How Rotary Pumps Complement Reciprocating Pumps

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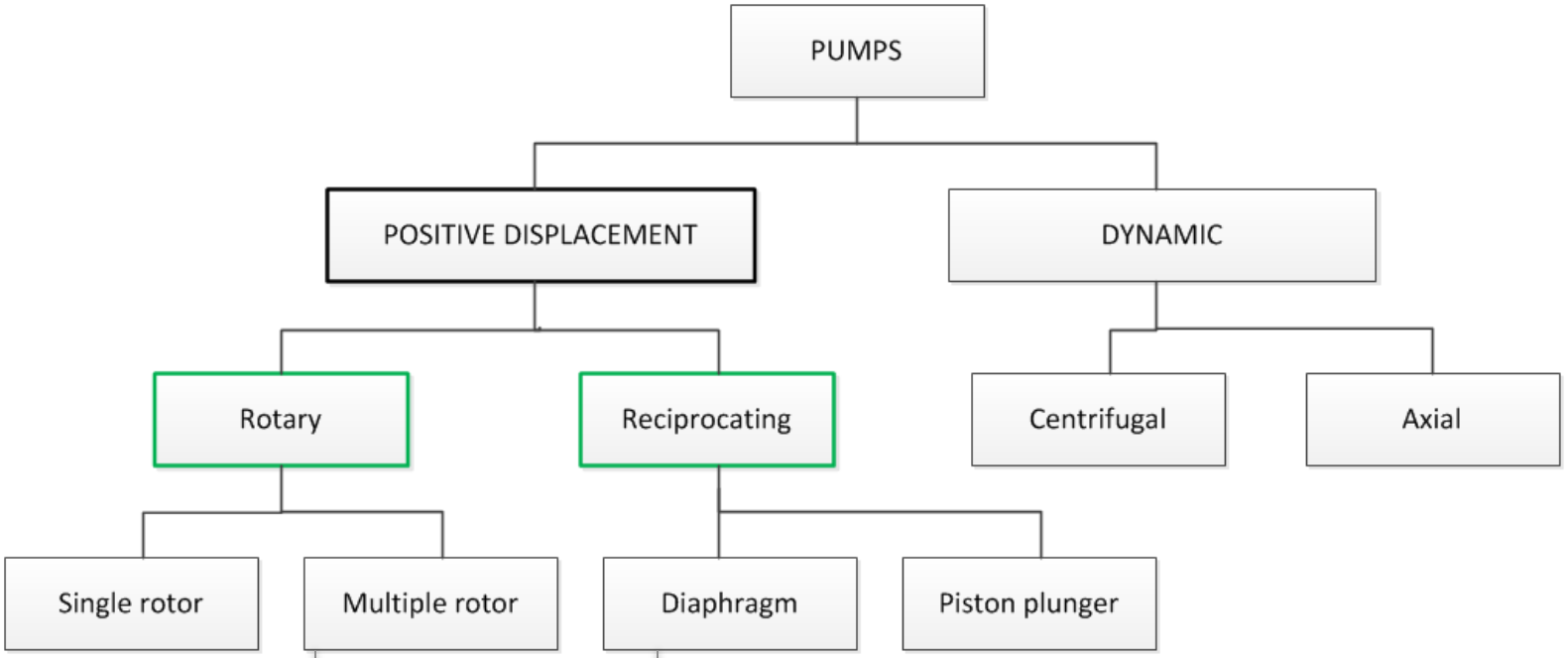
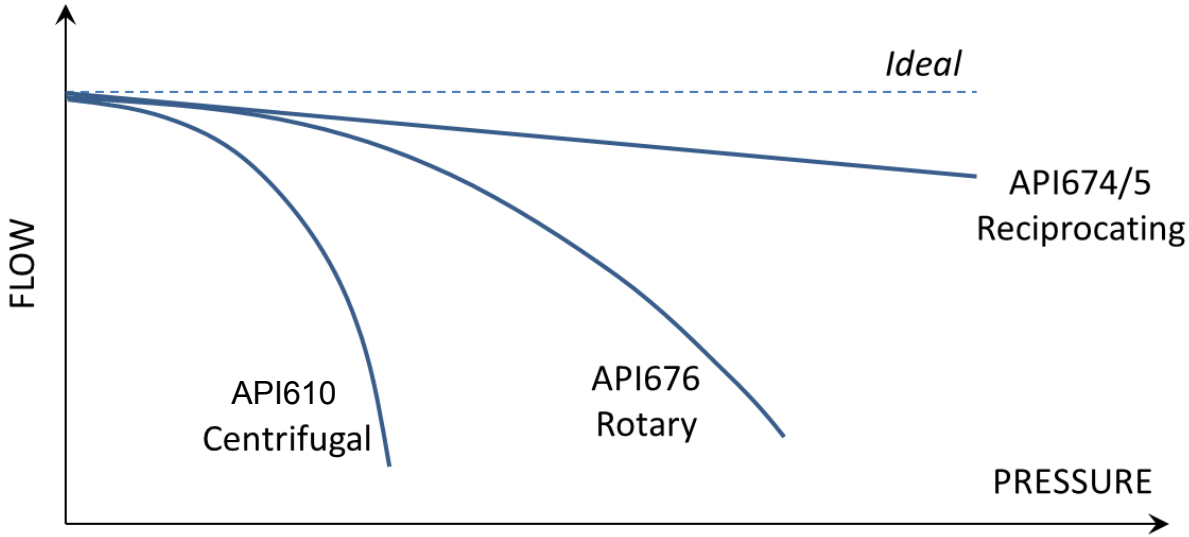
PUMPS&SYSTEMS

