Maintenance and Cleaning of Thermic Fluid System (TFS) – A guideline

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***Abstract*—Thermic Fluid (TF) and Thermic Fluid systems (TFS) are extremely expensive and valuable assets for industry, its maintenance is critical to the effectiveness and safety of TFS. Routine monitoring of TF condition is a critical part of ongoing TFS maintenance as its degradation is a complicated chemical process, laboratory techniques can provide rapid insights into the status of a TF and TFS. Foreign contamination like moisture, environmental and system build contaminants are the major cause of degradation, which act to accelerate the ageing of a TF. In this paper a guideline is given that is to be adopted for easy working with TFS; analysis of TF like Hi-Tech Therm-60(HT-60) by its parameter and the method for cleaning the TFS using ionic based cleaning chemicals like Hi-Tech Clean – 205 and Hi-Tech Clean- 206.**

***IndexTerms*—Heat Transfer Fluid (HTF), Thermic Fluid (TF), Hi-Tech Therm-60, Thermal Degradation, Oxidation, Laboratory analysis, Thermic Fluid System (TFS) cleaning.**

I.INTRODUCTION

In India TFS are mainly used for drying and heating in various industries like textiles, food, plywood, chemicals, packing, etc.. The cost and production efficiency of such plants is paramount with interruptions or inefficient production leading to a reduction in overall output relative to increased production costs. The maintenance of a TFS is central to maintaining plant operation and also ensuring the longevity and safety of the overall plant. In every day practise, the condition of a TF is assessed routinely and is an indirect measure of the condition and safety of the plant itself. The ageing of a heat transfer fluid (HTF) is a complicated chemical process [7] and the sporadic analysis of fluids, such as measurement of carbon residue, total acid number, viscosity flash point, etc., gives critical insights into the ageing process like oxidative state, thermal degradation and contamination from foreign particles including water and wear particles[4]. The various tests are conducted in *Generation Four Engitech Ltd. Laboratory* which follows the international test methods as per **ASTMD5372 − 04** [1], [8] for testing TF.

II.LABORATORYEXPERIMENTS

Prior to any process for maintenance and cleaning the analysis of TF is required. Table 1 shows parameters and their typical values of *TF-medium* as per IS**:** 14745:1999 [2] and *HT-60*.

III.CHEMICAL ANALYSIS AND ASSESSMENT

The analysis of the TF sample helps in determining condition of oil which is very helpful in determining breakdown and maintenance requirement of TFS. The parameters shown in Table 1 [2] are analysed for up to 1500 samples of the many TFS throughout India in *G4 laboratory*.The sampling method given to TF user is:

a) A 1000 ml is required to chemically analyse the condition of the TF.

b) Closed sampling devices should be used to get a representative sample of the TF.

c) Before sampling, the sampling device should be thoroughly washed.

d) A TF should be taken from the main circulating line of the TFS, but samples may be required from other parts of the system if a specific issue is being investigated.

A. Appearance

By looking at the sample in transparent container one can find the presence of solid debris, or any suspended particles in given sample. It may be sludgy plain or separated.

B. Kinematic viscosity

The viscosity at 40 ^{O}C, represents a change in the fluid's molecular sizes and structures. The kinematic viscosity of TF should be as minimum as possible so as to have least resistance to flow and power required for same. The increase in TAN and carbon

value, work to increase viscosity of TF which shows the oxidised products are present in TF. Scheduled cleaning and to-up of new fluid maintain the viscosity of oil by diluting it.

Table 1 Requirements of Thermic Fluid [1] [5]

Parameters (Test Method)	**Characteristics**	
	TF-medium	**Hi-Tech Therm-60**
Appearance	Clear Bright	Clear Bright
Color	--------	Green
Total Acid Number (mg KOH/g) (ASTM D 664)	0.05	0.01
Kinematic Viscosity (cSt) at 40℃ (ASTM 455-8)	24-35	18-24
Flash point COC (ASTM D 92)	208 ℃	205 ℃
Carbon residue (Rams Bottom Carbon Residue)	0.00 - 1 %	0.00%
Density at ambient temperature (ASTM D 4052)	0.86 g/ml	0.86 g/ml
Moisture content (ppm) (ASTM D 6304)	< 220 ppm	< 90 ppm

