

SQUIRTER JET ULTRASONIC CLEANING

BACKGROUND OF THE INVENTION

5 This invention relates generally to the cleaning of turbine blades. More specifically this invention relates to a method and device for cleaning internal surfaces of a turbine blade.

Typically, a turbine blade is thoroughly cleaned prior to repair and reconditioning. The internal cavities are difficult to clean and require a tedious and time-consuming process. Conventional cleaning of turbine blades includes the use
10 of an ultrasonic cleaning method. The conventional ultrasonic cleaning method utilizes a transducer that emits an ultrasonic high frequency wave into a cleaning solution filled tank. Energy from the transducer is transmitted through the tank walls into the liquid cleaning solution. The ultrasonic wave travels through the cleaning solution to the outer surface of the turbine blade. A portion of the
15 ultrasonic wave is then transmitted through the turbine blade to the inner surfaces. The ultrasonic wave then loosens and dislodges dirt from the inner surface.

Disadvantageously, the many surfaces and mediums that energy must travel through reduces the amount of energy actually present within the turbine blade to clean away dirt. Energy is drained and absorbed by the tank walls, the cleaning
20 solution and the turbine blade such that only a small portion of energy emitted from the transducer actually reaches the inner surfaces of the turbine blade. The resulting process is inefficient and time consuming. Further, because only a portion of energy actually penetrates the turbine blade to clean the interior surfaces, a very high level of energy is required. The high amount of energy impacts the outer surfaces of the
25 turbine blade potentially distorting delicate features and edges of the turbine blade.

Accordingly, it is desirable to develop a process and device for cleaning interior surfaces of the turbine blade that does not require excessive amounts of energy, decreases cleaning time and reduces any potential damage to exterior surfaces.

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SUMMARY OF THE INVENTION

This invention is a method and device for cleaning a turbine blade utilizing a squirter jet transducer. The squirter jet transducer is inserted within the turbine blade to clean internal surfaces of the turbine blade.

5 The device and method according to this invention includes a tank filled with a cleaning solution and a squirter transducer. The turbine blade and transducer are partially submerged within the tank. The squirter jet transducer is inserted at least partially within the cavity of the turbine blade. The portion that is inserted within the turbine blade emits an ultrasonic wave that directs energy against the interior
10 surfaces of the turbine blade to remove dirt and any other unwanted material.

Accordingly, the method and device for cleaning and reconditioning a turbine blade assembly according to this invention provides for cleaning of the interior surfaces of the turbine blade without excessive energy in a shorter time period without potentially damaging exterior surfaces of the turbine blade assembly.

15 These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

20 Figure 1 is a schematic representation of a turbine blade within a cleaning assembly according to this invention.

Figure 2 is an enlarged view of a portion of the squirter jet transducer mounted within the turbine blade.

25 Figure 3 is a schematic representation of a turbine blade and mask for protecting an exterior surface of the turbine blade.

Figure 4 is a schematic representation of a fixture for cleaning multiple turbine blades.

Figure 5 is a flow diagram illustrating the method steps for cleaning a turbine blade according to this invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, a cleaning assembly 10 for cleaning a hollow article includes a tank 12 filled with a cleaning solution 14. The cleaning solution 14 is preferably comprised of a 30-45% concentration of potassium hydroxide. Although, a specific amount and type of cleaning solution is specified in this disclosure other concentrations and mixtures of cleaning solution are within the contemplation of this invention. The cleaning assembly 10 further includes a transducer 16. The transducer 16 is of the type that emits a high frequency ultrasonic wave. The transducer 16 includes a body portion 18 and an agitator 24. The transducer 16 is controlled by a controller 20.

In the illustrated example the hollow article is a turbine blade assembly 28 including a cavity 34 having inner surfaces 36. The transducer 16 is inserted within the cavity 34 of the turbine blade assembly 28. Actuation of ultrasonic waves from the transducer 16 produces ultrasonic waves at a frequency within the cavity 34 that removes dirt and other contaminants that have been adhered to the interior surfaces 36 of the turbine blade assembly 28.

The turbine blade assembly 28 includes a root section 32 and a blade portion 30. The blade portion 30 includes a plurality of openings 40. The root section 32 includes an opening 38 through which the transducer agitator 24 is inserted. The cleaning assembly 10 produces and utilizes ultrasonic waves to clean dirt and grim that builds within the interior surfaces 36 of the turbine blade assembly 28.

