

1 INTRODUCTION

On the conditions of take-off and landing are very crucial conditions of all types of flight, so that all types of aircraft should be tested in the low-speed wind tunnel (G.B. Gratton, 2008). Aircraft testing in the wind tunnel is necessary for the design cycle of an aircraft and come up with the design for a prototype.

In terms of wide range angle of attack air intake aircraft testing, the angle of attack (AOA) is varied so that it requires a mechanism that is not like the testing of commercial aircraft. AOA varies from -20° to 40 ° requires facilities specially prepared support along with the measuring instrument air intake engine. This condition can be done by design an appropriate air intake model (Subagyo, 2016),(Doyle D. Knight, 2006),(Ahmed F. El-Sayed and Mohamed S. Emearat, 2016).

The Wind Tunnel Test (WTT) facility shown in figure 1-1 (Jaarsma F., 1996) is belonging to National Laboratory for Aerodynamics Aero-elastics and Aero-acoustics Technology (BBTA3), Agency for the Assessment and Application of Technology (BPPT). Furthermore diagrammatic of the WTT facility shown in figure 1-2. The task of National Laboratory for Aerodynamics Aero-elastics and Aero-acoustics is to provide aerodynamic testing services to both the customers from domestic and abroad. Test objects that can be done in National Laboratory for Aerodynamics Aero-elastics and Aero-acoustics Technology not only complete model of the aircraft but also allows for the test model which is a component of the aircraft, such as two-dimensional wing model, half model, tail performance and air intake test.

Unlike the machines in general, pusher aircraft jet engines require a certain amount of compressed air to produce thrust so that aircraft can fly. A provider of air on an aeroplane in particular aircraft depends on a few constraints, among others, the range of speed flying, flight situation, anti-radar who designed (Gérard Laruelle, 2002),(András Sóbester, 2007). The working principle is simple; jet engines can be described as a rubber balloon is moving to the fore that are moved by the reaction of blowing air when blowing out of the balloon. In order to increase the jet engine thrust, the air pressure is raised. A technique to increase of the pressure is by installing compressor in jet engines. In addition, the temperature of the air is also increased in a high pressure chamber. Where fuel at high pressure and room burned can increase jet impulse coming out of the exhaust (Gordon C. Oates, 1989). The compressor is driven by way of installed turbines in the back before the exhaust. The turbine shaft mounted shaft connected to the compressor.

Figure 1-1: Indonesia Low-Speed Wind Tunnel (ILST)

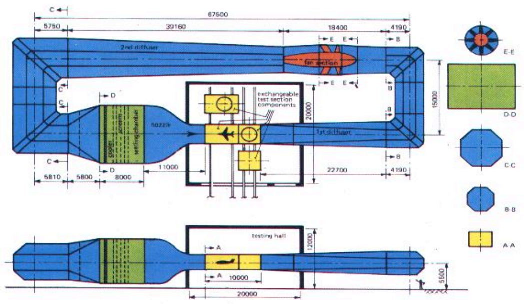

Figure 1-2: Wind tunnel testing facility diagram.

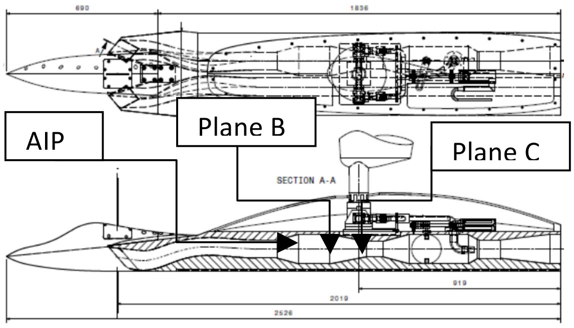

Figure 1-3: Diagram of pipeline systems provider air

A combat aircraft that can fly at Mach number speeds range from 0.3 to 2.5 and has a design of pipeline aerial providers needs special testing inlet duct engines. Testing for fighters requires a testing provider of air by measuring the pressure recovery on Aerodynamics Interface Plane (AIP) (AGARD, 1997). While the air piping system provider tested shows in Figure 3. In this test previously, required calibration testing explained (Subagyo dan Yanto Daryanto, 2018).

