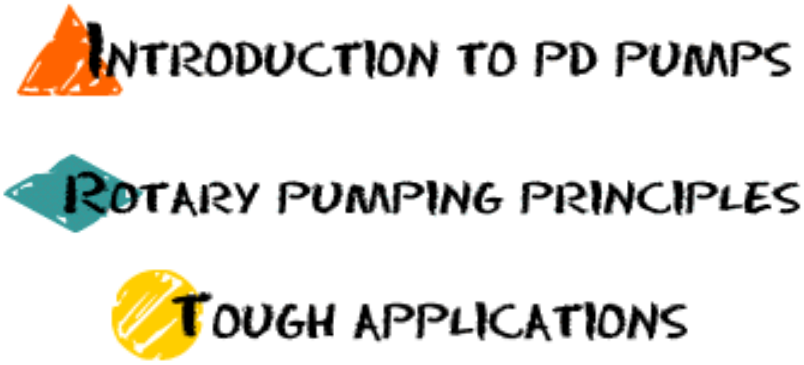
Master Pumps Product Training Session III is an introduction to Positive Displacement (PD) pumps, and in particular, Rotary pumps.



Introduction to PD Pumps

By definition, Positive Displacement (PD) pumps displace a known quantity of liquid with each revolution of the pumping elements. This is done by trapping liquid between the pumping elements and a stationary casing. Pumping element designs include gears, lobes, rotary pistons, vanes, screws and hoses.

Positive Displacement Pump Applications

- Chemical-processing
- Liquid Delivery
- Marine
- Biotechnology
- Pharmaceutical
- Food
- Dairy
- Beverage Processing

Positive Displacement Advantages

- Versatile
- Compact Design
- High-Viscosity Performance
- Continuous Flow Regardless of Differential Pressure
- Ability to Handle High Differential Pressure

Rotary Pump Family Tree

- Positive Displacement (PD) pumps are divided into two broad classifications, Reciprocating and rotary
- PD Pumps displace a known quantity of liquid with each revolution
- PD Pumps displace liquid by creating a space between the pumping elements and trapping liquid in the space
- The rotation reduces the size and space and moves the liquid out of the pump

- PD Pumps handle fluids up to 1,320,000 centistokes or 6,000,000 SSU (Refer to page 611 in the 2008 Master Pump Catalog)
- Capacities up to 1,150 M^3 / HR / 5,000 GPM
- Pressures up to 700 BAR / 10,000 PSI

Rotary Pumps are self-priming and deliver a constant, smooth flow regardless of pressure variation.

Internal Gear 

- Carries fluid between the gear teeth from the inlet to outlet ports
- The outer gear (rotor) drives the inner or idler gear on a stationary pin
- The gears create voids as they come out of mesh and liquid flows into the cavities
- The volume is reduced and the liquid is forced out of the discharge port as they come back into mesh
- The crescent prevents liquid from flowing backwards from the outlet to the inlet port

CAN YOU NAME ONE?

External Gear

- Use gears which come in and out of mesh
- As the teeth come out of mesh, liquid flows into the pump and is carried between the teeth and the casing to the discharge side of the pump
- The teeth come back into mesh and the liquid is forced out the discharge port
- Rotate two identical gears against each other
- Both gears are on a shaft with bearings on either side of the gears

CAN YOU NAME ONE?

Vane 

- Other names for a Vane; Blades, Buckets, Rollers, or Slippers
- Work with a cam to draw fluid into and force it out of the pump chamber
- May be located in either the rotor or stator
- Vane in rotor may be made with constant or variable displacement pumping

CAN YOU NAME ONE?

Flexible Member

- Similar to the Vane Principle except the vanes flex rather than slide
- Fluid pumping and sealing action depends on the elasticity of the flexible members
- Flexible members may be tube, vane or a liner

CAN YOU NAME ONE?

Lobe

- Fluid is carried between the rotor teeth and pumping chamber
- The rotor surfaces create continuous sealing
- Gears are driven and synchronized by timing gears
- Rotors include bi-wing, tri-lobe and multi-lobe

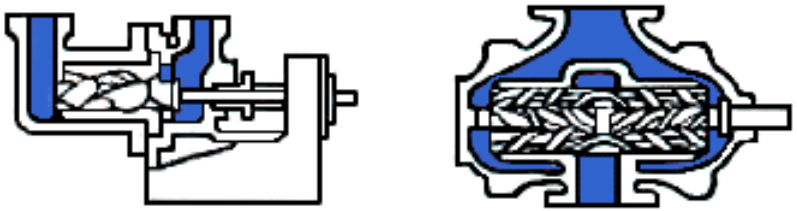
CAN YOU NAME ONE?

