

VIDEO TRIGGER SYNCHRONIZATION FOR IMPROVED PARTICLE DETECTION IN A VESSEL

FIELD OF THE DISCLOSURE

[0001] The present application relates generally to particle detection in fluid-filled vessels.

BACKGROUND

[0002] A fluid may contain particles in a variety of different shapes and sizes. The fluid may intentionally contain particles, or may unintentionally contain particles. Unintentional particles can originate from a number of different sources, such as from the environment, from incorrect handling or storage of the fluids, or as a residual from forming, packaging or filling of a vessel holding the fluid. The fluid can also contain bubbles.

SUMMARY OF THE DISCLOSURE

[0003] According to a first aspect of the present disclosure, there is provided a method including: during an agitation period of an agitation profile, applying a motion to a transparent vessel containing a fluid, and while applying the motion; acquiring a sequence of original images of a portion of the transparent vessel, the acquisition of the sequence of original images being synchronized to the agitation profile such that each original image in the sequence of original images corresponds to the transparent vessel being in the same position; generating a background image from the sequence of original images; generating a resultant image from the background image and an original image in the sequence of original images; and identifying from the resultant image a particle in the fluid.

[0004] According to a second aspect of the present disclosure, there is provided an inspection system including: an agitator configured to receive a transparent vessel containing a fluid and apply a motion to the transparent vessel during an agitation period of an agitation profile; an imager configured to acquire a sequence of original images of the transparent vessel as the agitator applies the motion, the imager being synchronized to the agitation profile such that each original image in the sequence of original images corresponds to the transparent vessel being in the same position; and a controller configured to: receive from the imager the sequence of original images; identify common features of at least two original images in the sequence of original images; generate a background image including the common features; generate one or more resultant images from the background image and the sequence of original images; and identify, from the background image, a particle in the fluid.

[0005] According to a third aspect of the present disclosure, there is provided a method including: during an agitation period of an agitation profile, acquiring a sequence of original images of a portion of a transparent vessel, the acquisition of the sequence of original images being synchronized to the agitation profile such that each original image in the sequence of original images corresponds to the transparent vessel being in the same position; determining a background image from the sequence of original images; generating at least one resultant image from the background image and the sequence of original images; and identifying from the resultant image at least one particle in the fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The skilled artisan will understand that the figures, described herein, are included for purposes of illustration and are not limiting on the present disclosure. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the present disclosure. It is to be understood that, in some instances, various aspects of the described implementations may be shown exaggerated or enlarged to facilitate an understanding of the described implementations. In the drawings, like reference characters throughout the various drawings generally refer to functionally similar and/or structurally similar components.

[0007] FIG. 1 illustrates a visual inspection system according to an embodiment of the present disclosure.

[0008] FIG. 2 illustrates a visual inspection system according to an embodiment of the present disclosure.

[0009] FIG. 3 illustrates an example of a method for identifying particles in a fluid.

[0010] FIG. 4 illustrates a vessel at different time points during application of an agitation profile.

[0011] FIG. 5 illustrates an example of images acquired and processed according to techniques of the present disclosure.

[0012] FIG. 6 illustrates an example of a controller.

DETAILED DESCRIPTION

[0013] The various concepts introduced above and discussed in greater detail below may be implemented in any of numerous ways, and the described concepts are not limited to any particular manner of implementation. Examples of implementations are provided for

CLAIMS

1. A method comprising:
 - during an agitation period of an agitation profile, applying a motion to a transparent vessel containing a fluid, and while applying the motion:
 - acquiring a sequence of original images of a portion of the transparent vessel, the acquisition of the sequence of original images being synchronized to the agitation profile such that each original image in the sequence of original images corresponds to the transparent vessel being in the same position;
 - generating a background image from the sequence of original images;
 - generating a resultant image from the background image and an original image in the sequence of original images; and
 - identifying from the resultant image a particle in the fluid.
2. The method of claim 1, wherein the agitation period is a second agitation period subsequent to a first agitation period of the agitation profile, and the motion is a second motion, further comprising applying a first motion during the first agitation period.
3. The method of claim 2, wherein the first motion or the second motion comprises spinning, rotating, shaking, oscillating or flipping the transparent vessel.
4. The method of claim 3, wherein the first motion is spinning the transparent vessel at a first rate.
5. The method of claim 4, wherein the second motion is spinning the transparent vessel at a second rate slower than the first rate.
6. The method of claim 1, wherein the agitation profile further comprises applying energy or ultrasonic energy to the transparent vessel prior to the agitation period.

7. The method of claim 1, further comprising rotating the transparent vessel an integer multiple of 360 degrees between acquiring sequential images of the sequence of original images.
8. The method of claim 7, wherein the integer multiple of 360 degrees is a variable integer.
9. The method of claim 1, wherein the transparent vessel is a syringe.
10. The method of claim 1, wherein the fluid fills the transparent vessel substantially without an air gap.
11. The method of claim 1, wherein the transparent vessel is asymmetrical about a long axis of the transparent vessel.
12. The method of claim 1, wherein a cross-section of the transparent vessel varies along a length of the transparent vessel.
13. The method of claim 1, wherein the transparent vessel is non-cylindrical.
14. An inspection system comprising:
 - an agitator configured to receive a transparent vessel containing a fluid and apply a motion to the transparent vessel during an agitation period of an agitation profile;
 - an imager configured to acquire a sequence of original images of the transparent vessel as the agitator applies the motion, the imager being synchronized to the agitation profile such that each original image in the sequence of original images corresponds to the transparent vessel being in the same position; and
 - a controller configured to:
 - receive from the imager the sequence of original images;
 - identify common features of at least two original images in the sequence of original images;
 - generate a background image including the common features;

generate one or more resultant images from the background image and the sequence of original images; and
identify, from the background image, a particle in the fluid.

15. The system of claim 14, wherein the agitator is configured to spin, rotate, oscillate, or flip the transparent vessel.

16. The system of claim 14, wherein the agitator is configured to apply at least one of acoustic energy or ultrasonic energy to the transparent vessel.

17. The system of claim 14, wherein the agitation period is a second agitation period subsequent to a first agitation period of the agitation profile, and the agitator is configured to spin the transparent vessel at a first rotational velocity during the first agitation period and at a second slower rotational velocity during the second agitation period.

18. The system of claim 14, wherein the agitator is further configured to flip the transparent vessel prior to the agitation period.

19. The system of claim 18, wherein the agitator is further configured to spin the transparent vessel during the flipping of the transparent vessel.

20. The system of claim 14, wherein the agitator comprises a motor, the system further comprising a triggering circuit configured to receive rotational information from the motor and provide a trigger signal to initiate the imager to acquire an image of the transparent vessel.

21. A method comprising:

during an agitation period of an agitation profile, acquiring a sequence of original images of a portion of a transparent vessel, the acquisition of the sequence of original images being synchronized to the agitation profile such that each original image in the sequence of original images corresponds to the transparent vessel being in the same position;
determining a background image from the sequence of original images;

generating at least one resultant image from the background image and the sequence of original images; and

identifying from the resultant image at least one particle in the fluid.

22. The method of claim 21, wherein the sequence of original images is a sequence of two original images.

23. The method of claim 21, wherein the agitation period is a second agitation period, and the agitation profile includes a first agitation period prior to the second agitation period.