Pump classification



Positive displacement pumps

- A positive displacement pump makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe
- Unlike roto-dynamic pumps, positive displacement pumps theoretically produce the same flow at a given speed (RPM) no matter what the discharge pressure
- Positive displacement pumps are **constant flow machines**. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate.

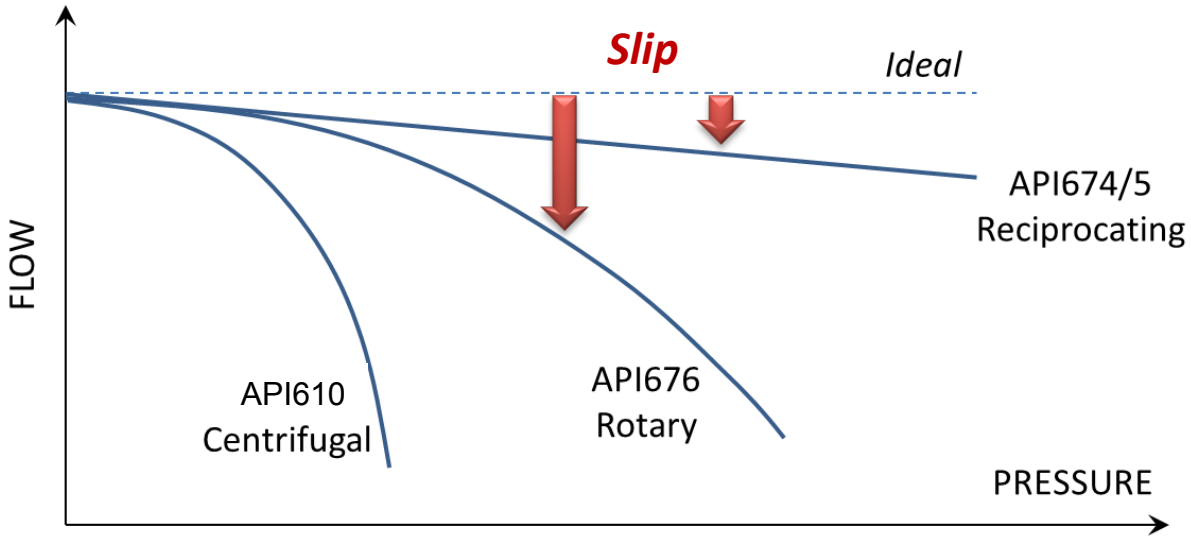


*(*) **API** stands for American Petroleum Institute. Mainly used in Petroleum, Chemical Processing, and Oil&Gas Industry. Describes and specifies constructional design, qualification criteria, and how pumps and documentation shall be executed.*

Positive displacement pumps

- A positive displacement pump has a phenomenon known as **"slip",** which is the recirculation of the pumped fluid from the discharge side of the pump back to the suction side of the pump. The amount of slip is affected by the system discharge pressure requirement and the fluid viscosity. As the discharge pressure increases, it will force more fluid from the discharge to the suction side of the pump.

