Module 4:
Fundamentals of Fluid Mechanics

Pump Engineer is pleased to be able to bring you sample data from the HI's e-learning program. Here is module 4 in a selection of slides from each of the six course modules.

HI's e-Learning Program

Centrifugal Pumps: Fundamentals, Design and Applications

Course I: Pump basics: applications, types & construction

- Module 1: Typical applications of centrifugal pumps
- Module 2: Types of pumps
- Module 3: Centrifugal pump construction

Course II: Pump fundamentals: fluid mechanics, performance and selection

- Module 4: Fundamentals of fluid mechanics
- Module 5: Centrifugal/vertical pump performance characteristics
- Module 6: Pump selection and application

Further details

For further details, please visit www.pumplearning.org to try a free demonstration course of "How To Learn" on-line.

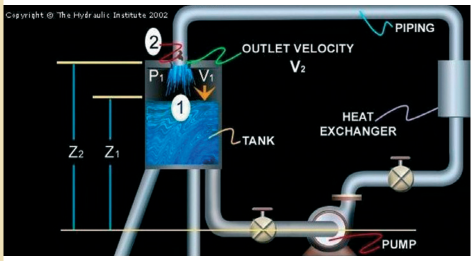
Introduction

Moving liquid is what pumps are all about. The properties of the liquids to be pumped have a profound effect on how well the pump does its job, and the properties of these liquids will be studied here. We will also study the flow of liquids in pumps, piping and pump systems.

Properties of Liquids

- All liquids exert pressure on the walls of the containers that hold them. Pressure is the amount of force in pounds, which acts on a small area of the container, usually one square inch. The units of pressure are expressed as pounds per square inch or psi.
- Another property of liquids is specific weight, which is a measure of the weight of liquid in a unit volume, usually a cubic foot.

  The specific weight of water at room temperature at sea level is 62.3 pounds per cubic foot. For comparison, the specific weight of some hydrocarbons is 49.8 lb/ft^3.
- Energy or head in liquids is often expressed in units of foot pounds per pound of liquid and is simplified as feet. For example, the energy in the bottom of a liquid column, which is 100 feet high, is 100 feet.

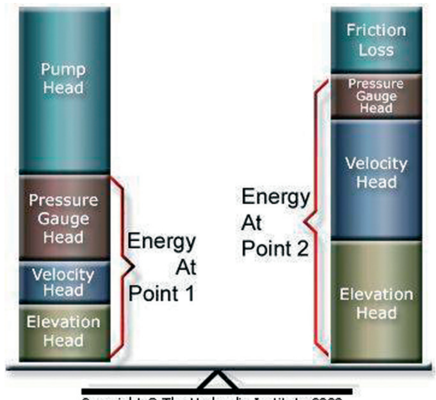


- Viscosity is the property of a liquid which causes it to offer resistance to shear stress such as that caused by liquid flow, primarily in the area of the pipe wall. This figure shows the velocity of a liquid flowing relative to a static boundary surface. At the static boundary surface or wall, the velocity of the liquid is zero.

Bernoulli's Equation

In this pump and system diagram, there is a pump which is taking liquid from a tank. The pump adds energy to the liquid, which then flows through the heat exchanger and then back to the tank. In order to determine the energy required from the pump, we begin at point 1.

- The liquid is under pressure, p1, and at an elevation, Z1. The velocity, v1, is practically zero.
- In addition to the head already in the liquid at point 1, the head produced by a pump is added.
- Between the pump and point 2, there is friction loss due to the piping and heat exchanger. At point 2, the liquid still has energy from its pressure, elevation and velocity.



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- This analysis of head in the system can easily be done by simple arithmetic.
- That is, pressure head at point one plus elevation head at point one plus velocity head at point one plus pump head is equal to pressure head at point two plus elevation head at point two plus velocity head at point two plus friction loss between points one and two.

This equation is more properly written as shown here, where each term is converted to units of foot pounds of energy for each pound of liquid. The unit "foot pounds per pound" is normally expressed simply as feet in U.S. units.

This equation is also referred to as Bernoulli's Equation. ●

Bernoulli's Equation

$$p_1/\gamma + Z_1 + v_1^2/2g + H = p_2/\gamma + Z_2 + v_2^2/2g + h_f$$

p	=	gauge pressure	–	lb/ft^2
z	=	elevation	–	feet
v	=	liquid velocity	–	feet/sec
h_f	=	friction loss between points 1 & 2	–	feet
γ	=	specific weight	–	lb/ft^3
g	=	gravity constant	–	$32.2 ft/sec^2$
H	=	pump energy	–	feet