2 BACKGROUND THEORY AND MEASUREMENT METHOD

The effectiveness of the system provider of the air is the preferred focus in this research. This is can do by measuring the pressure recovery in AIP using the method of pressure measurement. Fundamentally, BBTA3-BPPT has an on-site measurement of pressure. Further pressure measurement facilities have been developed for the measurement of pressure in the AIP. The application of measurement of pressure in the AIP, by the way, is did on holes in the form of a pressure rake that paired in the AIP is associated with a pressure transducer (Jewel W. Barlow, William H. Rae, Alan Pope, 1984). Pressure rake coordinates show in Figure 2-1.

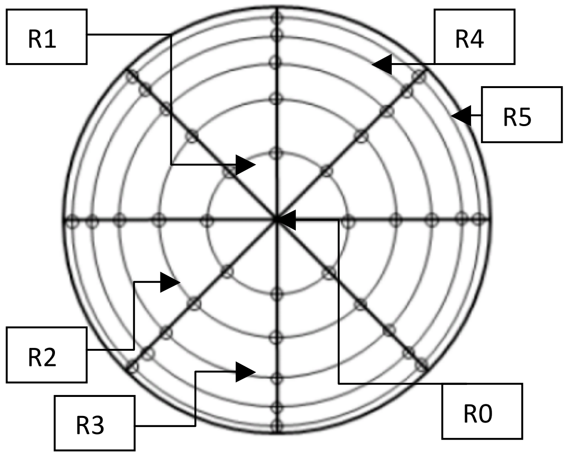

Figure 2-1: Pressure rake at the AIP model

Method of measurement of pressure recovery, with facilities owned by BBTA3-BPPT, diagrammatically is shown in Figure 2-2. Data based on a diagram of Figure 2-2 is the speed of wind tunnel tests, at the section inlet mass flow with pressure P [bar] in the ADS is given then the pressure data in the model areas A, B and C (see Figure 1-2), as well as the temperature in the plane B, is measured. Furthermore, the obtained whole data is processed (De Vries, O., 1987) to get the output on the computer processes the data. While the models that installed on the test facilities is shown as in Figure 2-3.

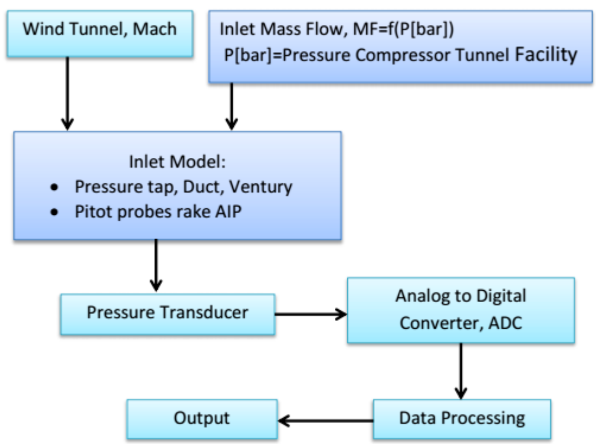

Figure 2-2: Calibration and pressure recovery measurement.

Table 3-1: WTT TABLE OF PRESSURE RECOVERY MEASUREMENT

No	Run	Polar	Vo(ms^{-1})	Alpha	Beta	BV	PBar	MF
1	1	1	65	A	0	0	15	-
2	2	1	65	A	0	0	30	-

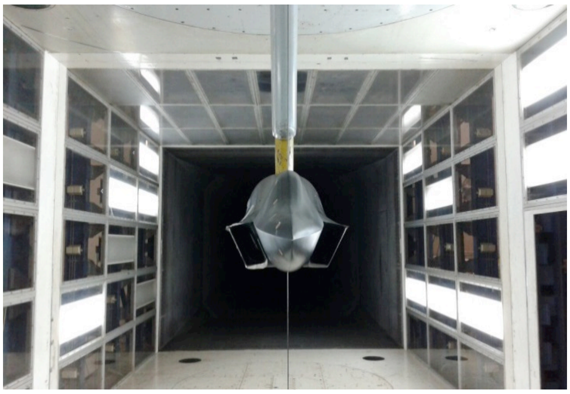

Figure 2-3: Model testing facilities for pressure measurement.

