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BERNOULLI EQUATION FOR PIPE FLOW FOR FLUID FLOW WITH OPTIMUM HEIGHT

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ABSTRACT

The elevation of the height and the pressure flow are in relation and the Bernoulli equation is fulfilled. The equation gives the pressure and energy relation for many such application. The fluid flow known velocity and pressure at a certain point, you can calculate the height the fluid will reach at another point where the velocity and pressure are zero (e.g., at the maximum height of a fountain). helps understand how changes in height, pressure, and velocity are interconnected within the fluid system. For example, if the height decreases, either the pressure or velocity (or both) must increase to maintain the constant total energy

Keywords: Bernoulli, Equation, Height, Pipe, Pressure.

1. INTRODUCTION

If a pipe containing an ideal fluid undergoes a gradual expansion in diameter, the continuity equation tells us that as the diameter and flow area get bigger, the flow velocity must decrease to maintain the same mass flow rate. Since the outlet velocity is less than the inlet velocity, the velocity head of the flow must decrease from the inlet to the outlet. If the pipe lies horizontal, there is no change in elevation head; therefore, the decrease in velocity head must be compensated for by an increase in pressure head. Since we are considering A ideal fluid that is incompressible, the specific volume of the fluid will not change. The only way that the pressure head for a fluid can increase is for the pressure to increase. So the Bernoulli equation indicates that a decrease in flow velocity in a horizontal pipe will result in an increase in pressure.

2. METHODOLOGY

Bernoulli's equation is a steady-state energy balance. It states that the sum of a fluid's kinetic energy, potential energy and pressure are constant along a streamline. For incompressible flow, Bernoulli's equation is:

$$\rho u^2/2+\rho gz+P= \text{constant}$$

where u is fluid velocity,g is the gravitational constant (9.81 m/s2), P is pressure, and μ is fluid density. Thus, the properties at the outlet can be determined given the properties at the inlet:

$\rho u_{in}\ 2/2+\rho Z_{in}\ g+Pin=\rho u^2_{out}/2+\rho gz_{out}+Pout$

A mass balance is required to solve foruout. The volumetric flowrate is constant because the fluid is assumed to be incompressible, meaning velocity times cross-sectional area remains constant:

$\pi D^2{}_{in}\ u_{in}/4=\pi D^2{}_{out}\ u_{out}\ /4$ where Di s pipe diameter. Solving for the fluid velocity at the outlet, $u_{out}=u_{in}\ D^2{}_{in}\ /D^2{}_{out}$ Bernoulli's equation makes it easy to examine how energy transfers take place among elevation head, velocity head, and pressure head. It is possible to examine individual components of piping systems and determine what fluid properties are varying and how the energy balance is affected.

3. MODELING AND ANALYSIS

Since the units for all the different forms of energy in Equation are measured in units of distance, these terms are sometimes referred to as "heads" (pressure head, velocity head, and elevation head).The term head s used by engineers in reference to pressure. It is a reference to the height, typically in feet, of a column of water that a given pressure will support. Each of the energies possessed by a fluid can be expressed in terms of head. The elevation head represents the potential energy of a fluid due to its elevation above a reference level. The velocity head represents the kinetic energy of the fluid. It is the height in feet that a flowing fluid would rise in a column if all of its kinetic energy were converted to potential energy. The pressure head represents the flow energy of a column of fluid whose weight is equivalent to the pressure of the fluid.

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The sum of the elevation head, velocity head, and pressure head of a fluid is called the total head. Thus, Bernoulli's equation states that the total head of the fluid is constant.

