Pump Types
Learning Objectives

• Review different pump types commonly used
• Understand the difference between centrifugal pumps and positive displacement pumps
• Understand the working principle of the Tuthill PD pump types
Basic Pump Types

Two Main Pumping Principles

Centrifugal

Positive Displacement
Basic Pump Types

Centrifugal Pumps

- Develop pressure by increasing the velocity of the liquid
- Liquid is literally flung out of the cutwater

Positive Displacement Pumps

- Allow liquid to flow into an open cavity
- Trap the liquid in the pump
- Transport liquid from the suction to discharge port
- Mechanically force liquid out of the pump
Hierarchy

Types of PD Pumps Available

- Pumps
  - Positive Displacement
    - Rotary
      - Multiple Rotor
        - Gear
        - Lobe
        - Circumferential Piston
        - Screw
      - Single Rotor
        - Vane
        - Piston
        - Progressing Cavity
        - Screw
        - Peristaltic
    - Dynamic
      - Reciprocating
  - Reciprocating
    - Diaphragm
    - Simplex Multiplex
    - Fluid Operated
      - Mechanically Operated
  - Piston, Plunger
    - Power
    - Single Acting
      - Double Acting
    - Simplex Duplex
    - Triplex Multiplex
    - Simplex Duplex
    - Steam-double acting
Positive Displacement Pumps

• Wide variety of types and styles of PD pumps

• All operate on the principle of filling, trapping, transporting, and forcing out
Tuthill Positive Displacement Pumps

- **GlobalGear®**: Internal Gear
- **LubeTech**: Internal Gear
- **HD**: Circumferential Piston
- **Mini Magnetically Coupled**: External Gear
External Gear Action View
Internal Gear Pump Action View
Internal Gear Pumps

Two Working Parts

• Rotor and Shaft
• Idler Gear
Internal Gear Pumps

• Crescent is attached to pump head

• Crescent is stationary and separates the rotor and idler teeth, providing the pumping cavities during operation
Applications

• Asphalt
• Adhesives & Glues
• Lubricants & Greases
• Paints, Coatings, Resins, and Print Inks
• Polymers, Plastics, and Synthetic Rubber
• Soaps, Surfactants, and Personal Products
• Starch, Liquid Sugars, Vegetable Oil, & Chocolate
Versatile Advantages

• Viscosity Ranges from 32 - 1,000,000 ssu
• Temperatures to 600°F (315.6°C)
• Pressures to 200 psi (13.8 bar) Differential
• Moderate Fine Solids Handling Capability
• Brief Period Run Dry Capability
• Only 1 Shaft Seal
• Compact
• Easy to Service
Limitations

• Not a high pressure pump, 200 psi (13.8 bar) differential
• Not a solids handling pump
• Not a FDA/3A sanitary pump
Internal Gear Pumps

Advantages Over External Gear

Only 2 Bushings for Shaft Support vs. 4
Circumferential Piston
Circumferential Piston Pumps

Tuthill HD Line
Applications

• Black Liquor Soap
• Filled Asphalt
• Chocolate
• Rendering
• Plastics and Films
Advantages

- High Pressure Capability, up to 450 psi (31 bar)
- Imparts low shear to the pumped fluid
- Good solids handling capability
- No metal to metal contact between rotors
Disadvantages

- Requires timing gears that makes for higher first cost

- Two or four shaft penetration locations to be sealed
## Alsip Products

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<thead>
<tr>
<th>Line</th>
<th>Performance Envelope</th>
<th>Type</th>
<th>Typical Applications</th>
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<td>Up to 500 GPM</td>
<td>Internal Gear Pump</td>
<td>Chemical Processing</td>
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<td>Up to 200 PSI</td>
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<td>Internal Gear Pump</td>
<td>Lubricant and Circulation OEM Applications</td>
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<td>Up to 500 GPM</td>
<td>Circumferential Piston Pump</td>
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<td><strong>Technaflo</strong></td>
<td>Up to 9 GPM</td>
<td>External Gear Pump</td>
<td>Medical Equipment Metering and Chemical Treatment for Water &amp; Wastewater</td>
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Pump Type Comparisons

With a Centrifugal Pump
Flow Varies with Pressure
Pump Type Comparisons

Positive Displacement Pumps

Produce constant flow that is relatively independent of pressure
Pump Type Comparisons

