Slurry Piping

Miguel Sanmartín

Spain Chapter

Slurry Piping Objectives

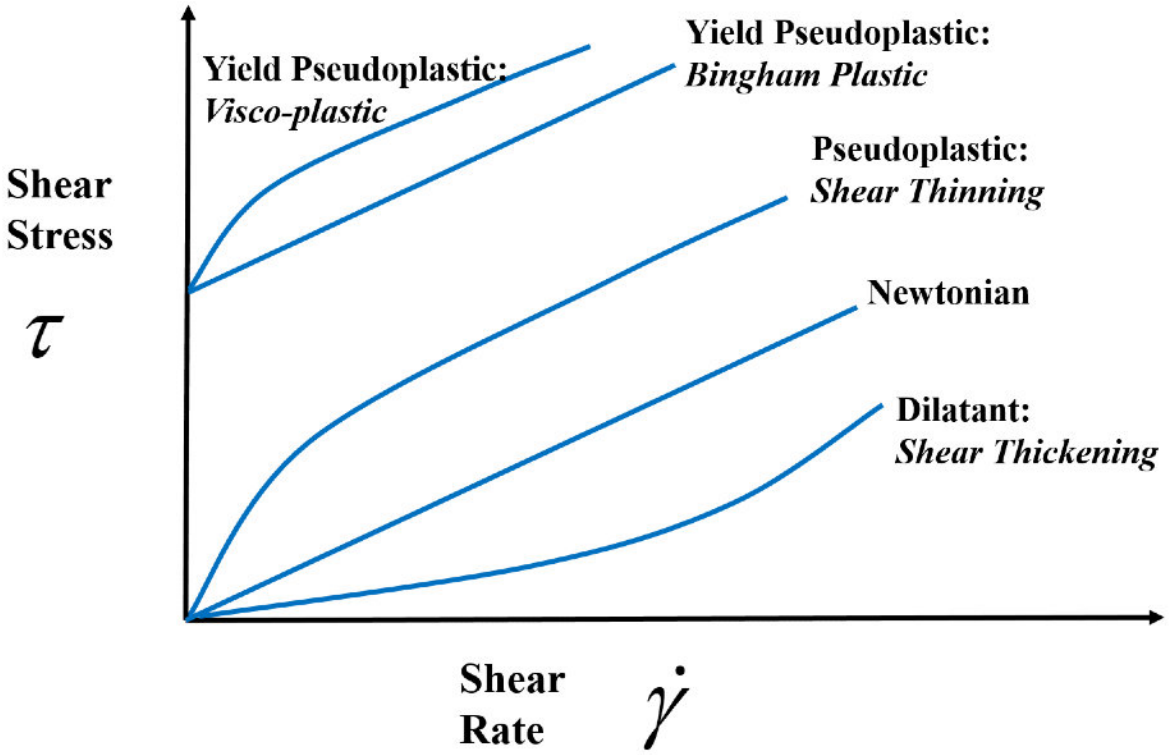
- Define slurrys and their characteristics
- Compare and Contrast Newtonian vs non-Newtonian liquids
- Explain Critical Velocity as a desired flow speed
- List Common Pumps specialized for slurry flow
- List Valves specialized for slurry flow
- List good practices in slurry pipe routing

What is a Slurry?

- Slurry: Mixture of solids and liquid, generally water
- Why Slurries?
  - Pump a medium where abrasive particles are present
  - Transport as much solids as possible, hydraulically
  - Pump the end product in a process

Newtonian vs Non-Newtonian Fluids
(Diagram: Jose A Sorrentino, Wikimedia Commons)