C. Flash point

The open flash point temperature was assessed and judged to be at a serious level (< 170 ^{O}C). Flash point is the temperature at which liquid fuels develop volatile vapours. There are two methods to assess flash point temperature – open and closed. Open flash tests mimic the scenario of vapours mixing with air and being partly removed by air movement as the most volatile escape. This leads to a slightly higher test value because of the air being added. Closed flash point temperature mimics vapours not mixing with air (i.e., being kept together and the most volatile are maintained in the fluid) and so the test value is lower. Flash point temperature reflects the extent of flammable decomposition products. The flash point is the lowest temperature where there is sufficient flammable vapour to ignite in the presence of an ignition source. The dropping flash point temperature indicates that the system is not venting effectively and so highly volatile decomposition products are starting to accumulate in TFS. A problem of reduced flashpoint is discussed by *Ian Wright* [3].

D. Carbon residue

This measures the unevaporated carbon (coke) residue after a sample of oil is completely evaporated by heating and the oil vapour burned. The carbon residue is weighed and represented as a percentage of the original amount of oil. Carbon residue indicates the formation process whereby high molecular compounds are transforming into coke-like deposits. Hence, it is an indicator of ageing.The elevated level of carbon leads to system fouling in which carbon will deposit and bake on the internal surfaces of system. The window for a change, and action to be taken, is ideally whilst the carbon residue level is less than 2% weight (i.e., between 0.75 and 2.00% of weight). This is where the carbon is still soft and can be cleaned off using anionic based carbon dispersant and varnish emulsifier liquid like *Hitech clean 205 and Hitech clean 206*.

If cleaning is not done at this level, carbon starts to bake on to the internal pipework and cannot be easily removed. The consequence of this being that the system starts to lose its thermal efficiency as carbon has an insulating effect and the system will require more energy to heat the TF. The baking of carbon on to the internal pipework is the most common form of heater/coil failure as hot spots can occur. In such cases, the heater coil breaches and at this stage a thermal TF fire may occur. One important point to mention here is that systems should be designed with safety interlocks. For example, a “fusible” link to cut-off the gas supply in the event of fire within the heater and pumps that cut out to prevent further fuelling of a fire.

E. Total acid number (TAN)

TAN and fire point were defined as being cautionary. The TAN assesses those components with an acid function (weak organic acids). The test quantifies the amount of potassium hydroxide that is needed to neutralise free acids contained in a 1- mg sample of the test oil. In the form of water solid acids, these can be particularly damaging as they attack the material in contact with the oil and can lead to corrosion of pipework. A high TAN is indicative of ageing of the fluid, oxidation progress and corrosion problems in a system. If oil left untreated the TAN would continue to climb and lead to the exponential formation of heavy ends (more carbon) as well as corrosion, particularly in the expansion tank. Means the regular cleaning of expansion tank is required which is not practical.

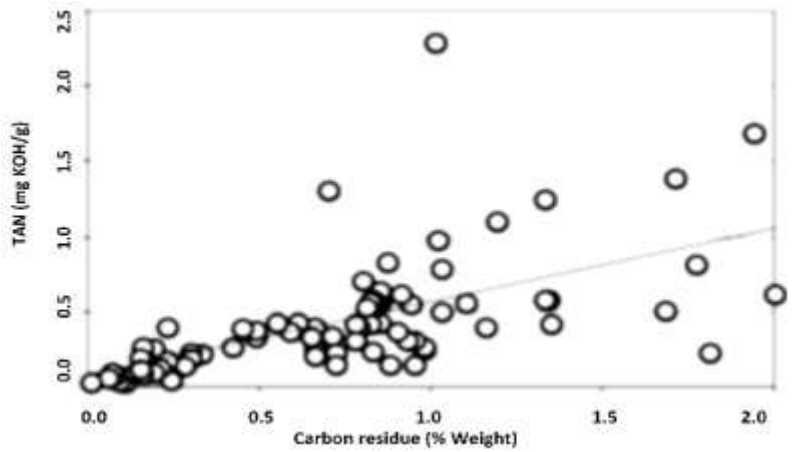

Fig. 1Relation between carbon residue & TAN [6]

It is normally recommended that customers dilute their fluid to achieve a TAN below 0.2 mg KOH/g. At levels below this, the effects of accelerated carbon production and corrosion are reduced to insignificant levels or to values close to those seen with a new TF.