3 PRESSURE RECOVERY TESTING

WTT actually observes airflow interaction phenomenon whether external or internal flow. When an aircraft is flying, then there is airflow occured aircraft. The design of the pressure recovery testing is drawn up in table 3-1.

These events can simulate in WTT of aircraft models. The inlet duct aircraft model installed in the test section and then give varies of AOA at the constant freestream airflow at 65 ms^{-1}. Internal flow inlet duct supply air of the engine one of curiosity in this research. Pressure rake is placed in a model test and connected to the central strut Support Mechanism which can move at the position alpha(AOA) or beta (β) angle is varied.

4 RESULTS AND DISCUSSIONS

Developed facility inlet duct aircraft testing is implemented in the ILST. Pressure Recovery at Aerodynamic Interface Plane is observed by pressure measurement method. The effect of angle of attack alpha investigation is conducted in the ILST. The result is discussed in the following paragraph.

4.1 Mass Flow

The comparison of the mass flow results at a P = 15 bar and P = 30 bar is shown in Figure 4-1. As we know that mass flow [5] is increased if the pressure given by ADS is raised.

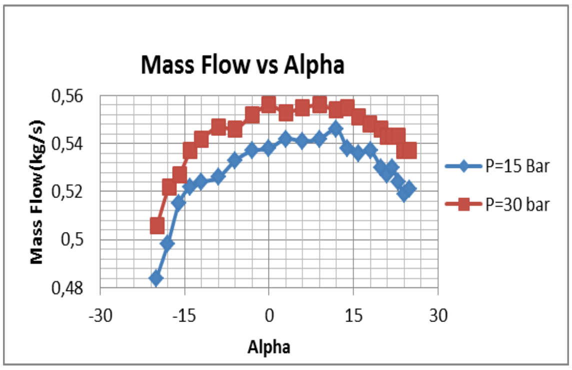

Figure 4-1: Mass Flow versus AOA.

4.2 Pressure Recovery

Pressure Recovery at AOA ≅ -20° in the conditioned pressure in the exhaust ejector 15 bar is shown in Figure 4-2 and at the pressure 30 bar is shown in figure 4-3.

The curve in Figure 4-2 shows coefficient pressure at the AIP in the pressure condition 15 bar. On the other hand, figure 4-3 shows coefficient pressure at the AIP in the pressure condition 30 bar.

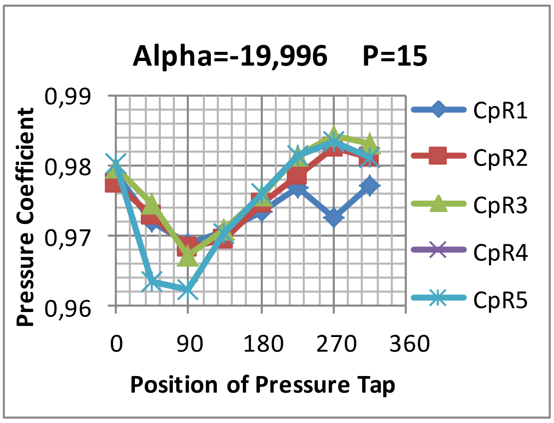

Figure 4-2: Pressure Recovery at AOA=19.996°.

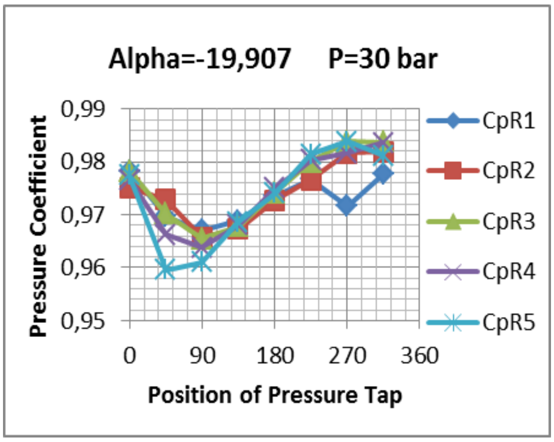

Figure 4-3: Pressure Recovery at AOA =-19.907°.

