SUMMARY OF THE INVENTION

Foam material is introduced at the gas-path entry of turbine equipment while off-line. The foam will coat and contact the internal surfaces, scrubbing, removing, and carrying fouling material away from equipment.

One aspect of the present invention pertains to an apparatus for foaming a water soluble cleaning agent. Some embodiments include a source of compressed gas and a pump for pressurizing liquid. Some embodiments include a housing defining an internal flowpath having first, second, and third flow portions arranged sequentially, a gas inlet, a liquid inlet for the water soluble cleaning agent, and a foam outlet. The first flow portion includes a gas plenum that is adapted and configured for receiving gas from the source under pressure from the gas inlet and including a plurality of apertures, the plenum and the interior of the housing forming a mixing region receiving liquid under pressure from the pump from the liquid inlet and receiving gas expelled from the apertures. The first portion provides a first foam of the liquid and the gas into the internal flowpath. The second flow portion receives the first foam and flows the first foam past a foam growth member adapted and configured to provide surface area for attachment and merging of the cells to increase the size of at least some of the cells of the first foam to create a second foam. The third flow portion receives the second foam and flows the second foam through a foam structuring member adapted and configured to reduce the size of at least some of the cells of the second foam to create a third foam provided to the foam outlet. It is understood that yet other embodiments of the present invention contemplate a housing having only a first portion; or a first and second portion; or only a first and third portion in various other nucleation devices.

Another aspect of the present invention pertains to a method for foaming a water soluble liquid cleaning agent. Some embodiments include pressurizing a source of water soluble liquid cleaning agent. Some embodiments include mixing the pressurized water soluble liquid cleaning agent and a pressurized gas to form a first foam. Other embodiments include flowing the first foam over a member and increasing the size of the cells of the first foam to form a second foam. Yet other embodiments include flowing the second foam through a

structure and decreasing the size of the cells of the second foam to form a third foam.

Yet another aspect of the present invention pertains to a system for providing an air-foamed water soluble liquid cleaning agent. Other embodiments include an air pump at pressure higher than ambient pressure, and a liquid pump providing the water soluble liquid at pressure. Still other embodiments include a nucleation device having an air inlet receiving air from the air pump, a liquid inlet receiving liquid from the liquid pump, and a foam outlet, the nucleation device turbulently mixing the pressurized air and the liquid to create a foam. Yet other embodiments include a nozzle receiving the foam through a foam conduit, the internal passageways of the nozzle and the conduit being adapted and configured to not increase the turbulence of the foam, the nozzle being adapted and configured to deliver a low velocity stream of foam.

Still another aspect pertains to a method for providing an air-foamed water soluble liquid cleaning agent to the inlet of a jet engine installed on an airplane. Some embodiments include providing a source of a water soluble liquid cleaning agent, a liquid pump, an air pump, a turbulent mixing chamber, and a non-atomizing nozzle. Other embodiments include mixing pressurized air with pressurized liquid in the mixing chamber and creating a supply of foam. Still other embodiments include placing the nozzle in front of the installed inlet and streaming the supply of foam into the installed inlet from the nozzle.

Yet another aspect of the present invention pertains to an apparatus for foaming a water soluble liquid cleaning agent. Some embodiments include means for mixing a pressurized gas with a pressurized water soluble liquid to create a foam. Other

WHAT IS CLAIMED IS:

1. An apparatus for foaming a water soluble liquid cleaning agent, comprising:

a source of compressed gas;

a pump for pressurizing liquid;

a housing defining an internal flowpath, the flowpath having first, second, and third flow portions arranged sequentially, said housing having a gas inlet, a liquid inlet for the water soluble cleaning agent, and a foam outlet;

said first flow portion including a gas plenum that is adapted and configured for receiving gas from the source under pressure from the gas inlet and including a plurality of apertures, said plenum and the interior of said housing cooperating to form a mixing region receiving liquid under pressure from the pump from the liquid inlet and receiving gas expelled from the apertures, said first portion providing a first foam of the liquid and the gas into the internal flowpath;

said second flow portion receiving the first foam and flowing the first foam past a foam growth member adapted and configured to provide surface area for attachment and merging of cells to increase the size of at least some of the cells of the first foam to create a second foam; and

said third flow portion receiving the second foam and flowing the second foam through a foam structuring member adapted and configured to reduce the size of at least some of the cells of the second foam to create a third foam provided to the foam outlet.

2. The apparatus of claim 1 wherein the first flow portion, the second flow portion, and the third flow portion have substantially the same flow area.

11. The apparatus of claim 9 wherein said mesh comprises a plastic material.

12. The apparatus of claim 9 wherein said mesh comprises a metallic material.

13. The apparatus of claim 1 wherein said structuring member includes a wire mesh.

14. The apparatus of claim 1 wherein said structuring member includes an aperture plate.

15. A method for foaming a water soluble liquid cleaning agent, comprising:

pressurizing a source of water soluble liquid cleaning agent;

mixing the pressurized water soluble liquid cleaning agent and a pressurized gas to form a first foam;

flowing the first foam over a member and increasing the size of the cells of the first foam to form a second foam; and

flowing the second foam through a structure and decreasing the size of the cells of the second foam to form a third foam.

16. The method of claim 15 wherein said flowing the first foam over a member increases the turbulence of the first foam.

17. The method of claim 15 which further comprises flowing the third foam within a chamber having an inlet and an outlet, the chamber being adapted and configured to decrease the turbulence of the third foam.

18. The method of claim 17 wherein the chamber is adapted and configured to provide laminar flow of the third foam between the inlet and the outlet.

19. The method of claim 15 wherein said mixing includes flowing the liquid in a first direction and injecting the gas in a second direction that has a velocity component at least partly opposite to the first direction.

20. The method of claim 15 wherein said flowing the second foam is at a velocity, and which further comprises flowing the third foam at substantially the same velocity onto an object and cleaning the object.

21. An apparatus for foaming a water soluble liquid cleaning agent, comprising:

means for mixing a pressurized gas with a pressurized water soluble liquid to create a foam;

means for growing the size of the cells of the foam; and

means for reducing the size of the grown cells.

22. The apparatus of claim 21 wherein said growing means includes a growing mesh, said reducing means includes a reducing mesh, and the mesh size of the reducing mesh is smaller than the mesh size of the growing mesh.

23. The apparatus of claim 21 wherein said growing means is adapted and configured to provide surface area for attachment and merging of cells of the foam from said mixing means.

24. The apparatus of claim 21 wherein said growing means includes a plurality of first passageways, and said reducing means is adapted and configured to reduce the size of at least some of the grown cells by passing the grown cells through a plurality of second passageways smaller than the first passageways.

25 The apparatus of claim 21 wherein said mixing means is the injection of the gas from within a tube into flowing liquid.

26 The apparatus of claim 21 wherein said mixing means is by providing the pressurized gas into flowing liquid through a porous metal filter.

27. The apparatus of claim 21 wherein said mixing means includes a motorized rotating impeller.

28. The apparatus of claim 21 wherein said mixing means imparts swirl into the flowing liquid by injection of the gas.

29. The apparatus of claim 21 wherein said growing means is a vibrating rod.

30. The apparatus of claim 29 wherein the vibrating rod is an ultrasonic transducer.

31. The apparatus of claim 21 wherein said reducing means is a wire mesh.