ENGINEERING PHARMACEUTICAL INNOVATION

Centrifugal and Positive Displacement Pumps for Hygienic Applications

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Presented by:
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Primary Issues:

- Selection of Technology.
- Control of Pumps.
- Materials of Construction / Certifications.
- Mechanical Seals.
- Suction Conditions.
- Efficiency / Power Consumption.
- Cleanability / Drainability / CIP-ability.

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Selection of Technology

When to Apply a Centrifugal Pump.

When to Apply a Positive Displacement .
(Discussion limited to rotary lobe style)

Centrifugal vs. Positive Displacement

Centrifugal vs Rotary Lobe

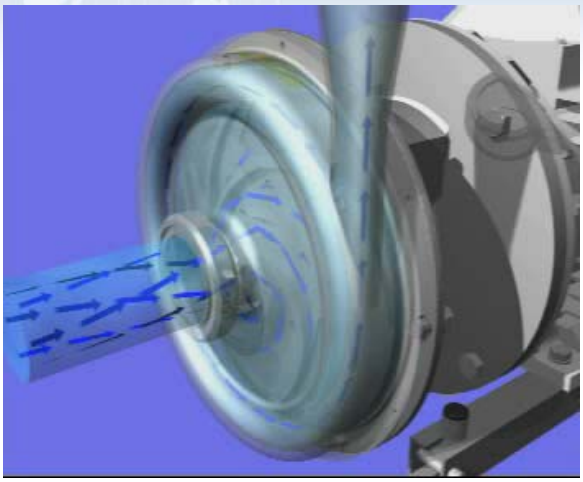
Centrifugal Pump

- Velocity Machine.
- Generates flow and head by the centrifugal action of a spinning impeller.

Rotary Lobe Pump

- Fixed Displacement Machine.
- Delivers a fixed flow rate per revolution of the rotors.

Centrifugal Pump Operation



Rotary Lobe Pump Operation

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Centrifugal vs Rotary Lobe

Centrifugal Pump

- Low Viscosity Fluid.
- Generally up to 500 Cps.
- Can go to 1500 Cps in special circumstances, but with large sacrifice in efficiency.
- Medium to high flows. Medium to low pressures.
- Both direct drive (1800 and 3600 rpm) and variable speed operation are common.
- Impeller diameter is usually trimmed to meet desired flow and head (pressure).

Rotary Lobe Pump

- High Viscosity Fluids.
- Generally 500 Cps and higher.
- Can use in low viscosity applications with sacrifice in efficiency.
- Low to medium flows. Medium to high pressures.
- Precise flow volume control, especially low flow rates.
- Generally operates at low speeds (up to 500 rpm) with a variable speed gear-motor.

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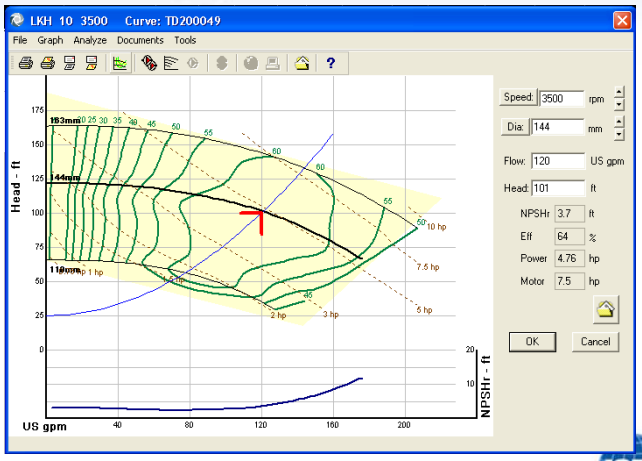
Control of Pumps

Centrifugal Pumps:

A centrifugal pump will operate where the Pump Flow-Head Curve Intersects with the System Resistance Curve.

Example:
DI Water
120 gpm
100 ft tdh (43 psi)
1.0 spgr

System Head:
25 ft Static
100 ft @ 120 gpm



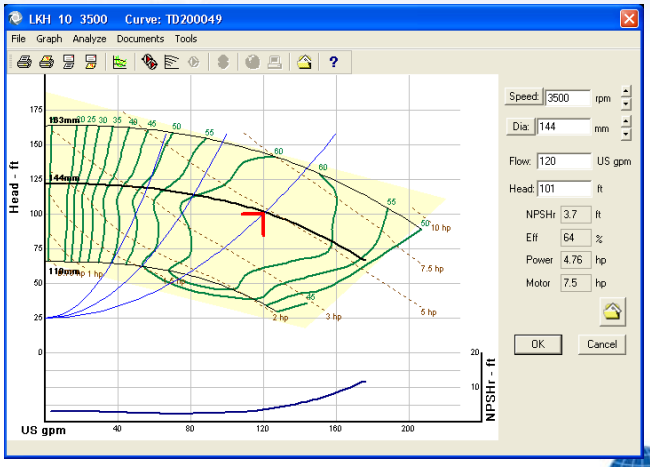
Centrifugal Pumps:

Flow control – throttling the discharge with a control valve & flow meter.

