P-11

/N-63
149923

NASA CASE NO. LAR 14004-1

PRINT FIG. 1

NOTICE

The invention disclosed in this document resulted from research in aeronautical and space activities performed under programs of the National Aeronautics and Space Administration. The invention is owned by NASA and is, therefore, available for licensing in accordance with the NASA Patent Licensing Regulation (14 Code of Federal Regulations 1245.2).

To encourage commercial utilization of NASA-owned inventions, it is NASA policy to grant licenses to commercial concerns. Although NASA encourages nonexclusive licensing to promote competition and achieve the widest possible utilization, NASA will provide the necessary incentive to the licensee to achieve early practical application of the invention.

Address inquiries and all applications for license for this invention to **NASA Patent Counsel, Langley Research Center, Code 143, Hampton, Virginia 23681-0001.**

Serial No.: 07/647,097
01-29/91

LaRC

(NASA-Case-LAR-14004-1) NUMERICAL CONTROL FABRICATION TECHNIQUE FOR DYNAMIC COMPOSITE MODELS Patent Application (NASA) 11 p

N93-19024

Unclas

G3/63 0149923

NUMERICAL CONTROL FABRICATION TECHNIQUE
FOR DYNAMIC COMPOSITE MODELS

NASA Case No. LAR 14004-1

AWARDS ABSTRACT

The prior art of fabricating composite dynamic models and parts is a long and tedious process that involves three steps. First, a wooden pattern is made using a series of templates and hand-carving techniques. Next, a hand-laid fiberglass mold is created. This second step of creating the fiberglass mold involves three sub-steps: (a) applying to the wooden pattern a series of alternating layers of resin and fiberglass cloth; (b) breaking the wooden pattern apart; and (c) removing and discarding the wooden pattern leaving a hard fiberglass shell or mold. In the final step, the fiberglass mold is filled with another series of resin and fiberglass layers, and any specified hardware is attached. Aside from being tedious and time-consuming, the prior art suffers from another serious drawback. In general, dynamic models used in simulating how a vehicle or aircraft will respond in actual situations must necessarily meet strict tolerance specifications for the tests to yield realistic results. Because by using the prior art the model is entirely crafted by hand, it is often difficult to achieve accuracy within the desired tolerance specifications.

In the present method of fabricating an article such as a dynamic model or a part thereof, a computer-driven machining means, such as a numerically controlled machine, is used to cut a core material, such as a rigid foam, into a desired shape and to a size specification that is slightly smaller than the final size desired for the article. Alternating layers of a polymer resin such as polyester and a reinforcing fabric such as fiberglass cloth are then applied to the surface of the core material, causing a build-up of layers of polymer resin and reinforcing fabric to a point at which the item being fabricated is oversized from that desired. Finally, a computer-driven machining means is used to cut the article being fabricated to exact size and shape specifications, leaving a desired thickness of reinforcing material.

The present invention differs significantly from the prior art. Because the hand-carving of a wooden pattern is replaced by cutting a pattern with a computer-driven machining means, the present invention is far less time consuming and much more accurate in meeting tolerance specifications. Also, when two halves of an article are created and then bonded together to form a whole, greater symmetry can be achieved with the present invention because the same computer program is used to cut both halves. Furthermore, unlike the prior art, the pattern upon which the reinforcing fabric is laid is retained as part of the model and not discarded.

Inventor: John B. Kovtun
Address: 103 Warehouse Course
Yorktown, VA 23692
SS: [redacted]
Employer: NASA LaRC
Initial Evaluator: John Powell

Serial No.: 07/647,097
Filed: 01-29-91

07/647,097
1-29-91

NUMERICAL CONTROL FABRICATION TECHNIQUE FOR DYNAMIC COMPOSITE MODELS

Origin of the Invention

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefore.

Background of the Invention

1. Field of the Invention

This invention relates to a method for fabricating articles. In particular, the process involves manufacturing composite materials consisting essentially of a core material and resins and reinforcing fabric by using a computer-driven machining means and hand-laying techniques.

2. Description of the Prior Art

The prior art of fabricating composite dynamic models and parts is a long and tedious process that involves three steps. First, a wooden pattern is made using a series of templates and hand-carving techniques. Next, a hand-laid fiberglass mold is created. This second step of creating the fiberglass mold involves three sub-steps: (a) applying to the wooden pattern a series of alternating layers of resin and fiberglass cloth; (b) breaking the wooden pattern apart; and (c) removing and discarding the wooden pattern leaving a hard fiberglass shell or mold. In the final step, the fiberglass mold is filled with another series of resin and fiberglass layers, and any specified hardware is attached.

Aside from being tedious and time-consuming, the prior art suffers from another serious drawback. In general, dynamic models used in simulating how a vehicle or aircraft will respond in actual situations must necessarily meet strict tolerance specifications for the tests to yield realistic results. Because by using the prior art the model is entirely crafted by hand, it is often difficult to achieve accuracy within the desired tolerance specifications.

