HYDROCARBON ENGINEERING

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Figure 1. Regular sampling can help detect problems before they occur or escalate.

MONITOR TO MAINTAIN

Matthias Schopf, Eastman, Germany, shares the importance of including a fluid monitoring system when designing and operating heat transfer fluid systems.

While designing and operating a heat transfer fluid system, an important maintenance aspect sometimes gets low priority – monitoring the conditions of the heat transfer fluid in service. Suitable corrective actions, taken at the right time, may not only extend the in-service life of the heat transfer fluid, but also reduce the risk of unwanted equipment failures or unexpected shutdowns. Insurance contracts or local regulations may also stipulate regular fluid monitoring. Finally, regular sampling histories allow for comparisons that can help detect problems before they occur or escalate. Therefore, including a fluid monitoring scheme using the appropriate equipment for safe and reliable sampling should be part of any design and operating manual for heat transfer systems.

Sample ports should be designed to enable the safe collection of representative samples. The port should be connected to a line containing flowing liquid and should allow purging of the line before taking the sample.

Cooling the sample to temperatures below 60˚C (140˚F) may be necessary to prevent thermal burns, but also to prevent unwanted evaporation of potential moisture and low boiling components in the sample. After sampling, the bottle should be sealed promptly, and should be safe and appropriate to handle and ship. Some suppliers of heat transfer fluids may provide sample kits containing suitable bottles and instructions for sample taking and shipping.

A regular schedule for sampling the heat transfer fluid should be established right from the beginning. For a new system, the first sample, which will function as a baseline, should be taken within 24 hours of the plant start-up. A second sample should be collected after approximately six months of operation, and annually thereafter. Additional samples should be analysed after system cleaning, fluid changeout or major changes in operating conditions (e.g. different fluid used or higher operating temperatures). Also, in case of system operation issues, the heat transfer fluid should be analysed to determine whether the fluid properties have changed in a manner to contribute to these issues, or exclude the fluid from the list of potential root causes.

What properties should be evaluated to determine the status of the in-service fluid?

Moisture

Excess moisture in high temperature systems may lead to interruptions of the fluid flow due to its low boiling point and hence cause evaporating (or flashing) at pump inlet, creating cavitation. In cooling systems, the moisture could lower the efficiency of heat transfer due to the formation of ice crystals on chiller surfaces. Typical sources for moisture can be residues from system construction and testing, contamination with process water in-leakage or intake of humidity via expansion tanks open to atmosphere.

Acidity

Increased acidity, typically reported as the total acid number, may be caused by fluid oxidation, which often occurs if hot fluid is exposed to air in a non-inerted expansion tank. Acidity could also be increased by contamination from a process stream. High acidity may result in enhanced corrosion and, consequently, cause equipment failures. Oxidation and corrosion products may result in sludge or deposits, and could compromise system performance and reliability.

Flash point

Most heat transfer fluids have relatively high flash points when starting service. However, due to degradation, the flash point might become depressed over time. While heat transfer fluids are typically operated in closed systems and it is safe to operate a fluid in a well-designed and maintained system even significantly above the fluid flash point, a depressed flash point might increase the potential fire hazard in case of leakages. This situation may also affect the overall classification of the system. Therefore, corrective measures should be taken if the flash point decreases significantly.

Viscosity

The viscosity of the fluid is an important property to evaluate the flow characteristics of a liquid. Greater viscosity fluids require more energy to pump and have less turbulence at the same conditions as less viscous fluids, resulting in lower heat transfer coefficients. An increased viscosity may negatively impact the system start-up, especially at low ambient temperatures. As the viscosity is linked to the molecular weight of the fluid constituents, it can be influenced in two extremes. Low molecular weight components may reduce the viscosity while components with higher molecular weight can increase the viscosity. During standard maintenance over the life of the fluid, the lower molecular weight thermal degradation components removed will gradually increase the fluid's average molecular weight and viscosity.