The horizontal axis indicates the position of pressure taps in the rake expressed in units of degrees. Both images figure 4-2 and figure 4-3 shown results similar to the values pressure coefficient varies between 0.96 to 0.985. The average value of Cp with the condition angle of attack ≅ -20˚, -14˚, -6˚, 0˚, 6˚, 16˚, 22˚ pressured ADS 15 bar and 30 bar in the position on R1, R2, R3, R4 and R5 can be seen in table 4-1.

The average value of Cp (Pressure Coefficient) in the angle of attack of -20˚ is about 0.97. Then the angle of attack is increased with the value of Cp is increased that becomes 0.98 at the angle of attack-14˚. The average value of the Cp has a value of approximately 0.99 at the angle of attack -6˚, 0˚, 6˚. It then decreases to 0.98 at an angle of attack at 16˚ and 22˚.

Table 4-1. WTT TABLE AVERAGE OF THE COEFFICIENT PRESSURE.

	R1	R2	R3	R4	R5
Alpha=-20					
15 bar	0.973681	0.975559	0.97704	0.975875	0.974745
30 bar	0.97525	0.977198	0.978433	0.977944	0.976938
Alpha=-14					
15 bar	0.985323	0.984954	0.98477	0.984966	0.984556
30 bar	0.980937	0.98124	0.981766	0.981809	0.981586
Alpha=-6					
15 bar	0.993627	0.991216	0.98918	0.988325	0.986774
30 bar	0.992731	0.990283	0.987975	0.986208	0.984814
Alpha=-0					
15 bar	0.992578	0.990699	0.989381	0.987596	0.985774
30 bar	0.992987	0.989988	0.988204	0.986508	0.984174
Alpha=6					
15 bar	0.991308	0.98926	0.988554	0.98686	0.985081
30 bar	0.990407	0.988715	0.988164	0.985905	0.983939
Alpha=16					
15 bar	0.988209	0.986939	0.98732	0.986711	0.985205
30 bar	0.985308	0.984116	0.985219	0.985011	0.984473
Alpha=22					
15 bar	0.985171	0.984306	0.984991	0.984068	0.982868
30 bar	0.98237	0.982203	0.982833	0.98219	0.98163

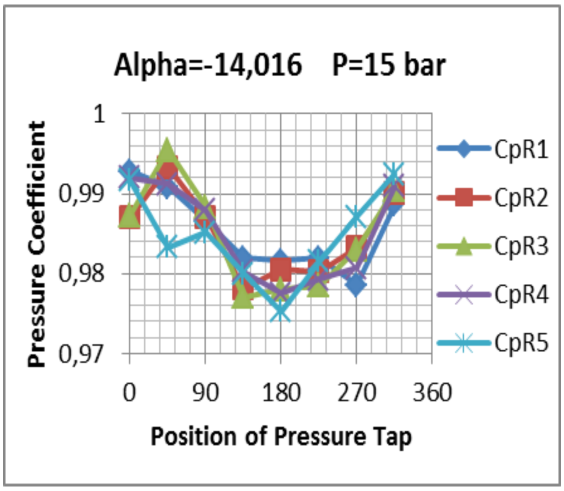

Figure 4-4: Pressure Recovery at AOA=-14.016°.

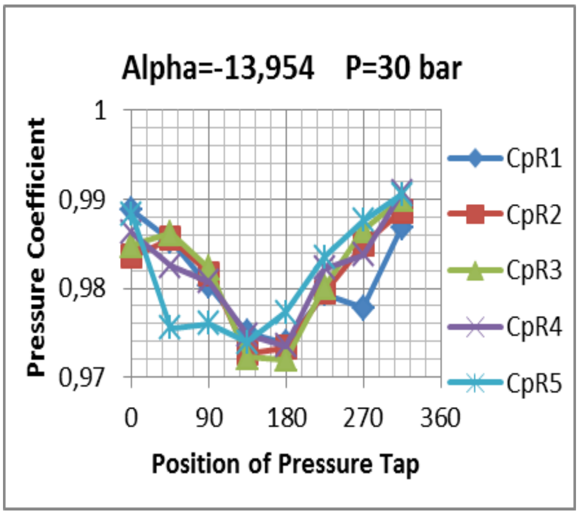

Figure 4-5: Pressure Recovery at AOA=-13.954°.