The transducer 16 of this invention is a squirter type transducer. Squirter type transducers include an agitator 24 that is inserted into an opening 38 of the root section 32. The agitator 24 is the emitter of the transducer 16 that generates the ultrasonic waves that are transmitted through the cleaning solution 14 within the cavity 34 to dislodge dirt and other material built up on the interior surfaces 36 of the turbine blade assembly 28.

Referring to Figure 2, an enlarged view of the agitator 24 disposed within the cavity 34 of the turbine blade assembly 28 is shown. The agitator 24 is inserted into the cavity 34 a sufficient distance so that it may efficiently distribute energy to the surrounding cleaning solution 14 that will fill the cavity 34. Energy generated from the agitator 24 from the transducer 16 is emitted and transferred through the cleaning

solution 14 against the interior surfaces 36 of the cavity 34. This vibration and ultrasonic frequency that is transmitted through the cleaning solution 14 provides for the loosening and vibration of dirt, schematically indicated at 25 so that it may be removed and flushed from the turbine blade assembly 28.

5 This specific configuration and shape of the agitator 24 is designed and developed to fit within the opening 38 of the turbine blade assembly 28. Other shapes as required by application specific requirements are also within the contemplation of this invention. The opening 38 in this instance is slot shaped. Thereby the agitator 24 is a corresponding generally rectangular shaped member that
10 transmits ultrasonic energy through the cleaning solution 14 to remove the dirt 25 from the interior surfaces 36 of the turbine blade assembly 28.

 Referring to Figure 3, the turbine blade assembly 28 is shown with the root section 32. The root section 32 includes an exterior surface. In some instances it may be desirable to clean a plurality of turbine blade assemblies 28 at the same time.
15 A mask 42 is provided with a cavity 44. The cavity 44 fits and is designed to accommodate the root section 32 of the turbine blade assembly 28. The mask 42 serves not only to protect the exterior surface of the turbine blade assembly 28 during cleaning but also as a mounting block for mounting within a cleaning fixture 46.

20 Referring to Figure 4, the cleaning fixture 46 includes a tank portion 48. Attached to the tank portion 48 are the masks 42. The masks 42 are first assembled to each of the turbine blade assemblies 28 and then secured to the tank 48 by way of a plurality of brackets 50. The brackets 50 hold each turbine blade assembly 28 in a desired orientation such that the transducer assembly 16 is can easily insertable into
25 each of the turbine blade assemblies 28.

 Referring to Figure 5, the method according to this invention is schematically illustrated and includes the first step of mounting the transducer 16 to the turbine blade assembly 28 as indicated at 54. Mounting of the transducer 16 can be accomplished in several different ways. The transducer assembly 16 includes the
30 agitator 24. The agitator 24 is designed specifically for each turbine blade assembly 28 such that it may insert into the opening 38. The agitator 24 is inserted into the root section 32 with sufficient clearance to prevent contact between interior surfaces

of the cavity 34. However, the clearance is also determined to maximize the amount of energy that is transmitted through the liquid and against the interior surfaces 36 to affect the dislodgement of dirt.

5 Once mounted to the transducer 16, the entire turbine blade assembly 28 is submerged within the cleaning solution 14 as indicated at 56. The cleaning solution 14 utilized in the example embodiment is of a 30-45% concentration of potassium hydroxide. As appreciated, it is within the contemplation of this invention to utilize other concentrations and types of cleaning solutions.

10 The squirter transducer assembly 16 emits an ultrasonic wave at a pre-determined and desired frequency as indicated at 58. The pre-determined frequency utilizes much less energy than is required when the transducer assembly 16 is utilized to transmit energy through a turbine blade. In instances where ultrasonic cleaning is used to clean internal surfaces where a transducer is used outside of the turbine blade assembly 28 upwards of 6 kilowatts of energy may be required. In the
15 method according to this invention, because the transducer 16 is inserted within the cavity 34 of the turbine blade assembly 28 a much lower power, of about 0.3 kilowatts is all that is required. Other levels of power may be utilized depending on the specific application and level of contamination and dirt adhere to the interior surfaces 26 of the turbine blade 28.

