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The Basic Principles of Heat Exchanger Cleaning

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Many different designs and applications of compact heat exchangers are used in military, commercial, and business aviation applications as well as ground support equipment.

They primarily encompass water, oil, fuel, and air coolers as well as evaporators and condensers used in vapor compression systems (air conditioning and refrigeration).

New heat exchangers are usually cleaned of raw material preservative oils as well as manufacturing debris and fluxes. Many times, after being in service, it is clearly specified to flush and clean a used heat exchanger after being contaminated from a component failure or as preventive maintenance service.

The ultimate goal for both the technician and the customer is to be sure the job is done right the first time, in the most economical and professional manner; and that the repaired system will operate properly. Regardless of the heat exchanger application, what equipment, method, and chemical you choose to use, it is ultimately the technician's responsibility that the flushing project has a positive, rather than a negative effect on the system. Flushing done right is a proven way to reduce the expense of comebacks and warranty repairs.

Unfortunately, we also find little or no references on how to flush or what to use; and definitely no warnings that some methods are expensive, time consuming, and ineffective on certain heat exchanger designs.

So the questions are:

• Can we clean them?

• How do we clean them?

• What works, what does not, and why?

It is globally accepted that industry standard methods to clean heat exchangers requires some form of appropriate cleaning chemical, velocity, and at times agitation. To meet the goal of a clean component, it is critical that you understand and evaluate the failure, the debris load that may be present, and how it entered the component; as well as any other debris binding residues that will need to be removed. If you cannot identify or determine what is in there how can you select the proper solution? To do this properly requires some basic understandings of the application, component designs, as well as some simple chemistry and physics principles.

Look at the design

Some applications were listed in the first paragraph and they can be as far reaching as component designs, so for the sake of brevity with this article let's just talk basics.

First we have the "tube and fin," which is nothing more than one long tube weaving back and forth; with one inlet, one outlet, and one common single pathway, which by design pose no real issues to clean. However, this tried and true "tube and fin" design has been somewhat abandoned for more intricate designs that produce more surface area for improved thermal transfer while maintaining a smaller and more compact size. These are "parallel flow" and other "multi pass" designs as well as, open web, cross flow, stack plate, multiple tube "tube and fin," and many more.

The commonality here is the multiple paths and passageways that bring the "path of least resistance" rule into play when considering effective cleaning methods. If not familiar, this is a fluid flow principle that basically states that fluid will flow around an obstruction when provided with an alternative "path of least resistance."

Most lubricating, fluid, and gas systems using heat exchangers are designed for smooth linear flow without cavitations or vibration. This allows for swirls, eddies, and pools to occur in the corners and crevices of the multiple path heat exchangers, where residues will accumulate and trap or bind debris. This is why many times we see that simple circulating equipment will not get heat exchangers completely clean, even after flowing for hours and hours.

Selecting a cleaner

So now we know what the system is (application — oil, air, water, A/C, etc.), and the challenges facing us given the type of heat exchanger being used (design); now we must select a chemical cleaner. The chemical properties of a solvent or cleaner will displace, dissolve, or in some way chemically alter and or displace the contamination on a surface; and must be selected for its known effectiveness on the known residues.

There are three primary types of solvents and cleaners that we use for various heat exchanger and other cleaning and degreasing processes.

• Hydrocarbons are comprised of petroleum distillates, synthetic (paraffinic) hydrocarbons and Terpenes (distillates from plant oils). Hydrocarbons have a high solvency for "hard-to-clean" organic soils, including heavy oil, grease, and tar. They have a low liquid surface tension, which allows them to penetrate and clean small spaces. Many hydrocarbons are blends and less volatile components may be left on the parts after the bulk liquid has evaporated.

• Hydrofluorocarbons, as with the chlorinated and now regulated CFC-113, CFC-11 and HCFC-141b solvents of the past. Today's HFCs are used for precision cleaning, foam blowing, and refrigeration. HFCs target applications where non-VOC, low-toxicity, low-residue, and nonflammable solvents are required. HFCs high solvency and low boiling points make them an excellent choice for A/C flushing, where rapid evaporation by vacuum recovery leaves no solvent residue.

