Optimal Selection and Maintenance of Heat Transfer Fluids in Cannabis Oil Processing Plants

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Abstract – The legalization of Cannabis and Cannabis products for recreational and medicinal use in multiple states across the United States and country-wide in Canada in recent years has led to increased commercial and technical interest in processing technologies capable of extracting different useful components from the bioresource. Heaters and chillers feature prominently in most Cannabis processing equipment assembly and often require an optimal heat transfer fluid for appropriate thermoregulation of the extraction and purification process. In this paper, we highlight important factors that should be considered for an optimal choice and maintenance of heat transfer fluids used in chillers and baths. To buttress our positions, we make specific references to popular OEM brands, matching them up with heat transfer fluid products from a leading manufacturer of heat transfer fluids.

I. Introduction

Cannabis processing primarily commences with an extraction of active compounds from the green plant material using a solvent. The extract is isolated through distillation or evaporation. Therefore, precise temperature control is critical for the optimization of product purity and yield. Heating circulators and chillers are used to achieve thermoregulation in this regard. Therefore, adequate attention must be paid to the choice of thermal fluids used in these circulators and chillers. Due to the infancy of the Cannabis industry, there are many misconceptions about which heat transfer fluids to use and the factors to consider when facility owners choose to fill/refill their chillers and heaters. This paper intends to serve as a guide to the Cannabis industry on heat transfer fluids.

II. CHILLERS & CIRCULATING BATHS THAT UTILIZE HEAT TRANSFER FLUIDS

Certain Original Equipment Manufacturers (OEM) are prominent for fluid thermoregulation in the Cannabis space.
They include Huber, Julabo, Lauda and Polyscience. For brevity in this paper, we focus on circulating heaters and chillers manufactured by the first two. While the general designs are similar, operating temperatures and the appropriate heat transfer fluid choices vary. For instance, Huber Unistats and CC temperature control units are models that utilize Silicone based heat transfer fluids and run over a temperature range of -90^{O}C to 300^{O}C. The Huber CS model units run from -20^{O}C to 15^{O}C and generally utilize glycol-based heat transfer fluids

WHAT MAKES A GREAT HEAT TRANSFER FLUID?

A heat transfer fluid, also known as a thermal fluid, is a liquid or gaseous medium designed to transfer heat energy indirectly from one stream or system to another. An effective thermal fluid must have a high heat capacity, high oxidation resistance under exposure to air, a high maximum use temperature, an appropriate viscosity index and a low pour point capable of handling low temperature process conditions. (Vutukuru, R., Pegallapati, & Maddali, 2019).

Non-toxicity and plant safety are also important qualifiers. A great heat transfer fluid must maintain decent fluidity over a broad temperature spectrum. Interestingly, many Cannabis equipment operators select great heat transfer fluids for the wrong applications, and this can create many process problems. For this reason, the optimal choice of heat transfer fluids in Cannabis oil processing is a necessity.

III. FACTORS TO CONSIDER WHEN SELECTING HEAT TRANSFER FLUIDS FOR CANNABIS OIL PROCESSING

Several factors must be considered when selecting thermal fluids for chillers and heaters in Cannabis oil processing applications.

A. Process Objective: It is important to establish whether you desire to heat or cool a process fluid and over what temperature range. In any case, operators must select a temperature control unit with an operating temperature range that covers the specified process temperature range. In turn, the appropriate heat transfer fluid is one with a bulk temperature high enough for your process. Selecting a fluid with a low bulk temperature or heat capacity will result in thermal cracking, a scenario where the long chain hydrocarbon is broken into smaller chains with adverse effect on fluid viscosity and heat transport. It must also have a pour point lower than the minimum process temperature so that fluid viscosity does not rise above the handling capacity of common pumps in the Cannabis market.