Circumferential Piston

- Fluid is carried from inlet to outlet in spaces between piston surfaces
- Rotors must be timed by separate means
- Each rotor may have one or more piston elements

CAN YOU NAME ONE?

Screw



- Carries fluid in the spaces between the screw threads
- Fluid is displaced axially as the screws mesh
- Single screw pumps are commonly called progressive cavity pumps
- Contain a rotor with external threads and a stator with internal threads
- Rotor threads are eccentric to the axis of rotation
- Multiple screw pumps have multiple external screw threads

CAN YOU NAME ONE?

Differences Between a Centrifugal or Positive Displacement Pump

- The Centrifugal has varying flow depending on pressure or head
- The Positive Displacement (PD) has more or less constant flow regardless of pressure
- The Centrifugal loses flow as the viscosity goes up
- The PD actually increases flow due to the thickening of the product

Differences Between a Centrifugal or Positive Displacement Pump (continued)

- Changes in pressure have little effect on a PD
- Changes in pressure have a dramatic effect on a Centrifugal
- NPSHr in a Centrifugal varies with flow which is determined by pressure
- NPSHr in a PD varies with flow which is determined by speed

Differences Between a Centrifugal or Positive Displacement Pump (continued)

- Centrifugal perform their best in the center of the curve
- PD can operate on any point of the curve
- Centrifugal is very inefficient at even modest viscosity
- PD is very efficient with high viscosity applications

Differences Between a Centrifugal or Positive Displacement Pump (continued)

- More horsepower is required to operate a Centrifugal outside of its BEP (Best Efficiency Point)
- A PD is a better choice when further away from its BEP
- Centrifugal will “walk” up/down the curve which can cause process problems
- PD is very efficient with variable pressure conditions

Differences Between a Centrifugal or Positive Displacement Pump (continued)

- If there is changing viscosity in the application the PD is the best choice
- PD pumps can produce more pressure than Centrifugal
- PD create a vacuum on the suction side so they are capable of creating a suction lift
- Centrifugal doesn’t create a vacuum so it can’t lift liquid into the suction port

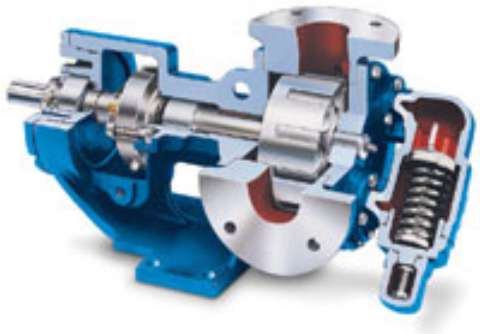
Differences Between a Centrifugal or Positive Displacement Pump (continued)

- PD pump seals tend to last longer than Centrifugal pump seals
- Centrifugals are more efficient in high flow conditions
- PD pumps are very well suited for low flow conditions

Comparing 4 Types of PD Pumps

- Internal Gear
- External Gear
- Lobe
- Vane

Internal Gear Pump



- Ideal for high viscosity applications and where suction conditions call for minimal inlet pressure requirements
- Speed is relatively slow compared to Centrifugal types – 1,150 rpm up to 3,450
- Can handle viscosities above 1,320,000 cST / 6,000,000 SSU as well as very low, ex. liquid propane and ammonia
- Made to close tolerances and are damaged when pumping large solids

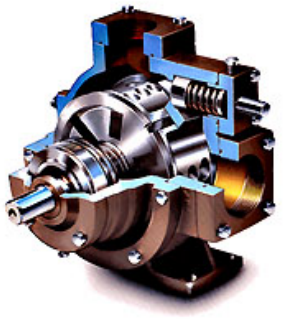
External Gear Pump

- Similar in pumping action to Internal Gear pumps in that two gears come into and out of mesh to produce flow
- Ideal for high pressure applications such as hydraulics
- Smaller versions operate between 1,750 and 3,450 rpm and larger versions at speeds up to 640 rpm
- Design allows them to be made to closer tolerances
- Can handle viscous and watery-type liquids
- Does not perform well under critical suction conditions

Lobe Pump

- Similar to External Gear pumps in operation, except the pumping elements or lobes to not make contact
- Handles low viscosity liquids with diminished performance
- Loading characteristics are not as good and suction ability is low
- Ideal for food applications because they handle solids without damaging the pump