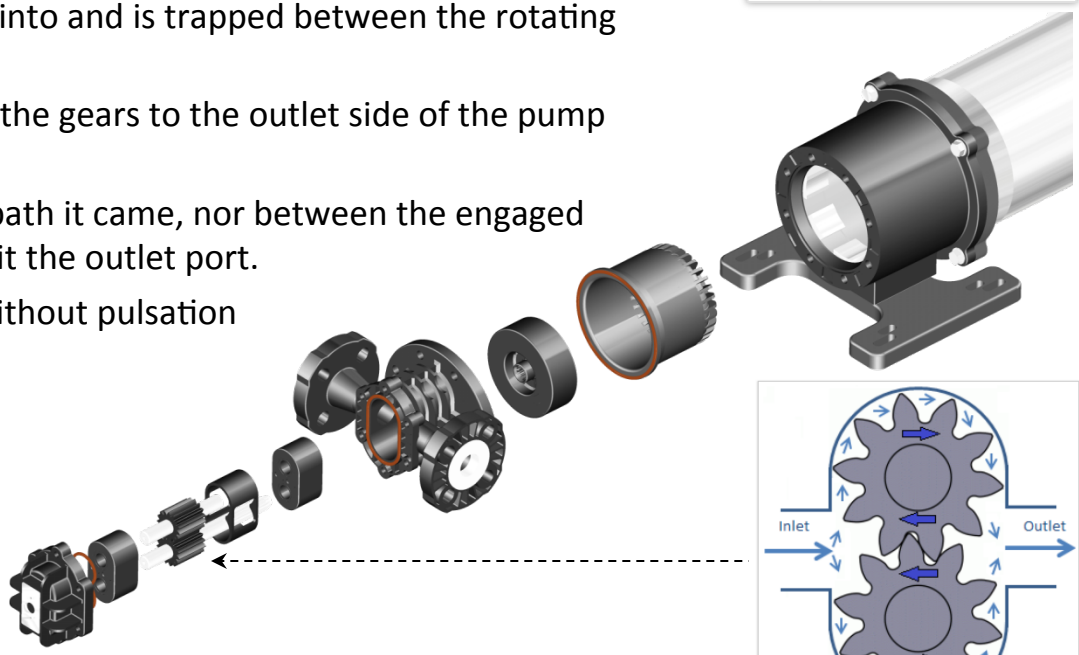
- And as the fluid viscosity increases, the amount of slip will decrease due to the fact that it is more difficult for a high viscosity fluid to slip back through the clearance in a pump than a thin fluid.



External gear pumps

Working principle

- Two gears side by side, external to each other
- One of the two shafts is driven by the motor
- The gear mounted to this shaft (driving gear) engages the other gear (driven gear)
- The fluid on the inlet side (suction) flows into and is trapped between the rotating gear teeth and the housing
- The fluid is carried around the outside of the gears to the outlet side of the pump (discharge)
- As the fluid can not seep back along the path it came, nor between the engaged gear teeth (they create a seal,) it must exit the outlet port.
- The fluid then flows outside the pump without pulsation



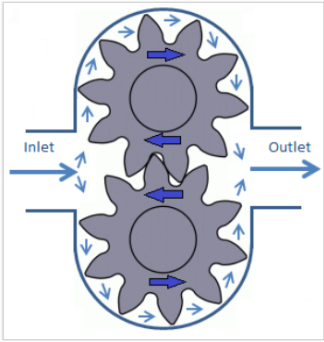
External gear pumps

Advantages

- Laminar flow
  - Gear pumps smoothly transfer chemicals on the discharge side, with no pulsation, which fulfills the uniform injection requirement of some applications (e.g. pH control)

- High suction lift – Self priming capability
  - The rotating gears evacuate the air in the suction line and create a vacuum. The process fluid is then forced into the pump inlet under the atmospheric pressure. This is allowed by tight clearances between the gears and the pump housing
  - Inlet degasing without air compression