B. System Configuration (Open/Closed System):
Understanding your system configuration and how a heat

transfer fluid is supposed to help you heat or cool a process fluid is critical for the selection of an appropriate thermal fluid. Is your system an open bath, a bath with a lid or an airtight closed loop system? A mineral oil-based heat transfer fluid will experience rapid oxidation problems in open bath applications. The darkening of the thermal fluid and sludge formation not only impact heat transport, it will also discolor glassware. Equipment owners and operators must consider alternative fluid options in order to avoid this issue.

C. Heat Transfer Fluid Chemistry: Heat Transfer fluids come in a few chemical forms. There are thermal fluids composed primarily of petroleum-based mineral oils. Others are composed of synthetic fluids, Silicone/Silicone derivatives and glycol-based heat transfer fluids. Huber and Julabo offer many temperature control units that run on silicone-based heat transfer fluids. Because the units are not airtight, mineral-oil based heat transfer fluids are inappropriate and tend to oxidize (turn dark and viscous) over a fairly short period of time. It is important to note that the different chemical forms have their temperature specifications and limitation. In the event of a refill or top up, it is not advisable to mix thermal fluids of dissimilar chemistries. For instance, silicone-based heat transfer oil should not be topped off with Ethylene Glycol and vice versa. Equipment owners and operators must ensure that the selected fluid chemistry matches the process objective and is adequately designed to carry out the heat transfer task at hand.

D. Pumpability/Fluid Viscosity: Thermal fluids should maintain a pumpable viscosity over the applicable process temperature range. This is particularly important for low temperature applications and for open bath applications exceeding 200^{O}C. The former is pertinent because heat transfer fluid viscosity increases with decrease in temperature. Many of pumps used in Cannabis processing plants can only handle a viscosity of 50 cSt or less. Furthermore, certain grades of silicone fluids cannot be used past 200^{O}C because of a polymerization reaction that results in a sharp increase in viscosity. This essentially turns the thermal fluid into a gel that cannot be pumped. Therefore, pumpability and maintaining a reasonable fluid viscosity cannot be ignored.

E. Material Compatibility: Heat transfer fluids come in contact with gaskets, seals, diaphragms and other trims made from elastomers. It is interesting to note that silicone-based heat transfer fluids are not compatible with silicone trims. Synthetic fluids can also cause corrosion damage to carbon steel pipes, valves and other equipment. Equipment owners and operators can consult readily available compatibility charts online to determine the compatibility of mineral oil, silicone, glycol, and synthetic thermal fluids with their internal trims.

F. Health, Safety and the Environment: Cannabis processing facilities are mandated to comply with municipal, state and federal regulations that relate to employee health and safety as well as environmental pollution. For this reason, it is important to select a heat transfer fluid that is non-toxic, non-hazardous and environmentally friendly. Silicone-based heat transfer fluids like Relatherm S-1 and Relatherm S-LT are known to be safe, non-toxic and non-hazardous. Where food-grade heat transfer fluids are required, Relatherm FG-1 and Relatherm FG-2 are great options. The synthetic fluids are the most unfriendly when it comes to toxicity and the environment. It is important to note that synthetic fluids should not be jettisoned solely because of this demerit, it is important to keep in mind that high temperature operation in an open bath will likely result in a high vapor pressure that will necessitate adequate ventilation.

G. Cost: Thermal fluids of different chemistries have different cost implications. Glycols are known to be most inexpensive. These are followed closely by mineral oils. Synthetic fluids and silicone-based fluid generally sit at the top of the price chart. We have placed commercial considerations at the tail end of this list because operators should not select heat transfer fluids based solely on price. Nonetheless, commercial considerations cannot be jettisoned altogether. Procuring heat transfer fluids directly from fluid manufacturers can help optimize the cost. Many OEMs buy from the same fluid manufacturers and resell at exorbitant prices. To the best of our knowledge, no temperature control unit manufacturer has fluid formulation or manufacturing expertise or production capacity. In section V, we make the argument that the use of non-OEM heat transfer fluids is appropriate and safe from a technical perspective. It is also commercially expedient if the selection and maintenance criteria in this paper are met.