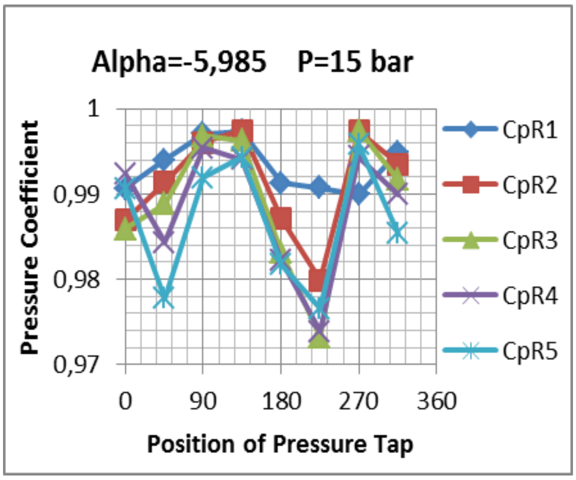

Figure 4-6: Pressure Recovery at AOA=-5.985°.

The form of distribution of Cp against the angle of attack appears to have been influenced by the geometry of the model and the position of the angle of attack. On the situation of pressure tap which caught the flow of misbehaving by the shape of the air duct and position angle of attack causes the average value of the Cp to change. Figure 4-4 and Figure 4-5 in 14° angle of attack changes the situation Cp distribution values at the position of maximum and minimum values compared to the figure 4-2 and 4-3.

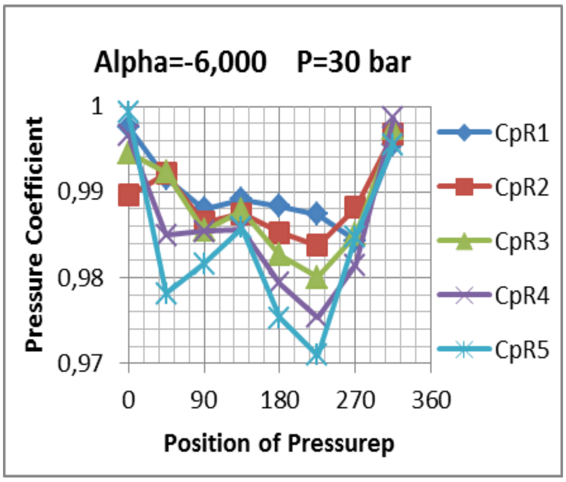

Figure 4-7: Pressure Recovery at AOA = -6.0°.

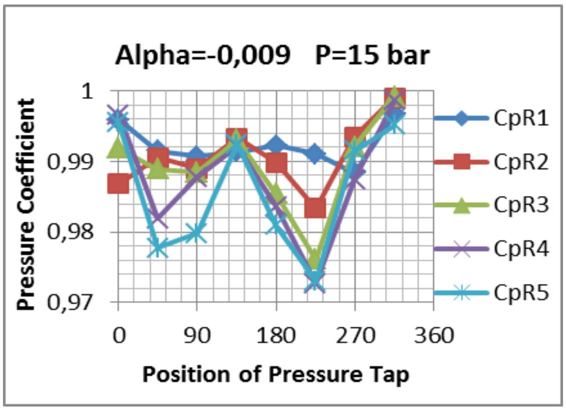

Figure 4-8: Pressure Recovery at AOA=-0.009°.

On the alpha angle of attack low i.e. -6°, 0°, 6° as shown in Figure 4-6 , Figure 4-7, Figure 4-8, Figure 4-9 , Figure 4-10, Figure 4-11 distribution curve, Cp symmetry in the W shape like approaching towards the position of the tap 135°.