Table 2 TF Tests and their Objectives

TF Chemical Test	What is assessed?
Viscosity	Flowability and power requirement
Flash point temperature-closed cup	Light chain hydrocarbon
Flash point temperature-COC	Light chain hydrocarbon
Carbon residue	Heavy chain hydrocarbon
TAN	The extent of TF oxidation

IV.MAINTENANCE AND MANAGEMENT PROGRAMS FOR THERMIC FLUID SYSTEMS (TFS)

The thermal stability of a TF depends not just on the chemical structure, but also on sound engineering practices and sound maintenance programs to monitor and manage the rate of thermal degradation and degree of oxidation. Some highlights for maintaining the TFS are:

A. Thermic Fluid Circulating Pump and Its Location Requirements

1. Always use Circulating pump motor having RPM 2800-2900.
2. Add a standby pump with same specification of pump and motor.
3. Always check the pump vibration, noise and leakages.
4. Always keep pump away from the water because presence of water can leads to electrical faults.
5. Always put the diesel engine of sufficient size connected to pump for emergency.
6. Centrifugal pump should be with proper air/water cooling system.
7. All pumps should be equipped with pressure gage at inlet and outlet point.
8. Proper ventilated space should be chosen for installing pumps.
9. If pump is water cooled, cooling water temperature should not be more than $65^{O}C$ and oil droplets not more than 20 drops per minutes.
10. Pump location should be such that maintenance can be done easily.
11. Use "Y" strainer with 40meshes filter media for pump safety.
12. Periodically clean the pump area.
13. All electric connection should be accordance with safety as FM 7-99 [9].
14. Coupling connecting pump and motor should have safety guard properly fitted.
15. All strainers and filters should have dual pressure gauge on discharge point.

B. Initial Start of TFS

1. Check system leakages at 7 kg/cm^2 pressure from dry air or nitrogen,
2. Fill the oil from expansion tank and remove air form system through vents,
3. Run system for 30 minutes to remove trapped air from system and do this till you have stable pressure in the system,
4. Start Fire and raise the temperature of the system up to 99 ^{O}C,
5. Increase temperature by 2 ^{O}C in every 15 minutes and keep eyes on expansion tank to see any steam coming out of the system,
6. If steam comes out you observe any vibration in the pressure gauge and some of the pipelines, don't increase temperature till all comes to stable condition,

7. After attaining temperature up to 120 ^{O}C check the whole system by laser temperature sensor gun, that no area should have temperate below 110 ^{O}C,
8. If o.k. then increase temperature as per point 5.
9. After required temperature achieved check full system for any leakage.

C. Shutdown procedure of Thermic fluid system (TFS)

1. Remove remaining fuel.
2. Start I.D and F.D fan
3. Do not stop circulating pump, also do not shift circulating pump to lower capacity pump.
4. Start all heat transfer system like existing fan blower to reduce heat in system.
5. If using water tank maintain temperature of tank to avoid thermal shock to oil
6. Stop circulating pump only after temp is less than 90^{O}C.
7. Stop I.D & F.D fan open doors of firing grit.
8. Recalculate oil after 30 minutes for 10 minutes.
9. Stop circulating oil by shutting off electric supply.
10. At last we have to shut down control panel of the plant.

D. RE-starting of TFS

1 Check your panel board. It should be in Dry condition
2 Before starting pump checks that the level in expansion tank is not less than 25 %.
3 If your circulating pump is water cooled then starts the water supply and confirm sufficient and clean supply of water.
4 Circulate thermic fluid for 15 minutes in the system in extinguished (non-fired) condition and check your pressure gauge. Stable reading shows there are no leakages, in the system. The pre- circulation will equalize thermic fluid viscosity and disperse separated carbon if any.
5 Start heating the thermic fluid and as you reach 110^{O} C again check your pressure gauge, system leakage, pump noise, expansion tank air vent and pipeline shaking if any.
6 If everything is stable and ok continue heating up to desired temperature.
7 The rate of heating should be such that the time to increase the temperature from room temperature to desire temperature should be at least 2 to 2.5 hours.
8 Now when the temperature reaches to required temperature check your expansion tank's level (should be nearly ¾ filled) and temperature should not exceed 60^{O}C in expansion tank.
9 Note down your temperature and pressure readings of heater inlet and outlet.
10 Check, change in inlet and outlet temperatures of oil (Δt); temperature of flue gases and water coolant outlet of circulating pump.

