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METHOD OF CLEANING HEAT EXCHANGERS

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This invention has to do with a method of cleaning surfaces and more particularly relates to the cleaning of heat transfer equipment which has become fouled in certain types of service, especially in various petroleum processing operations.

It is of common occurrence in industrial processes involving the indirect transfer of heat between two fluids for surfaces of the heat transfer equipment to become fouled during prolonged service due to scale formation, corrosion or deposition of solid or semi-solid materials, resulting in depreciation in efficiency of the heat transfer operation. In design of heat transfer equipment it is usual practice to over-design the equipment to allow for a normal amount of such fouling; nevertheless, in many cases, fouling becomes so serious as to necessitate cleaning the equipment in order to maintain the desired or requisite heat transfer capacity. This often has proved to be a difficult and costly task, requiring cessation of operation for as much as a number of days with a resulting loss in processing time, as well as necessitating the expenditure of many man-hours of labor in the cleaning operation. In some cases, where the heat transfer equipment is so designed that the fouled surfaces are inaccessible for mechanical cleaning and the usual cleaning solutions are ineffective, the methods of cleaning heretofore used have proved to be entirely unsatisfactory.

The present invention is directed to and provides an improved method of cleaning fouled heat transfer surfaces, which may be carried out in relatively short time and which is considerably more effective in removing fouling deposits of certain types than methods heretofore known. More specifically, the invention provides an effective method for removing fouling deposits which accumulate during heat transfer operations carried out at ordinary or moderately elevated temperatures and which contain substantial proportions of organic constituents. It is particularly useful for cleaning relatively low temperature exchangers used in various petroleum processing operations, for instance, absorption oil exchangers and water coolers.

According to the invention fouling deposits of the aforesaid types are removed from surfaces by contact, preferably at an elevated temperature, with a so-called soluble oil, such as the type used widely as cutting oil in the metal working arts or as spray oil, the contact being

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effected with the oil in concentrated form, i. e. not in substantial aqueous dilution. It has been discovered that undiluted soluble oils are very effective in removing such fouling deposits, and that the use of such oils provides a particularly suitable means of cleaning the fouled equipment.

Any soluble oil of the type used as cutting oil and which is fluid at ordinary temperatures may be used as the cleaning agent. Preferred soluble oils, containing alkali soaps of naphthenic acids, are described in U. S. Patent No. 2,056,913 issued to Terrell et al. and in the patent application of Carter et al., Serial No. 479,264 filed March 15, 1943, now issued as Patent No. 2,433,646 dated Dec. 30, 1947; and another particularly suitable soluble oil, containing alkali soaps of synthetic acids derived by partial oxidation of petroleum hydrocarbons, is described in the patent application of Johnson et al., Serial No. 485,844 filed May 6, 1943 now issued as Patent No. 2,395,627 dated Feb. 26, 1946. All of these have usual characteristics of commercial cutting oils, including the capacity for infinite dilution with water and low volatility. In metal working operations such soluble oils are used in sufficient aqueous dilution so that the diluted oils are invariably in the form of oil-in-water emulsions or dispersions. For purposes of the present invention, however, the oils are used with a proportion of water which, at most, is substantially insufficient to cause reversal from the water-in-oil to the oil-in-water type of dispersion and preferably are used in concentrated form.

For the purpose of illustrating the invention its application to the cleaning of absorption oil coolers serves as an appropriate example. In the processing of petroleum large quantities of lower boiling hydrocarbon gases are formed in such operations as topping and cracking, and in order to recover valuable constituents such as butanes and pentanes these gases customarily are passed through an absorption column where they flow countercurrently to an absorption oil which serves to absorb higher boiling components from the gases. The enriched absorption oil then is passed to a distillation unit for removal of absorbed gases, and the resulting lean absorption oil flows through suitable coolers and is circulated back to the absorption column for reuse. In prolonged operation the absorption oil coolers often become fouled with a deposit comprising a mixture of solid and semi-solid, grease-like material containing oil, resins, water and

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inorganic salts. The accumulation of this material, by effectively cutting down the heat transfer rate in the coolers, will cause the lean oil stream circulating to the absorption column to rise slowly in temperature, and thus progressively will decrease the efficiency of absorption and increase the loss of valuable hydrocarbons as unabsorbed gas.

In large-scale refinery operations wherein absorption oil coolers become fouled in the above described manner a very considerable loss of valuable constituents usually results, and it is not unusual in such cases for the loss of butane alone to be equivalent to as much as one thousand to two thousand dollars per day, computed as the difference between the values of recovered butane and of fuel gas. In one typical case where the coolers were of the widely used tube and shell type, with cooling water passing through the tube side and absorption oil passing through the shell side, and were of such construction that the shell side was inaccessible for mechanical cleaning, it was found that on prolonged operation the passages between tubes became almost filled with a semi-solid, grease-like emulsion comprising oil, resinous organic material, water and inorganic salts, and that the grease-like material closest to the tubes apparently resinified to form a solid scale thereon. Various heretofore known methods were tried for cleaning the coolers without success. Flushing with water or with commercially known cleaning solutions comprising tri-sodium phosphate was found to be totally ineffective. Prolonged circulation of a heated petroleum heavy naphtha through the shell side of the coolers, followed by steaming and air blowing, produced a slight improvement which lasted for only two or three days on resuming operation, which shows the fouling material to be substantially oil insoluble. Application of the method of the present invention, however, resulted in a very satisfactory cleaning.