IV. COMMON HEAT TRANSFER FLUID PROBLEMS IN CANNABIS OIL PROCESSING

1. Thermal Cracking: This results from the overheating of a heat transfer fluid which causes the viscosity and flash point to drop resulting in less effective heat transfer. To mitigate thermal cracking, a heating bath with the appropriate watt density must be selected. It is also important to get some agitation in the bath where possible to prevent idle fluid directly in contact with the inductor coil from accumulating thermal energy in excess of its heat capacity. During shutdown, operators should keep the pump on until the fluid temperature has dropped below 50^{O}C. Periodic thermal fluid analyses

should help ensure that viscosity and flashpoint are within allowable limits (Beemsterboer, 2019).

2. Oxidation: As suggested in the preceding section, fluid oxidation occurs when organic thermal fluids react with air, causing sludge formation as well as increased Total Acid Number (TAN) and viscosity (Soni, Gamble & Schopf, 2017). An optimal selection of thermal fluid based on system configuration should help avoid this issue in open bath circulators. In closed loop systems, putting an inert gas blanket over the thermal fluid in an expansion tank is another proven oxidation mitigation strategy (Gamble, 2018). It is important to note that this mostly applies to larger installations with hundreds of gallons of heat transfer fluids, however. Periodic thermal fluid analyses should help ensure that viscosity and TAN are within allowable limits.

3. Contamination: Mixing virgin fluid with degraded fluid can result in contamination. Therefore, it is important to rid a thermal system of any degraded fluid before charging virgin fluid. In cases where sludge or carbon deposits are present in a heat transfer ssystem, the use of a cleaner like Rescue HTF Cleaner and a flushing fluid like Rescue Flush is highly recommended.

4. Polymerization: Silicone Heat Transfer Fluids cannot be used at temperatures exceeding 200^{O}C because of a polymerization reaction that causes the fluid to become a gel. Proper fluid selection will help avoid this problem. For instance, in open bath applications with a maximum operating temperature higher than 200^{O}C, a synthetic fluid may be more appropriate.

5. Smoke & Fumes: It is not uncommon for some thermal fluids to emit smoke and fumes from an open bath during operation. Apart from the attendant health risks, there are liability and fire safety considerations at stake. Smoke formation may result from an overheating of the fluid or from a poor fluid selection. Operators and equipment owners must ask to see a vapor pressure table or chart set against temperature during fluid selection so that they can determine the onset of smoke or fume formation. Optimal fluid selection will ordinarily ensure that the thermal fluid has a negligible/low vapor pressure over the operating temperature range.

V. COMMON MYTHS ABOUT HEAT TRANSFER FLUIDS IN THE CANNABIS INDUSTRY

1. ***"I must <u>only</u> use heat transfer fluids supplied by Huber or Julabo".***

No! Equipment owners and operators of Cannabis oil processing equipment can utilize any heat transfer fluid that meets the process specification and the criteria set in Section III. Here's why:

-We have examined the technical specifications and the active ingredients listed on the Material Safety Data Sheets of Huber and Julabo fluids and established direct equivalence with some of the heat transfer fluids supplied by fluid manufacturers like Relatherm Heat Transfer Fluids. For instance, DW-Therm M90.200.02 has the same physical properties and chemical composition (Alkoxy Silane) as Relatherm S-LT Low Temperature Heat Transfer Fluid. Furthermore, Thermal C50S from Julabo has the exact same physical properties and chemical composition (polydimethylsiloxane) as Relatherm S-1 Silicone Heat Transfer Fluid. As shown in Section VI, Relatherm S-LT and Relatherm S-1 has been proven to work well in several Huber Unistats and Julabo FP circulators respectively.