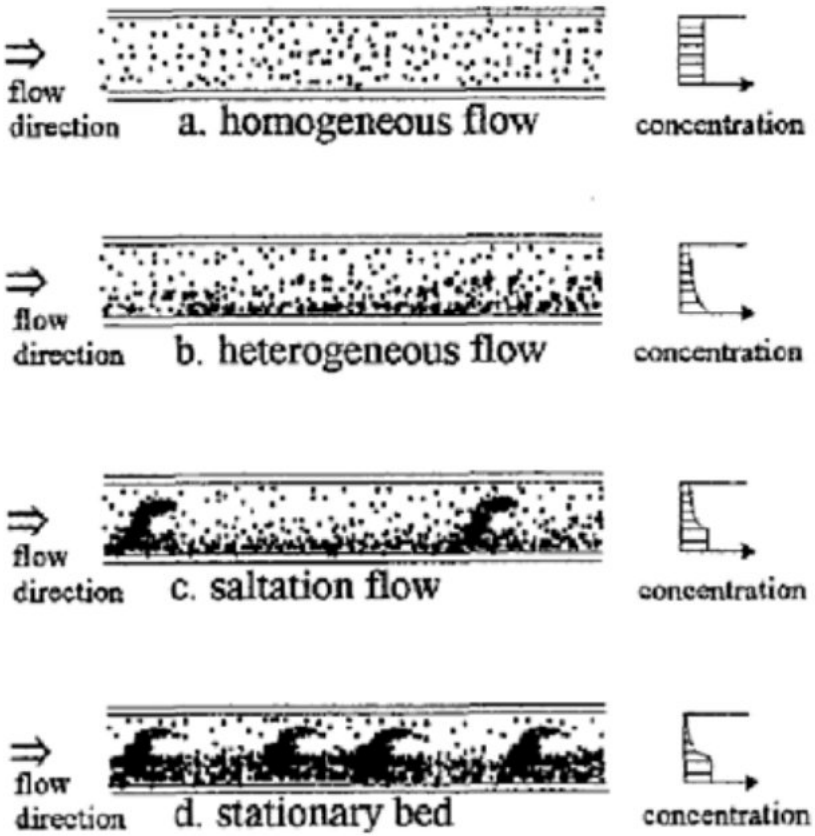
- Newtonian
  - Shear Stress Proportional to Shear Rate
  - Viscosity is constant
  - Easy to Model
- Non-Newtonian
  - Certain Liquids
  - Most Slurries

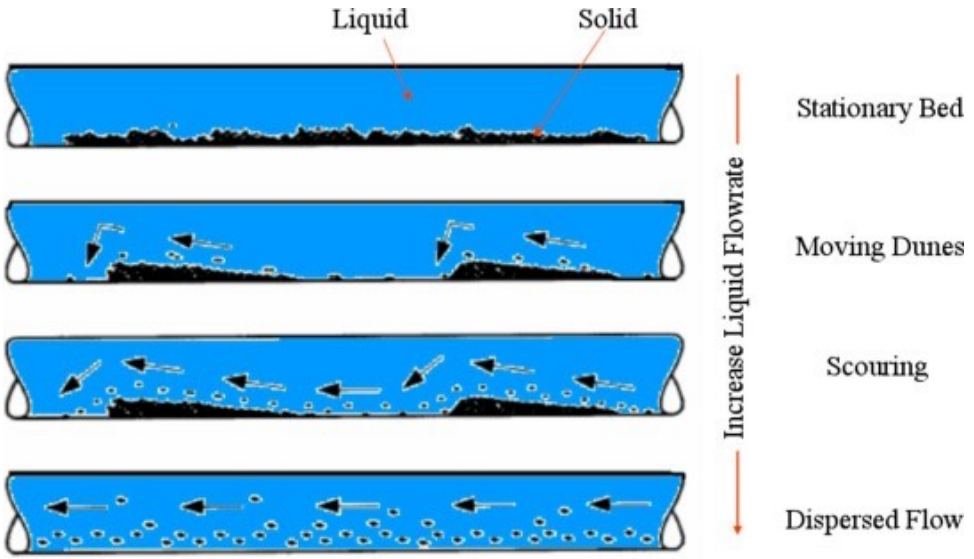


Non-Newtonian fluid
(Source: Ciacho5, Wikimedia Commons)

- mixture of water and potato starch
- *more viscous as you increase shear - a dilatant fluid*

