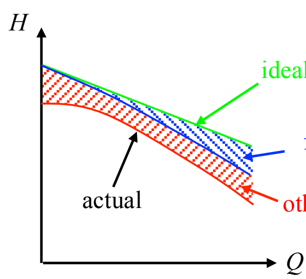
The derivation for the ideal case is not covered in this course.

b. In an actual flow, losses occur within the pump due to friction with the blades (which varies with Q^2), flow separation, impeller blade-shroud clearance flows, and other 3D flow effects.



A quadratic curve is often used to fit experiment pump head curves: $H = H_0 - A\,Q^2$.

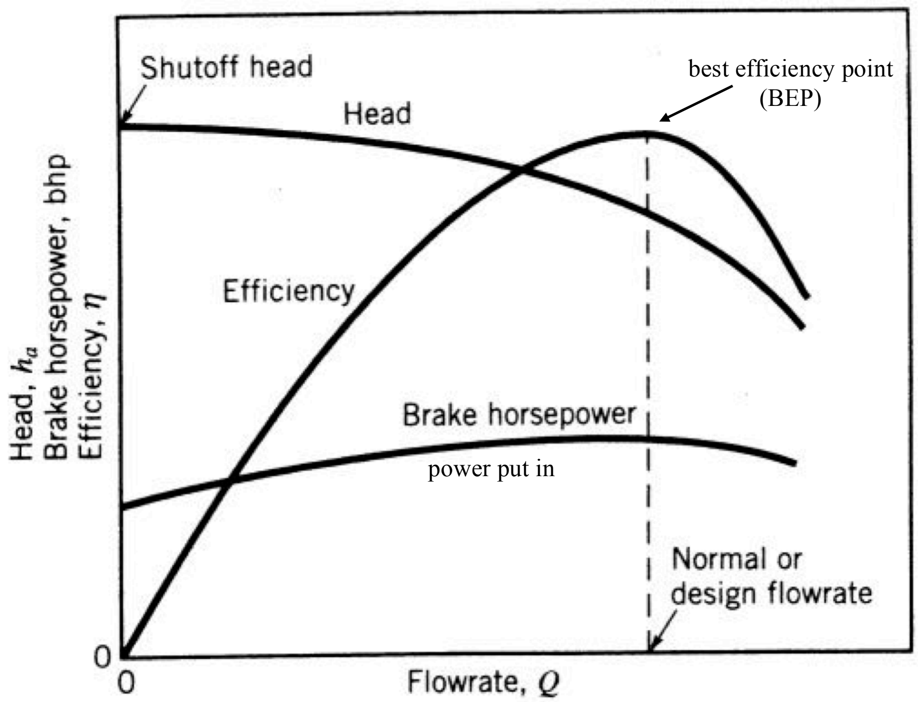
5. **Pump efficiency** is defined as:

$$\eta_p \equiv \frac{\dot{m}gH}{\omega T}$$

$\dot{m}gH$ ← water or hydraulic horsepower (power you get out)

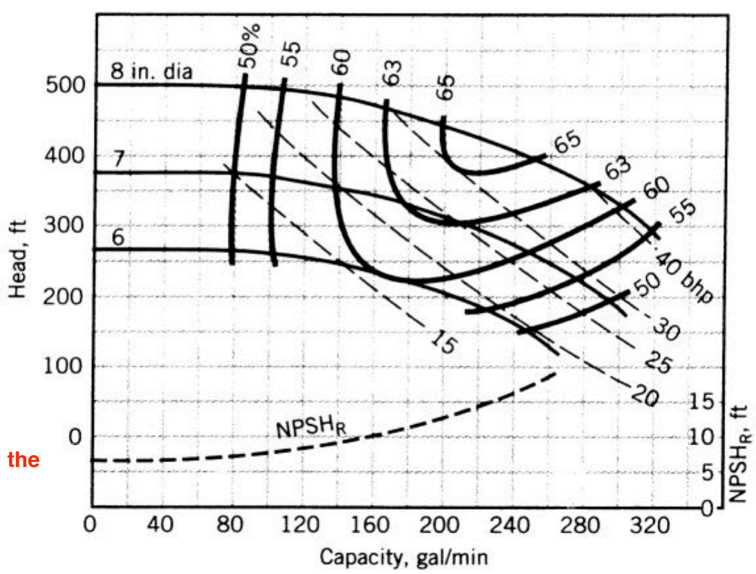
ωT ← brake horsepower (power you put in)

a. typical pump efficiencies: η_p = 85% (well-designed) – 60% (poorly-designed)
b. As pump size ↓, the ratio of surface area to volume ↑ ⇒ frictional losses ↑ ⇒ η_p↓.



(From Munson, B.R., Young, D.F., and Okiishi, T.H., *Fundamentals of Fluid Mechanics*, 3rd ed., Wiley.)

We'll cover NPSH later in the course.



■ **FIGURE 12.12 Performance curves for a two-stage centrifugal pump operating at 3500 rpm. Data given for three different impeller diameters.**

(From Munson, B.R., Young, D.F., and Okiishi, T.H., *Fundamentals of Fluid Mechanics*, 3rd ed., Wiley.)