Example:
DI Water
120 gpm
100 ft tdh (43 psi)
1.0 spgr

Pump:
3500 rpm
144mm impeller

Throttle:
80 gpm
55 gpm



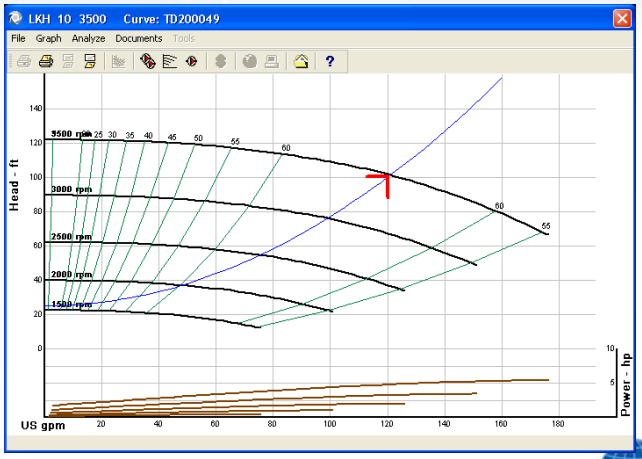
Centrifugal Pumps:

Flow control – variable speed drive (control motor rpm).

Example:
DI Water
120 gpm
100 ft tdh (43 psi)
1.0 spgr

Pump:
3500 rpm
144mm impeller

Speed Change:
80 gpm – 2550 rpm
55 gpm – 2000 rpm



Rotary Lobe Pumps:

Flow control – variable speed drive (control motor rpm).

Example:	**Rotary Lobe Pump**
Fluid XYZ	Model ABC
30 gpm	9.25 gal / 100 Rev.
100 psi	0.0925 gal / Rev.
600 Cps	
1.0 spgr	30 gpm = 324 rpm
	25 gpm = 270 rpm
	20 gpm = 216 rpm

Note: an RPM adjustment would be required for low viscosity fluids due to pump slip.

Materials of Construction and Certifications

Materials of Construction:

Application Dependent – For Example:

Pump Construction & Metallurgy

- Wetted Parts: 316L ss.
- Elastomers: EPDM, FPM, FDA Compliant, USP Class VI
- Finish: 32Ra, 20Ra, 15Ra, 10Ra, Electropolish, Passivation, etc.
- Mechanical Seal: Single or Double; Balanced vs Unbalanced; Face Materials; Flush or No Flush.
- Exterior: Painted or No Paint.
- Drainability, Cleanability, CIP-ability (more later).
- Standards: 3A, BPE, FDA, EHEDG, cGMP

Certifications & Tests

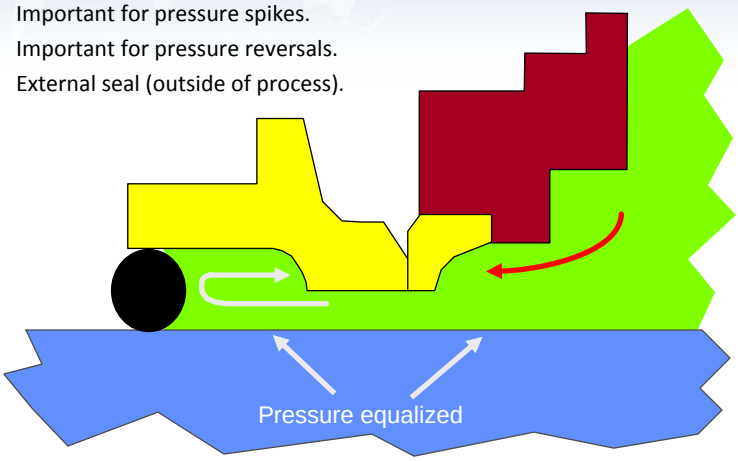
- Certifications: Material Traceability
- Performance Guarantees / Factory Tests: Q, H, E, P, N, etc.

Mechanical Seals

Mechanical Seals:

Hydraulically Balanced Seal Design:

- Important for pressure spikes.
- Important for pressure reversals.
- External seal (outside of process).