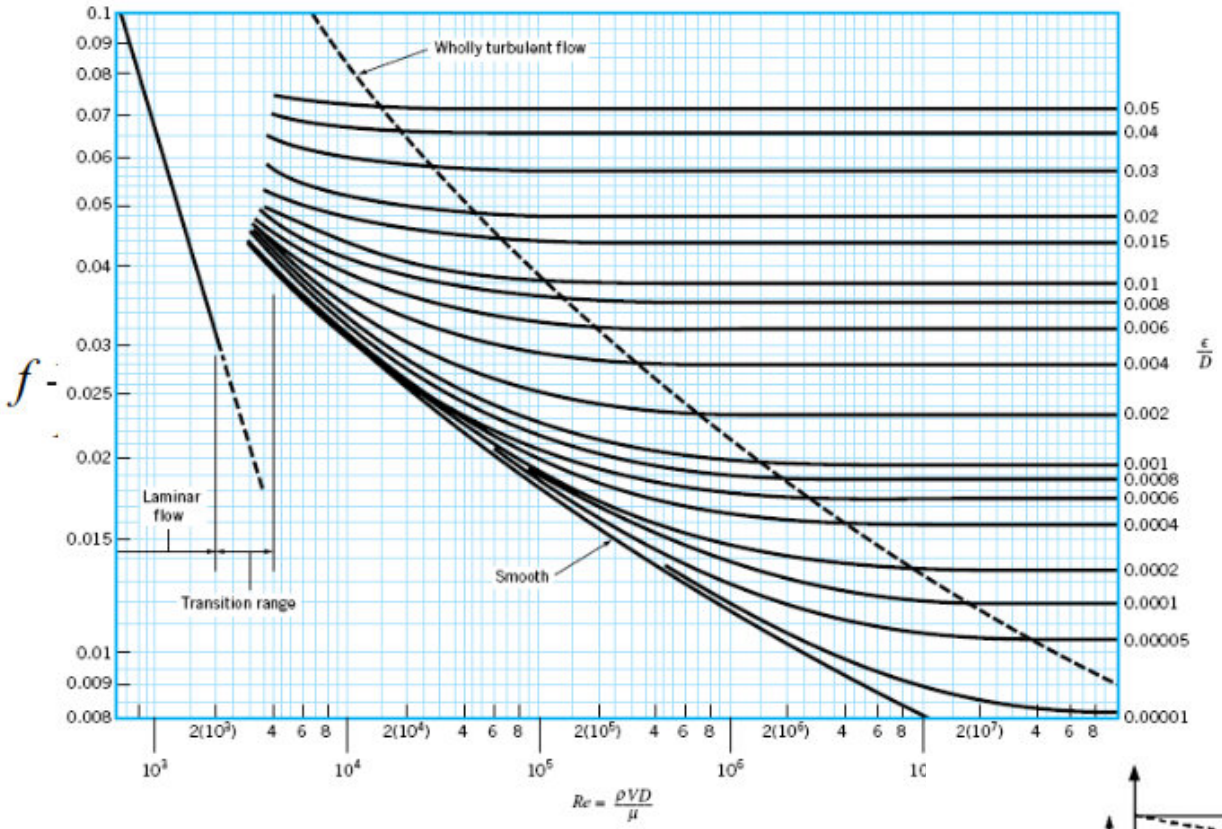
Slurry Flow





Regimes of slurry flow

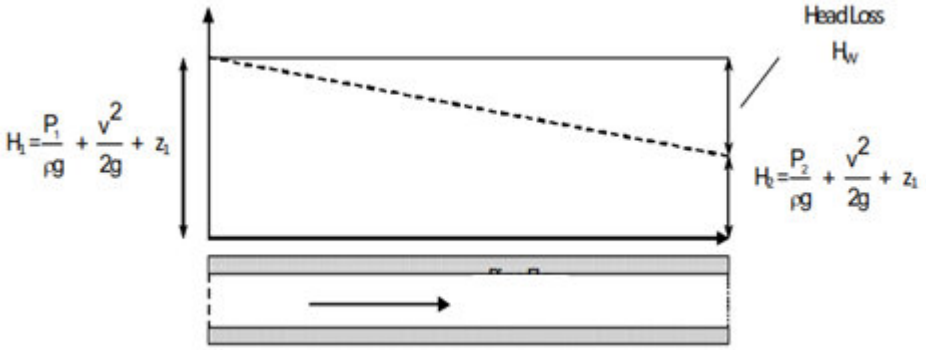
No Slurry Flow (Newtonian Liquids)