• Curve bends to left slightly to reflect “slip”
• The fluid that flows through the clearances in the pump from the discharge to the suction of the pump
Comparison of Centrifugal and PD Pumps

PD Flow Rate is Relatively Independent of Viscosity

Flow vs. Viscosity

- PD
- Centrifugal

Viscosity ssu

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Comparison of Centrifugal and PD Pumps

PD Flow Rate is Relatively Independent of Viscosity

Flow vs. Viscosity

PD
Centrifugal

% Maximum Flow

Efficiency

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Why Positive Displacement Pumps?

• Viscosity is higher than 250 cps
• Desire for constant flow, independent of pressure
• Efficiency for low flow, higher pressure combinations
• Self priming capability
• Low cost and compact size for low flow, higher pressure combinations
Gear Pumps vs. Centrifugal

Why Customers Buy Centrifugal Pumps

• Low cost for water like liquids
• Economical for large flows

Centrifugal Pumps - Generally not used on dispensing or metering applications because flow can vary significantly with small changes in differential pressure
Gear Pumps vs. Centrifugal

- Centrifugal Pumps limited to about 200 cps maximum viscosity
- Centrifugal Pumps are inefficient for low flow high head applications
  - Larger HP motors
  - Larger pumps
  - Expensive radial impeller designs
Other Types of PD Pumps
Progressive Cavity Pumps

Rotor turns in stator, moving fluid in and out of the cavities
Operating Principle

Pumping element consists of a metal rotor rotating in an elastomeric stator
Applications

• Yogurt
• Paper Coatings
• Calcium Carbonate for Wallboard
• Caulk Compounds, Viscous Adhesives
• Sludge, Municipal Waste, and Industrial Waste
Advantages

• Low Shear
• Sanitary Designs Available
• Solids Handling Capability
• High Pressure Capability, up to 1000 psi (68.95 bar)
• Handle Very Viscous Liquids up to 1,000,000 cps
Advantages

• Versatility in handling low viscosity and high viscosity liquids, e.g. flushing
• Special designs with augmenters and hoppers available for very viscous liquids
• Mechanical seals are usually placed on the low pressure side of the pump
Limitations

• Intolerant of running dry
• First cost higher than gear
• Foot print is very long and narrow
• Seal-less designs are not available
• Upper end temperature limitation is for practical purposes about 275°F (135 °C)
• No compatible elastomer for solvents and other chemicals
Gear vs. Progressive Cavity Pumps

Tuthill PD Pump Advantages

• Compact Foot Print
• More Material Choices
• First Cost Generally Lower
• More Tolerant of Running Dry
• Seal-Less Designs are Available
• Avoids elastomer compatibility issues for pumping solvents or handling higher temperatures
• Repair costs are generally much lower
On the topic of shear...

When using equivalent pump speeds, gear pumps have comparable shear imparted compared to progressive cavity pumps.
Cavitation

- Cavitation is the formation of “vapor” bubbles at the pump inlet
- When the vapor bubbles return to liquid, the vapor collapses violently...
  >> Implosion
Positive Displacement Pumps

Vane Pumps

Image Courtesy SAE International
Vane Pump Principle

- As the rotor turns the vane moves outward at the intake port creating a void/drawing liquid in
- Fluid is transferred between vanes
- At the outlet, fluid is discharged as pumping chamber is squeezed (and vanes forced back)
Vane Pump Applications

Common Applications

• Tank Car unloading because of the good self priming nature of the pump

Other Applications

• Petroleum Based Fuels
  • Kerosene, Solvents, Alcohols, Ammonia, and Liquefied Gases
3 Forces in Vane Pumps

- Centrifugal Force
- Mechanical Force
- Hydraulic Force
Vane Pumps

- Fluid flow through the pump
- Inlet - Expansion
- Transport - Static
- Outlet - Reduction

Image: Courtesy Blackmer
Limitations

- Abrasive solids are a challenge for vane pumps
- Size of pump increases substantially for viscous liquids
Peristaltic (Tube or Hose) Pumps

Image: Courtesy Pump-Zone.com
Hose Pump Working Principal

- A pulsing flow is generated by the pushing action of shoes on the wall of an elastomeric hose
- Shoes are assembled on a rotating wheel
- Sealing under the shoe is performed by the compression of a local area of the hose
- Friction between shoes and hose is reduced by using a lubricant which also acts as a coolant
Peristaltic Pump Action View
Hose Pumps: Two Types of Pumps

Peristaltic Pumps
Small units generally used in laboratories

Max. Pressure
22 psi (1.5 bar)

Hose Pumps
Process Services

Max. pressure
~200 psi (~13.8 bar)
Hose Construction

- Hose is made by piling layers of rubber material and weaves of synthetic fibers.

