operator needs to measure the pH of the solution before it travels into and through the vessel to be treated as compared to the pH measurement afterward. To obtain that comparative measurement, the operator must circulate within a closed loop. Moreover, this measurement and testing need precludes even the thought of a once-through application.

SUMMARY

[0013a] In one aspect, there is provided a method for removing metal sulfides from a spent catalyst located within a reactor vessel, the method comprising:

a) purging a reactor vessel containing a spent catalyst using a dry gas;

b) bringing the reactor vessel to a first operating temperature;

c) injecting an oxidizing agent formulation solution into the reactor vessel;

d) subjecting the reactor vessel to a dry gas purge;

e) bringing the reactor vessel temperature to a second operating temperature; and

f) isolating the reactor vessel from external contaminant sources and introducing air into the reactor vessel.

[0013b] In another aspect, there is provided a method for removing metal sulfides from a spent catalyst located within a reactor vessel, the method comprising:

a) purging a reactor vessel containing a spent catalyst;

b) bringing the reactor vessel to a first operating temperature;

c) partially or completely filling the reactor vessel with an oxidizing agent formulation solution;

d) subjecting the reactor vessel to a first inert gas purge;

e) bringing the reactor vessel to a second operating temperature while subjecting the reactor vessel to a second inert gas purge and removing remaining oxidizing agent formulation solution from the reactor vessel;

f) bringing the reactor vessel to a third operating temperature; and

g) isolating the reactor vessel from external contaminant sources and introducing air into the reactor vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a schematic flowchart of a method for removing metal sulfides from a catalyst bed in a reactor vessel and removal of sulfides and halides in a reactor system within which the reactor vessel is integrated in accordance with various aspects of the disclosure;

[0015] FIG. 2 is a schematic flowchart of another method for removing metal sulfides from a catalyst bed in a reactor vessel and removal of sulfides and halides in a reactor system within which the reactor vessel is integrated in accordance with various aspects of the disclosure;

CLAIMS

What is claimed is:

1. A method for removing metal sulfides from a spent catalyst located within a reactor vessel, the method comprising:

a) purging a reactor vessel containing a spent catalyst using a dry gas;

b) bringing the reactor vessel to a first operating temperature;

c) injecting an oxidizing agent formulation solution into the reactor vessel;

d) subjecting the reactor vessel to a dry gas purge;

e) bringing the reactor vessel temperature to a second operating temperature; and

f) isolating the reactor vessel from external contaminant sources and introducing air into the reactor vessel.

2. The method of claim 1, further comprising monitoring off-gases expelled from the reactor vessel during step a).

3. The method of claim 1, wherein the oxidizing agent formulation solution is injected into the reactor vessel continuously, incrementally or variably over a predetermined period of time.

4. The method of any one of claims 1-3, wherein the oxidizing agent formulation solution comprises one or more oxidizing agents.

5. The method of any one of claims 1-3, wherein the oxidizing agent formulation solution comprises a pH buffer.

6. The method of any one of claims 1-3, wherein the oxidizing agent formulation solution comprises one or more water-soluble organic solvents and/or one or more water-soluble surfactants.

7. The method of any one of claims 1-3, wherein injecting the oxidizing agent formulation solution into the reactor vessel while maintaining the reactor vessel at the first operating temperature further comprises monitoring off-gases expelled from the reactor vessel H_2S and SO_2.

8. The method of any one of claims 1-3, wherein subjecting the reactor vessel to the dry gas purge further comprises removing liquid from the reactor vessel and drying the contents of the reactor vessel.

9. The method of any one of claims 1-3, wherein the metal sulfides comprise one or more of nickel sulfides, molybdenum sulfides, cobalt sulfides, iron sulfides, copper sulfides, tungsten sulfides, titanium sulfides, manganese sulfides, chromium sulfides, noble metal promoted-molybdenum sulfides, non-noble metal promoted-molybdenum sulfides, zinc sulfides, and lead sulfides.

10. The method of any one of claims 1-3, wherein the oxidizing agent formulation solution comprises sodium nitrite.

11. The method of any one of claims 1-3, wherein the oxidizing agent formulation solution comprises lauryldimethylamine oxide (LDAO).

12. The method of any one of claims 1-3, wherein the oxidizing agent formulation solution has a pH ranging from 7 to 9.5.

13. The method of any one of claims 1-3, wherein c) injecting the oxidizing agent formulation solution into the reactor vessel is performed while maintaining the reactor vessel at the first operating temperature.

14. The method of any one of claims 1-3, further comprising injecting a pH buffering solution into the reaction vessel between steps c) and d).

15. A method for removing metal sulfides from a spent catalyst located within a reactor vessel, the method comprising:

a) purging a reactor vessel containing a spent catalyst;

b) bringing the reactor vessel to a first operating temperature;

c) partially or completely filling the reactor vessel with an oxidizing agent formulation solution;

d) subjecting the reactor vessel to a first inert gas purge;

e) bringing the reactor vessel to a second operating temperature while subjecting the reactor vessel to a second inert gas purge and removing remaining oxidizing agent formulation solution from the reactor vessel;

f) bringing the reactor vessel to a third operating temperature; and

g) isolating the reactor vessel from external contaminant sources and introducing air into the reactor vessel.

16. The method of claim 15, further comprising monitoring the oxygen content of off-gases expelled from the reactor vessel during the first or second inert gas purge.

17. The method of claim 15, wherein after the reactor vessel has been partially or completely filled with the oxidizing agent formulation solution, the oxidizing agent formulation solution is maintained or circulated within the reactor vessel for a period of time.

18. The method of claim 15, wherein subjecting the reactor vessel to the first inert gas purge further comprises monitoring off-gases expelled from the reactor vessel H_2S and SO_2.

19. The method of claim 15, wherein subjecting the reactor vessel to the second inert gas purge further comprises removing liquid from the reactor vessel and drying the contents of the reactor vessel.

20. The method of any one of claims 15-19, wherein c) partially or completely filling the reactor vessel with an oxidizing agent formulation solution is performed while maintaining the reactor vessel at the first operating temperature.

21. The method of any one of claims 15-19, further comprising injecting a pH buffering solution into the reaction vessel between step e) and step f).

22. The method of any one of claims 1 to 3, wherein the method further eliminates formation of polythionic and thionic acids, and/or eliminates formation of halide acids in piping and/or components of a reactor system comprising the reactor vessel.

23. The method of any one of claims 15 to 19, wherein the method further eliminates formation of polythionic and thionic acids, and/or eliminates formation of halide acids in piping and/or components of a reactor system comprising the reactor vessel.