Troubleshooting Centrifugal Pumps and their Systems

By Fluensys | Sept 3, 2024 | Troubleshooting Pumps

This article is meant to help operators and reliability engineers having to troubleshoot for recurring pump failures in their plants.

Bearings and seals are the "fuses" of the pump and will usually fail prematurely, signalling something is wrong, but shaft breakage and motor burnout can also happen. It is important to differentiate between the root cause and its effect(s); pumps may fail as a consequence of many factors 'external' to it. It is therefore imperative to take a holistic approach, appreciating that the pump is part of a system, in troubleshooting activities.

Generally, pumps are designed for at least two years of uninterrupted service, with a minimum service life of 20,000 hours for bearings, mechanical seals and motors. See table 1. Failures withing the next few weeks and months of operation is abnormal.

During the initial launch on the market, pumps can exhibit bathtub failure characteristics with early failures in the field. But once the design has been 'fine tuned', the pump should provide a durable phase of problem free operation. In the latter years, beyond its service life, pump failures can become more frequent mandating major refurbishment or replacement. The normal service life of equipment is around 20 years with a mechanical guarantee of 2 years of uninterrupted service after commissioning.

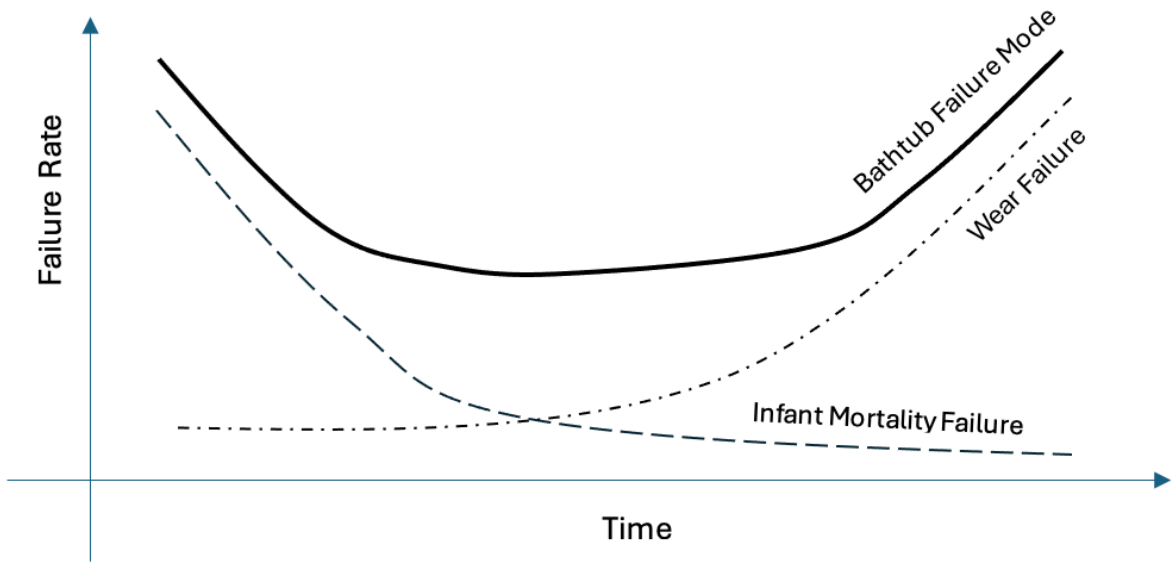

Figure 1: Bathtub Failure Curve

Methodology

It is important to adopt a methodical approach to troubleshooting. The audit starts with the hydraulic review, which aims to confirm that the pump meets the current duty at the expected power, has a healthy NPSH margin and is operating in a stable region of its curve. Some duties can be severely constrained, and pumps may have to operate close to their minimum stable flow (MCSF), where recirculation and forces are excessive, but they will have to be monitored closely and maintained as necessary.