Insoluble solids

The presence of insoluble solids in a solvent could be a result of contamination from solid particles, corrosion products, severe thermal degradation or oxidation. High amounts of solids may result in fouling or residues, which negatively impacts the heat transfer performance. Plugging of tubes, especially those with smaller diameters like control device lines, may also occur. Lastly, solids may increase the wear and lead to damage of mechanical seals and valve surfaces.

Thermal degradation, low and high boilers

Heat transfer fluids will degrade due to thermal decomposition, or cracking. The cracking leads to components with lower molecular weight and are usually referred to as low boilers. Some of these molecules may recombine to form higher molecular weight products (high boilers).

Low boilers can influence system operation in multiple aspects. Due to the lower boiling point, the vapour pressure will be increased, which can lead to pump cavitation and unexpected pressure relief. The pump cavitation has not only the potential to damage the impeller, but flow disruptions are also likely to occur, which could lead to fluid overheating or system shutdowns. Excessive amounts of low boilers may also cause a depression of the flash point, while high rates will require more maintenance efforts to remove them, and can result in high fluid make-up costs.

High boilers will typically increase the viscosity of the fluid at ambient temperatures and could lead to potential start-up problems. This increase could also negatively influence the heat transfer efficiency, as high boilers cannot be easily separated from the system. Therefore, they will accumulate up to the maximum concentration set by the supplier, and the fluid will eventually need to be partially or totally replaced. If no corrective action is taken the concentration will further increase and sludge and tar deposits may be formed if the solubility limits for higher molecular weight components are exceeded.

Post analysis

Once the sample is analysed, a detailed report should be issued providing a thorough fluid evaluation including suggested corrective actions, if required. The quality of such evaluation and recommendations highly depends on the experience and knowledge of historical fluid trends. This is because every heat transfer fluid system is specific, and the recommended limits are a composite of the fluid suppliers' experience in the analyses of used heat transfer fluid samples and plant performance data. Therefore, only by capturing the analysis history will it be possible to form an understanding of fluid trends. Monitoring of sudden fluid property changes, which may have been caused by changing operation conditions or system malfunctions, is also advantageous.

The following customer cases demonstrate how a regular in-service sampling programme supported customers by setting the right operating and maintenance conditions and by optimising the heat transfer fluid lifetime and operating costs.

Case 1

A customer experienced an unexpected high viscosity increase, which could not be explained by the current operating temperature. While analysing the sample, an unusual boiling profile was obtained. Discussing with the customer potential reasons, the technical expert of the heat transfer fluids supplier found this boiling profile was the result of a permanent inert gas sweep through the expansion tank. This not only removed low boiling components, but also increased the evaporation of components, which were not intended to be removed. The resulting viscosity increase could lead to start-up delays, greater pressure drop and increased pumping cost. Also, the consumption of nitrogen and higher fluid make-up rates would be a cost factor.

By implementing the suggested changes to eliminate the continual sweeping of vapours, the viscosity was kept in the normal ranges and the fluid life time was protected and optimised.

Case 2

After many years of operating, an analysis of the heat transfer fluid showed an increased degradation rate. Although the fluid parameters were still within normal ranges, the customer was concerned whether the fluid conditions were changing too fast. A trend analysis of the samples from the past 10 years helped to identify the timeframe when the degradation rates became higher. Looking also at maintenance and operating records at this time window of concern, it was found that the operating temperature of the heat transfer fluid had increased in order to increase the yield of the production. Combining this trend analysis together with the decades of knowledge of degradation mechanisms of heat transfer fluids, the experts of the heat transfer fluid supplier enabled the customer to choose an operating temperature to optimally balance production yield and projected fluid degradation.

Conclusion

A well-planned fluid monitoring programme supported by the technical expertise of the heat transfer fluid supplier can help enable effective predictive maintenance, enabling corrective actions to be taken before a major problem occurs, optimising the fluid's lifetime.