

Flow past aerofoil

Profession



ME2135E Lab Report Flow Past an Aerofoil by LIN SHAODUN Lab Group Date
 A0066078X 2B 10th Feb 2011 TABLE OF CONTENTS EXPERIMENTAL DATA –
 TABLE 1, 2, 3 2 GRAPH – ? 4 GRAPH – ? 5 GRAPH – 6 SAMPLE CALCULATION 7
 DISCUSSION 8 1 EXPERIMENTAL DATA Table 1: Coordinate of Pressure
 Tapping Tapping No. 1 2 3 4 5 6 7 8 9 10 11 Note: Table 2: Pressure
 Readings Manometer inclination: Pressure Readings Pitot Pressure Static
 Pressure Atmospheric Pressure Atmospheric Temperature Stall angle: At the
 end of the experiment 474 mm 497 mm 500 mm 29°C (mm) 0. 0 2. 5 5. 0 10
 20 30 40 50 60 70 80 (mm) 0. 000 3. 268 4. 443 5. 853 7. 172 7. 502 7. 254
 6. 617 5. 04 4. 580 3. 279 0 0. 025 0. 049 0. 098 0. 197 0. 295 0. 394 0. 492
 0. 591 0. 689 0. 787 0 0. 032 0. 044 0. 058 0. 071 0. 074 0. 071 0. 065 0.
 056 0. 045 0. 032 At the beginning of the experiment 474 mm 497 mm 500
 mm 29°C 2 Manometer Readings at various Tapping 1 2 3 4 5 6 7 8 9 10 11
 478 489 494 501 505 506 506 505 502 501 500 496 478 484 492 498 500
 502 502 500 499 499 495 475 478 486 494 497 499 500 498 498 498 493
 476 475 480 488 493 495 498 496 496 498 486 540 532 528 522 518 516
 514 507 503 502 509 562 550 546 526 522 518 514 508 504 502 495 523
 520 520 518 517 516 516 515 515 515 498 516 514 515 516 515 514 514
 512 513 514

Table 3: Pressure Coefficients () Free Stream Velocity v v v () Reynolds
 Number 3 Coefficients at various Tapping 1 2 3 4 5 6 7 8 9 10 11 -0. 956 -0.
 478 -0. 261 0. 043 0. 217 0. 261 0. 261 0. 217 0. 087 0. 043 0. 000 -0. 174 -
 0. 956 -0. 696 -0. 348 -0. 087 0. 000 0. 087 0. 087 0. 000 -0. 043 -0. 043 0.
 783 -1. 087 -0. 956 -0. 609 -0. 261 -0. 130 -0. 043 0. 000 -0. 087 -0. 087 -0.
 087 2. 174 -1. 043 -1. 087 -0. 869 -0. 522 -0. 304 -0. 217 -0. 087 -0. 174 -0.

174 -0.087 -0.609 1.739 1.391 1.217 0.956 0.783 0.696 0.609 0.304 0.
 130 0.087 0.391 2.695 2.74 2.000 1.130 0.956 0.783 0.609 0.348 0.
 174 0.087 -0.217 1.000 0.869 0.869 0.783 0.739 0.696 0.696 0.652 0.
 652 0.652 -0.087 0.696 0.609 0.652 0.696 0.652 0.609 0.609 0.522 0.
 565 0.609 GRAPH ? 3.0 2.5 2.0 1.5 CPL , CPU against X/C @ 4° Cpl 3.0 2.
 5 CPL , CPU against X/C @ 8° Cpl Cpu 2.0 1.5 Cpu CPL , CPU CPL , CPU 1.0
 0.5 0.0 -0.5 -1.0 -1.5 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.0
 0.5 0.0 -0.5 X/C -1.0 -1.5 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 X/C 0.9
 1.0 Area = 0.437 Area = 0.813 4 3.2 5 2.0 1.5 CPL , CPU against X/C @
 12° 3.0 2.5 CPL , CPU against X/C @ 16° Cpl Cpu 2.0 1.5 Cpl Cpu CPL , CPU
 CPL , CPU X/C 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.0 0.5 0.0 -
 0.5 -1.0 -1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.
 7 0.8 X/C 0.9 1.0 Area = 0.858 GRAPH ? Area = 0.729 3.0 2.5 2.0 1.5
 CPF , CPR against Y/C @ 4° Cpf Cpr 3.0 2.5 2.0 1.5 CPF , CPR against Y/C @
 8° Cpf Cpr CPF , CPR 1.0 0.5 0.0 -0.5 -1.0 CPU , CPR Y/C 1.0 0.5 0.0 -0.5
 -1.0 Y/C -1.5 -0.10 -0.08 -0.06 -0.4 -0.02 0.00 0.02 0.04 0.06 0.08 0.
 10 -1.5 -0.10 -0.08 -0.06 -0.04 -0.02 0.00 0.02 0.04 0.06 0.08 0.10
 Area = 0.032 Area = 0.079 5 3.0 2.5 2.0 CPF , CPR against Y/C @ 12° Cpf
 Cpr 3.0 2.5 2.0 1.5 CPF , CPR against Y/C @ 16° Cpf Cpr 1.5 CPL , CPU CPL
 , CPU Y/C 1.0 0.5 0.0 1.0 0.5 0.0 -0.5 -1.0 -0.5 -1.0 Y/C -1.5 -0.10 -0.
 08 -0.06 -0.04 -0.02 0.00 0.02 0.04 0.06 0.08 0.10 -1.5 -0.10 -0.08 -0.
 06 -0.04 -0.02 0.00 0.02 0.04 0.06 0.08 0.10 Area = -0.038 GRAPH
 Area = -0.053 0.437 0.813 0.858 0.729 0.32 0.079 -0.038 -0.053 0.434
 0.794 0.847 0.715 0.062 0.191 0.141 0.150 0.439 0.877 1.316 1.755
 1.8 1.6 1.4 1.2 Cl Cd CL , CD against ? CL, CD, ??? 1.0 0.8 0.6 0.4 0.2 0.
 0 2*Pi*a -0.2 0.0 2.0 4.0 6.0 8.0 ? 10.0 12.0 14.0 16.0 6 SAMPLE