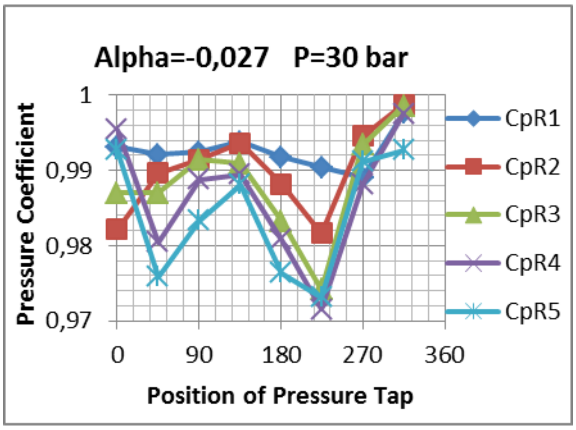

Figure 4-9: Pressure Recovery at AOA =-0.027˚.

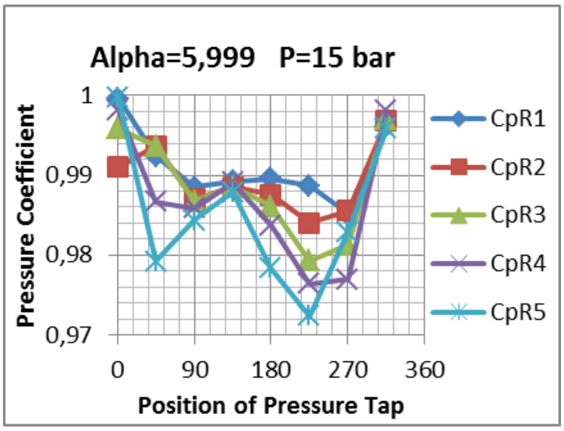

Figure 4-10: Pressure Recovery at AOA=5.999˚.

At low angle of attack, the air flow enters in the channels can be said to be almost in a direct frontal straight. In geometry, a pressure tap rake position 45˚ and 225˚ captures the incoming air which is disrupted by two walls of the inlet.

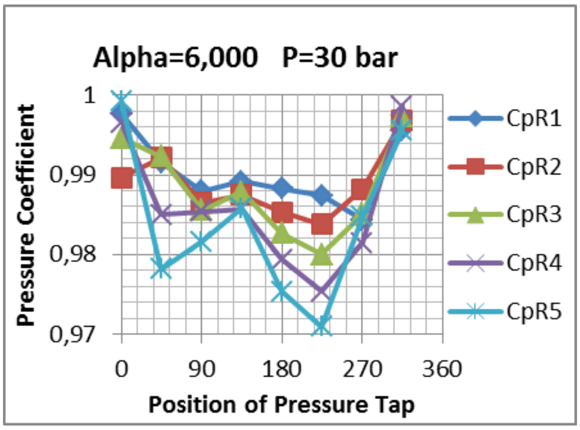

Figure 4-11: Pressure Recovery at AOA=6,0°

This shows the value of Cp in that position is mostly small. The Cp value in R1 appears slightly fluctuating against the average value of the Cp. Flow obtained in the position indicates no disruption means. Position R2, R3, R4, and R5 which has a larger radius are experiencing disruption due to friction with the wall of the pipeline.

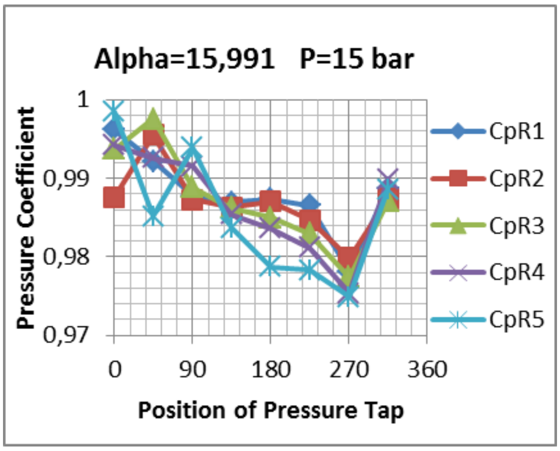

Figure 4-11: Pressure Recovery at AOA=15.991˚.

Furthermore, Figure 4-11, Figure 4-12, Figure 4-13 and figure 4-14 is the Cp distribution on a higher angle of attack alpha i.e. 16˚ and 22˚. The Cp distribution changes. It is detected on a pressure tap angle 135˚ to 270˚ that Cp has decreased. The friction that occurs at the inner part wall inlet which allegedly is the cause factor is the declining value of Cp at the pressure tap angle 135˚ to 270˚.

