loading, impacts, high temperatures and the like during operation. Such indications may lead to the scheduling of further evaluation, maintenance and/or replacement of the structural components at appropriate times.

Summary of the Disclosure

In one aspect of the present disclosure, there is provided an inspection system for assessing strain in a structural component, comprising:

a first geometric pattern of grooves within the structural component having a first set of grooves each having a first groove width and a second set of grooves each having a second groove width, said structural component being formed by a first outer layer, a second outer layer and a first patterned layer disposed between the first outer layer and the second outer layer, said first patterned layer comprising a wire mesh scrim defining said first geometric pattern, said wire mesh scrim comprising a first set of parallel wires oriented in a first direction and a second set of parallel wires oriented in a second direction that is not parallel to the first direction, wherein the first groove width is equal to a first wire spacing distance between adjacent wires of the first set of parallel wires and the second groove width is equal to a second wire spacing distance between adjacent wires of the second set of parallel wires, the first set of parallel wires and the second set of parallel wires being woven together;

a first electromagnetic, EM, energy source being configured to project EM energy at predetermined wavelengths that correspond to the first groove width, wherein, when first projected beams of EM energy coming from the first EM energy source are projected onto the structural component, the first projected beams of EM energy pass through the structural component to the first geometric pattern of grooves, and are diffracted by the first set of grooves to create first diffracted beams of diffracted EM energy having first diffracted wavelengths indicating changes in the first groove width due to the strain caused when the structural component is exposed to an environmental condition;

a second EM energy source being configured to project EM energy at different wavelengths that correspond to the second groove width, wherein, when second projected beams of EM energy coming from the second EM energy source are projected onto the structural component, the second projected beams of EM energy pass through the structural component to the first geometric pattern of grooves, and are diffracted by the second set of grooves to create second diffracted beams of diffracted EM energy having second diffracted

wavelengths indicating changes in the second groove width due to the strain caused when the structural component is exposed to the environmental condition;

an EM energy detector for detecting the first diffracted beams of diffracted EM energy from the first set of grooves as the first EM energy source projects the first projected beams of EM energy onto the structural component, wherein the second diffracted beams of diffracted EM energy reflected from the second set of grooves are detected by the EM energy detector as the second EM energy source projects the second projected beams of EM energy onto the structural component; and

a processor configured to send to the EM energy sources control signals causing the EM energy sources to project EM energy at predetermined wavelengths, said processor being operatively connected to the EM energy detector and being configured to receive the first diffracted wavelengths of the first diffracted beams of diffracted EM energy from the EM energy detector and to correlate the first diffracted wavelengths to the strain in the structural component and wherein the processor is configured to receive the second diffracted beams of diffracted EM energy from the EM energy detector and to correlate the second diffracted wavelengths to the strain in the structural component.

In a further aspect of the present disclosure, there is provided a method for assessing strain in a structural component having a first geometric pattern of grooves within the structural component, the first geometric pattern of grooves having a first set of grooves each having a first groove width and a second set of grooves each having a second groove width, said structural component being formed by a first outer layer, a second outer layer and a first patterned layer disposed between the first outer layer and the second outer layer, said first patterned layer comprising a wire mesh scrim defining said first geometric pattern, said wire mesh scrim comprising a first set of parallel wires oriented in a first direction and a second set of parallel wires oriented in a second direction that is not parallel to the first direction, wherein the first groove width is equal to a first wire spacing distance between adjacent wires of the first set of parallel wires and the second groove width is equal to a second wire spacing distance between adjacent wires of the second set of parallel wires, the first set of parallel wires and the second set of parallel wires being woven together, the method for assessing strain comprising:

projecting a first projected beam of electromagnetic,EM, energy through the structural component to the first geometric pattern of grooves, wherein the first projected beam of EM energy has a first wavelength that corresponds to the first groove width, and wherein the first set of grooves diffracts the first projected beam of EM energy to create a first diffracted beam of diffracted EM energy having a first diffracted wavelength indicating changes in the first groove width due to strain caused when the structural component is exposed to an environmental condition;

projecting a second projected beam of EM energy through the structural component to the first geometric pattern of grooves, wherein the second projected beam of EM energy has a second wavelength that corresponds to the second groove width, and wherein the second set of grooves diffracts the second projected beam of EM energy to create a second diffracted beam of diffracted EM energy having a second diffracted wavelength indicating changes in the second groove width due to strain caused when the structural component is exposed to an environmental condition;

detecting the first diffracted beam of diffracted EM energy from the first set of grooves as the first projected beam of EM energy is projected onto the structural component;

detecting the second diffracted beam of diffracted EM energy from the second set of grooves as the second projected beam of EM energy is projected onto the structural component;

in response to determining that projected beams having various wavelengths have not projected, repeat the step of projecting the first and the second projected beam with different wavelengths and then repeat the step of detecting the corresponding first and second diffracted beams of EM energy;

correlating the first diffracted wavelengths of the first diffracted beams of diffracted EM energy from the first geometric pattern of grooves to the strain in the structural component;

correlating the second diffracted wavelengths of the second diffracted beams of diffracted EM energy from the first geometric pattern of the grooves to the strain in the structural component.

