solved by currently available techniques. Accordingly, the subject matter of the present application has been developed to provide apparatuses, systems, and methods for detecting kissing bonds in bonded joints of parts that may overcome at least some of the above-discussed shortcomings of prior art techniques.

According to an aspect, there is provided an assembly comprising an electromagnetic shockwave generator, configured to generate an electromagnetic shockwave through a target portion of the bonded joint, wherein the electromagnetic shockwave has a predetermined intensity that is known to be sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion; and an ultrasonic sensor, configured to generate a transmitted ultrasonic pulse, direct the transmitted ultrasonic pulse into the target portion of the bonded joint, and receive a received ultrasonic pulse from the target portion of the bonded joint in response to the electromagnetic shockwave generator generating the electromagnetic shockwave through the target portion of the bonded joint.

According to another aspect, there is provided a system for detecting kissing bonds in a bonded joint of a part. The system includes a detection assembly, comprising an electromagnetic shockwave generator, configured to generate an electromagnetic shockwave through a target portion of the bonded joint, wherein the electromagnetic shockwave has a predetermined intensity that is known to be sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion; and an ultrasonic sensor, configured to generate a transmitted ultrasonic pulse, direct the transmitted ultrasonic pulse into the target portion of the bonded joint, and receive a received ultrasonic pulse from the target portion of the bonded joint in response to the electromagnetic shockwave generator generating the electromagnetic shockwave through the target portion of the bonded joint. The system also includes a controller, configured to synchronize the generation of the transmitted ultrasonic pulse relative to the generation of the electromagnetic shockwave.

According to another aspect, there is provided a method of detecting kissing bonds in a bonded joint of a part. The method includes generating an electromagnetic shockwave

through a target portion of the bonded joint, wherein the electromagnetic shockwave has an intensity sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion. In response to generating the electromagnetic shockwave through the target portion of the bonded joint, the method includes generating a transmitted ultrasonic pulse; directing the transmitted ultrasonic pulse into the target portion of the bonded joint; and receiving a received ultrasonic pulse from the target portion of the bonded joint. The method also includes identifying at least one characteristic of the received ultrasonic pulse; performing a comparison between the at least one characteristic of the received ultrasonic pulse and at least one predetermined characteristic; and determining a presence or absence of a kissing bond in the target portion of the bonded joint based on the comparison. The bonded joint of the part comprises a first layer bonded to a second layer by a bond. The bond within the target portion of the bonded joint comprises the kissing bond. The electromagnetic shockwave separates the first layer from the second layer at the kissing bond to form a void between the first layer and the second layer. While the first layer and the second layer are separated by the electromagnetic shockwave, at least a portion of the transmitted ultrasonic pulse reflects off the void to form the received ultrasonic pulse.

The following is a non-exhaustive list of examples, which may or may not be claimed, of the subject matter, disclosed herein.

Disclosed herein is a detection assembly for detecting kissing bonds in a bonded joint of a part. The detection assembly comprises an electromagnetic shockwave generator that is configured to generate an electromagnetic shockwave through a target portion of the bonded joint. The electromagnetic shockwave has an intensity sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion. The detection assembly also comprises an ultrasonic sensor that is configured to generate a transmitted ultrasonic pulse, direct the transmitted ultrasonic pulse into the target portion of the bonded joint, and receive a received ultrasonic pulse from the target portion of the bonded joint in response to the electromagnetic shockwave generator generating the electromagnetic shockwave through

the target portion of the bonded joint. The preceding subject matter of this paragraph characterizes example 1 of the present disclosure.

The detection assembly is movable along the part. The preceding subject matter of this paragraph characterizes example 2 of the present disclosure, wherein example 2 also includes the subject matter according to example 1, above.

The electromagnetic shockwave generator and the ultrasonic sensor are non-movably fixed relative to each other. The preceding subject matter of this paragraph characterizes example 3 of the present disclosure, wherein example 3 also includes the subject matter according to example 2, above.