E. Action to be taken at the time of power failure

1 Start Generator, if not possible start engine set (fighter pump) within 3 minutes of power failure.
2 Remove all fuel from the firing bed.
3 The possibility of overflow of TF through expansion tank is highest at the time of power failure, so take precautions to avoid accidents.
4 If engine set started remove some oil from buffer tank.

V.CLEANING PROCEDURE OF TFS USING HITECH CLEAN 205 AND HITECH CLEAN 206

A. Empting the System

1. Open all the drain valves and put the container below that as much as possible.
2. Either Buffer tank should make empty through the drain valve or it should be empty by making hole at lowest point of buffer tank.
3. Check all drain valve, which should be at lowest point if it is then ok otherwise arrange it at proper location.
4. Wait till the last drop of fluid come from all drain point.
5. Make section to give air pressure to empty the system.
6. Check the cover of expansion tank it should be air tight.
7. Make sure that air pressure goes to the next section after empty the first section through drain valve.
8. Change leakage packing sheet if any.
9. Clean mesh of strainer in the system.

B. Flushing/Cleaning the system

1. Open all line valve and close all drain valve by this we make sure that circular path is clear for flow of water in whole the line and machines.
2. System fill by fresh water through expansion tank up to10% level.
3. Start circulating pump.
4. Start fire and heat the system temp up to 80^{O}C and maintain this temp till cleaning procedure not done through chemicals.
5. Run circulation pump for ½ hour

6. Open all vent till clean water comes out, during this filling of fresh water in expansion tank and circulating pump running should be continue.
7. Now it takes too many hours to complete and time is according to the system used.
8. Prepare the solution of *Hitech clean 205* and fill into the system through expansion tank and check all drain valve should be close now.
9. This emulsify solution should be run in the system for minimum 6 hours or as per guided.
10. Prepare the solution of *HiTech Clean 206* and fill into the system through expansion tank. Remove water first from vent in same quantity as *Hitech Clean 206* solution.

Fig. 1Cleaning Results of Hitech Clean 205+ Hitech clean 206 [5]

11. This emulsifier and detergent solution should be run in the system for minimum 6 hours or depending on the system
12. After this procedure, drain all the running water and stop firing.
13. Start draining water from different –different point or 1 point during this fresh water filling in to expansion tank and circulating pump running continue.
14. Continue previous step till fresh/clean water comes out from all drain point.
15. Repeat same step 1 to 9 as in first heading.
16. Use hot air to dry the system.

C. Refilling the system with new thermic fluid

1. Check line valve, all line valve at inlet and outlet of any point should be close.
2. Fill new thermic fluid into expansion tank up to 10% level.
3. Start removing air through new thermic fluid from boiler's coil first
4. Open line valve at inlet to the system Now start removing air from machines and start that machine which is connected first in the line (at outlet of boiler).
5. After filling all machine start circulating pump (Level Should be 10% in expansion tank).
6. After 4 hours running start firing.
7. When temp reaches 80 ^{O}C, take 15 to 30 minutes to increase 5^{O}C temp.
8. Check all vent and drain valve again and again till temp reach 120^{O}C and stable system pressure at inlet /outlet.
9. When working of system seems o.k. at 120^{O}C increase temperature to maximum limit according to requirement.

VI. DISCUSSION

Likewise a human body and its blood TF is a flowing liquid in thermic fluid systems, which reflects the problems related to system in laboratory analysis; and helps us in maintaining TFS. The test results from the oil sample indicate both the health status of the system and the fluid within the system, so it is very important to have a scheduled sampling procedure which briefs the TFS health. In general the flushing and cleaning of TFS done only for used TFS, to regain its efficiency, but it is recommended to clean a newly built TFS and followed by filling of virgin TF in system. In this paper the author discussed the way of maintaining a TFS by its vast experience in this field

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