Additional aspects are defined by the claims of this patent.

Brief Description of the Drawings

Fig. 1 is an isometric view of a structural component of a mechanical system having a geometric pattern of grooves in accordance with the present disclosure;

Fig. 2 is a partial cross-sectional view of the structural component of Fig. 1 having the geometric pattern of grooves;

Fig. 3 is a partial cross-sectional view of an alternative embodiment of a structural component having an alternative geometric pattern of grooves;

Claims

1. An inspection system for assessing strain in a structural component, comprising:

a first geometric pattern of grooves within the structural component having a first set of grooves each having a first groove width and a second set of grooves each having a second groove width, said structural component being formed by a first outer layer, a second outer layer and a first patterned layer disposed between the first outer layer and the second outer layer, said first patterned layer comprising a wire mesh scrim defining said first geometric pattern, said wire mesh scrim comprising a first set of parallel wires oriented in a first direction and a second set of parallel wires oriented in a second direction that is not parallel to the first direction, wherein the first groove width is equal to a first wire spacing distance between adjacent wires of the first set of parallel wires and the second groove width is equal to a second wire spacing distance between adjacent wires of the second set of parallel wires, the first set of parallel wires and the second set of parallel wires being woven together;

a first electromagnetic, EM, energy source being configured to project EM energy at predetermined wavelengths that correspond to the first groove width, wherein, when first projected beams of EM energy coming from the first EM energy source are projected onto the structural component, the first projected beams of EM energy pass through the structural component to the first geometric pattern of grooves, and are diffracted by the first set of grooves to create first diffracted beams of diffracted EM energy having first diffracted wavelengths indicating changes in the first groove width due to the strain caused when the structural component is exposed to an environmental condition;

a second EM energy source being configured to project EM energy at different wavelengths that correspond to the second groove width, wherein, when second projected beams of EM energy coming from the second EM energy source are projected onto the structural component, the second projected beams of EM energy pass through the structural component to the first geometric pattern of grooves, and are diffracted by the second set of grooves to create second diffracted beams of diffracted EM energy having second diffracted wavelengths indicating changes in the second groove width due to the strain caused when the structural component is exposed to the environmental condition;

an EM energy detector for detecting the first diffracted beams of diffracted EM energy from the first set of grooves as the first EM energy source projects the first projected beams of EM energy onto the structural component, wherein the second

diffracted beams of diffracted EM energy reflected from the second set of grooves are detected by the EM energy detector as the second EM energy source projects the second projected beams of EM energy onto the structural component; and

a processor configured to send to the EM energy sources control signals causing the EM energy sources to project EM energy at predetermined wavelengths, said processor being operatively connected to the EM energy detector and being configured to receive the first diffracted wavelengths of the first diffracted beams of diffracted EM energy from the EM energy detector and to correlate the first diffracted wavelengths to the strain in the structural component and wherein the processor is configured to receive the second diffracted beams of diffracted EM energy from the EM energy detector and to correlate the second diffracted wavelengths to the strain in the structural component.

2. The inspection system according to claim 1, wherein the first direction of orientation of the first set of parallel wires is perpendicular to the second direction of orientation of the second set of parallel wires.

3. The inspection system according to claim 1, wherein the first set of parallel wires and the second set of parallel wires are angled with respect to each other in orientations other than orthogonal depending on the stresses to be monitored.

4. The inspection system according to any one of the preceding claims, wherein the first groove width and the second groove width are the same in both said directions and the thicknesses of the wires of the first set and of the second set are the same.

5. The inspection system according to any one of the claims 1 to 3, wherein the first groove width and the second groove width are different and the thickness of the wires of the first set is different than the thickness of the wires of the second set.

6. The inspection system according to any one of the preceding claims, wherein the first outer layer is fabricated from a material that reflects the EM energy while the second outer layer is fabricated from a material that is transparent to the EM energy, or both the outer layers are fabricated from a material that is transparent to both the projected and diffracted EM energy.

7. The inspection system according to claim 1, comprising a portable inspection device containing the first EM energy source and the EM energy detector, and transmitting the first diffracted wavelengths of the first diffracted beams of diffracted EM energy to the processor via wireless communications.

