Applied Thermal Engineering 84 (2015) 94–103

Contents lists available at ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Research paper

Food processing: The use of non-fouling food grade heat transfer fluids

Christopher Ian Wright [a, *], Thomas Bembridge [b, 1], Eole Picot [c, 1], Julien Premel [c, 1]

[a] Global Group, Cold Meece Estate, Cold Meece, Staffordshire ST15 0SP, United Kingdom
[b] Kinetic Partners, 1 London Wall, London EC2Y 5HB, UK
[c] Pole Etudes Locomotive et TGV Optimisation de la Maintenance TGV chez SNCF, Paris, France

HIGHLIGHTS

- Food grade heat transfer fluid (HTF) is colourless, non-toxic and non-irritating.
- This HTF is non-fouling and less carbon forms.
- Such HTFs can be safely used in food processing if they are HT-1 certified.
- A number of controls (e.g., HACCP) are used to ensure such fluids are safe.
- An additional check is to sample fluids to ensure food grade fluids are being used.

ARTICLE INFO

Article history:
Received 30 October 2014
Accepted 8 March 2015
Available online 1 April 2015

Keywords:
Heat transfer fluid
Food grade
Food processing
Manufacturing

ABSTRACT

It is reported that there are some 4000 companies operating high temperature thermal fluid systems in the UK and Ireland. This excludes steam or water based systems. The heat transfer fluids (HTFs) used in food processing are highly refined mineral HTFs that are non-toxic, non-irritating and lack an odour. If an HTF has been certified for use in food processing it carries an HT-1 certificate. HTFs suitable for use in food processing are commonly referred to as 'non-fouling' which means as they thermally degrade they produce small carbon particles that are suspended in the HTF. Moreover, the carbon formations are less sticky and this reduces the extent of adhesion to the internal surfaces of an HTF system. The current paper analysed the test reports from 1223 HTF systems and showed that, on average, the carbon residue for food grade HTF was lower than non-food grade HTF. This clearly demonstrates what the non-fouling nature of a food grade HTF. This paper then explored the regulatory, legal and environmental landscape for food grade HTFs. In this area of manufacturing, it is critical that the HTFs used are suitable for incidental contact with food. Other measures put consumer safety at the heart of all operations (i.e., internal company procedures such as hazard analysis and critical control points [HACCP]) and that food is safe for consumer consumption (e.g., external controls such as auditing manufacturers to ensure good quality and distribution practice). The authors introduce the idea that safety could be further enhanced through independent HTF sampling and chemical analysis of HTFs to ensure they are food grade and should be done without any interruption to a manufacturer's production.

1. Introduction

A recent report estimated that the value of the heat transfer fluid (HTF) market in 2011 was $1684.0 million and by 2017 this will increase to $2557.2 million [1]. Heat transfer refers to the transfer of thermal energy. In this process, HTFs are a heat carrier between a heater and a heat consumer and back [2]. This is the basic requirement of a wide variety of industrial processes and the principle behind indirect heat transfer plants. HTFs are used in a

Abbreviations: HTF, heat transfer fluid; TAN, total acid number; SOP, standard operating procedure; HACCP, hazard analysis and critical control point; REACH, registration, evaluation, authorisation and restriction of chemicals; CLP, classification, labelling and packaging; BRC, British retail consortium.

* Corresponding author. Tel.: +44 7967 230 155.
E-mail address: chrisw@globalgroup.org (C.I. Wright).

[1] Previously employed by Global Group.

http://dx.doi.org/10.1016/j.applthermaleng.2015.03.033
1359-4311/

wide array of industries and in multiple applications. These are briefly outlined by industry in Table 1 [3] with the main focus being given to the food industry as this is the subject of this paper.

Highly refined mineral HTFs are food grade and designed to be used in the processing of food as they are non-toxic, non-irritating and have no odour [4,5]. Food grade HTFs consist of a complex combination of hydrocarbons obtained from the intensive treatment of a petroleum fraction with sulphuric acid and oleum, by hydrogenation or by a combination of hydrogenation and acid treatment. A food grade HTF consists of saturated hydrocarbons having carbon numbers predominantly in the range C15–C50 [4]. Such HTFs are typically associated with fewer handling complaints such as occurs when they are spilled or leak, which is potentially one way that an HTF comes into contact with food.