- High viscosity capability
  - Thanks to their high suction power and due the lower slip with higher fluid viscosity, gear pumps can inject fluid as viscous as 250,000 cPs



- Low cost of ownership
  - Low initial cost – No need for pulsation dampener
  - Fewer moving parts result in lower maintenance cost
  - Front pull-out design reduces downtimes duration by allowing service without disconnecting piping or motor conduit

- Compact design

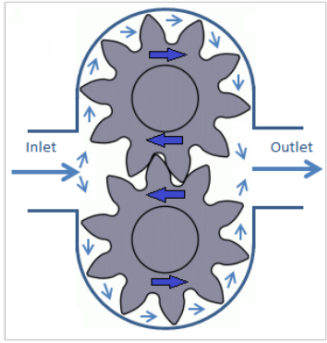
External gear pumps

Limitations

- Low to moderate pressure range
  - Maximum differential pressure between discharge and suction typically cannot exceed 500 PSI in common applications. 10,000 PSI is still possible but at prohibitive extra cost from very tight mechanical tolerance and clearances

- Standard accuracy ± 3%
  - In open loop setting gear pump injection accuracy is typically of ± 3% and will drift with wear
  - In closed loop the gears rotation speed can be adjusted to compensate the flow drop

- Low viscosity fluids
  - The high amount of slip and deficit of lubrication with thin or low viscosity fluids limit the use of gear pumps for the applications that require injection of such fluids



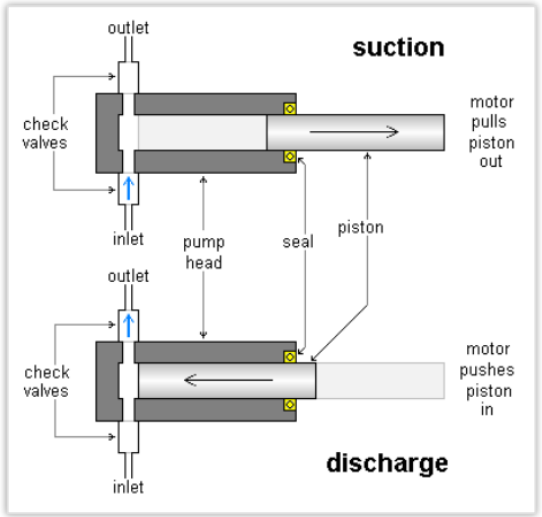
- Pumping abrasive liquids or fluids carrying particles
  - Due to the meshing of gears, gear pumps can be damaged by pumping large solids. When solids are present in the fluid they may act as abrasives, causing damage to the gears and then reducing the pumping performance
  - Viscous fluids capability excludes fluids carrying particles (e.g. slurries)

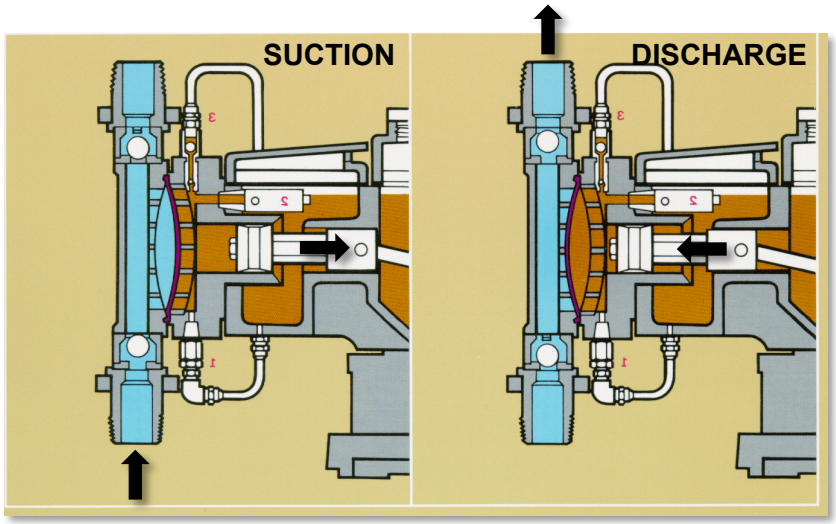
Reciprocating diaphragm pumps

Working principle

Hydraulically Actuated Diaphragm pumps

- The liquid being pumped goes through the pump head sealed off by a diaphragm from the hydraulic oil inside the pump
- Reciprocating compression/decompression motion is transmitted by a piston
- The diaphragm is then hydraulically driven
- Such motion changes the volume of a chamber in the pump head so that the process fluid enters through an inlet unidirectional check valve during decompression (suction) and exits through an outlet unidirectional check valve during compression (discharge)
- The process fluid flows outside the pump in an alternative pulsed mode during the discharge phase as the piston reciprocates





