CLAIMS

1. A system (100) for inspecting a composite material structure (115) for defects comprising:

an inspection apparatus (110) including a heating device (310) for heating a section of a surface of the structure, an infrared camera (320) for receiving infrared radiation from the surface in response to heating, a controller (330) configured to generate thermal images from the received infrared radiation, and a communication device (350);

a training system (130) including an arrangement for obtaining thermal images from a known composite material sample, the arrangement including a plurality of heating elements positioned to apply heat to an entire surface of the sample, an infrared camera for capturing thermal images of the sample when heated, and a processor configured to establish a plurality of correlations between the known parameters of the composite material samples and the obtained thermal images; and

a computer system (120) communicatively coupled to the training system (130) and the inspection apparatus (110), the computer system adapted to receive thermal images received from the inspection apparatus and to detect quantitative parameters of defects in the structure using the training database (134).

2. A system according to Claim 1, in which the heating elements (1610) of the training system are arranged on at least one circular rail (1620) and surround the sample in a 360-degree manner.

3. A system according to Claim 1, in which the computer system (120) determines a possible presence of a defect by comparing a distance between the infrared camera (320) and a point on the surface of the structure (115) as calculated based on a) the thermal images versus b) images in the training database (134).

4. A system according to Claim 3, in which the computer system (120) issues an alert to inspection personnel if there is a threshold difference between the distance between the infrared camera (320) and the point on the surface as calculated by the thermal images versus the images in the training database (134).

5. A system according to Claim 1, in which the infrared camera (320) is movable around the circumference of the sample, and is operative to acquire thermal images from the entire circumference of the sample.

6. A system according to Claim 5, in which the arrangement for obtaining thermal images includes a circular slider (1635) upon which the infrared camera is slidably coupled so as to move circumferentially around the sample in a full 360 degrees.

7. A system according to Claim 1, in which the composite material structure (115) is a pipe made of a composite material.

8. A system according to Claim 7, in which the composite material (115) is one of reinforced thermosetting resin (RTR), fiber-reinforced-polymer (FRP), glass reinforced polymer (GRP) and glass reinforced epoxy (GRE).

9. A method for inspecting composite material structure (115) for defects comprising, the method comprising:

training a thermal image database (134) by heating known composite material samples with a plurality of heating elements (1610) and capturing resulting thermal images from the samples using an infrared camera (1630) to establish correlations between the composite material samples with known parameters and thermal images of the samples;

heating the structure to be inspected;

capturing thermal images of the structure (115);

delivering the thermal images to a computing system (120) coupled to the thermal image database;

matching the captured thermal images to images in the thermal image database; and

determining, at the computing system (120), whether there are defects in the structure by comparing the thermal images of the structure to matched thermal images in the thermal image database.

10. A method according to Claim 9, in which an entire circumference of the structure is heated.

11. A method according to Claim 9, in which the step of determining whether there are defects includes comparing a distance between the infrared camera (1610) and a point on the surface of the structure as calculated based on the captured thermal images versus the matched images of the training database.

12. A method according to Claim 11, further comprising alerting inspection personnel if there is a threshold difference between the distance between the infrared camera and the point on the surface as calculated by the captured thermal images versus the matched thermal images of the training database (134).

13. A method according to Claim 9, further comprising moving the infrared camera around the circumference of the sample to acquire thermal images from an entire surface of the sample.

14. A method according to Claim 9, in which the composite material structure (115) is a pipe made of a composite material.

15. A method according to Claim 14, in which the composite material is one of reinforced thermosetting resin (RTR), fiber-reinforced-polymer (FRP), glass reinforced polymer (GRP) and glass reinforced epoxy (GRE).

16. A method according to Claim 1, in which the correlations pertain to material properties of the samples, and thermal and environmental parameters describing conditions under which the thermal images of the samples are obtained by the training system.

17. An expert system for inspecting a composite material structure for defects in comparison to thermal images obtained from a known composite material sample from which a plurality of correlations between the known parameters of the composite material samples and the obtained thermal images are stored in a training database, comprising:

an inspection apparatus including:

a heating device for heating a section of a surface of the structure;

an infrared camera for receiving infrared radiation from the surface in response to heating;

a controller configured to generate thermal images from the received infrared radiation, and

a communication device; and

a computer system communicatively coupled to the inspection apparatus, the computer system adapted to receive thermal images received from the inspection apparatus and to detect quantitative parameters of at least one defect in the structure in comparison to the thermal images in the training database.

18. An expert system according to Claim 17, in which the quantitative parameters of defects in the structure detected by the computer system include one or more of a length, width and depth of the at least one defect.

19. An expert system according to Claim 17, in which the quantitative parameters of defects in the structure detected by the computer system include each of the length, width and depth of the at least one defect, and in which the computer system is further adapted to generate a 3-dimensional rendering of the locations of the at least one defect, including axial position, reference point of start of inspection, radial position and the depth of the defects detected within the structure.

20. An expert system according to Claim 17, in which the inspection apparatus further includes a laser detector adapted to measure a surface temperature of the structure.

21. An expert system according to Claim 20, in which the computer system is adapted to use the surface temperature detected using the laser detector of the inspection apparatus to calibrate the heating device and data received by the infrared camera.

22. An expert system according to Claim 17, in which the inspection apparatus is adapted to move around a circumference of the structure to acquire thermal images.

23. An expert system according to Claim 17, in which the composite material structure is a pipe made of a composite material.

24. An expert system according to Claim 23, in which the composite material is one of reinforced thermosetting resin (RTR), fiber-reinforced-polymer (FRP), glass reinforced polymer (GRP) and glass reinforced epoxy (GRE).

25. An expert system according to Claim 17, in which the computer system is configured to determine, from comparison between the receive thermal images of the structure and thermal

images in the training database, a distance between the infrared camera and each surface point of a section of the structure.

26. An expert system according to Claim 25, in which the computer system is further configured to:

determine, whether the distance between the infrared camera and the surface points of the section are different from an average based on data in the training database; and

generate a notification to inspect the section if the difference between the distance between the infrared camera and the surface points of the section and an average based on data in the training database are above a threshold indicative of a defect.