An important feature of food grade HTFs is that they are non-fouling, which means as they thermally degrade they produce small carbon particles that are suspended in the HTF and so carbon formations are less sticky and adhesions to the internal surfaces of an HTF system are reduced [6]. It is important to remember that all HTFs undergo thermal degradation over time. Indeed, at high operating temperatures, the bonds that exist between hydrocarbon chains will start to break and form shorter (commonly referred to as 'light-ends') and longer chained hydrocarbons ('heavy-ends') [7–9]. Both of these products have consequences for the safety of an HTF system and for HTF sampling, but the key point is that chemical analysis can be used to routinely assess the condition of HTFs.

The build-up of light-end components is a potential fire risk as they decrease the ignition temperature of the HTF [9]. The accumulation of heavy-ends results in the formation of sticky carbon deposits or sludge and can be monitored by analysing the carbon residue in an HTF. The same is true for as oxidation of an HTF leads to the formation of carbon sludge and acids and these are therefore also routinely part of the testing conducted on the condition of an HTF in the laboratory [8]. The formation of sludge or soft carbon will lead to a carbon coat forming on the internal surfaces of the HTF system and with time this will harden. The insulating effect of carbon means that the HTF system is less efficient (i.e., heat transfer rates are reduced resulting in longer heat-up time and lower production rates). Also, the hard carbon deposits work to form hot spots and have the potential to cause heater tubes and electrical elements in the HTF system to burn-out.

The non-fouling nature of food grade HTFs indicates that the physical characteristics of HTFs differ. Therefore, the first aim of this research was to compare the non-fouling nature of a food grade HTF with that of a non-food grade HTF. This was done to assess whether differences in carbon levels exist between these fluids and what this looks like when tested in the laboratory.

The second aim was outline the audits and control processes involved in the supply of food grade HTFs. Indeed, the supply of food grade HTFs is highly regulated in Europe and companies must comply with REACH and CLP regulations [6,10]. In addition, a manufacturer should source food grade HTFs that are suitable for use in food processing. Food grade HTFs carry an HT-1 certificate that is issued by governing bodies such as the NSF, which means the HTF contains ingredients considered safe for incidental contact with food [11,12]. Furthermore, a list of recommended food grade HTFs is commonly defined by insurers [13] and food retailers. Empirical evidence suggests that insurers normally define a list of suitable HTFs as opposed to recommending a single HTF [13]. Furthermore, manufacturers are audited to ensure that an appropriate HTF is being used in the processing of food. However, the current framework of self-governance and external audits means that there is a potential for companies to use HTFs not suitable for incidental contact with food. One justification being that a company may choose to dispose all foods should they come into contact

Table 1
Heat consumers by industry.

Industry	Heating of (example)
Chemical and plastics	Distillation plants
Bitumen and tar processing	Bitumen tank storage
Mineral oil	Heavy oil plants in processing, storage, transport and in transfer stations
Rubber	Plants for the production of synthetic rubber
Food	1. Large kitchens 2. Pommes-frites plants 3. Potato chips plants 4. Plants for fat hardening and rendering 5. Bottle cleaning plants 6. Can washing plants 7. Spray drying plants for milk powder and blood powder production 8. Roller driers 9. Fat and oil vats 10. Baking ovens 11. Plants for the production of sweets 12. Plants for chocolate production 13. Plants for starch drying 14. Plants for the removal of smelly waste gases
Soaps and detergents	Spray and drying towers
Wood	Press boards, plywood and veneer presses
Paper	Coating rollers
Construction, stones and earths	Ore preparation plants
Textile	Tensioning frames for drying and/or fixing
Metal	Acid and pickling tanks
Electrical	Drying cabinets
Shipping	Heavy oil and bitumen tanks on ships
Aircraft and airlines	Galvanising tanks
Heating heat supply	Warm water generators
Energy generation	Concentrated solar plants

Extracted from Ref. [3].