The ultrasonic sensor is integrated into the electromagnetic shockwave generator. The preceding subject matter of this paragraph characterizes example 4 of the present disclosure, wherein example 4 also includes the subject matter according to example 3, above.

CLAIMS

1. An assembly comprising:

an electromagnetic shockwave generator, configured to generate an electromagnetic shockwave through a target portion of the bonded joint, wherein the electromagnetic shockwave has a predetermined intensity that is known to be sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion; and

an ultrasonic sensor, configured to generate a transmitted ultrasonic pulse, direct the transmitted ultrasonic pulse into the target portion of the bonded joint, and receive a received ultrasonic pulse from the target portion of the bonded joint in response to the electromagnetic shockwave generator generating the electromagnetic shockwave through the target portion of the bonded joint.

2. The assembly according to claim 1, wherein the assembly is movable along the part.

3. The assembly according to claim 2, wherein the electromagnetic shockwave generator and the ultrasonic sensor are non-movably fixed relative to each other.

4. The assembly according to claim 3, wherein the ultrasonic sensor is integrated into the electromagnetic shockwave generator.

5. The assembly according to claim 1, wherein the electromagnetic shockwave generator comprises an electromagnetic dent remover.

6. The assembly according to claim 1, wherein the electromagnetic shockwave generator is directly contactable with the part when the electromagnetic shockwave generator generates the electromagnetic shockwave and when the ultrasonic sensor generates the transmitted ultrasonic pulse, directs the transmitted ultrasonic pulse into the target portion of the bonded joint, and receives the received ultrasonic pulse from the target portion of the bonded joint.

7. The detection assembly according to claim 1, wherein the electromagnetic shockwave generator and the ultrasonic sensor are co-movable into a position in which the electromagnetic shockwave directly contacts the target portion of the bonded joint.

8. The detection assembly according to claim 7, wherein, when in the position, the electromagnetic shockwave generator generates the electromagnetic shockwave through the target portion of the bonded joint and the ultrasonic sensor generates the transmitted ultrasonic pulse and transmits the ultrasonic pulse into the target portion of the bonded joint.

9. A system for detecting kissing bonds in a bonded joint of a part, the system comprising:

a detection assembly, comprising:

an electromagnetic shockwave generator, configured to generate an electromagnetic shockwave through a target portion of the bonded joint, wherein the electromagnetic shockwave has a predetermined intensity that is known to be sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion; and

an ultrasonic sensor, configured to generate a transmitted ultrasonic pulse, direct the transmitted ultrasonic pulse into the target portion of the bonded joint, and receive a

received ultrasonic pulse from the target portion of the bonded joint in response to the electromagnetic shockwave generator generating the electromagnetic shockwave through the target portion of the bonded joint; and

a controller, configured to synchronize the generation of the transmitted ultrasonic pulse relative to the generation of the electromagnetic shockwave.

10. The system according to claim 9, wherein:

the controller comprises an EM shockwave module and an ultrasonic sensing module;

the EM shockwave module is configured to transmit a shockwave command to the electromagnetic shockwave generator;

the electromagnetic shockwave generator is configured to generate the electromagnetic shockwave in response to receiving the shockwave command;

the ultrasonic sensing module is configured to automatically transmit an ultrasonic wave command to the ultrasonic sensor in response to the transmission of the shockwave command by the EM shockwave module; and

the ultrasonic sensor is configured to generate the transmitted ultrasonic pulse in response to receiving the ultrasonic wave command.

11. The system according to claim 10, wherein:

the ultrasonic sensor is further configured to transmit ultrasonic data, corresponding with one or more characteristics of the received ultrasonic pulse received by the ultrasonic sensor; and

the ultrasonic sensing module is further configured detect a kissing bond in the bonded joint based on at least the ultrasonic data.