Reciprocating diaphragm pumps

Advantages

- High pressure capability
  - Discharge pressure up to 20,000 PSI
- High accuracy
  - Steady state accuracy of ± 0.5% without instrumentation
- Diaphragm longevity
  - No diaphragm stress - Equal pressure between the hydraulic and process fluids
- Low viscosity fluids
  - Low amount of slip allows pumping of thin fluids like alcohol
- Leakage free handling of toxic, corrosive, high particle content slurries and expensive fluids

Reciprocating diaphragm pumps

Limitations

- Pulsed injection
  - Causes noise, surging and non-uniform chemical injection
  - Requires pulsation dampner in order to smoothen the discharge flow
- Low suction lift - Not self priming
  - Reciprocating pumps inlet line has to be degased as gas compressibility may prevent the pump from priming
  - Additional instrumentation (e.g. degasing valve) is required to prime the pump
- Low to moderate viscosity
  - Reciprocating pumps can pump high viscous fluids up to ~5,000 cPs provided that the installation Net Positive Inlet Pressure available exceeds the required inlet pressure to move the fluid into the pump chamber. Creating these conditions can be costly with a diaphragm pump.

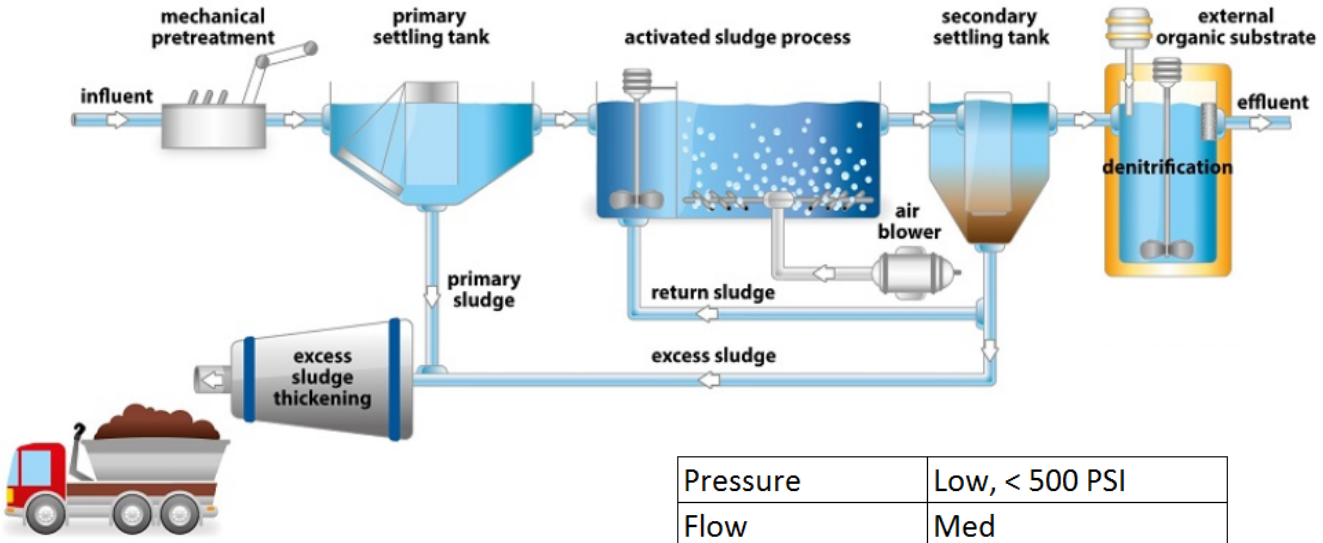
Applications

Positive displacement pumps are used to transfer a countless number of chemicals in multiple industries