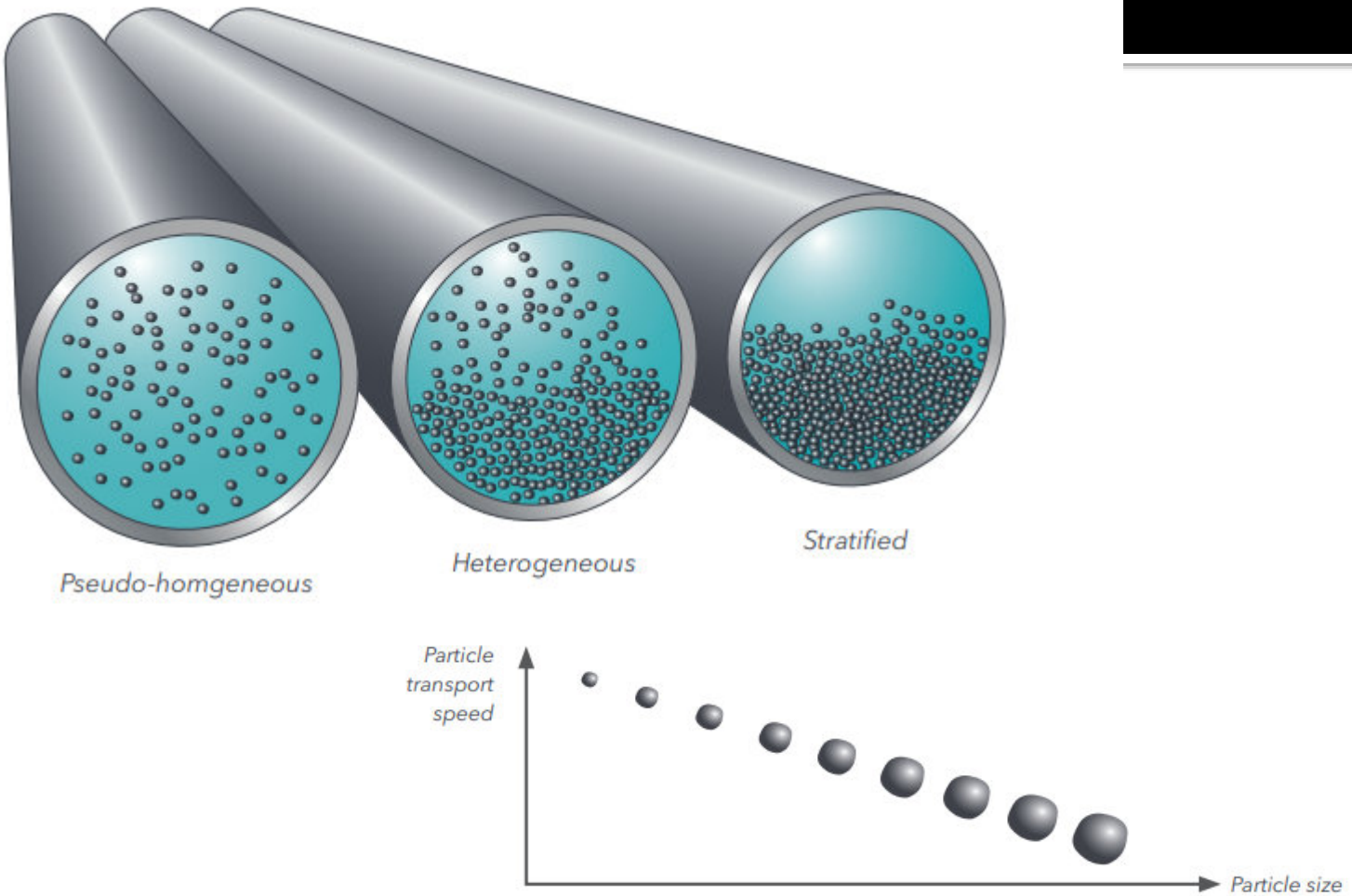
$$H_W = \frac{\Delta P}{\rho g} = f \frac{L}{D} \frac{V^2}{2g}$$

Darcy-Weisbach equation

H_W	=	head loss due to friction	(m)
f	=	friction factor	(dimensionless)
L	=	length of pipe	(m)
D	=	internal diameter of pipe	(m)
g	=	accelaration due to gravity	(m^2/s)
V	=	mean Flow velocity	(m/s)