12. The system according to claim 9, wherein:

the electromagnetic shockwave generator and the ultrasonic sensor form a probe head;

the system further comprises a robot; and

the probe head is fixed to and movable, along the part, by the robot.

13. A method of detecting kissing bonds in a bonded joint of a part, the method comprising:

generating an electromagnetic shockwave through a target portion of the bonded joint, wherein the electromagnetic shockwave has an intensity sufficient to induce a separation of a kissing bond in the target portion of the bonded joint and insufficient to induce a separation of a healthy bond, adjacent the kissing bond, in the target portion;

in response to generating the electromagnetic shockwave through the target portion of the bonded joint:

generating a transmitted ultrasonic pulse;

directing the transmitted ultrasonic pulse into the target portion of the bonded joint; and

receiving a received ultrasonic pulse from the target portion of the bonded joint;

identifying at least one characteristic of the received ultrasonic pulse;

performing a comparison between the at least one characteristic of the received ultrasonic pulse and at least one predetermined characteristic; and

determining a presence or absence of a kissing bond in the target portion of the bonded joint based on the comparison,

wherein:

the bonded joint of the part comprises a first layer bonded to a second layer by a bond;

the bond within the target portion of the bonded joint comprises the kissing bond;

the electromagnetic shockwave separates the first layer from the second layer at the kissing bond to form a void between the first layer and the second layer; and

while the first layer and the second layer are separated by the electromagnetic shockwave, at least a portion of the transmitted ultrasonic pulse reflects off the void to form the received ultrasonic pulse.

14. The method according to claim 13, wherein:

the at least one characteristic of the received ultrasonic pulse comprises a measured signal response of the received ultrasonic pulse;

the at least one predetermined characteristic comprises a predetermined signal response;

the absence of a kissing bond is determined when the measured signal response is equal to the predetermined signal response; and

the presence of a kissing bond is determined when the measured signal response is not equal to the predetermined signal response.

15. The method according to claim 13, wherein the part is made of an electrically-conductive material.

16. The method according to claim 13, wherein:

the electromagnetic shockwave is generated by an electromagnetic shockwave generator; and

the electromagnetic shockwave generator is in direct contact with the part when the electromagnetic shockwave generator generates the electromagnetic shockwave and when the transmitted ultrasonic pulse is generated, the transmitted ultrasonic pulse is directed into the

target portion of the bonded joint, and the received ultrasonic pulse is received from the target portion of the bonded joint.

17. The method according to claim 13, further comprising determining the intensity, of the electromagnetic shockwave, sufficient to induce a separation of a kissing bond in the target portion of the bonded joint by:

generating test electromagnetic shockwaves through a target portion of a bonded joint of a test part; and

incrementally increasing an intensity of each one of the test electromagnetic shockwaves while monitoring the test part for visual signs of anomalies.

18. The method according to claim 17, wherein the step of determining the intensity, of the electromagnetic shockwave, sufficient to induce a separation of a kissing bond in the target portion of the bonded joint further comprises:

measuring a temperature of the test part after each incremental increase in the intensity of the test electromagnetic shockwaves; and

waiting to generate a subsequent one of the test electromagnetic shockwaves until after the temperature of the test part is at or below a predetermined threshold temperature.

19. The method according to claim 17, wherein determining the intensity, of the electromagnetic shockwave, sufficient to induce a separation of a kissing bond in the target portion of the bonded joint further comprises inspecting the test part for structural anomalies.

20. The method according to claim 13, wherein:

the electromagnetic shockwave is generated by an electromagnetic shockwave generator;

the transmitted ultrasonic pulse is generated by an ultrasonic sensor;

the transmitted ultrasonic pulse is directed by the ultrasonic sensor;

the received ultrasonic pulse is received by the ultrasonic sensor; and

the method further comprises co-moving the electromagnetic shockwave generator and the ultrasonic sensor into a position in which the electromagnetic shockwave directly contacts the target portion of the bonded joint.