AUTOMATED PLACEMENT OF VIBRATION DAMPING MATERIALS

TECHNICAL FIELD

This disclosure generally relates to damping materials used to absorb or attenuate acoustic and/or mechanical vibrations, and deals more particularly with a method and apparatus for automated placement of damping materials on structures.

BACKGROUND

Damping materials are used in a variety of applications to dampen or attenuate acoustic and/or mechanical vibrations in a structure. For example acoustic dampening materials are commonly used in parts of vehicles to reduce the noise in passenger cabins produced by external sources such as engines and turbulent airflow.

In aircraft applications, patches of viscoelastic material have been added to various parts of an aircraft structure in order to reduce noise and vibration. These patches may be relatively expensive to install, in part due to the hand labor required to fit, cut and bond the patches to uniquely shaped structures on the aircraft. Moreover, these patches add weight to the aircraft which may reduce operating efficiency since several hundred and even thousands of such patches may be required for a typical commercial aircraft.

More recently, relatively lightweight composite laminates have been devised which may incorporate viscoelastic materials that act to absorb and thereby attenuate vibration in aircraft structures. While these new damping materials have a number of advantages, their widespread use on aircraft structures may be limited because of the time and manual labor required for their installation, particularly where the aircraft structure has a complicated geometry and precise hand placement of the viscoelastic material on or within the lamina of the structure is required.

Accordingly, there is a need for automated placement of damping materials on structures such as aircraft which reduces the need for hand labor to install the material, and which may provide rapid placement of the materials with high placement accuracy.

SUMMARY

The disclosed embodiments provide for automated placement of acoustic damping materials which reduces reliance on hand labor for installation and may result in higher placement accuracy. A method and apparatus are provided for placing damping materials at high laydown rates, and which are compatible with the layup and assembly processes commonly used to produce large scale aircraft at higher production rates.

According to one method embodiment, damping material may be installed on a structure using a material placement head. The material placement head is moved over the structure and is used to place the damping material on the structure. The head compacts the damping material against the structure, and the movement of the head may be controlled using a programmed computer.

According to another method embodiment damping acoustic vibrations in a structure is performed. A vibration damping tape is produced, and automatic tape placement equipment is employed to place the tape in any of various configurations as a single strip or as multiple side-by-side strips, either of which may be continuous or discontinuous.

The tape may include a removable backing which is removed and accumulated on a take-up spool as the tape is being placed on the structure.

According to another embodiment, apparatus is provided for placing damping material on a structure. The apparatus includes a material placement head for placing damping material on the structure, and means for moving the head over the structure. Control means are provided for controlling the operation of the head and the movement of the head. The head may include a supply of damping material, means for dispensing the damping material from the supply, and means for compacting the damping material on the structure. The damping material may be in the form of a tape which is placed by the head as strips onto the structure.

The disclosed embodiments therefore satisfy the need for a method and apparatus for rapidly placing damping material on a structure at high laydown rates with high placement accuracy, and which reduces the need for hand labor.

BRIEF DESCRIPTION OF THE ILLUSTRATIONS

FIG. **1** is an illustration in perspective of a structure on which contiguous strips of damping material has been placed over an entire area of a structure according to the disclosed embodiments.

FIG. **2** is an illustration similar to FIG. **1**, wherein only several separated strips have been placed on the structure.

FIG. **3** is an illustration in section taken along the line **3-3** in FIG. **1**.

FIG. **4** is an illustration in cross section of the acoustic damping tape shown in FIG. **3** but prior to being placed on the structure.

FIG. **5** is an illustration in section taken along the line **5-5** in FIG. **2**, showing another form of the acoustic damping tape.

FIG. **6** is an illustration in cross section of the acoustic damping tape shown in FIG. **5** but prior to being placed on the structure.

FIG. **7** is an illustration of a sectional view of a composite ply on which strips of the damping tape have been placed.

FIG. **8** is an illustration similar to FIG. **7**, but showing an additional ply having been placed over and adhered to the damping tape.

FIG. **9** is an illustration of a functional block diagram of apparatus for placing damping materials on a structure.

FIG. **10** is an illustration of a side view of a material placement head suitable for placing strips of damping tape on a structure.

FIG. **11** is an illustration of a perspective view of the material placement head shown in FIG. **10**.

FIG. **12** is a further illustration in perspective of the material placement head shown in FIGS. **10** and **11**.

FIG. **13** is an illustration of an isometric view of mobile apparatus for operating multiple material placement heads used in high production application.

FIG. **14** is an illustration in perspective of an aircraft fuselage layup on which damping material is being automatically placed according to the disclosed embodiments.

FIG. **15** is an illustration of a functional block diagram of an alternate form of the apparatus used to automatically place preformed units of damping material on a structure.

FIG. **16** is an illustration a functional block diagram of a control system forming part of the disclosed embodiments.

FIG. **17** is an illustration of a flow diagram showing the overall steps of a method of installing damping material on a structure.

FIG. **18** is an illustration of a flow diagram showing additional details of the disclosed method.