Vane Pump



- Operate quite differently from Gear and Lobe types
- Operates between 1,000 and 1,750 rpm
- Frequently used with low viscosity non-lubricating liquids such as propane or solvent
- Has better dry priming capability than other PD pumps

Positive Displacement Pump Characteristics

Internal Gear Pump

Advantages

- Two moving parts
- One stuffing box
- Positive suction, non-pulsating discharge
- Ideal for high viscosity liquids
- Constant and even discharge regardless of varying pressure conditions
- Low NPSH required
- Easy to maintain

Disadvantages

- Low speeds usually required
- Medium pressure
- One bearing runs in pumped product
- Overhung load on shaft bearing

Applications
Internal Gear Pump

- Barge, Tanker, Terminal Loading/Unloading
- Filtering
- Circulating
- Transferring
- Lubricating
- Booster
- General Industrial
- Marine
- Petrochemical
- Light, Medium or Heavy-Duty Service

Positive Displacement Pump Characteristics

External Gear Pump

Advantages

- High speed
- Medium pressure
- No overhung bearing loads
- Relatively quiet
- Design lens itself to use of a wide variety of materials

Disadvantages

- Four bushings in liquid area
- Four stuffing boxes
- No solids allowed
- Fixed end clearances

Applications
External Gear Pump

- Industrial and Mobile
- Fuel and Lubrication
- Metering
- Mixing and Blending
- Hydraulic
- OEM Configurations
- Precise Metering
- Low-Volume Transfers
- Light or Medium Duty

Positive Displacement Pump Characteristics

Lobe Pump

Advantages

- Pass medium solids
- No metal-to-metal contact
- Superior CIP/SIP capabilities
- High acceptance
- Little galling possibility
- Positive suction, non-pulsating discharge

Disadvantages

- Timing gears
- More space required
- May require factory service to repair
- Two seals
- Reduced lift with thin liquids

Applications

Lobe Pump

Has Metering Capabilities

- Food Processing
- Beverages
- Dairy Produce
- Personal Hygiene Products
- Pharmaceutical
- Biotechnology
- Chemical
- Industrial
- Medium and Heavy Duty Cycles

Food and Cosmetic Product Examples

Alcohol	Cream	Molasses	Soup
Baby Food	Custard	Mussels	Starches
Batter	Egg Yolk	Mustard	Sugar
Beans	Fish	Olive Oil	Syrup
Beer	Gelatin	Onions	Tea
Caramel	Gravy	Pastes	Ketchup
CottageCheese	Hand Cream	Peanut Butter	Toothpaste
Cat Food	Honey	Perfumes	Vegetables
Cherries	Jelly	Soap	Yeast
Chocolate	Mascara	Solvents	Yogurt

Positive Displacement Pump Characteristics

Sliding Vane Pump

Advantages

- Medium capacity
- Medium speed
- Thin liquids
- Sometimes preferred for solvents, LPG
- Can run dry for short periods
- Can have one seal or stuffing box
- Develops good vacuum

Disadvantages

- Can have two stuffing boxes
- Medium pressure
- Complex housing
- Not suitable for high viscosity
- Not good with abrasives

Applications

Vane Pump

- Aerosol/Propellants
- Aviation Service (Fuel Transfer, Deicing)
- Auto Industry (Fuels, Lubes, Coolants)
- Barge Unloading
- Bulk Transfer of LPG and NH_3
- Chemical Process
- LPG Cylinder Filling
- Ethanol/Alcohol Refining
- Fertilizer Production
- Lubrication Blending (Solvents, Oils)

Applications
Vane Pump

- Mobile Transport (Chemicals, Fuel, LPG, NH_3)
- Petroleum Industry (Crude Oil, Hydrocarbons)
- Power Generation (Fuels, Lubrication)
- Pulp and Paper
- Railroad Transfer (Fuels, Lube Oils, Coolant)
- Refrigeration (Freons, Ammonia)
- Rubber and Plastic
- Seed Refining (Solvents, Oils)
- Solvent Distribution
- Textile

Pump Selection Guide

	Abrasives	Thin Liquids	Viscous	Solids	Dry Prime	Diff. Pressure
Internal Gear	**G**	**G**	**E**	**P**	**A**	**G**
External Gear	**P**	**G**	**G**	**P**	**A**	**E**
Lobe	**G**	**A**	**E**	**E**	**A**	**G**
Vane	**P**	**E**	**A**	**P**	**G**	**A**

E = Excellent, G = Good, A = Average, P = Poor

Rotary & Centrifugal Pumps

- Rotary pumps operate in a circular motion and displace a constant amount of liquid with each revolution of the pump shaft