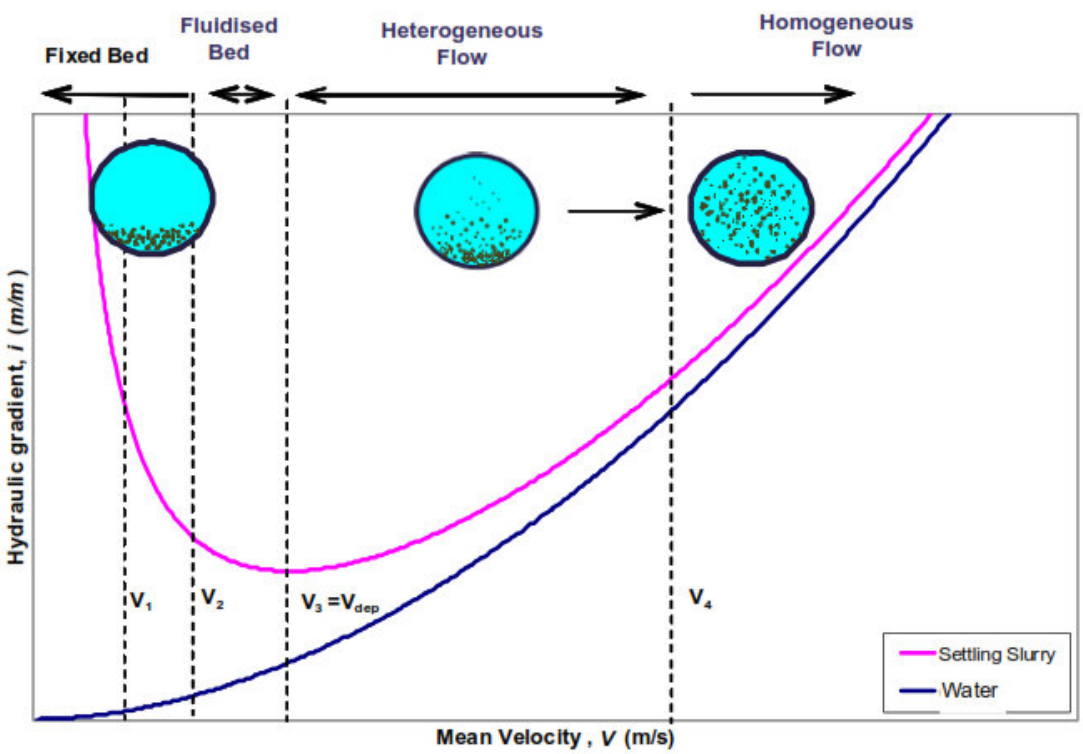


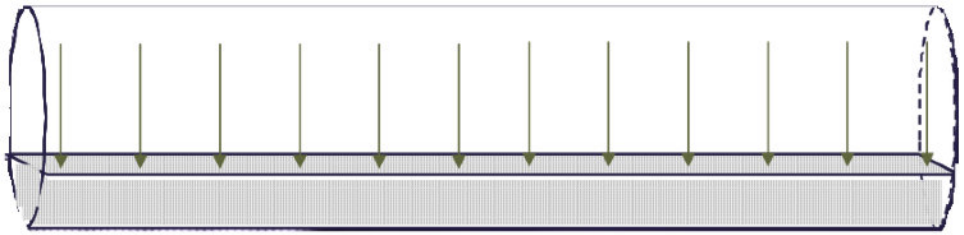
Slurry Flow



Regimes of slurry flow (source: FLYGT)

Slurry Flow





- Size does matter
  - Large particles require increased transport velocity
  - Smaller particles (particularly fines < 40 µm) can modify viscosity. Helps to suspend large particles
- Flow velocity generates turbulence which keeps particles suspended
- The system curve has a mínimum that bounds different Flow/friction processes

Correlation theories are used to calculate loss head
Durand 1952
Wilson Addie & Clift 1997
.....

Slurry Flow Problems: Sanding (Photo: KSB, Inc.)

- **Sanding**

Particles or solids accumulate in a pipeline which in turn reduces the pipe cross section area

An accumulation of sanding can result in lower flow rates

The reduction in pipe cross section area from sanding results in a lot of energy being transferred to a small volume in the system pump. Over time, the carrier fluid or liquid will boil and the resultant steam can become pressurized.

