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DEPARTMENT: CHEMICAL ENGINEERING

CHE 311 - ASSIGNMENT

QUESTION; Derive Bernoulli’s equation from newtons second law

SOLUTION

To derive Bernoulli's Equation, we first apply Newton's Second Law to a fluid in a segment of a pipe. During a particular time interval, the fluid travels the length of the segment.

F = m a

where

F - force (newtons)

m - mass of fluid (kilograms)

a - acceleration (meters / second2)

The force arises because of the difference in pressure at either end of the segment, and the acceleration is related to the change in velocity. Since the force is in the direction of decreasing pressure (i.e. the segment is pushed away from the higher pressure), a minus sign is required.

-A dP = m dv/dt

where

A - area (meter2)

dP - static pressure difference (newtons per meter2)

dv - fluid velocity difference (meters per second)

dt - time interval (seconds)

Replacing the mass and area by the density and the segment length gives:

dP = -rho dx dv / dt

where

rho - density of fluid (kilograms per meter3)

 - segment length (meters)

Since the fluid travels the length of the segment during the time interval, we introduce the velocity to arrive at an equation that is ready for integration:

where

v - velocity of fluid (meters / second)

Integrating, we arrive at Bernoulli's Equation:

P(b) - P(a) = rho (v(a)^2 - v(b)^2) / 2

