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METHOD OF CLEANING HEAT EXCHANGERS

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The invention relates to the cleaning of heat exchangers which have been rendered inefficient by the deposition of combustible material, particularly carbonaceous material.

Many heat exchangers, especially heat exchangers of the shell and tube type tend to become less efficient with length of service due to the formation of scales and deposits on the heat exchanging surfaces which reduce the rate of heat transfer between the fluid streams passing through the exchanger, and which may ultimately cause complete blockage of some or all of the tubes. In petroleum refineries many of these deposits are carbonaceous and may be formed by deposition of suspended solid material or by the cracking and coking of the fluid streams.

It is common practice to clean out heat exchanger tubes in which carbonaceous material such as coke has been deposited by drilling out the totally blocked tubes and then flame-cleaning the partly blocked tubes. Overheating is prevented by fitting the tube bundle into a spare shell through which water is then circulated. This method is both laborious and expensive. Cleaning the outside surfaces of exchanger tubes is also troublesome due to difficulties of access and is usually done by acid washing, or sand and water blasting.

According to the present invention a method of removing combustible material from heat exchanging surfaces in heat exchangers of the shell and tube type comprises the controlled oxidation of the combustible material in the presence of a stream of an oxygen-containing gas but in the absence of any additional fuel or the products of combustion of any additional fuel at a temperature which is less than that at which damage to the exchanger tubes might occur.

The method is especially suitable for removing combustible material from the inside surfaces of heat exchanger tubes and the preferred oxygen-containing gas is air. The oxygen-containing gas preferably initially includes a minor amount of steam.

The oxygen-containing gas may be introduced at a convenient point in the inlet to the exchanger and the waste gases may be removed at a convenient point in the outlet from the exchanger or vice versa. Where the inside tube surfaces of a two-pass heat exchanger are to be cleaned, oxygen-containing gas may be admitted simultaneously to each pass of the exchanger, at for example twice the rate used when cleaning a single-pass exchanger, and the waste gases removed at a convenient point, thereby conducting the cleaning in two parts with a consequent time saving of up to 50% or more. This may be extended if required to multi-pass exchangers with even greater time saving.

A particular advantage of the present invention is that the cleaning may be carried out without moving the heat exchanger from its normal operating position resulting in a great saving of man-hours and cost of materials.

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The method of the present invention is particularly suitable for cleaning the circulating oil heaters commonly used for heating a furfural-extract mixture in the well known furfural extraction process. These heaters become coked after relatively short periods of service due to the instability of furfural and/or extract at high temperatures.

The saving in cost and time by using the controlled oxidation method allows cleaning to take place more frequently and before the exchanger becomes very badly blocked.

As stated above it is necessary to maintain the oxidising temperature below that at which damage to the tubes might occur. This temperature varies with the material from which the tube is made. Generally speaking the oxidation temperature should not exceed 350° C. and preferably not exceed 300° C. Above this range mild steel tubes, which are commonly used in the above mentioned heaters are corroded by oxidation, and the stainless steel tubes which are also frequently used are embrittled by the formation of chromium carbide. The temperature may be controlled by removing the heat of combustion partly in the exit gases and partly by passing a suitable medium through the side of the exchanger not being cleaned. The rate of flow of air is ideally that which produces carbon dioxide at the greatest rate consistent with the temperature limitation hereinbefore described, but this may be limited in practice by difficulties in measuring low carbon dioxide percentages in the exit gases, and low air-flow rates to the exchanger. Steam is preferably introduced in small quantities with the air in at least the early stages of the oxidation, the endothermic water-gas reaction tending to quench any "hot spots" which may form. Heat may be supplied to start the oxidation by heating the air prior to its introduction to the exchanger or preferably by passing a suitable medium through the side of the exchanger not being cleaned. This medium is preferably a hydrocarbon mixture and where the cleaning is carried out in the heat exchanger's normal operating position, the medium may conveniently be the material which normally passes through the side of the exchanger which is not being cleaned for example, in a furfural/extract heater the medium may be a gas oil. Once under way this medium controls the temperature in the tubes by carrying away part of the heat of combustion. The oxidation is discontinued when the volume of carbon dioxide in the exit gases indicates that most of the carbonaceous deposit has been removed.

The invention may be illustrated by the following examples.