• Aqueous cleaning and degreasing can be performed for a wide variety of cleaning applications. There is a primary environmental benefit of no VOCs and no ozone depletion, which is growing the applications of aqueous cleaning. However, some ferrous metals will exhibit flash rust in aqueous environments. Aqueous cleaners are usually a mixture of water, detergents, and other additives that promote the removal of organic and inorganic contaminants from a hard surface. Surfactants (surface action agents), provide detergency by lowering surface and interfacial tensions of the water so that the cleaner can penetrate small spaces better, get below the contaminant, and help lift it from a hard surface. Oil in water emulsifiers causes water immiscible contaminants, such as oil or grease, to become dispersed in the water.

It is always recommended that a commercial solvent chosen must be 100 percent volatile for it to completely evaporate and be removed. There are a lot of false claims being printed on the labels today, and this is why we emphasize the importance of studying and understanding the chemical product. Remember, you must be "Smarter than the label."

Whatever chemical you choose to use, it is your professional responsibility to obtain a MSDS with sub component CAS numbers. It is extremely important you know what you're using. Understand the effectiveness of both the chemical and physical properties of the product you choose to use. Know how and why this chemical will remove the undesirables (or paint). Know how this chemical will be removed from the system when cleaning is completed. Know if it is compatible with the metal and elastomer materials of the system, components, and the flushing equipment. Know the toxicity, hazard classification, flammability, combustibility, and proper handling. Know the local, state, and federal regulations regarding the use and disposal of the products you choose.

Basic physics

Now we can get to some basic physics principles. Complete and many times partially assembled systems cannot be flushed. You must always isolate the heat exchangers and flush through the most direct and unrestricted path to obtain the most satisfactory flushing results. You cannot flush through check valves, filters, orifices, or any device that would slow or restrict the heat exchanger flushing process and or solvent recovery and removal.

Some form of mechanical energy is almost always used to enhance a solvent cleaning process. Even the best suited chemicals for the job will produce poor results. If not introduced with the adequate energy necessary to defeat the "path of least resistance" rule, scrub the internals down into the corners and crevices; to dislodge trapped debris and carry it away.

It is just like holding a dirty part under your parts washer outflow; you know the cleaning will be accelerated and improved when you add your elbow (energy) and a scrub brush.

Agitation, pulse, vibration, and ultrasonic; are some examples of typical methods that are used to apply energy to enhance a cleaning process. A warning: These multiple path heat exchanger internals are constructed somewhat light and delicate, and even when encased in a hard shell such as for severe-duty and military applications, the internal construction is very similar. Testing done with ultrasonic cleaning has produced many internal destructive results. Also, another issue to always be aware of is the damage that can be caused by overpressurizing.

One method of applying mechanical energy is "Pulsating", a HECAT patented process, which uses fixed dimensional control of the air and liquid flow paths to produce solid impacting slugs of solvent separated by segments of compressed air. Compressed air is not just used to pressurize the liquid; the stored energy in compressed air is used and applied to push the slugs of solvent deep into the internals (corner and crevices) of a heat exchanger.

The "Pulsating" frequency is about 5 to 6 pulses per second and backpressure only enhances and intensifies the "Pulsating" scrubbing action. It is one of the few methods proven to defeat the "path of least resistance" rule and effectively scrub down deep into the parallel paths and passageways to effectively clean today's complex heat exchangers. It is just like applying the energy of your parts washer scrub brush down inside a component, where you cannot reach.

Velocity is a fundamental energy component that is often overlooked, but critical to successful heat exchanger cleaning. The solvent must be introduced with adequate velocity to completely flood the component. Velocity is the necessary energy component needed to carry away weighted debris. Velocity cannot be sustained if the solvent is not introduced with an adequate volume to support it. There must be enough solvent supplied to support the velocity of the flushing process, and there must also be enough solvent supplied to effectively do its job at dissolving the residues. This is why common and inexpensive A/C flushing methods such as pour in-blow out, aerosol cans, and 1-quart flush guns won't work.

Now that some of the questions of how to clean heat exchangers have been answered, the job should be easier.

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