

Chapter 13

Pump Selection and Application



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General Energy Equation

$$h_A = \frac{p_2 - p_1}{\gamma} + (z_2 - z_1) + \frac{v_2^2 - v_1^2}{2g} + h_L$$

- The total head on the pump or Total Dynamic Head (THD) must increase the fluid head to satisfy the individual heads in the system 2

Power Equations

- Power delivered to the fluid
 - $P_A = h_A \gamma Q$
- Power input into the pump
 - $P_I = P_A / e_M$

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Pump Selection Parameters

- Nature of fluid to be pumped
- Conditions of Suction and Discharge
- Flow capacity and total head req'd
- Power source and cost
- Pump and installation costs
- Codes and Standards

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Types of Pumps

- Positive Displacement (PD pumps)
 - Rotary and Reciprocating
- Kinetic Pumps
 - Centrifugal and Axial
- Jet or Ejector Pumps
 - Centrifugal with ejector (deep well)

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Pumping Hydraulics vs. Water

	Hydraulic	Water (flow)
Typ. Flows	1 – 50 gpm	1 - 500 gpm
Press. Head	2000 psi typ	200 feet
High Press.	10,000 psi	100 psi
Power	100's hp	Up to 1000's
Size	Compact	Moderate
Use	Transfer Power	Transfer Fluid 6

Positive Displacement Pumps

- Rotary
 - Gear, vane, screw, and cam or lobe
- Reciprocating
 - Piston, plunger and diaphragm

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Performance of PD Pumps

- Figure 13.9
 - Capacity changes with rpm
 - Capacity drops off slightly as pressure increases
 - Volumetric efficiency stays flat
 - Overall efficiency flat at op. pressure

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Performance of Centrifugal Pumps

- Figure 13.19
 - Pump can dead head
 - Capacity and head are almost inversely proportional
 - High head, low flow (or no flow)
 - Low head, maximum flow

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Centrifugal Pumps

- Figure 13.20
 - Efficiency peaks at higher flows, then drops off dramatically
 - Typical eff = 60 to 80 percent
- Centrifugal pumps have large impeller clearances

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Affinity Laws

- When speed of pump varies:
 - Capacity varies directly with speed
 - Total head varies with $(\text{speed})^2$
 - Power required varies with $(\text{speed})^3$

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Affinity Law Continued

- When impeller diameter varies:
 - Capacity varies directly with diameter
 - Total head varies with $(\text{diameter})^2$
 - Power required varies with $(\text{diameter})^3$
- Multiple impeller offerings means wide range of requirements available with basic range of housings

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Bell and Gossett Pumps

- Typical pump curves show:
 - Capacity
 - Total head
 - Power required
 - Efficiency
 - Various impeller diameters for same pump housing

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Operating point of pumps

- Figure 13.36
- We know that total system head varies with flow
- And centrifugal pumps vary flow and head
- Pump and system curves will intersect at the operating flow rate¹⁴

Centrifugal Pump Systems

- Figure 13.36
- Flow can be reduced by throttling
 - Increase flow restrictions – close valve
 - System Curve B shows new pressure and flow rate
- Better to size pump accurately than control via restrictions (wasted energy)

Pump Selection Example

- Example Problem 13.4
- Note requirements for pump
- Figure 13.42 shows system curve
 - Static elevation head “lifts” fluid 80 feet
 - Pressure head raises pressure to 35 psig
 - Piping losses then a function of flow

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Net Positive Suction Head - NPSH

- All fluids have a vapor pressure
- Vapor pressure increases with temp
- When vapor pressure = local pressure, boiling occurs (vapor)
- Suction side of pump is low press.
- Always want fluid pressure at suction to be above vapor pressure¹⁷

Effects of low suction pressure

- Entrained air can evolve = vapor
- Fluid can boil = vapor
- As fluid travels up impeller, pressure increases - **Cavitation** occurs
 - Rapid collapse of vapor bubbles destroy impeller
 - Wear erosion looks like pumping sand

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NPSH

- Always make sure:
 - Available NPSH > Required NPSH
- Pump curves show Required NPSH
- Best way is to provide “flooded suction” (supply above suction)
- Minimize losses on suction side
 - Bigger pipe, lower fluid velocity, short run

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Calculating Available NPSH

$$NPSH_A = h_{sp} \pm h_s - h_f - h_{vp}$$

- Where:

- h_{sp} = Supply tank pressure
- h_s = Height of fluid above suction
- h_f = Pipe and minor losses in suction
- h_{vp} = Vapor pressure of fluid

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Life Cycle Costing

- Figure 13.49
- Method of sizing system
- Minimize the sum of installation cost (dashed line) and operating cost (solid down sloping line)
- The optimum pipe size is at the intersection of these two costs

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