-We have also carried out a physical properties test on samples of the above-named Huber & Julabo fluids provided by end users and the results match up quite well with the data reported on the technical datasheets of Relatherm S-1 and Relatherm S-LT

-To the best of our knowledge, neither Huber or Julabo has any fluids/chemicals formulation, R&D and manufacturing experience. Neither do they own any fluid production plants anywhere in the world. They are thermoregulation equipment experts, not heat transfer fluid experts.

- The heat transfer fluids provided by Huber and Julabo are sourced from heat transfer fluid manufacturers. End users pay an exorbitant markup and limit their choices when they fail to shop around for other available thermal fluid options.

Relatherm S-1 and Relatherm S-LT have been extensively tested at the Relatherm laboratory and in the field (Cannabis processing facilities in the USA). They possess physical and chemical properties that match those provided on the OEM fluid data sheets. We have ample confidence that Relatherm S-1 and Relatherm S-LT work well in Huber and Julabo Temperature Control Units and will cause no adverse operational effects if the operational parameters stated herein are met.

2. *I should change out my heat transfer oil once it's no longer crystal clear.*

While fluid discoloration is suggestive of the onset of thermal fluid degradation, the only definitive way to determine if a fluid change is due is through a heat transfer fluid analysis. Manufacturers like Relatherm Heat Transfer Fluids offer a complimentary fluid analysis program that allows end users to take charge of their fluid health and change out schedule. Typically, a drastic reduction in viscosity is suggestive of thermal cracking. For mineral oil applications, a TAN value greater than 1.0 should trigger a fluid change out. With slight discoloration, our experience has been that the fluid probably still has some life left in it.

3. *I am trying to save on cost, I will use water/lubricant/motor oil in my bath instead of engineered thermal fluids.*

Heat transfer fluids are specifically designed and formulated to heat or cool a process over a temperature range. While water is an effective heat transfer medium, it has limitations at $0^{O}C$ and $212^{O}C$. Furthermore, motor oils are not designed to transport heat and they are known to leave varnishes and deposits on heat transfer surfaces. At high temperatures, they disintegrate and are thermally unstable.

VI. FIELD APPLICATION EXAMPLES

Relatherm Heat Transfer Fluids have been successfully deployed in numerous Cannabis oil processing facilities. Here are few anonymized case studies.

1. An Oregon-based Cannabis processor approached Relatherm Heat Transfer Fluids with a thermal fluid inquiry. They had previously utilized Paratherm NF in their Huber CC 505 unit with an operating temperature range of $-50^{O}C$ to $200^{O}C$. The end user had advanced fluid oxidation problems with sludge and hard carbon deposits formed in the temperature control unit. Relatherm recommended a cleaning schedule that utilized a concentrate cleaner called RelaClean SC. Thereafter, a silicone fluid flush was administered using the RelaFlush S fluid before the charging of Relatherm S-1 Silicone Heat Transfer Fluid. The processor has run this fluid in their Huber units for 18 months without any fluid oxidation problems.

2. A Seattle-based Cannabis processor was shopping around for a more economical fluid option. They were paying exorbitant rates for the Huber DW-Therm M90.200.02 fluid. Therefore, they sought a technically sound alternative that offered considerable cost savings. The end-user's buyer stumbled on www.relatherm.com and reached out to the team at Relatherm Heat Transfer Fluids. Relatherm S-LT Low Temperature Heat Transfer Fluid was proposed as a direct drop-in replacement for the Huber fluid at a 50% cost reduction rate. The change to Relatherm S-LT was seamless and the fluid met the process cooling needs of the customer. Because the fluid worked just as well as those supplied by the OEM, the end-user had reordered the fluid twice as they expand. This indicates a high level of customer satisfaction.

VII. CONCLUSION

In this paper, we focus on the use and maintenance of heat transfer fluids in Cannabis oil processing equipment. We highlight the criteria for optimal selection of thermal fluids and discuss common problems faced by operators and equipment owners. In the concluding segments, we establish the chemical and physical equivalence between certain OEM supplied fluids and some of those provided by Relatherm Heat Transfer Fluids.

VIII. REFERENCES

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