Suction Condition

Suction Conditions:

Huge Area for Potential Operational Problems:

Rule of Thumb:

- Fluid need to be able to get to pump suction, under sufficient pressure (no vaporization), as fast as the pump want to take it, or the pump will cavitate.

General Guidelines:

- Keep suction lines as short as practical. Short is good.
- Keep suction line at least one size larger than pump discharge. Bigger is better.
- Keep suction line velocity low. Especially with viscous fluids.
- Minimize pressure drop in suction line.
- Avoid air traps in suction line. Can cause loss of prime.

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Suction Conditions:

If You are Involved in Sizing & Selecting a Pump for a New Application:

Take Careful Note of the NPSH Required by the Pump:

- NPSH = Net Positive Suction Head.
- NPSHR = Suction Head (pressure) required at the pump to prevent cavitation.
- Do an NPSH Available calculation for your specific piping arrangement.

NPSHA must be greater than NPSHR, or you will be Not Pumping So Hot !

What is Cavitation:

- Vaporization of fluid at eye of impeller.
- As the fluid & bubbles travels along the vane, the pressure increases.
- The collapse of those gas bubbles back to fluid is a high energy impact.
- Enough to remove metal from impeller. Deflect shafts. Rotor strike.

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Suction Conditions:

Cavitation Damage – Centrifugal Pump Impeller:

Signs of Cavitation:

- Centrifugal Pump – Sounds like pumping marbles, vibration, noise, damage.
- Rotary Lobe Pump – Banging noise (rotors hitting case), vibration.

Pump Efficiency and Power Consumption

Efficiency & Power consumption:

Positive Displacement Pumps

- Generally highly efficient. Typical 90 – 99%.
- Exception is with low viscosity fluids.

Centrifugal Pumps

- Generally range of efficiency – from < 10% (if running at very low flows) to 60 – 70%.
- Lots of room for careful review.
- The newer designs are generally 25% to 50% more efficient than the older pump technology.
- Reasons: Impeller geometry, improved manufacturing methods, tighter clearances, less slip (recirculation).

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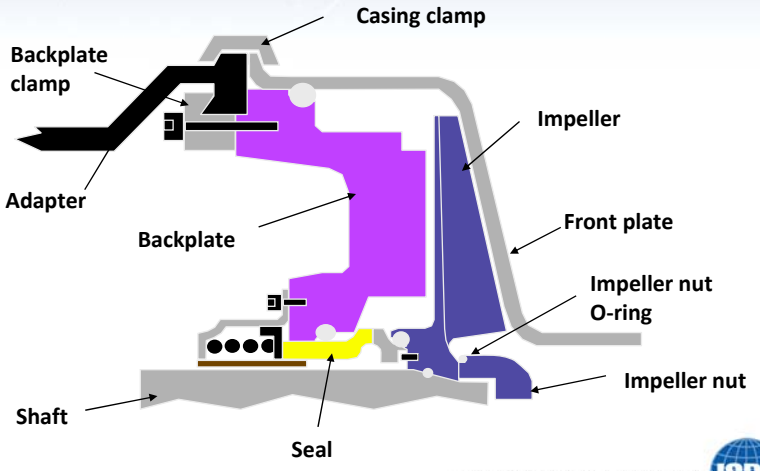
Typical Centrifugal Pump:



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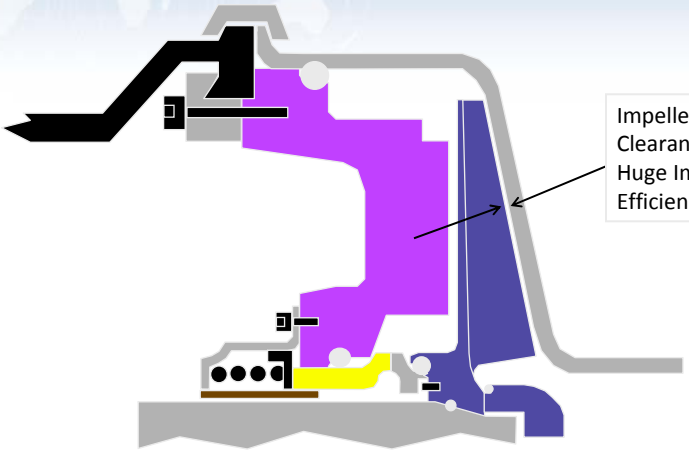
Centrifugal Pump – Impeller Clearance:



Impeller Front Clearance Has a Huge Impact on Efficiency

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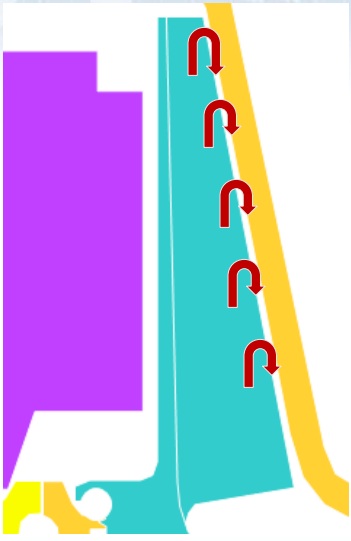
Large Clearance = Recirculation (slip):



The greater the clearance between the impeller vanes and the pump volute, the higher the recirculation "slip" as more fluid simply churns within the pump, and the lower the resulting pump efficiency.

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Energy Savings:

Centrifugal Pumps – is it worth a look ?

Example: Centrifugal Pump - 100 gpm @ 100 ft tdh

Typical "old" Series	55% Eff	5.18 hp	
High Eff. Pump	67% Eff	3.73 hp	28 % power reduction

At $0.10/Kwh and 24/7 operation …. Power cost is $4380/yr (High Eff)
Power cost is $6084/yr (Old Series)
Savings = $1704/yr.

Consider upgrading existing pumps too ?

Rule of thumb: 1 HP power reduction @ $0.10/Kwh = $1100/Yr. (cont. op).

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Cleanability
Drainability
CIP-ability

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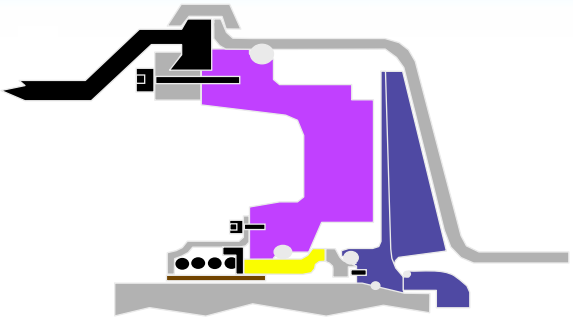
Centrifugal Pumps



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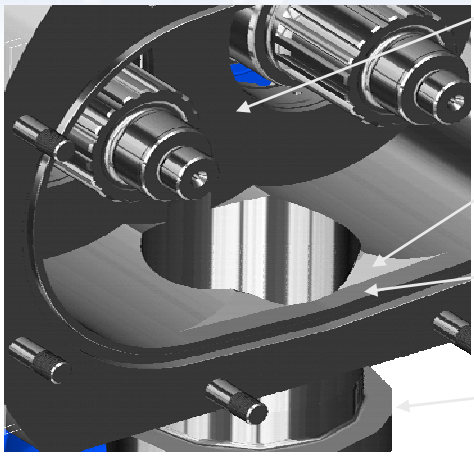
Rotary Lobe Pumps

Drainability & Cleanability



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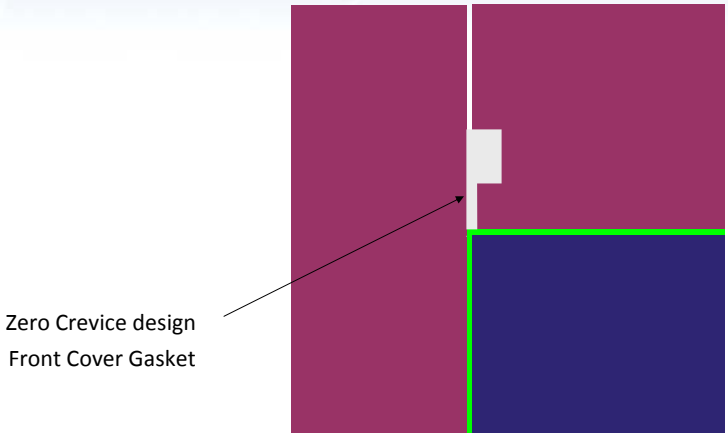
Rotary Lobe Pumps

Drainability & Cleanability



Cleanability, Drainability, CIP-ability:

Centrifugal Pumps

- 3A, FDA, EHEDG certifications.
- Internal finish.
- Low point drains.
- Design & position of o-rings & gaskets.

Positive Displacement Pumps

- Look beyond the 3A certification.
- Vertical porting.
- Drainable cusps.
- Smooth, flat, flush rotor case back & front.
- Mechanical seal position for cleanability.

Centrifugal and Positive Displacement Pumps For Hygienic Applications

Thanks for your attention.

Questions.

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