The procedure employed was as follows. A cooler requiring cleaning was emptied of its fluid contents from previous operation, and the shell side of the cooler then was filled with a commercial soluble oil. The soluble oil was heated to a temperature above that at which the cooler normally operated, for instance, to a temperature of 200-220° F. by applying steam within the tubes. This heating also could have been accomplished by circulating the soluble oil from and back to the cooler through any suitable heating zone until the main body of soluble oil reached the desired temperature. Heating of the soluble oil to a temperature above that at which the cooler normally operated served to cause sufficient expansion of the tubes to fracture the film of solid scale thereon, and contact with the hot soluble oil caused disintegration of the grease-like fouling material surrounding the solid scale with a resultant loosening of the solid scale also. Due to the emulsifying capacity of the soluble oil for oil, water and other constituents of the fouling material, the loosened deposits formed an emulsion or suspension with the soluble oil. The soluble oil with fouling material admixed therewith then was withdrawn from the cooler and the procedure was repeated until the cooler was clean, as evidenced by the appearance of the withdrawn soluble oil.

The following comparison of actual stream temperatures during operation of an absorption

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oil cooler clearly illustrates the effectiveness of the above described cleaning method:

	Absorption oil outlet temperature	Water inlet temperature	Difference in temperature
Before cleaning (average for 7-day period)	°F. 136	°F. 79	°F. 57
After cleaning (average for 11-day period)	80	78	2

As shown by the tabulated data the average temperature of the absorption oil leaving the cooler was 57° F. higher than that of the entering water before cleaning but was only 2° F. higher after the cooler had been cleaned by the method described above. This difference represents a very considerable improvement in the absorbing capacity of the absorption oil.

A heat exchanger of commercial size usually may be cleaned in the manner described above by one workman in an elapsed time of only three to four hours. In comparison with cleaning methods heretofore known this represents a considerable saving both in labor and in time of shutdown of the exchanger.

The exact mechanism by which the soluble oil acts as an effective cleaning agent is not thoroughly understood, and any theories advanced herein should not be taken by way of limitation of the invention. It is believed that the soluble oil effectively disintegrates the fouling deposits due to its emulsifying ability, and also that the emulsifying power plays an important role in keeping the loosened fouling material in suspension within the oil, thereby preventing the loosened material from settling to the bottom of the heat exchanger, depositing between baffles therein and thus remaining within the exchanger when the soluble oil is withdrawn. When a heavy naphtha was tried as the cleaning agent as mentioned above, some loosening of the fouling deposits undoubtedly occurred, accounting for the slight, temporary improvement in heat transfer rate. However, due to the lack of any emulsifying ability of the heavy naphtha the loosened deposits appear to have settled to the bottom of the cooler and remained therein on removal of the heavy naphtha, so that on resumption of operation they soon were flushed up and again accumulated on the heat transfer surfaces. The higher viscosity of the soluble oil also may have a part in keeping the loosened deposits in suspension. In addition the low volatility of the soluble oil as compared to heavy naphtha or other organic solvents is advantageous in that it allows the use of higher temperatures than would be practical with these other solvents. The primary requisite of the oil used, however, is that it have the emulsifying ability indicated by a capacity for infinite dilution with water.

The method of cleaning described above as applied to absorption oil coolers also may be used on various other relatively low temperature exchangers wherein fouling deposits of a similar nature are formed. The term, relatively low temperature, as used herein is meant to designate a range of operating temperatures not sufficiently high as to cause formation of coke-like or carbonized fouling deposits such as often are obtained in high temperature operations, for instance, thermal cracking operations. Thus the method of this invention is not intended for use in removing such carbonized material as results

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from high temperature operation; nor is it intended to be used for cleaning out fouling deposits predominantly of an inorganic nature. On the other hand, it has particular utility when the fouling material contains a substantial proportion of resinous organic matter as formed in various relatively low temperature operations.

We claim:

1. The method of cleaning the interior surfaces of heat transfer equipment in a substantially closed container, which interior has become fouled by deposition of material containing a substantial proportion of non-carbonized oil insoluble organic constituents while operating at a temperature below that required to form coke-like or carbonized deposits, which comprises contacting said non-carbonized oil insoluble fouling material at a temperature of at least 200° F. and above that at which the equipment operates under normal conditions, and below carbonizing temperature, with a soluble oil, said soluble oil consisting of a water in oil type of dispersion, continuing the contact of said non-carbonized oil insoluble fouling material with said soluble oil until a substantial amount of the material is loosened, and removing said soluble oil admixed with said fouling material from said equipment.

2. The method of cleaning the interior surfaces of heat transfer equipment in a substantially closed container, which interior has become fouled by deposition of material containing a substantial proportion of non-carbonized oil insoluble

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organic constituents while operating at a temperature below that required to form coke-like or carbonized deposits, which comprises contacting said non-carbonized oil insoluble fouling material at a temperature above that at which the equipment was operated during deposition of the deposit, and below carbonizing temperature, with a soluble oil, said soluble oil consisting of a water in oil type of dispersion, continuing the contact of said non-carbonized oil insoluble fouling material with said soluble oil until a substantial amount of the material is loosened, and removing said soluble oil admixed with said fouling material from said equipment.

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