https://giw.ksb.com/blog/clogged-slurry-pipeline-learn-how-to-prevent-sanding

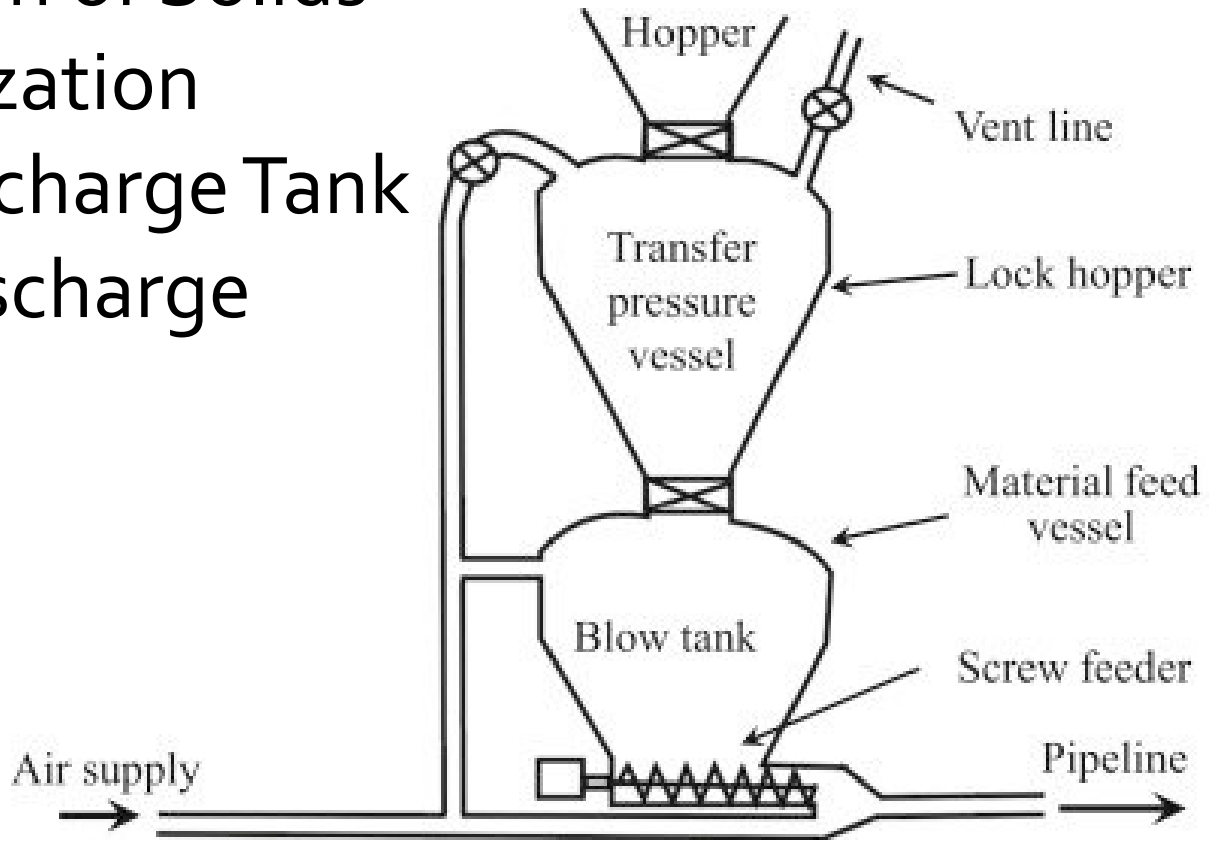
Flushing out Sanding (Video: KSB, Inc.)

(source: KSB)

https://giw.ksb.com/blog/clogged-slurry-pipeline-learn-how-to-prevent-sanding

Injecting Solids into Fluids - Lock – Hopper (Source: David Mills)

- Hopper addition of Solids
- Batch Pressurization
- Transfer to Discharge Tank
- Continuous Discharge