Extraction	Production	Refineries	Petrochemical industry	Boilers & cooling towers	Waste water treatment	Desalination
• Biocides • Cleaning compounds • Coagulants • Corrosion inhibitors • Defoamers • Glycol • Methanol • Oxygen scavengers • Polyelectrolytes • Scale inhibitors	• Anti-foams • Anti-scaling agents • Corrosion inhibitors • Emulsion breakers • Methanol • Water clarifiers	• Amines • Additives • Catalysts • Caustic soda • Condensates • Ethanol • Methanol • Naphta • Sulfuric acid	• Catalysts • Chlorine • Condensates • Demineralised water • Dehydrogenators • Oxydators	• Anti-foams • Anti-scaling agents • Biocides • Corrosion inhibitors • Oxygen scavengers • pH regulators	• Biocides • Clarifying agents • Coagulants • pH regulators • Polyelectrolytes	• Anti-fouling agents • Anti-scaling agents • Biocides • Lime • pH regulators

Methanol in wastewater treatment

- **Wastewater Denitrification -** Methanol is used by municipal and private wastewater treatment facilities to aid in the removal of nitrogen from effluent streams.
- As wastewater is collected in a treatment facility, it contains high levels of ammonia. Through a bacterial degradation process this ammonia is converted into nitrate.
- If discharged into the environment, the nutrient rich nitrate in sewage effluent can have a devastating effect on water ecosystems - creating miles long algae blooms that sap oxygen and sunlight from aquatic life. Methanol, which quickly biodegrades, is a cost-effective way to help revitalize waterways tainted by the effects of nitrates.



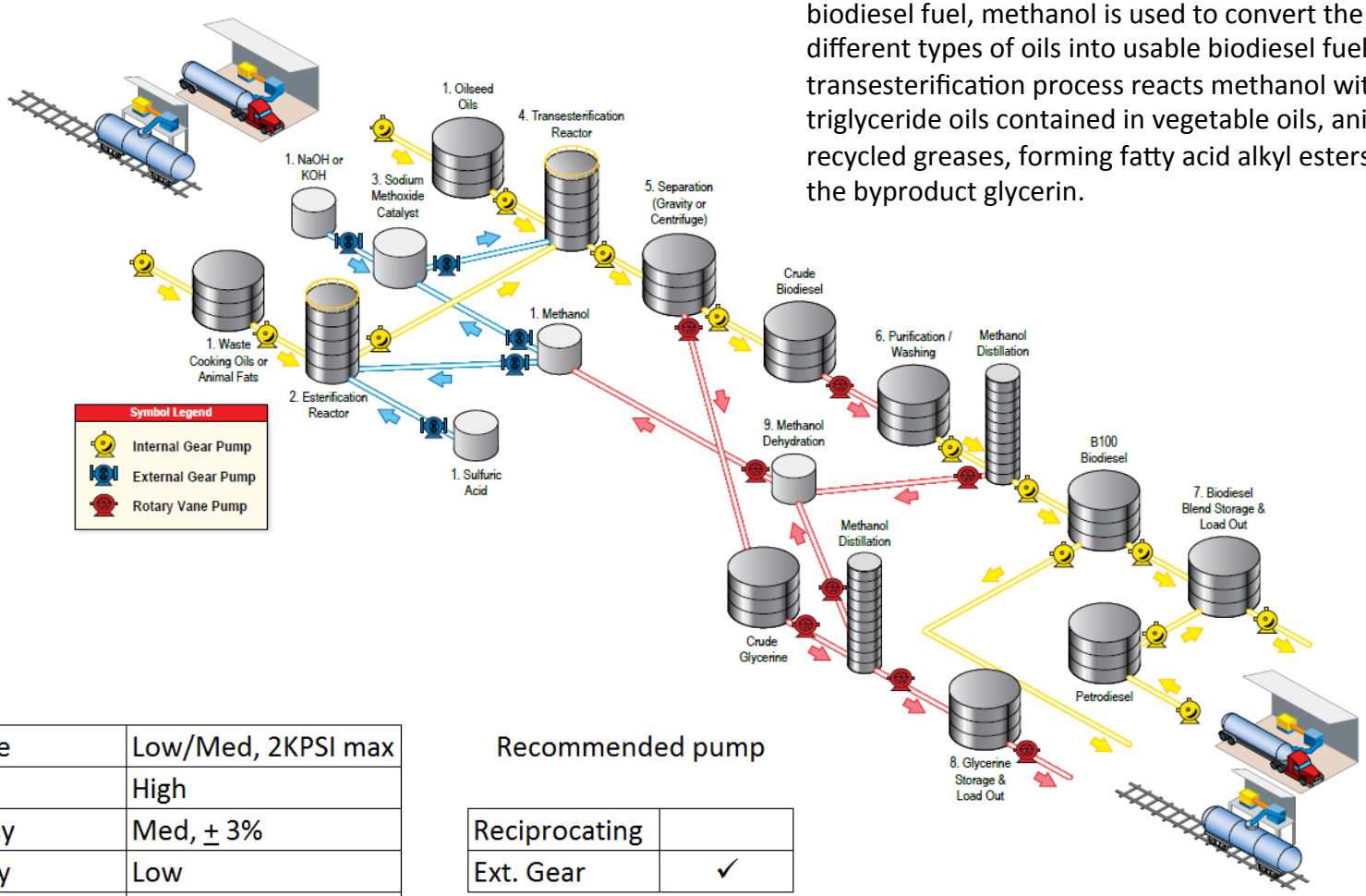
Pressure	Low, < 500 PSI
Flow	Med
Accuracy	Med, ± 3%
Viscosity	Low
Compactness	Low
Cost	Low