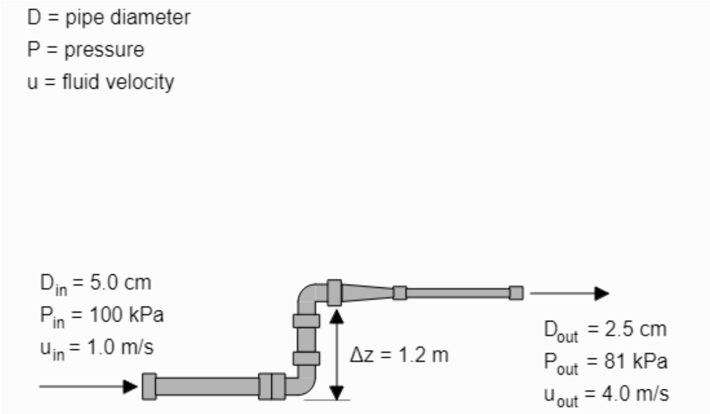

Figure 1: Pipe Flow

4. RESULTS AND DISCUSSION

Although the Bernoulli equation has several restrictions placed upon it, there are many physical fluid problems to which it is applied. As in the case of the conservation of mass, the Bernoulli equation may be applied to problems in which more than one flow may enter or leave the system at the same time. Of particular note is the fact that series and parallel piping system problems are solved using the Bernoulli equation.

Table 1: Result

Sn.	Change in height	Outlet pipe diameter	Inlet pressure	Inlet velocity	Dout	Pout	uout
	1.2m	3.5cm	100kPa	1.0m/s	2.5 cm	81k pa	4m/s
2	2.8m	2.5cm	100kPa	1.0m/s	2.5 cm	48k pa	4m/s
3	4.5m	2.5cm	100kPa	1.0m/s	2.5 cm	32k pa	4m/s
4	6.5m	2.5cm	100kPa	1.0m/s	2.5 cm	29k pa	4m/s
5	8.5m	2.5cm	100kPa	1.0m/s	2.5 cm	29k pa	4m/s

If a constant diameter pipe containing an ideal fluid undergoes a decrease in elevation, the same net effect results, but for different reasons. In this case the flow velocity and the velocity head must be constant to satisfy the mass continuity equation.

So the decrease in elevation head can only be compensated for by an increase in pressure head. Again, the fluid is incompressible so the increase in pressure head must result in an increase in pressure.

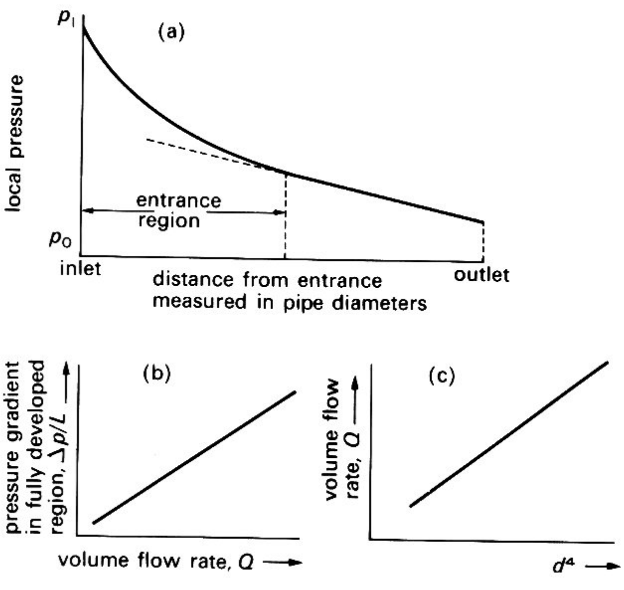

Figure 2: Pipe Flow Graph

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5. CONCLUSION

Bernoulli's equation provides a valuable, simplified framework for understanding the relationship between energy, pressure, and velocity in a fluid. It is a powerful tool for foundational fluid dynamics and is perfectly suited for modeling ideal fluids under steady, frictionless, and incompressible conditions. However, a complete fluid flow model for real-world pipe systems must acknowledge the equation's limitations and incorporate factors such as viscosity, turbulence, and external work to provide a more accurate representation of the system's behavior.

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