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**PROCESSES FOR REDISTRIBUTING HEAT FLUX ON PROCESS  
TUBES WITHIN PROCESS HEATERS, AND PROCESS HEATERS  
INCLUDING THE SAME**

**FIELD OF THE INVENTION**

5           The present invention relates generally to methods whereby heat  
fluxes on process tubes within process heaters may be manipulated so as  
to be more equal circumferentially. The methods of the invention are  
especially well suited for use in coke sensitive fired heaters employed in  
the petroleum refining industry, such as coker units, vacuum units; crude  
10 heaters, and the like.

**BACKGROUND AND SUMMARY OF THE INVENTION**

Most coke sensitive heaters or furnaces, such as coker, vacuum  
and crude heaters, are so-called single fired units which employ a source  
of combustion generally centrally of an array of process tubes. The  
15 process tubes are thus typically positioned closely adjacent the refractory  
wall of the heater which results in uneven circumferential heat flux  
distribution. That is, circumferential segments of the tube adjacent the  
combustion element of the heater are typically hotter than the  
circumferential segment of the tube adjacent the refractory wall of the  
20 process vessel.

The heat flux on the hotter fired side of the tube results in higher  
tube metal temperature as compared to the refractory wall side of the  
tube. A higher coking deposition rate internally of the tube at the hotter  
fired side thereof is the net result of such uneven circumferential heat flux  
25 deposition. Such unequal internal circumferential coking also leads to

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premature disadvantageously high pressure drop through the tube and/or a disadvantageously high temperature at the exterior surface of the tube (i.e., the coking on the internal tube surface acts as an insulator).

Consequently, reduced operational run lengths for the fired heaters  
5 ensue. For example, a typical coker unit requires decoking every six to nine months, with some coker units requiring decoking every three months.

There are also unequal heat fluxes which exist within the process heater itself which can result in relatively uneven coking from one tube  
10 section to another. Thus, some tubes or tube sections may be closer to the combustion source as compared to other tubes or tube sections within the process heater. Those tubes more remote from the combustion source (e.g., those tubes near the top of the heater when the combustion source is at the heater bottom) may have circumferential segments of the  
15 tube which exhibit a lesser heat flux as compared to similar circumferential segments of tubes closer to the combustion source even though the circumferential segments are oriented so as to face the heat generated by the combustion source.

It would therefore be highly desirable if process tubes or tube  
20 segments within fired vessels could be imparted with a more uniform circumferential heat flux distribution. It would also be desirable if heat flux within the process heater could be more equally redistributed by virtue of providing different tubes and/or tube sections with predetermined different, but locally substantially uniform, circumferential heat flux  
25 distribution. It is therefore towards fulfilling such needs that the present invention is directed.

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Broadly, the present invention is directed toward methods for providing more equal heat flux distribution about an exterior circumferential surface of at least one section of a process tube within a process heater, and to such process tubes on which a more equal  
5 circumferential heat flux distribution has been imparted. More specifically, according to the present invention, there is provided on at least one circumferential segment of at least one exterior circumferential surface section of the process tube, a coating of a material having a selected thermal emissivity and/or thermal conductivity which is different from the  
10 thermal emissivity and/or thermal conductivity of another circumferential segment of the same exterior circumferential surface section of the process tube. In such a manner, a more equal thermal conductance about an entirety of the exterior circumferential surface section of the process tube is established as compared to the thermal conductance  
15 thereabout in the absence of the coating, thereby resulting in a more equal heat flux distribution circumferentially on the tube section.

These and other aspects and advantages will become more apparent after careful consideration is given to the following detailed description of the preferred exemplary embodiments thereof.

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#### **BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS**

Reference will hereinafter be made to the accompanying drawings, wherein like reference numerals throughout the various FIGURES denote like structural elements, and wherein;

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FIGURE 1 is a cross-sectional schematic view of a single fired coker unit having process tubes in accordance with the present invention; and

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FIGURES 2A-2D are enlarged cross-sectional schematic views of one presently preferred technique to impart a more uniform circumferential heat flux distribution to process pipes in accordance with the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

Accompanying FIGURE 1 depicts schematically a fired process heater 10, such as a single fired coker unit. In this regard, the heater 10 includes refractory walls 12 for purpose of minimizing heat loss from the vessel, and a number of process tubes (a few of which are identified by reference numeral 14) arranged adjacent to the walls 12. A heater unit 16 is provided so as to provide a source of heat as schematically shown by flame 16a. Thus, as can be seen from FIGURE 1, those portions of the tubes 14 which are directly exposed to the flame 16a are hotter as compared to those portions of the tubes 14 which are immediately adjacent the refractory wall 12 thereby leading to the problems discussed briefly above.

Accompanying FIGURES 2A-2D depict schematically preferred techniques in accordance with the present invention so as to impart a more uniform circumferential heat flux distribution to the tubes 14. In this regard, as shown in FIGURE 2A, a representative process tube 14 is shown with a circumferential scale deposit 20 on its exterior surface. The scale 20 can of course itself provide decreased heat flux. Thus, according to the present invention, a circumferential region (noted by the dashed line representation and reference numeral 20a) of the scale deposit 20 may be removed from the tube 14 adjacent the refractory wall 12. Removal of the scale deposit 20a may be accomplished via any suitable technique. For example, the sand blasting technique described in commonly owned

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copending U.S. Patent Application No. 10/219943 (the entire content of which is expressly incorporated hereinto by reference) may be employed so as to selectively remove the circumferential region of scale deposit 20a and thereby expose the bare metal of the underlying tube 14.

