Impact of jet

kkkkkkkkk CVEN-3313 Theoretical Fluid Mechanics MODULE#4 : Application of Impact on a Jet 1. OBJECTIVE To use the momentum equation to estimate the force exerted by a jet on a stationary target. 2. THEORY The momentum equation in the vertical (z) direction can be written as: Applying the momentum equation for a control volume including the forces acting on a flat target or hemispherical target gives: (1a : flat) (1b : hemi) It is assumed that the velocity going out of the control volume is equal to the velocity coming in. Additionally, the elevation difference within the control is assumed to be negligible. The vertical force caused by the jet is balanced by the mass placed on the weight pan. (2) The initial velocity of the jet, v0, is : (3) From Bernoulli's equation, the jet velocity, v, in the control volume at the target is : (4) Combining equations (1) through (4), the following equations can be obtained for the flat and hemispherical targets, respectively. (5a : flat) (5b : hemi) 3. PROCEDURE 1) Install the flat target in the jet apparatus. 2) Level the apparatus and adjust the pointer for zero deflection. 3) Place a 50g mass on the weight pan. 4) Increase the flow rate until the weight induced by the 50g is balanced by the force of the jet. 5) Measure the actual flow rate, Qactual, by recording the time required to collect 10L. Use the volume gauge on the bench. 6) Repeat steps 3-5 for 100, 200, 300, 400 and 500g mass increments. 7) Repeat the procedure for the hemispherical target. 4. RESULTS & ANALYSIS 1) Equations (5a) and (5b) are non-linear with respect to flow rate Qtheor. These can be solved for Qtheor by trial and error or by using some type of solver. In this case, however, the equations can be further reduced by making an appropriate assumption/approximation. Make an appropriate assumption and simplify the equations. (Hint : Think about the velocity of the jet and recall how equation (4) is derived.) 2) Using the simplified equations derived in part 1), calculate the theoretical flow rate, Qtheor, for each mass for both the flat and hemispherical targets. Present your results in a table. 3) Plot m vs. Qactual and m vs. Qtheor (m on the y-axis) on the same graph for each target. Include a point (Q, m) = (0, 0) so that the trend is clearer. Relate these results to the equations derived in part 1). 4) Using the original equations (5a) and (5b), recalculate Qtheor for both targets and confirm that your assumption in part (1) was appropriate. Determine the percent difference for the two Qtheor you have calculated. You may use trial and error, an Excel solver, or some other type of solver. 5. DISCUSSION 1) For what flow rates, in general, is the assumption/approximation made above, valid? 2) From equations (1a) and (1b), the momentum equation can be written in a general form as: , where ï�¡ is a constant. The mass that can be pushed up with the same Q increases as ï�¡ increases. Theoretically speaking, what would be the maximum and minimum values of ï�¡? Clearly state why. Extra Credit) Two other target shapes were included with this module. Choose one, draw a neat picture of the resulting jet flow, then work through the theory to determine an appropriate equation for Qtheor. Try it out if you like! 6. MISCELLANEOUS 1) Type a lab report, completely answering all questions in this handout. 2) Please specify all variables and units. Remember units in graphs and tables. 3) You will be graded as much for neatness and presentation as you will for correctness. 4) Lab Reports are due November 21, 2003, by 3: 00 p. m. 5) To improve the ITLL lab session in the future, please comment on the four labs. Were the modules helpful in understanding the material? How were the demonstrations and handouts? How was the work load and expectations? Please provide your answer on the last page separately. Definitions : Fz : force in z-direction acting on water in the control volume (N) m : mass of weight (g) ï€ ï�² : density of water (= 1g/cm3) v : velocity of water at target (cm/sec) v0 : initial velocity at nozzle (cm/sec) g : gravity (= 981 cm/sec2) A : nozzle area (= 0. 50265 cm2) h : height of the jet from the nozzle top to the target bottom (= 2. 8cm) Qactual : measured flow rate of jet (cm3/sec) Qtheor : theoretical flow rate of jet (cm3/sec) Flat target Hemispherical taget mass (g) volume (cm3) time (sec) Qactual (cm3/s) volume (cm3) time (sec) Qactual (cm3/s) 0 10, 000 - 0 10, 000 - 0 50 10, 000 10, 000 100 10, 000 10, 000 200 10, 000 10, 000 300 10, 000 10, 000 400 10, 000 10, 000 500 10, 000 10, 000