- Only 4 to 5 manufacturers worldwide are capable of making these hoses.
Hose Materials

- EPDM
- Hypalon
- NBR (Buna)
- NR (Natural Rubber)
- Teflon® and Viton Not Available
- Not suitable for many solvents and corrosive chemicals
Hose Pump Advantages

• Low Shear
• No Mechanical Seal
• Capable of handling applications with wide ranges of viscosities
• Better than average tolerance for running dry
Hose Pump Advantages

• Self priming pump with high suction lift (up to 29.5 ft./9 Meters of water)
• Appropriate for abrasive products
• Excellent volumetric capacity (dosing)
• Particles up to 15% of hose ID can be pumped (not sharp)
Hose Pump Disadvantages

• The flow has pulsations
• Relatively high first cost compared to other designs
• Frequent hose replacement is required
• Relatively large foot print
• Size is physically larger for higher range of flow rates
Hose Life

Depends On

• Pump RPM
• Differential Pressure
• Typical hose life for 100 psi (6.9 bar) differential pressure may be 1000-2000 hours
Hose Pump Applications

- **Ceramic** - Ceramic Slips, Mould Filling, Filter Press
- **Mining** - Sludge up to 60,000 cps, Clay Slurry up to 6.67 lbs./gal. (800 grams/lt), Lead Sulfate, Pyrite Slurry
- **Water Treatment** - Lime Slurry, Flocculate Dispersion, Sludge, and Slurries
- **Building Industry** – Fibrous Mortar, Liquid Plaster, Light Concrete
- **Chemical Industry** - Acids, Alcohols, Detergent Pumping, etc...
Typical Hose Pump Applications

- **Nuclear** - Contaminated Slurries and Mud, Ammonium Dioxide, Uranyle Nitrate
- **Food Industry** - Tomato Sauce, Mashed Potatoes, Gelatin, Beer Slurries, Fish Paste, and Olive Oil
- **Paint** - Water Base and Acrylic Paint, Pigments, and Wall Coating
- **Filter Press** - Filling and Pressing
- **Paper Industry** - Latex, Slurries, Kaolin, Glue, Liquid Salt, Seed Fertilizer, etc...
Gear Pumps vs. Hose Pumps

Application Overlap

• Water Treatment Chemicals

• Chemical Applications

• Adhesives
Gear Pumps vs. Hose Pumps

Reasons for Peristaltic Pumps

• Low Shear
• Seal-Less
• Self-Priming
• Capability to Handle Thin to Thick Liquids
• Capability to Handle Solids and Abrasives
Gear Pumps vs. Hose Pumps

Consider GlobalGear®

• TuffSeall™
• Self-Priming
• Versatility for thin to thick liquids
• Can be sized and selected for low shear
• Options for fine abrasives handling
Gear Pumps vs. Hose Pumps

Gear Pump Advantages

• Compact & No Pulsations
• No hose ruptures to leak chemicals
• Properly selected, a gear pump will be more reliable and less maintenance intensive
• Handle solvents, hot liquids and many chemicals that cannot be handled with peristaltic pumps
Gear Pumps vs. Lobe Pumps
Lobe Pump Cutaway View
Lobe Pumps

Reasons Why Customers Buy

• FDA or 3A accepted sanitary design

• Low Shear

• Solids Handling
Lobe Pumps - Inside Story

- Many Lobe pumps are sold in industrial applications where low shear is the main criteria, and sanitary construction is not important.
- Properly sized and selected gear pumps can offer the same low shear performance at about half the cost.
- Customer gets an easier to maintain pump:
  - 1 Seal vs. 2 Seals
  - No Timing Gears
  - Easily Rebuilt in the Field
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