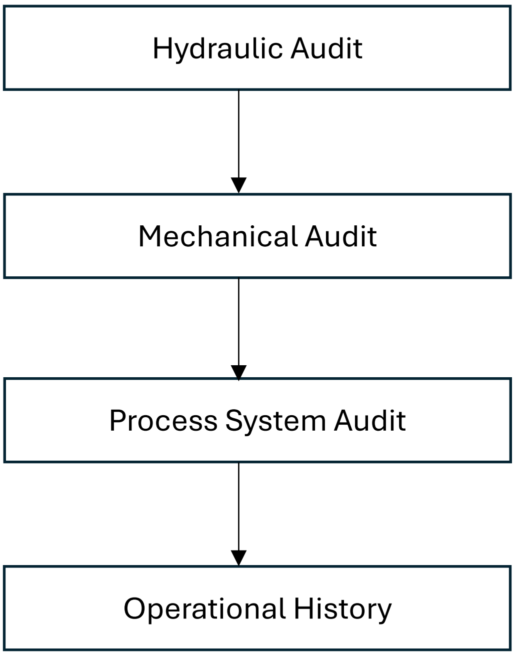

Figure 2: Methodology for Troubleshooting Pumps

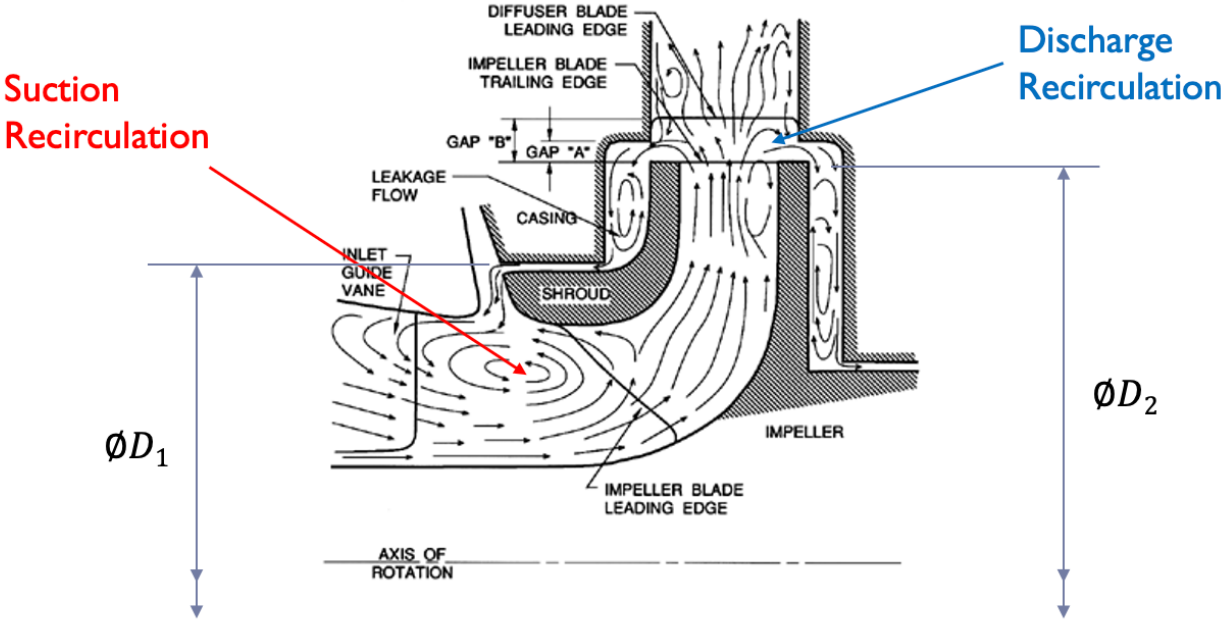

Figure 3: Flow instabilities in Centrifugal Impeller

The mechanical audit checks for the integrity of the construction, material selection and rotordynamic stability of the machine. Applicable design standards, such as API 610, provide the guidelines for the audit.

The process audit verifies the heat and mass balance, operational philosophy, pressure drops in the system as well the required pump duty. The process is usually modelled in HYSYS, either as a steady state or dynamic model, and validated using operational data. Operational discrepancies can then be identified at stage.

Finally, an operational review can be done to identify key time stamps and operational changes coinciding with the failures.

Usually, it is required to go through the complete series of steps to have a complete picture of the operational mode and possible failure mechanisms and root causes.

Common Checks

Common checks to perform on problematic pumps are given below.

- **Off-Design Operation**: Check that the pump is operating above its MCSF and preferably within its POR.
- **Priming:** Check that the pump is properly primed. Air leaks in the suction line can cause the pump to lose its prime and stop pumping.
- **Impeller**: Check for damage or blockages in the impeller, which is the pressuring device in the pump. Corrosion can severely affect impeller performance.
- **Speed**: Make sure the pump is operating at the correct speed.
- **Alignment:** Check that the pump is properly aligned with the driver.
- **Bearings / Seals:** Inspect and replace worn or damaged bearings and mechanical seals.
- **Blockage:** Check for blockage in the pump, suction strainer, recirculation port, valve, or discharge line.
- **NPSH Margin**: Rework the NPSH margin based on actual site data. In the absence of sufficient margin, the pump will cavitate. Damage would be observed in the volute and impeller.
- **Electrical connections**: Check electrical connections for correct voltage and continuity.
- **Control devices**: Check that control devices, such as pressure switches and starters, are operating properly.
- **Suction limit**: Don't exceed a suction height of 18 feet when using a centrifugal pump.
- **Vortex Flow** – Check for vortex flow in the intake or sump as it can affect the pump's operational stability and cause failure.

