

and produce a treated material 20, such as a regenerated carbon product. In an embodiment, the treated material 20 includes a sludge (solid/liquid portion), which may include the regenerated carbon (when activated carbon is present), and a gaseous portion (offgas 24) having an oxygen content.

In accordance with an aspect of the present invention, the WAO process in the WAO unit 16 may be carried out at a temperature of about 200°C or less, and in a particular embodiment from about 150°C to about 200°C. The WAO process may also take place at any suitable pressure. In an embodiment, the pressure may be from about 10 to about 220 barg (about 150 to about 3200 psig, or about 1034 kPa to about 22063 kPa), and in another embodiment from about 10 to 62 barg (150 to about 900 psig, or 1034 kPa to about 6205 kPa), and in a particular embodiment about 10 to about 35 barg (about 150-500 psig, or about 1034 kPa-3447 kPa). In addition, the residence time is extended due to the lowered temperature in accordance with an aspect of the present invention. In an embodiment, the residence time is at least about 1 hour, and in a particular embodiment from about 3 to 8 hours, and in still further embodiments from about 4 to about 6 hours.

To accomplish the desired regeneration under the lower temperatures described herein, in an aspect, the regeneration is carried out under elevated oxygen conditions. As shown in FIG. 1, an oxidant stream 22 (from a suitable source) is introduced into the feed stream 14, 30 at a suitable flow rate upstream or downstream from the heat exchanger 18. In certain embodiments, the oxidant stream 22 may also be introduced directly into the WAO unit 16. Without limitation, the oxidant stream 22 may comprise at least about 20% by volume (vol. %) oxygen upon addition to the feed stream 14, 30.

By the outlet of the WAO unit 16 and following wet air oxidation, a gaseous portion, e.g., offgas 24, is produced having an oxygen content which is less than the oxygen content of the oxidant 22 stream. The offgas 24 includes a reduced oxygen content relative to the oxygen content in the oxidant stream 22 as result of oxygen being consumed in the WAO unit 16. In an embodiment, the treated portion 20 comprises the offgas 24. In certain

track its performance. As shown in FIG. 2, the U-value (parameter used to track heat exchanger performance) for the first bundle (cold inner pipe fluid) held relatively constant. The U-value for the second bundle, which is exposed to higher temperature within the inner tube, showed a rapid decline in performance, which soon shut the system down due to lack of heat recovery.

Example 2

The following example illustrates that equivalent regeneration of carbon was accomplished under reduced temperature conditions when at least residence time and residual oxygen concentration were increased. In this example, pressure was also decreased; however, it is appreciated that reduced pressure is not required for successful regeneration at the lower temperatures. That said, there may be a significant cost savings associated with operation at a reduced pressure, as well as reduced temperature. For example, operating at a reduced pressure may allow for direct injection of steam since most refineries have onsite steam with a pressure of at least 500 psig (about 3447 kPa). In one aspect, reducing the temperature from 240 to 200° C did not reduce regeneration effectiveness when residence time was increased from 1 to 4 hours: oxygen input to the WAO unit (resulting in a higher residual oxygen in the offgas) was increased; and pressure was reduced in the unit. See Table 1 below.

Table 1: Carbon Regeneration Results

Treatment Conditions	Units	2	3
Reactor Temperature	°C	240	200
Residence Time	Hour	1	4
Pressure	PSIG	900 (6205 kPa)	400 (2758 kPa)
Offgas Oxygen	% O ₂	3-4	10-12
Feed Results			

Soluble COD	mg/L	298	217
Suspended Solids	mg/L	16,300	16,771
Effluent Results			
Soluble COD	mg/L	1850	1800
MRE	%	65%	61%

As shown in Table 1, the MRE (molasses relative efficiency), which is an indication of regeneration, are the same for the two conditions.

Further, long term SBR (sequencing batch reactor) testing was performed, which also showed that treatment performance with carbon regenerated at the two conditions was equivalent. The SBR simulates a full scale PACT treatment system in which carbon and wastewater are contacted. In addition, the SBR also contains biological material to assist in the treatment of the wastewater. During the long term SBR test, wastewater was mixed with biological material and activated carbon for a specific time to allow for treatment of the wastewater. After the specified time, a portion of the treated material was removed, the carbon along with the biological material was concentrated and regenerated using WAR. The regenerated carbon was then returned to the system with fresh wastewater to be treated. This testing confirmed regeneration of the carbon with multiple regeneration cycles through the side by side comparison of the SBR effluent performance under the two conditions. See FIG. 3 for illustration of the results. The left column at 200°, 240°, and CFR (left to right) shows COD (chemical oxygen demand) removed while the right column in each category shows TOC (total organic carbon) removed.

While various embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions may be made without departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

CLAIMS

The invention claimed is:

1. A treatment process comprising:
directing a feed stream (14) comprising spent carbon and an amount of a scale forming contaminant therein through a heat exchanger (18) and to a wet air oxidation unit (16) for regeneration of the spent carbon therein;
adding an oxygen-containing gas to the feed stream (14);
performing a wet air oxidation process on at least a portion of the feed stream (14) in the wet air oxidation unit (16) to produce a treated material (20) comprising a regenerated carbon material and an offgas (24) comprising a residual oxygen concentration of about 5% to about 15% by volume; and
directing the treated material from the wet air oxidation unit (16) through the heat exchanger (18), wherein heat from the treated material (20) is utilized to heat the feed stream (14) in the heat exchanger (18);
wherein the wet air oxidation process is carried out at a temperature of about 200° C or less with a residence time of at least about 1 hour.
2. The process of claim 1, wherein the wet air oxidation process is carried out at a temperature of from about 150° C to 200° C.
3. The process of claim 1, wherein the wet air oxidation process is carried out at a pressure of about from about 150 - 900 psig (about 1034 kPa - 6205 kPa).
4. The process of claim 1, wherein the wet air oxidation process is carried out at a pressure of about from about 150-500 psig (about 1034 kPa - 3447 kPa).

5. The process of claim 1, wherein the wet air oxidation process is carried out at a residence time of about 3 hours to about 8 hours.

6. The process of claim 1, wherein the wet air oxidation process produces an offgas (24) with a residual oxygen concentration of about 10 % by volume to about 12 % by volume.

7. The process of claim 1, wherein the treated stream (20) comprises a temperature less than a solubility temperature limit of the scale-forming contaminant at a given concentration of the scale forming contaminant.

8. The process of claim 1, wherein the scale-forming contaminant comprises a member selected from the group consisting of aluminum, calcium, carbonate, iron, magnesium, phosphorus, sulfate, and combinations thereof.

9. The process of claim 8, wherein the scale-forming contaminant comprises calcium.

10. The process of claim 9, wherein the scale-forming contaminant comprises calcium sulfate.

11. The process of claim 1, wherein the feed stream (14) is derived from at least one of a powdered activated carbon treatment (PACT) system or a granular activated carbon (GAC) system.

12. The process of claim 1, wherein the spent carbon comprises spent powdered activated carbon.

13. The process of claim 1, wherein the feed stream (14) comprises an amount of biological solids.

14. The process of claim 1, wherein the oxygen-containing gas added to the feed stream (14) comprises an oxygen concentration of at least about 20% by volume.