Effective Filtration on the Suction Side of Pumps

March 2020

3 minute read

The impact of particulate solids on hydrocarbon liquid pump performance, maintenance and longevity is an extensive topic and the subject of much discussion. So is the subject of effective particulate control in pump applications. Examples of particulate impacts, including black powder contamination impacts, on differing types of pumps abound, but here are a few examples that highlight some common issues:

a. Particulate contaminants in a high pressure NGL stream passing through suction screens and causing constant replacement of mechanical seals due to contaminated NGL seal flush (~$30,000 including materials & labor);
b. Suction-side cone strainer plugged by particulate build up in kerosene pump service resulting in cavitation, impeller damage and pump seizure, then requiring pump repair and change-out every ~2 months;
c. Suction screen plugged by particulate-loaded propane stream, resulting in ship loading shutdown and cleaning of screens and filters, with associated demurrage of $50,000 on average; and
d. Continuous flow of iron sulfide particles in stabilized condensate accumulating on a magnetic drive pump rotor and wearing through both the rotor and the containment shell, resulting in parts replacement and rebuilds every ~3 months.

This technical brief summarizes (1) particulate control issues in pump applications, (2) key issues with conventional particulate control methods and (3) how magnetic separation can be an effective alternative to conventional suction-side contamination control methods.

Figure 1. (a) Centrifugal pump wear. (b) Magnetic drive pump wear. (c) Mating ring wear & residue.

Particulate Control in Pump Applications

Surprisingly, there are few methods to control particulates such as black powder (ie. ferrous and non-ferrous contamination) in hydrocarbon streams in pump suction applications, and none of them are fully effective. The common focus is stopping visible contamination above 100 microns with various size mesh screens by using devices such as suction screens, basket strainers, cone strainers, wye-strainers and in some cases, single use filters. The removal of this contamination and the positive impact on pump performance needs to be balanced against the impacts of progressive accumulation of particulates in these filtration devices and the corresponding decrease of net pump suction head (NPSH) at the pump intake. A failure to manage the reduction in NPSH due to increasing pressure differential across the filtration device can lead to pump cavitation and mechanical damage.

During pipeline and facility commissioning, as well as during maintenance and turnaround activities, various forms of suction screens and strainers can be quite effective at controlling large contamination left in a pipeline or piece of process equipment; this includes welding slag, cutouts, tools and other large visible debris. As commissioning is completed and regular operations commence, screens and strainers are often left in place as the permanent solution (and last line of defense) for contamination control. However, the contamination in these facilities changes from a majority of large, visible particulates to a majority of sub-100 micron particulates – in particular, sub-40 micron particulates not visible to the naked eye.

Figure 2. Contamination not captured by conventional filters.

Screen and strainer mesh is offered in a large variety of sizes, from 20 mesh (830 microns) to 300 mesh (50 microns), with operators often using mesh in the 80-150 mesh (180 micron - 100 micron) range in screens and strainers. However, with a large majority of black powder contamination typically in the sub-100 micron range, suction screens and strainers do very little to control this contamination from entering pumps.

Particulate Impacts on Pumps

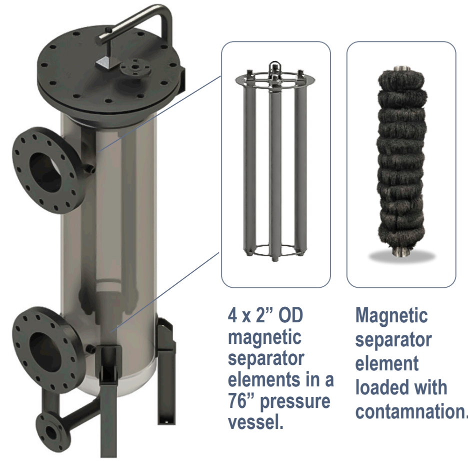
Many types of pumps are employed in the movement of hydrocarbon fluids in oil and gas pipeline and facility applications, and each has varying tolerances to particulate size and amount of contamination. There are both pro and con arguments for the use of screens and strainers, with the pro side of the argument generally aligned with preventing 100+ micron contamination from entering pumps and downstream equipment, and the con side of the argument generally aligned around issues created by the screen or strainer itself, as follows:

- Reduction in NPSH, resulting in lower pump efficiency.
- Clogged screens or strainers introducing turbulent flow conditions.
- Inability to size the mesh small enough to prevent contaminants from entering the seal flush.
- Screen or strainer plugging off causing a large pressure differential across the screen/strainer, a drop in suction head pressure below $NPSH_{min}$ and subsequent pump cavitation (and related damage).
- Potential for vapor formation in the liquid stream as vapor pressure is lowered, particularly for higher temperature applications (2 phase flow and vapor lock).
- Inability to control the introduction of sub-100 micron – and particularly sub-10 micron - particulates from entering pump bearings.
- Certain strainer configurations requiring frequent replacement because they are prone to crushing and breakage under variable pressure and flow conditions. Breakdown of screen and strainer material causing catastrophic pump damage.
- Inability to deploy certain types of pumps (ie. magnetic drives) due to the inability of screens and strainers to effectively filter ferrous materials that are often prone to shearing and breakage.
- Oversizing pumps (ie. higher capex) in abrasive liquid applications in order to run at slower speeds and differential pressures to avoid maintenance and replacement costs.

Figure 3. Examples of damaged strainers.

Due to significant contamination loading from high thresholds for BS&W, most hydrocarbon liquids cannot be effectively filtered with single use conventional filters (ie. elements, cartridges, etc). Many of the above-noted issues are further exaggerated if conventional depth media filters are employed in suction side pump service.

Magnetic Separation in Suction-Side Pump Service



As an alternative to suction screens and other strainer configurations, magnetic separators offer an alternative that addresses most of the issues for suction-side pump deployment. They can be configured to all liquid applications as a permanent contamination removal system and have been employed for over 15 years in numerous hydrocarbon liquid applications.

a. Use high strength permanent magnetic fields to remove black powder contamination, and there is no requirement for the use of screens or membranes (magnetic versions of cone, basket and wye-strainers are available).
b. Clean magnetic separators show pressure differentials in the sub-0.5 psi range and are at 0 psi in most liquid applications.
c. Contamination-loaded magnetic separators in liquid service show pressure differentials in the sub-5 psi range.
d. When fully loaded with contamination, magnetic separators continue to allow the product to flow through the unit – they do not plug off.
e. Are highly efficient at removing contamination no matter the size, from above 100 microns down below 0.1 microns.
f. Capture contamination on the suction side of pumps, that is normally caught in single use filters on the discharge side of pumps, resulting in operating cost savings related to a reduction in single use filters.
g. Will not collapse under varying pressure and temperature conditions.
h. Are more easily accessed for cleaning than cone strainers which require separation of pipeline flanges for access.
i. Infrequent cleaning. Significant holding capacity typically measured in dozens to hundreds of pounds, depending on the size of unit.
j. No disposable filter elements, no power or fuel requirements and 20+ year life service.

Magnetic separators are a proven alternative to conventional screen and strainer configurations and address most of the shortcomings of those systems. They are easily deployed in hydrocarbon liquid applications including crude oil, refined products, NGLs/ LPGs, condensate (C5), produced water and process fluids like amine and glycol. As a result, they should be considered for both existing and new pump applications as an improved alternative to suction screens and strainers.