Hymat Services

F – 9, " KIRIT ", EVERSHINE NAGAR, Malad (W), Mumbai – 400064
Tel. no. – 091-22-28814802 / Mobile – Mr. V.S.Dave – 09324414802,
E Mail ID – hymatservices@yahoo.co.in

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PUMP CAVITATION

Everyone and their grandma has heard the term *cavitation* as it relates to a pump. But does grandma even know what cavitation *is*; what it *really* is?

I first heard the term cavitation back in the day (which Dane Cook says was a Wednesday … fun fact) when I worked in the car wash business. I would occasionally hear that tell-tale sound of marbles in the pump. I was told cavitation was a bad thing, but was only taught it was caused by "starving the pump."

That explanation was accurate; however, it doesn't do much to explain the physics lying between starvation and damage. In a nutshell, cavitation is literally the formation of cavities — or bubbles — within hydraulic oil (or other liquid, should it not be a hydrostatic application) normally due to rapid drops in pressure.

Gases can be dissolved within liquid (think oxygen within your fish's bowl water), and it's no different with hydraulic fluid. The amount of air able to be saturated within the oil is a factor partially dictated by the pressure the oil is under. Pressure is nearly everywhere on Earth, and depending on your elevation, probably around fourteen or so pounds per square inch (14 psi). We don't feel the pressure because that pressure is equal on every surface and all directions, as laid out by good old Blaise Pascal.

A great example of pressure applied to a liquid to aid in saturation of a gas is the all-too-common soda pop. Straight from the bottling plant, pop has artificially high levels of carbon dioxide that cannot be sustained at atmospheric pressure. The manufacturer pressurizes the bottle or can to keep the CO_2 in a state of super saturation. When you open the container, you hear the pressure hiss out, and then immediately notice the carbon dioxide bubbles cavitating out of the liquid deliciousness.

Those bubbles formed spontaneously out of the liquid because pressure could no longer keep the gas in super saturation. This effect is absolutely no different in a hydraulic application (well, maybe different in that it's not just CO_2 dissolved in the oil).

The oil sitting in a hydraulic reservoir has dissolved air within it; mostly nitrogen and oxygen, just like the air we breathe. Generally, the oil will be as close to saturation point as possible for the given atmospheric pressure and other variables. If pressure on the oil were to decrease, air cavities — or bubbles — would form in the oil. The question is, how can the air pressure drop suddenly to create the cavitation?

For a pump to push fluid out, it has to first suck fluid in. Suction is a perceived effect where a partial vacuum causes fluid to be pushed from the

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atmosphere and into the pump. Fluid moves only from a path of higher pressure to lower pressure. The inlet chamber of the pump is a zone of increasing displacement. The vane/piston/gear of the pump moves away from the suction port leaving behind its own cavity to be filled with oil.

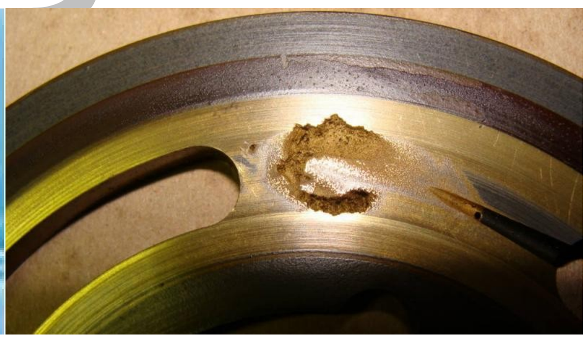
Under normal circumstances, this process allows little or no air bubbles to be released from the fluid. A problem occurs when the fluid being sucked in is restricted in any way. This could be from clogged suction filters, excessive suction hose length, insufficient suction hose diameter, oil viscosity too high (i.e., thick) or any combination of these factors. What matters is pressure in the suction side of the pump drops to a critical level which allows cavitation — the spontaneous formation of bubbles — to occur.

Okay, so now you understand where cavitation comes from, but how does this phenomenon damage a pump? There are a couple things happening to create the damage, and it's actually quite fascinating. As the bubbles make their way around to the pressure side of the pump, the high pressure in turn acts upon these air bubbles.

Pressure on the oil can go from less than atmospheric to thousands of PSI in fractions of a second. The bubbles will decrease in size to a factor that is inversely proportional to the increase in pressure. The bubbles will eventually implode, creating tiny danger zones of minute shock waves and intense heat. If these zones are created freely in oil away from any of the pump's hard surfaces, the worst case scenario could just be pockets of oxidation from the heat.

The heat is a result of compressing the air bubble. The Ideal Gas Law states that as you decrease the volume of a given amount of gas, you increase the temperature inversely proportional to the decrease in volume. Because the volume is decreased hundreds of times,

Implosion of bubble



Damaged surface due to implosion

Temperature could be **thousands of degrees in a spot small enough to fit on a pinhead**.

The real damage in hydrostatic cavitation situations is when the bubbles rest on a hard surface of the pump. The hard surface acts as a resistive force, changing the dynamic of the bubble collapse. As you can see in the image, the bubble flattens and is eventually pierced down the middle by a high pressure and extremely hot jet of fluid.

If that wasn't enough, the rest of the bubble then implodes, sending out that micro-sized shock wave into the surface of that now super heated metal surface. The hot jet and implosion combination blasts off tiny chunks of metal, and you eventually see small pitting in the surface of the metal. When left unchecked, irreversible damage occurs and the pump needs to be repaired or replaced.

How do I tell? Sometimes the noise around a machine is too loud to pinpoint the sound of pump cavitation, leaving the damage to occur unnoticed for long periods. If you rebuild pumps at any regular interval, you may have noticed the result of cavitation in your pump.

You can see the hardened outer surface of the piston pump wear plate pitted away and looking rather porous in the accompanying photo. Although the damage you've seen may not be so extreme, this is a good place to look for it if you suspect it could be happening. Rebuild your pump, but just as importantly, address the potential causes for cavitation. Not only could cavitation dampen the performance of your system, you want to avoid costly downtime and repairs.

And finally as with all other grease components, human toxicology, ecotoxicology and biodegradability of the thickener have become important issues.

The moral of the story is to prevent cavitation through good design and maintenance practices. A flooded suction prevents excessive suction vacuum, as does proper choice of suction hose diameter and location. On the maintenance end, always be aware if a hydraulic pump has a suction filter, which needs to be cleaned or changed regularly. Next month, I'll write about the ins and outs of modular multi-function manifolds and valve stacks. Have a great month!

Look out for
Next issue on –
"What is the Secret behind the ……. ? "

Compiled by Mr. V.S.Dave
Proprietor – Hymat Services.

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