Recommended pump

Reciprocating	✓
Ext. Gear	✓

Methanol injection in Biodiesel

Biodiesel Transesterification - In the process of making biodiesel fuel, methanol is used to convert the triglycerides in different types of oils into usable biodiesel fuel. The transesterification process reacts methanol with the triglyceride oils contained in vegetable oils, animal fats, or recycled greases, forming fatty acid alkyl esters (biodiesel) and the byproduct glycerin.



Pressure	Low/Med, 2KPSI max
Flow	High
Accuracy	Med, ± 3%
Viscosity	Low
Compactness	Low
Cost	Med

Recommended pump

Reciprocating	
Ext. Gear	✓

Methanol injection in oil production

Flow assurance - In the deepwater low temperature and high pressure conditions, produced crude oil would congeal immediately while moving from the reservoir to the surface

- Major risk : hydrates formation
  - *A hydrate is a crystal solid with a structure similar to ice, in which water molecules form a cage containing entrapped molecules of methane. Hydrocarbons form hydrates with water in conditions of low temperature and high pressure – precisely the environment encountered in the ocean deeps.*
  - *These hydrate blocks are liable to plug production lines*

- Methanol is injected to lower the freezing point of water percentages during the oil and gas transport. The methanol injection flow rate will mainly depend on the water content / oil dew point and the ability of the pipeline to collect water.

Pressure	High, 15-20KPSI
Flow	High
Accuracy	High, + 1%
Viscosity	Low
Compactness	High
Cost	Med

Recommended pump

Reciprocating	✓
Ext. Gear	

Sodium Hypochlorite

Water disinfection - Sodium hypochlorite is commonly used as a disinfectant or bleaching agent. Chlorine sterilization with sodium hypochlorite is one of the most powerful, longer lasting, and lower-cost water sterilization methods

Sodium hypochlorite has a variety of applications, including deodorization, decolorization, oxidation treatment, deferrization, and demanganization, in addition to sterilization of tap water, swimming pools, and public baths

Pressure	Low, < 500 PSI
Flow	Med
Accuracy	Low
Viscosity	Low
Compactness	Low
Cost	Low

Recommended pump

Reciprocating	
Ext. Gear	✓

Conclusion

- Complimentary - No « better » technology for any applications
- Both gear pump and diaphragm pump technologies offer advantages and limitations. In many cases each one overcomes the limitations of the other technology.

Diaphragm pump
High discharge pressure
High metering accuracy
Low process fluid viscosity
Hazardous chemicals (no leakage)
API & Explosion proof requirement

External gear pump
Low discharge pressure
Low meterging accuracy
High process fluid viscosity
Usual chemicals
Water & General industry

- External gear pumps should be considered more often as a valid alternative to reciprocating pumps
- Recommendation – Consult unbiased experts to make a sound decision as to which technology to opt for

Thank you

Questions ?