CLAIMS

What is claimed is:

1. A method for cleaning processing equipment, comprising:

generating a function characterizing a relationship between fouling formation in the processing equipment and operation of the processing equipment;

selecting a cleaning recipe based on properties of fouling material formed in the processing equipment during operation of the processing equipment;

determining operating costs associated with each of a plurality of cleaning schedules based on the first function and the cleaning recipe;

selecting one of the plurality of cleaning schedules based on the respective determined operating costs; and

executing a cleaning process on the processing equipment according to the selected cleaning schedule using the selected cleaning recipe.

2. The method according to claim 1, wherein the function provides an amount of fouling material per unit area formed as a function of operating days of the processing equipment.

3. The method according to any of claims 1 and 2, wherein the processing equipment comprises a heat exchanger,

wherein the method further comprises measuring and recording a temperature of each of a cold side utility entering the heat exchanger, the cold side utility exiting the heat exchanger, a hot side utility entering the heat exchanger, and the hot side utility exiting the heat exchanger, and

wherein the function is generated based on the recorded temperatures.

4. The method according to any of claims 1-3, wherein the cleaning recipe comprises a composition of a cleaning material circulated through the processing equipment during the cleaning process and a duration of circulating the cleaning material through the processing equipment.

5. The method according to any of claims 1-4, wherein the cleaning recipe comprises a plurality of cleaning materials and a respective plurality of durations of circulating the respective cleaning materials through the processing equipment.

6. The method according to any of claims 1-5, wherein the plurality of cleaning materials includes a first cleaning material and a second cleaning material different from the first cleaning material.

7. The method according to any of claims 1-6, wherein the plurality of durations comprises a first duration and a second duration different from the first duration.

8. The method according to any of claims 1-7, further comprising:

analyzing a sample of the fouling material to determine the properties of the fouling material,

wherein the properties of the fouling material include chemical composition, density, and thermal conductivity of the fouling material.

9. The method according to any of claims 1-8, wherein the operating costs comprise costs of executing the cleaning process and costs of operating the processing equipment at fouling levels determined based on the generated function.

10. The method according to any of claims 1-9, wherein the operating costs further comprise monetization of emission reductions due to operating and cleaning the processing equipment according to the selected cleaning schedule.

11. The method according to any of claims 1-10, wherein the plurality of cleaning schedules comprises a first cleaning schedule having a first cleaning interval and a second cleaning schedule having a second cleaning interval different from the first cleaning interval.

12. The method according to claim 11, wherein the plurality of cleaning schedules includes a maximum cleaning interval determined based on the properties of the fouling material.

13. The method according to any of claims 1-12, wherein the processing equipment comprises a plurality of components, and wherein the method further comprises, for each of the plurality of components:

generating a function characterizing a relationship between fouling formation in the processing equipment and operation of the processing equipment;

selecting a cleaning recipe based on properties of fouling material formed in the processing equipment during operation of the processing equipment;

determining operating costs associated with each of a plurality of cleaning schedules based on the first function and the cleaning recipe; and

selecting one of the plurality of cleaning schedules based on the respective determined operating costs.

14. The method according to any of claims 1-13, further comprising:

removing a sample of the fouling material from the processing equipment in association with the executed cleaning process; and

repeating the steps of generating the function, selecting the cleaning recipe, determining the operating costs, and selecting one of the plurality of cleaning schedules.

15. The method according to any of claims 1-14, wherein determining the operating costs associated with each of the plurality of cleaning schedules comprises executing simulations of operating the processing equipment.

Claims

[Claim 1] A method for cleaning processing equipment performed by an electronic system with one or more processors and memory, the method comprising:

generating a function characterizing a relationship between fouling formation in the processing equipment and operation of the processing equipment;

analyzing a sample of the fouling material to determine the properties of the fouling material, wherein the properties of the fouling material include chemical composition, density, and thermal conductivity of the fouling material and the chemical composition of the fouling material is selected from four or more types of predetermined fouling deposits;

selecting a cleaning recipe based on the properties of fouling material formed in the processing equipment during operation of the processing equipment, wherein selecting the cleaning recipe includes identifying two or more cleaning methods based on the chemical composition of the fouling material and selecting at least one cleaning method of the two or more identified cleaning methods;

determining operating costs associated with each of a plurality of cleaning schedules based on the first function and the cleaning recipe;

selecting one of the plurality of cleaning schedules based on the respective determined operating costs; and

executing a cleaning process on the processing equipment according to the selected cleaning schedule using the selected cleaning recipe.

[Claim 2] The method according to claim 1, wherein the function provides an amount of fouling material per unit area formed as a function of operating days of the processing equipment.

[Claim 3] The method according to claim 1, wherein the processing equipment comprises a heat exchanger,

wherein the method further comprises measuring and recording a temperature of each of a cold side utility entering the heat exchanger, the cold side utility exiting the heat exchanger, a hot side utility entering the heat exchanger, and the hot side utility exiting the heat exchanger, and

wherein the function is generated based on the recorded temperatures.

[Claim 4] The method according to any of claims 1-3, wherein the cleaning recipe comprises a composition of a cleaning material circulated through the processing equipment during the cleaning process and a duration of circulating the cleaning material through the processing equipment.

[Claim 5] The method according to any of claims 1-3, wherein the cleaning recipe comprises a plurality of cleaning materials and a respective plurality of durations of circulating the respective cleaning materials through the processing equipment.

[Claim 6] The method according to claim 5, wherein the plurality of cleaning materials includes a first cleaning material and a second cleaning material different from the first cleaning material.

[Claim 7] The method according to claim 5, wherein the plurality of durations comprises a first duration and a second duration different from the first duration.

~~[Claim 8] The method according to any of claims 1-3, further comprising:~~

~~analyzing a sample of the fouling material to determine the properties of the fouling material,~~

~~wherein the properties of the fouling material include chemical composition, density, and thermal conductivity of the fouling material.~~

[Claim ~~9~~8] The method according to any of claims 1-3, wherein the operating costs comprise costs of executing the cleaning process and costs of operating the processing equipment at fouling levels determined based on the generated function.

[Claim ~~10~~9] The method according to claim ~~9~~8, wherein the operating costs further comprise monetization of emission reductions due to operating and cleaning the processing equipment according to the selected cleaning schedule.

[Claim ~~11~~10] The method according to any of claims 1-3, wherein the plurality of cleaning schedules comprises a first cleaning schedule having a first cleaning interval and a second cleaning schedule having a second cleaning interval different from the first cleaning interval.

[Claim ~~12~~11] The method according to any of claims 1-3, wherein the plurality of cleaning schedules includes a maximum cleaning interval determined based on the properties of the fouling material.

[Claim ~~13~~12] The method according to any of claims 1-3, wherein the processing equipment comprises a plurality of components, and wherein the method further comprises, for each of the plurality of components:
generating a function characterizing a relationship between fouling formation in the processing equipment and operation of the processing equipment;
selecting a cleaning recipe based on properties of fouling material formed in the processing equipment during operation of the processing equipment;
determining operating costs associated with each of a plurality of cleaning schedules based on the first function and the cleaning recipe; and
selecting one of the plurality of cleaning schedules based on the respective determined operating costs.

[Claim ~~14~~13] The method according to any of claims 1-3, further comprising:
removing a sample of the fouling material from the processing equipment in association with the executed cleaning process; and
repeating the steps of generating the function, selecting the cleaning recipe, determining the operating costs, and selecting one of the plurality of cleaning schedules.

[Claim ~~15~~14] The method according to any of claims 1-3, wherein determining the operating costs associated with each of the plurality of cleaning schedules comprises executing simulations of operating the processing equipment.