5           With the circumferential region of scale deposit 20a removed, a coating 22 may be applied as shown in FIGURE 2B. In this regard, the coating 22 is a material which is selected for its emissivity and/or thermal conductivity properties so as to achieve a desired thermal conductance (e.g., in terms of heat transfer per unit area through the tube wall) about  
10           the entire circumferential surface region of the tube 14.

          As used herein, the emissivity (E) of a material is meant to refer to a unitless number measured on a scale between zero (total energy reflection) and 1.0 (a perfect "black body" capable of total energy absorption and re-radiation). According to the present invention, a  
15           relatively high emissivity (E) is meant to refer to coating materials having an emissivity of greater than about 0.80, and usually between about 0.90 to about 0.98. Relatively low emissivity is therefore meant to refer to coating materials having an emissivity of less than about 0.80, usually  
20           less than about 0.75 (e.g., between about 0.15 to about 0.75). Low emissivities of between about 0.45 to about 0.75 may likewise be employed. Thus, the range of emissivities of coating materials that may be employed in the practice of the present invention can be from about 0.15 to about 0.98 and will depend upon the specific requirements needed for a specified process vessel.

25           As can be appreciated, the scale deposit 20 will exhibit a relatively low thermal conductivity, but relatively high emissivity. As such, the coating 22 is selected so as to essentially provide a more uniform heat

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flux about the entire circumference of the tube 14. Thus, the differences in the emissivity and/or thermal conductivity of one circumferential region of the tube 14 as compared to another circumferential region (e.g., as between the region of the scale deposit 20 and the coating 22) is such  
5 that the entire circumferential heat flux (thermal conductance) is rendered on average more uniform when consideration is given to the fact that one region may be more hot in use as compared to another region (i.e., is subjected to differential thermal conditions in use). In practice, it is preferred that the emissivity differences of one circumferential region of  
10 the tube 14 as compared to another circumferential region of the tube be at least about 5%, and typically at least about 10% or more (e.g., an emissivity difference of between about 15% to about 50%).

It will be appreciated that, within the desired goal to impart a more uniform heat flux about the entire circumference of the tube 14 and/or to  
15 provide a more uniform heat flux within the process heater environment per se, a variety of techniques may be employed. For example, a relatively high-E or low-E coating 24 may be applied additionally onto the refractory wall 12 adjacent the coating 22 as shown in FIGURE 2C, or may be applied alternatively instead of the coating 22. Additionally (or  
20 alternatively), the scale 20 may be removed and a coating 26 possessing desired emissivity and/or conductivity properties may be applied on the hot side of the tube 14 as shown in FIGURE 2D.

It will be appreciated that within the environment of the process heater 10, it may be necessary to provide one or more tubes and/or  
25 longitudinal tube sections which exhibit a different heat flux as compared to one or more other tubes and/or tube sections within the heater 10. Individually, however, such tubes and/or tube sections will each most preferably exhibit substantially uniform heat flux circumferentially in

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accordance with the present invention as has been described previously. However, by providing preselected different circumferential heat fluxes of tubes and/or tube sections which are nonetheless individually substantially uniform will allow the heat flux within the environment of  
5 heater 10 to be more evenly redistributed.

Coating thicknesses on the tubes are not critical but will vary in dependence upon the desired resulting thermal flux and/or the particular material forming the coating. Thus, coating thicknesses of from about 1 to about 60 mils may be appropriate for a given tube application, with  
10 coating densities typically being greater than about 75%, more specifically 90% or greater.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed  
15 embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

CLAIMS:

1. A method for providing more equal heat flux distribution about an exterior circumferential surface region of a process tube (14) within a fired process vessel (10), said vessel (10) having a source of combustion (16a) and a refractory wall (12), said tube (14) being located between said source of combustion (16a) and refractory wall (12), which comprises providing, on at least one circumferential segment of the exterior circumferential surface region of the process tube (14), a coating (22) of a material having a selected thermal emissivity and/or thermal conductivity which is different from the thermal emissivity and/or thermal conductivity of another circumferential segment of the exterior circumferential surface region of the process tube (14) to thereby impart a more equal heat flux distribution about an entirety of the exterior circumferential surface region of the process tube (14) as compared to the heat flux distribution thereabout in the absence of the coating (22), characterized in that the surface region of the process tube (14) to which the coating (22) is applied is adjacent the refractory wall (12).
2. The method of claim 1, wherein the emissivity difference is at least 5% between said at least one circumferential segment and said another circumferential segment.
3. The method of claim 2, wherein the emissivity difference is at least about 10%.
4. The method of any preceding claim, wherein said at least one circumferential segment has a coating (22) which exhibits a high emissivity of at least about 0.80.
5. The method of claim 1, wherein said at least one circumferential segment is coated with a material having a relatively high emissivity of about 0.80 or greater, and wherein said another circumferential segment is coated with a material having a relatively low emissivity of less than about 0.80, provided that said relatively high and low emissivities differ by about 5%.
6. The method of claim 5, wherein said relatively high and low emissivities differ by about 10%.
7. A process tube (14) for a process heater (10) having a generally uniform circumferential heat flux provided by a method according to any one of claims 1-6.
8. A process heater (10) which includes at least one process tube (14) of claim 7.