- Centrifugal pumps differ from rotary pumps in that they rely on kinetic energy (centrifugal force) rather than mechanical means to move liquid

Comparisons Between Rotary and Centrifugal Pumps

	Rotary	Centrifugal
Max. Viscosity (cSt / SSU)	1,320,000 / 6,000,000	550 / 2,500
Max. Capacity (M^3/Hr / GPM)	750 / 3,300	27,250 / 120,000
Pumping Efficiency	E	A
Energy Costs	E	A
Self-Priming	Yes	No
Flow Control	E	P
Life-Cycle Cost	G	G
Initial Cost	A	E

E = Excellent, G = Good, A = Average, P = Poor

Quick Reference Liquid Guide

High-Viscosity Liquids

- Internal gear pumps

Sanitary Liquids

- Lobe pumps work well for most food, beverage, pharmaceutical and biotechnology applications

Solids

- Lobe pumps for food-type applications
- Internal Gear pumps for slurries and other industrial-type solids

Quick Reference Liquid Guide (continued)

Corrosive Liquids

- Composite external gear pump
- Stainless steel internal gear pump

Abrasive Liquids

- Internal gear pump with hardened steel parts

Toxic, Hazardous or Hard-To-Seal Liquids

- Magnetically-driven or mechanically sealed internal or external gear pump

Extreme Temperature Conditions

- Internal gear with jacketing cooling

ROTARY PUMPING PRINCIPLES

Rotary pumps are used in a wide range of applications – liquids, slurries, and pastes. Since they displace a known quantity of liquid with each revolution of the pump shaft, they are ideal for metering applications. They can accommodate high viscosity liquids, high pressures and high capacities.

Internal Gear Pump

- Well-suited for a wide range of viscosity applications due to their relatively low speeds
- Speed is relatively slow compared to Centrifugal types – 1,150 rpm up to 3,450
- Can handle viscosities above 1,320,000 cST / 6,000,000 SSU as well as very low, ex. liquid propane and ammonia
- Made to close tolerances and are damaged when pumping large solids

TOUGH APPLICATIONS

Not all applications are created equal. Elevated temperatures, increased pressures, abrasion, corrosion, increased capacities, and high viscosity liquids are a few problems fluid handling engineers may encounter. Rotary pumps are versatile and can be adapted to overcome such challenges.

- Abrasion and Corrosion
- Adhesives
- Fuel and Fuel Oil
- High Temperatures
- Liquid Containment

Abrasion and Corrosion

Abrasion

- Abrasive liquid is one that has particles in it
- Abrasive particles promote pump wear
- Abrasion causes uneven wear
- Reduction in wear can be reduced by lowering the speed at which the pump is operating
- Reduction in wear can be reduced by keeping the differential pressure at 60%
- Common in paint and coating industries

Abrasion and Corrosion

Corrosion

- Is a chemical reaction
- Corrosive liquids attack the materials the pump is constructed of
- Corroded parts show even wear and pitting
- Reduction in wear can be reduced by operating at lower temperatures
- Lower differential pressure will reduce the amount of slippage
- Common in the chemical and paper industries

Adhesives

- Will vary in corrosive, abrasive, viscosity and shear-sensitive properties
- Not overly corrosive
- Stainless steel provides protection against acidic and alkaline liquids
- Lowering the temperature will help reduce the corrosion
- Iron and ceramic bushings offer corrosion resistance

Fuel & Fuel Oil

- Reliable handling is critical for heating and transportation systems
- Use slower speeds, lower pressure and materials designed for the correct temperature
- Rotary pumps are ideal for loading/unloading, transfer and circulating fuel oil

Capacities:	.23 to 230 + M^3 / H	1 to 1,000 +GPM
Pressures:	1.75 to 175 BAR	25 to 250 PSI
Viscosities:	6.6 to 1,650 cSt	30 to 7,500 SSU
Temperatures:	Outdoor ambient to 120°C	Outdoor ambient to 250°F

High Temperatures

- More prevalent in the fluid handling industry
- An application is considered high in temperature when operating at temperatures above 110°C/ 250°F
- Pumps intended for ambient temperatures are not recommended

Liquid Containment

- Emphasis on decreasing leakage of pollutants in the industrial setting
- Effects the air, ocean and ground water
- Current seal focus is on centrifugal pump principles because they dominate the market
- Positive displacement pumps pose sealing issues since they are designed to handle viscous, non-Newtonian fluids under a wide range of physical conditions

QUESTIONS?

Please feel free to ask your instructor for today, Master Don Moilan