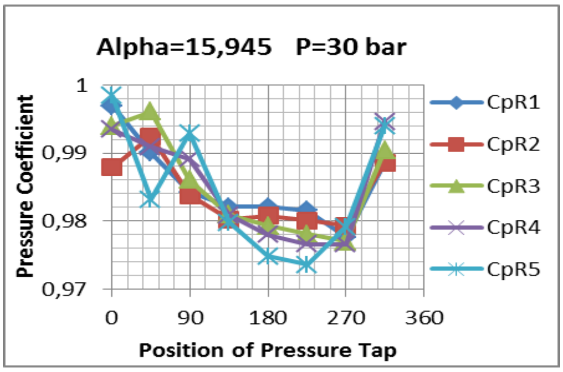

Figure 4-12: Pressure Recovery at AOA=15.945˚.

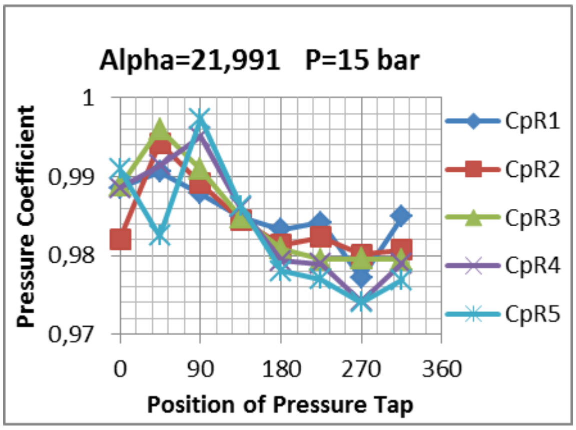

Figure 4-13: Pressure Recovery at AOA=21.991˚.

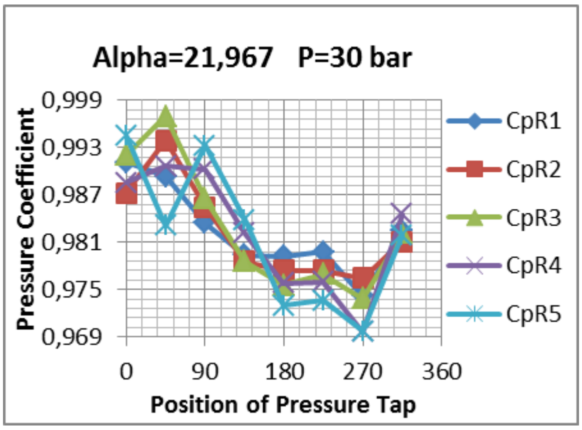

Figure 4-14: Pressure Recovery at AOA=21.967˚.

5 CONCLUSIONS

Measurement of pressure recovery of a wide range angle of attack aircraft model in the wind tunnel with pressure measurement method shows good results. Values mass flow and pressure recovery are influenced by the angle of attack. From the AOA -6˚ up to 6˚, pressure recovery has the highest average of Cp. This is caused by a small occurrence of flow separation around the inner wall inlet duct of the model. While the value of the coefficient of pressure (Cp) is influenced by the frontal area of an aircraft model to the direction of the wind.

The average value of Cp at a high angle of attack -20˚, -14˚, 16˚ and 22˚ is slightly smaller than the lower angle of attack. This is also due to the incoming flow channel friction and separation experienced in the wall indicated Cp values are relatively low in pressure taps 45˚ and 90˚ at -20˚ and -14˚ angle of attack and the pressure tap 45˚ up to 270˚ at the angle of attack 16˚ and 22˚.

The average value Cp of the measurement pressure tap in the region R1, R2, R3, R4 and R5 are listed in Table 2 has a minimum Cp value 0.9736 and maximum 0.9936. Cp value here is the ratio of total inlet pressure and the total pressure in the AIP that has a value nearly equals to one. This shows that the total inlet pressure does not change drastically. Thus the air supply pipeline can be said is optimal in conditions of angle of attack is quite high evenly.

The last but not least the function of the pressure measurement with central strut support mechanism equipped by pressurizing air system can measure and simulate pressure recovery in extreme flying conditions such as on wide range angle of attack aircraft with great result.

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