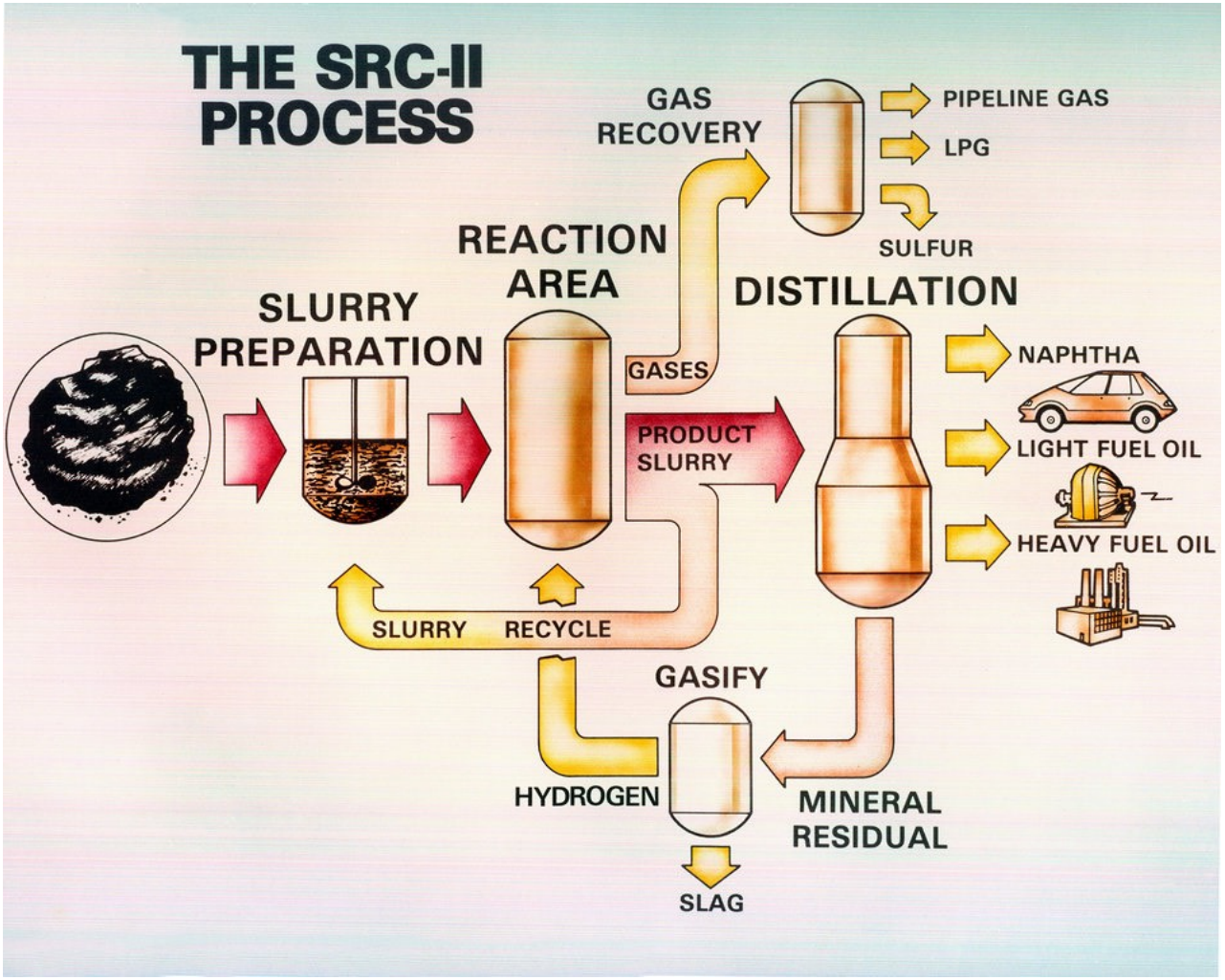


https://www.sciencedirect.com/book/9780081006498/pneumatic-conveying-design-guide

Concrete Mixing Plant
(Source: Brian Knox, Wikimedia Commons)

https://commons.wikimedia.org/wiki/File:Concrete-plants.jpg

Gassification Using Oil/Coal Slurry (Source: US DoE)