Example 1

A hot-oil/furfural-extract heater was taken out of service when the overall heat transfer rate was 30 B.t.u./hr./sq.ft./°F. Furfural was circulated through the tubes for 8 hours to remove oily material. The tube side of the exchanger was then isolated in the usual manner and steamed out to atmosphere for 8 hours to remove any remaining oily material. Air at 100 p.s.i.g. (nominal) was introduced into the tubes at the rate of 1325 s.c.f.h. (standard cubic feet per hour) together with a small quantity of steam estimated as 100 lb./hr. and the exhaust gases vented to atmosphere. Hot gas-oil at a temperature of 575° F. was circulated through the shell side of the exchanger and the operation continued for 115

hours the steam being shut off after 48 hours. The operating conditions are summarised in the following table:

Period (Hours) on steady Conditions.	Air Rate s.c.f./hr.	Total Air in Period (s.c.f.)	Combustion Products—Orsat Analysis				Temperatures, °F.			Air Pressure, p.s.i.g.
			Percent vol.		Total s.c.f. in Period		Gas Oil In	Gas Oil Out	Exit Gas	
			CO ₂	CO	CO ₂	CO				
1½	1,325						570	566		94
9	1,325	1,990	11.8	0.9	235	18	554	554	257	90
8½	1,325	11,950	9.2	1.0	1,100	120	571	567	244	90
11½	1,325	11,300	7.9	1.2	895	135	570	566	225	95
4	1,325	15,200	5.4	1.0	825	152	575	563	221	92
8	1,325	5,300	5.0	1.4	265	75	572	564	210	94
12	1,325	10,600	2.8	2.0	295	210	570	562	216	93
8	1,325	15,900	2.2	0.4	350	65	573	562	216	90
8	1,325	10,600	1.8	0.2	190	20	575	561	212	94
8	1,325	10,600	0.8	Nil	85	Nil	574	563	212	90
8	1,325	10,600	0.8	Nil	85	Nil	574	563	225	97
7	1,325	10,600	0.6	0.2	65	20	570	562	216	92
9	1,325	9,275	0.4	0.5	35	45	575	564	234	90
8	1,325	11,975	0.4	0.2	50	25	575	560	239	95
4½	1,325	10,600	0.2	Nil	20	Nil	570	561	230	90

The carbon removed was calculated to be 180 lbs. and on returning to service the overall heat transfer rate was found to be 55 B.t.u./hr./sq.ft./°F.

The saving realised over the conventional method amounted to 858 man-hours per exchanger.

Example 2

A hot oil/furfural-extract heater was taken out of service when the overall heat transfer rate was 43.6 B.t.u./hr./sq.ft./°F. Furfural was circulated through the tubes for 8 hours, the tube side of the exchanger isolated and steamed out to atmosphere for 8 hours as in Example 1.

Air at 100 p.s.i.g. (nominal) was introduced into the tubes at the rate of 400 s.c.f./hr. together with an estimated 100 lb./hr. of steam, and the exhaust gases vented to atmosphere. Hot gas-oil at a temperature of 575° F. was circulated through the shell side of the exchanger and the operation continued for 48 hours, the steam being shut off after 24 hours.

On returning the heater to service the overall heat transfer rate was found to be 63.0 B.t.u./hr./sq.ft./°F.

I claim:

1. A method for removing combustible material from heat exchanging surfaces in heat exchangers of the shell and tube type used as circulating oil heaters for heating a furfural-extract mixture in furfural extraction processes, particularly the inner surfaces of the heat exchanger tubes, without removing the heat exchanger from its normal operating position, comprising: oxidizing the combustible

material on one side of said heat exchanging surfaces under controlled conditions in the presence of a stream

of an oxygen-containing gas, but in the absence of any additional fuel and in the absence of the products of combustion of any additional fuel, while maintaining the oxidizing temperature below about 350° C. by passing a suitable medium comprising a hydrocarbon mixture through the side of the heat exchanger which is not being cleaned.

2. A method as claimed in claim 1 wherein the oxygen-containing gas is air.

3. A method as claimed in claim 1 wherein the oxygen-containing gas initially includes a minor amount of steam.

4. A method as claimed in claim 1 wherein the temperature does not exceed 300° C.

5. A method as claimed in claim 1 wherein the medium is the material which normally passes through the side of the exchanger which is not being cleaned.

6. A method as claimed in claim 1 wherein the medium is a gas oil.

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