8. A method for assessing strain in a structural component having a first geometric pattern of grooves within the structural component, the first geometric pattern of grooves having a first set of grooves each having a first groove width and a second set of grooves each having a second groove width, said structural component being formed by a first outer layer, a second outer layer and a first patterned layer disposed between the first outer layer and the second outer layer, said first patterned layer comprising a wire mesh scrim defining said first geometric pattern, said wire mesh scrim comprising a first set of parallel wires oriented in a first direction and a second set of parallel wires oriented in a second direction that is not parallel to the first direction, wherein the first groove width is equal to a first wire spacing distance between adjacent wires of the first set of parallel wires and the second groove width is equal to a second wire spacing distance between adjacent wires of the second set of parallel wires, the first set of parallel wires and the second set of parallel wires being woven together, the method for assessing strain comprising:

projecting a first projected beam of electromagnetic,EM, energy through the structural component to the first geometric pattern of grooves, wherein the first projected beam of EM energy has a first wavelength that corresponds to the first groove width, and wherein the first set of grooves diffracts the first projected beam of EM energy to create a first diffracted beam of diffracted EM energy having a first diffracted wavelength indicating changes in the first groove width due to strain caused when the structural component is exposed to an environmental condition;

projecting a second projected beam of EM energy through the structural component to the first geometric pattern of grooves, wherein the second projected beam of EM energy has a second wavelength that corresponds to the second groove width, and wherein the second set of grooves diffracts the second projected beam of EM energy to create a second diffracted beam of diffracted EM energy having a second diffracted wavelength indicating changes in the second groove width due to strain caused when the structural component is exposed to an environmental condition;

detecting the first diffracted beam of diffracted EM energy from the first set of grooves as the first projected beam of EM energy is projected onto the structural component;

detecting the second diffracted beam of diffracted EM energy from the second set of grooves as the second projected beam of EM energy is projected onto the structural component;

in response to determining that projected beams having various wavelengths have not projected, repeat the step of projecting the first and the second projected beam with different wavelengths and then repeat the step of detecting the corresponding first and second diffracted beams of EM energy;

correlating the first diffracted wavelengths of the first diffracted beams of diffracted EM energy from the first geometric pattern of grooves to the strain in the structural component;

correlating the second diffracted wavelengths of the second diffracted beams of diffracted EM energy from the first geometric pattern of the grooves to the strain in the structural component.

9. The method for assessing strain according to claim 8, comprises:

projecting the first projected beams of EM energy onto the structural component a first time before the structural component exposed to the environmental condition;

detecting baseline diffracted wavelengths of the first diffracted beams of diffracted EM energy from the first set of grooves as the first projected beams of EM energy is projected onto the structural component the first time;

projecting the first projected beams of EM energy onto the structural component a second time after the structural component is exposed to the environmental condition;

detecting the first diffracted beams of diffracted EM energy from the first set of grooves as the first projected beams of EM energy is projected onto the structural component the second time; and

comparing the first diffracted wavelengths of the first diffracted beams of diffracted EM energy to the baseline diffracted wavelengths as the first projected beams of EM energy is projected onto the structural component the second time to determine changes in the strain at corresponding locations of the structural component.

10. The method for assessing strain according to claim 8, wherein the first set of grooves reflects the first projected beams of EM energy to transmit the first diffracted

beams of diffracted EM energy back through the structural component, and wherein the method for assessing strain comprises projecting the first projected beams of EM energy onto the structural component and detecting the first diffracted wavelengths on the same side of the structural component.

11. The method for assessing strain according to claim 8, wherein the first diffracted beams of diffracted EM energy is transmitted through the structural component on an opposite side of the first geometric pattern of grooves from the first projected beams of EM energy, and the method for assessing strain comprises projecting the first projected beams of EM energy onto the structural component and detecting the first diffracted wavelengths on opposite sides of the structural component.

12. The method for assessing strain according to claim 8, comprising:

comparing the strain on the structural component to a minimum strain value; and

conducting further inspection of the structural component in response to determining that the strain on the structural component is greater than the minimum strain value.

13. The method for assessing strain according to claim 8, comprising:

generating and displaying a strain pattern derived from the strain in the structural component, wherein the strain pattern is a graphical representation of strain values in an inspected area of the structural component; and

conducting further inspection of the structural component in response to determining that the strain pattern is different than an expected strain pattern on the structural component.

14. The method for assessing strain according to claim 8, wherein the first groove width and the second groove width are different and the thickness of the wires of the first set is different than the thickness of the wires of the second set.

15. The method for assessing strain according to claim 14, wherein the structural component is an aircraft fuselage, the first set of wires being configured to diffract EM energy in the near infrared band to indicate hoop stresses around the fuselage, and the second set of wires being configured to diffract EM energy in the far infrared band to

indicate tensile stresses, compressive stresses or torsional stresses in the longitudinal direction of said fuselage.