http://www.publicdomainfiles.com/show_file.php?id=14002905019585

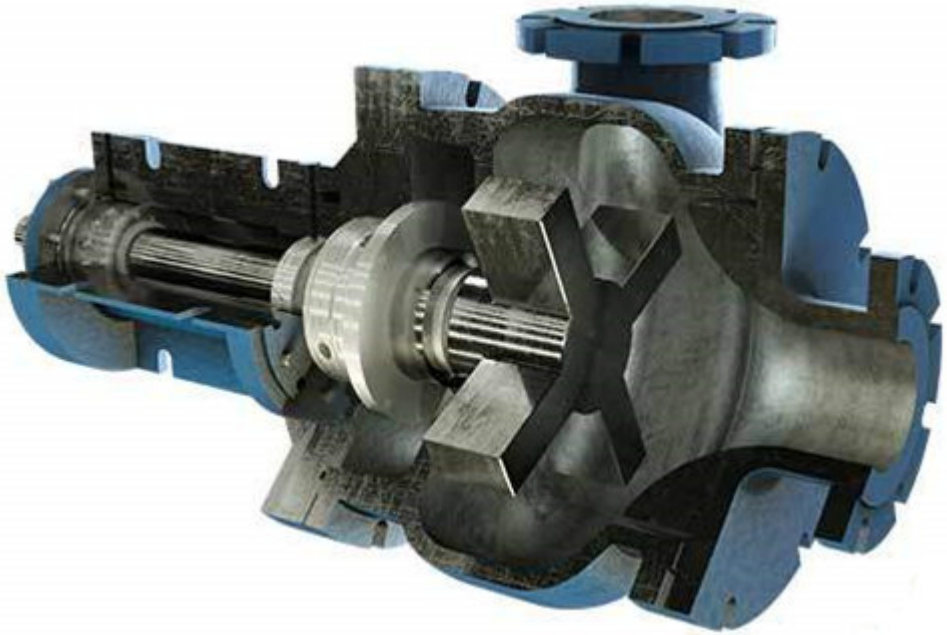
Slurry Pump Types

- **Centrifugal** - For very dilute Slurries
- **Positive Displacement (Plunger/piston type)** - For high discharge pressure (about 40 bar) and/or abrasive Slurries
- **Lock-hopper system** - For Slurries of coarse particles.
- **Diaphragm pumps** – For lower flows at low delivery pressure (Typically up to 1000 1pm, up to 3 bar)
- **Moyno pump ("advancing cavity") -** For moderate flows and at steady pressure, well suited for thick slurries.

Slurry Pumps

Slurry Pumps (source: KSB)

Slurry Pumps

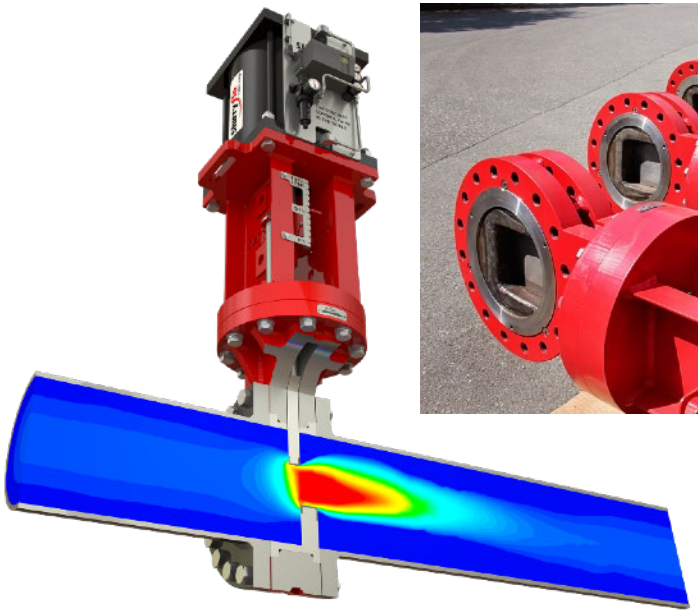


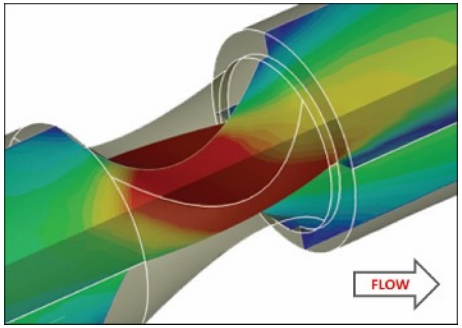
Abrasive Resistant Pumps (source: EddyPumps)

Slurry Centrifugal Pump Special Features (Source: FLYGT Pumps)

- Pump parts
  - designed to be in direct contact with the slurry
  - subject to wear by the slurry's solid particles.
- Impeller designed to smooth accelerate flows
- Volute designed to favor tangential flow
- Emersion in slurry favored for extra cooling
- Extra features on seals for long life
- Agitators to re-suspend settled particles

Heavy duty slurry valves





(source: Metso)

(source: Slurryflo)

Piping considerations with Slurry Flow

- **Short and Direct Routes** - Preferrable to relocate equipment to relocate lines, to avoid Stress problems).
- **Minimize changes of direction to Avoid Wear**.
  - Elbows should 5D or greater.
  - Y Branching over Tees
- **Eliminate all dead spots** where solids can accumulate.
  - Install valves in horizontal.
  - In manifolds, locate valves as close as possible to the manifold.
  - FOB Eccentric Reducers
- **Branches and Instruments from Fluid Space**
  - Locate steam and cleaning oil bleed connections at the top of the lines.
  - Fluid Filled Diaphram Pressure Gauges
- **Cleaning allowing for Solids Buildup**
  - Drain end point (long lines). Ensure that those lines can be properly cleaned.
  - Flushing connections shall be located at a minimum distance from the origin of the Slurry line.

Piping mistakes with Slurry Flow

1. Routing based on achieving valve accessibility.
2. Use connections for “Y” branches.
3. Locate drains at the bottom of the lines.
4. Route two or more drain lines to a common collector.
5. Use “Rodding out” connections.
6. Lines with pockets.