20 In the example cleaning assembly 10, a pump 26 is installed within the cleaning tank 12. The pump 26 provides for recirculation of the cleaning solution 14. In this application the cleaning solution 14 is pumped through the first opening 38 and then out openings 40 that are disposed within the blade section 30 of each turbine blade assembly 28. The flow of the cleaning solution 14 along with the
25 ultrasonic energy that is transmitted to the interior surfaces 36 of the cavity 34 affect a desired cleaning that removes substantially all of the dirt and grime that have built up over use.

The improved cleaning with the lower amount of energy increases the efficiency and reduces the amount of time required to clean each turbine blade
30 assembly. Prior art methods required days to clean the blades efficiently. The instant invention can clean within hours. Further, because ultrasonic energy is introduced on the internal surfaces directly within the turbine blade assembly 28

outer surfaces are protect in much less damage is possible. As appreciated in prior art methods where extreme high power is required to transmit ultrasonic energy through the turbine blade assembly. Outer surface, sharp edges, and delicate surfaces of the turbine blade assembly were susceptible to damage.

5 Accordingly, the method and device of this invention provides an improved cleaning method that quickly and efficiently cleans turbine blades with much less power and less possibility of potential damage to desirable and delicate external features.

10 Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

CLAIMS

1. A method of cleaning an interior surface of a hollow article comprising the steps of
 - a) at least partially submerging a portion of the hollow article within a tank filled with a cleaning solution;
 - b) flowing cleaning solution through the hollow article;
 - c) emitting a high frequency ultrasonic wave through an opening within the hollow article within the flowing cleaning solution; and
 - d) transferring energy through the cleaning solution and against the interior surface of the hollow article to remove unwanted material.
2. The method as recited in claim 1, including the step of masking an exterior surface of the hollow article prior to submerging in the tank.
3. The method as recited in claim 1, including the step of mounting a transducer adjacent the opening.
4. The method as recited in claim 3, wherein the transducer includes an agitator portion that is insertable within the opening of the hollow article.
5. The method as recited in claim 3, wherein the transducer is submerged with the hollow article within the tank.
6. The method as recited in claim 3, wherein the transducer is a directional transducer that produces ultrasonic waves in a desired direction.
7. The method as recited in claim 1, wherein the cleaning solution comprises at least some potassium hydroxide.
8. The method as recited in claim 1, wherein the hollow article comprises a turbine blade having the opening within a root section and at least a partially hollow blade portion having at least one opening.

9. The method as recited in claim 8, wherein the step of flowing cleaning solution includes flowing cleaning solution through the opening in the root section and out the at least one opening in the blade portion.

10. A cleaning assembly for removing dirt from a cavity of a turbine blade comprising;

a tank containing a cleaning solution;

a nozzle for directing cleaning solution into the cavity of the turbine blade; and

a transducer to generate an ultrasonic wave emitted through the cleaning solution directed through an opening within the turbine blade to agitate and remove dirt from interior surfaces of the cavity.

11. The assembly as recited in claim 10, wherein the transducer includes an agitator mountable through the opening and into the cavity of the turbine blade to generate the ultrasonic wave within the turbine blade.

12. The assembly as recited in claim 10, including a mask mountable to an exterior portion of the turbine blade to protect the exterior portion of the turbine blade.

13. The assembly as recited in claim 10, wherein the transducer comprises a squirter transducer that injects liquid into the cavity of the turbine blade.

14. The assembly as recited in claim 13, wherein the turbine blade includes blade openings, and liquid is exhausted through the openings within the blade.

15. The assembly as recited in claim 13, wherein the transducer comprises an approximately 0.3 kilowatt transducer.

16. The assembly as recited in claim 13, including a fixture for mounting a plurality of turbine blades and a corresponding plurality of transducers mounted to each of the plurality of turbine blades.

17. A method of reconditioning a turbine blade having a root opening and at least one blade opening, said method comprising the steps of:

- a) submerging a portion of the turbine blade into a cleaning solution;
- b) flowing cleaning solution through root opening into a cavity of the turbine blade;
- c) directing an ultrasonic wave through the root opening that travels through the flowing cleaning solution and against an interior surface of the turbine blade; and
- d) exhausting the cleaning solution from the turbine blade through the at least one blade opening.

18. The method as recited in claim 17, including mounting a portion of a transducer through the root opening to direct the ultrasonic wave against the interior surfaces of the turbine blade.

19. The method as recited in claim 18, wherein the transducer comprises a squirter transducer that injects cleaning solution through the root opening and into the turbine blade.