Aerofoil pressure distribution

Title of Experiment: Pressure distribution on an aerofoil Aim: The aim of this experiment is to examine the pressure distribution on an aerofoil and its variation with incidence. Introduction: An aerofoil is the two-dimensional cross section of a wing, tail or helicopter rotor blade. The lift and pitching moment on an aerofoil is determined by the pressure distribution on it. The pressure distribution changes with the angle of incidence. Understanding the behaviour of aerofoils requires some understanding of the variation of the pressure distribution with incidence. Apparatus:

This experiment uses a pressure tapped aerofoil mounted inside a low speed open return wind tunnel. The pressure tapings are connected to a multi-tube manometer, which is also used to measure the dynamic pressure. Students should check and record all the connections on the multitube manometer. Procedure: 1. Level and adjust the multitube manometer in the vertical position with the indicator registering 90 , then incline it to approximately 40 to the horizontal. 2. Check and record all of the manometer connections. 3. Record the NACA aerofoil designation of the aerofoil. . Set the model at zero incidence and turn the wind tunnel on. Run the fan up to about ? of its full speed. 5. Record all of the manometer heights. 6. Adjust the angle of incidence to -4 and repeat the previous step. Adjust the motor control if necessary to maintain a constant dynamic pressure. 7. Repeat the previous step for 4 , 8 and 12 8. Determine the stall angle of the aerofoil and qualitatively observe the changes in pressure distribution near the stall angle. Theory: The non-dimensional pressure coefficient is defined as: V 2 1 P P C 2 i

P Where Pi – pressure at tapping i P – free stream pressure ? – air density V – free stream velocity S – wing area c – aerodynamic mean chord The quantity of 2 2 1 V is known as the dynamic pressure and for low speeds it is equal to the difference between the stagnation pressure Po and the free stream pressure P . This means that we calculate CP using the relation: P P P P C i P 0 For an open return wind tunnel, we may assume that the stagnation pressure is equal to the room pressure and we measure the free stream pressure in the test section.

In this experiment students measure pressure differences using a multitube manometer. The difference in pressure is proportional to the difference in height of the liquid levels in the manometer. Since the pressure coefficient is a ratio of two pressure differences, it is also equal to the ratio of differences in height of liquid levels. h h h h C i P 0 where h indicates the height of the liquid in the manometer. The multitube manometer is inclined, which means that it does not read the difference in height directly. This is done to increase the difference in manometer reading.

Since all of the tubes are inclined at the same angle, the difference in manometer reading is proportional to the difference in height and it can be written: r r r r C i P 0 where r indicates the manometer reading. Aerofoil pressure plots are usually given with CP on the vertical axis, with negative values above the axis and x / c on the horizontal axis. Force Coefficients: The force coefficient on an aerofoil may be determined from the non-dimensional pressure plot. A typical pressure plot is shown below: The force coefficient perpendicular to the aerofoil is the area enclosed by the figure.

The lift is defined as the force perpendicular to the airflow, not the aerofoil, but for small angles of attack, the difference is negligible. Therefore the area enclosed is approximately equal to the lift coefficient at small angles of attack. Results 1. Complete the data table provided. Obtain the x-coordinates of the pressure tapings (corresponding to the marked numbers) on both upper and lower surfaces and the chord length c from the technician. 2. Convert all the manometer readings hi into pressure coefficients Cp using the equation given in the theory for all pressure tapping positions x.

Repeat this for all angles of attacks. A negative value of CP indicates low pressure (suction) , while a positive value corresponding to high pressure. 3. Plot CP on the vertical axis, with negative values above the axis and x / c on the horizontal axis. You should obtain two curves (the upper and lower surfaces) joining together at the leading edge at x / c = 0 and the trailing edge x / c = 1. 0 for each angle of attack. Count the area enclosed by the two curves, taking into account the scales of both vertical and horizontal axes. The area is equal to the force coefficient (approximately equal to the lift coefficient).

You should plot five graphs and obtain five values of force coefficients from the enclosed areas at different angles of attack. References: 1. Fundamentals of Aerodynamics – John D. Anderson, Jr. – McGraw-Hill, Inc. ISBN: 0-07-001679-8. 2. Low speed Wind Tunnel Testing-William H. Rae, ISBN: 047 1874027. Part Two Title of Experiment: Flow visualisation / Wind Tunnel testing of scale models Introduction: The second part of the assignment relates to flow visualisation techniques and wind tunnel testing of scale models. Procedure: In this laboratory session a scale model of a vehicle is mounted within the wind tunnel.

Air is passed around the model at a set velocity. Smoke is introduced upstream so that visualisation of the air flow is facilitated. Students are required to: a) Describe alternative flow visualisation techniques. b) Discuss how underbody channels can create downforce. c) Describe a real world case study of an open-wheel race car wings design. Discuss what the design features and aerodynamic phenomena can be applied to maximise the downforce. Marks will be awarded on the following basis: a) 10 Marks b) 20 Marks c) 20 Marks Total available for Part Two = 50