CALCULATION The sample calculation is based on Tapping 2 & Table 1: Coordinate of Pressure Tapping Table 3: Pressure Coefficients 1. Air Density at 29°C () () 2. Free Stream Velocity v () 3. Reynolds Number 4. Pressure Coefficient () () () () 5. Lift and Drag Coefficient 7 DISCUSSION 1.

Plot C_L and C_D against α . Please refer to Page 6. on the same graph. 2. Compare the experimentally measured C_L with the Thin Aerofoil Theory prediction of C_L . Discuss the similarity and discrepancy observed. The graph shows at small attack angle (4° and 8°), the measured Lift coefficient is quite close to theoretical predicted value, this is because at small attack angle, air stream flows along the aerofoil surface smoothly without flow separation, which fulfills the basic assumption of Thin Aerofoil Theory, hence the experimental result matches with theoretical value well.

When further increase attack angle, the streamline become highly curved, until at certain angle the streamline is no longer attached to the aerofoil surface and flow separation is occurred, massive turbulence wake appears on aerofoil upper surface, which greatly reduce the lift. At this moment aerofoil is actually “ blocking” the air flow, hence the Lift coefficient is significantly reduced after reach Stall angle, and can no long follow the theoretical predicted value. 3.

What would you expect the lift and drag force to be when $\alpha = 0^\circ$, since the 0015 aerofoil is symmetrical, the pressure on upper and lower surface of aerofoil is the same, hence it will not produce any lift force. The C_D of 0015 aerofoil is 0.0147 at (when $Re = 80000$), so there is small drag force even at $\alpha = 8^\circ$. Does the why. which you have obtained gives the total drag on the aerofoil?

Explain Total Drag of aerofoil is contributed by Parasite Drag and Induced Drag, the Parasite Drag is related to C_{D0} , while Induced drag is a byproduct of lift.

Induced drag is a drag force occurs when aerofoil redirects the airflow coming at it. Refer to below diagram, the lift force is normal to chord of aerofoil, when decompose the lift force to horizontal and vertical component, the horizontal component C_{Di} , which is in the same direction of drag.

5. Explain from the pressure distribution why there is a lift force. Using as example, the pressure distribution diagram shows the lower surface of aerofoil has lesser pressure drop \Rightarrow higher pressure, while upper surface of aerofoil has much higher pressure drop, result in lower pressure. The integration of pressure drop along the aerofoil is the area under the curve, which represents force in a unit length of aerofoil, compare the area enclosed for upper and lower surface, we can see there is a resultant lift force produced.

3.0 2.5 2.0 1.5 CPL, CPU against X/C @ 8° Cpl Cpu CPL, CPU 1.0 0.5 0.0 -0.5 -1.0 -1.5 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 X/C 9 6. Comment on the pressure distribution on the aerofoil when stall is reached. Using as example, when stall angle is reached, the pressure drop of upper surface become insignificant due to massive turbulent wake, hence the lift force is greatly reduce and stall happens.

3.0 2.5 2.0 1.5 CPL, CPU against X/C @ 16° Cpl Cpu CPL, CPU 1.0 0.5 0.0 -0.5 -1.0 -1.5 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 X/C 0.9 1.0 10