For more information and support, please contact us.

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<u>*Disclaimer:*</u>

While every effort has been made to provide a comprehensive overview of best practices in troubleshooting pumps, Fluensys do not claim that these will successfully apply to every system and reserve the right to adjust their technical opinion to reflect latest practices and specifics of application.

Description	API 610 / ISO 13709	ISO 5199	ISO 9908	ASME B73.1	ASME B73.2
Classification	Heavy Duty, High Cost	Medium Duty	Light Duty	Medium	Medium
Application	Oil & Gas	Various Industries (Class II)	Various Industries (Class III)	Various Industries (Horizontal)	Various Industries (Vertical in Line)
Design Life	Min. 20 yrs and 3 yrs uninterrupted service	2 yrs uninterrupted service	1 yr uninterrupted service	2 yrs uninterrupted service	2 yrs uninterrupted service
Bearing Design Life, L_{10h}	min. 25,000 (3 yrs)	min. 17,500 (2 yrs)	min. 10,000 (1yr)	min. 17,500 (2 yrs)	min. 17,500 (2 yrs)
Acceptable Vibration Level (RMS)	**OH** - BB: 3.0 mm/s **VS**: 5.0 mm/s	**OH** (Table 1) Rigid support: 3.0 mm/s / 4.5 mm/s Flexible support: 4.5 mm/s / 7.1 mm/s **VS**: 7.1 mm/s	**OH** (Table 1) N < 1800 rpm: 2.8 mm/s / 4.5 mm/s N > 1800 rpm: 4.5 mm/s / 7.1 mm/s **VS**: 7.1 mm/s	HI 9.6.4 **OH1** < 200 kW - 3.8 mm/s > 200 kW - 4.8 mm/s	HI 9.6.4 **OH3,4,5** < 200 kW - 3.8 mm/s > 200 kW - 4.8 mm/s
Balancing Grade	Dynamic G2.5	Dynamic G6.3	N/D	Dynamic G6.3	Dynamic G6.3
Design stress Limit	0.25 x UTS or 0.67 x Yield Strength	N/D	N/D	N/D	N/D
NPSH margin	Positive Margin across op. range	0.5m	0.5m	Hi 9.6.1 0.9m or 1.2x (whichever is greater)	Hi 9.6.1 0.9m or 1.2x (whichever is greater)
Rated Flow	80% < Q_{rated} < 110% of BEP	Close to BEP	Close to BEP	Close to BEP	Close to BEP
Pressure Casing	MAWP + 10% => 40 barg @ 38 degC Split BB3/BB5: 100 barg	=> 16 barg	=> 6 barg	=> 19.5 barg (Class 150#)	=> 19.5 barg (Class 150#)
Corrosion allowance on Pressure Casing	min. 3mm	min. 3mm	min. 3mm	min. 3mm	min. 3mm
Mechanical Seal design	ISO 21049, API 682 Balanced, cartridge type Table 7 of API 610	Balanced or Unbalanced Type Packing	Mechanical Seal or Soft Packing	Smaller Stuffing Box than API. Unless a large bore option is chosen, may not be able to accommodate optimal mechanical seal	Smaller Stuffing Box than API. Unless a large bore option is chosen, may not be able to accommodate optimal mechanical seal
Dynamic Stability Margin (1st Dry lateral critical)	20% above Max Cont. Speed	10% above Max Cont. Speed	10% above Max Cont. Speed	20% above Max Cont. Speed	20% above Max Cont. Speed
Critical Speed Margin	20% (1X, 2X)	10% (1X, 2X)	10% (1X, 2X)	20% (1X, 2X)	20% (1X, 2X)
Torsional Natural Frequencies Margin	10% (1X, 2X)	N/D	N/D	N/D	N/D
Driver Rating	Table 12 of API 610 (=> 10%)	Fig 2 of ISO 5199 (=> 10%)	Fig 2 of ISO 9908 (=> 10%)	N/D	N/D
Max. deflection @ seal face	50 µm (worst loading)	50 µm (worst loading)	50 µm (worst loading)	125 µm (worst loading)	125 µm (worst loading)

Table 1: Comparison of Common Pump Design Standards