U.S. Patent 4,150,084 (Arenas) uses a process of superposing a model with a woven reinforcing fabric. Once the reinforcing fabric hardens, the model is removed, thereby creating a mold. Resin with or without fiberglass reinforcement is then cast into the mold.

U.S. Patent 4,687,691 (Kay) discloses a method of fabricating airplane composite components. The invention uses a foam core surrounded by resin impregnated fibers. The improvement in Kay is the joining of foam sheets by aligning a layer of honeycomb such that its cells are perpendicular to two layers of sheet foam, thereby improving shear strength.

The present invention differs from the prior art. Because the hand-carving of a wooden pattern is replaced by cutting a pattern with a computer-driven machining means, the present invention is far less time consuming and much more accurate in meeting tolerance specifications. Also, when two halves of an article are created and then bonded together to form a whole, greater symmetry can be achieved with the present invention because the same computer program is used to cut both halves. Furthermore, unlike the prior art, the pattern upon which the reinforcing fabric is laid is retained as part of the model and not discarded. Although the prior art anticipates the use of a foam core reinforced by fiberglass and resin, the present invention pertains to a combination of steps in a fabrication process, not the use of a foam core itself.

Summary of the Invention

An object of the present invention is to provide a method of manufacturing articles, dynamic models and dynamic model parts which involves using a computer-driven machining means, thereby being more accurate and less time consuming than previous methods.

A further object of the present invention is to provide a method of manufacturing articles, dynamic models and dynamic model parts which yields greater symmetry than previous methods.

A further object of the present invention is to provide a method of manufacturing articles, dynamic models and dynamic model parts which uses a core material that is retained as part of the model.

A further object of the present invention is to provide a method of manufacturing articles, dynamic models and dynamic model parts which yields a core material strengthened with a desired thickness of reinforcing fabric.

To meet the foregoing and additional objects, a method of manufacturing articles such as dynamic models and dynamic model parts has been developed. A computer-driven machining means, such as a numerically controlled machine, is used to cut a core material into a desired shape and to a size specification that is slightly smaller than the final size desired for the article. It has been found beneficial to use foam as a core material, especially rigid foam such as polyurethane. Alternating layers of polyester resin and a reinforcing fabric are then applied to the surface of the core material, causing a build-up of layers of polyester resin and reinforcing fabric to a point at which the item being fabricated is oversized from that desired. Polyester resin has been especially successful, although epoxy resin and silicon will also produce satisfactory results. Similarly, fiberglass cloth has been preferred as a reinforcing fabric, but other reinforcing fabrics made from linen, cotton, Kevlar® aromatic polyamide and graphite will also be satisfactory. Finally, a computer-driven machining means is used to cut the article being fabricated to exact size and shape specifications, leaving a desired thickness of reinforcing material.

Brief Description of the Drawings

The drawings illustrate the present method being used with a numerically controlled machine to fabricate a fuselage for a dynamic airplane model.

FIG. 1 illustrates a rough-cut blank of commercial polyurethane foam 10 bolted to a numerical control (NC) machine table 11;

FIG. 2 shows the rough-cut blank of commercial polyurethane foam 10 after having been cut to a finished undersized core 12;

FIG. 3 shows a layer of fiberglass and resin build-up 13 applied to a finished undersized core 12;

FIG. 4 shows a finished machined exterior surface 14 after the fiberglass and resin build-up 13 has been machined to exact size and shape specifications, leaving a fiberglass skin of specified thickness;

FIG. 5 shows that extra machining may be done to meet article design specifications, such as a slot for a wing spar 15;

FIG. 6 shows a jig 16 which is constructed to rotate the workpiece 180°, and to locate it precisely on the NC table 11 by drilling pin holes 17 into the jig 16 and aligning the pin holes 17 with the set pins 18 of the NC table 11;

FIG. 7 shows a finished core 19 after its has been excavated with the NC machine;

FIG. 8 shows that various slots and pockets can be machined for locating hardware, such as a pocket for a balance mount 20 and a hole for an alignment dowel 21; and

FIG. 9 shows a completed fuselage 22 after the process is reversed and repeated for the opposite half of a fuselage core, and two finished cores 17 are bonded together.

Detailed Description of the Invention

The present invention can be explained with reference to the drawings. The drawings illustrate the new method applied to the fabrication of a model airplane fuselage.

As illustrated in FIG. 1, fabrication of the fuselage begins with a rough-cut blank of commercial polyurethane foam 10 large enough to encompass half of the fuselage structure: right, left, top, or bottom. For constructing dynamic model aircraft, 4 lb. density polyurethane foam has been found especially preferred. The rough-cut blank of commercial polyurethane foam 10 is bolted to a numerical control (NC) table 11, and a computer-generated program is operated to rough-cut the blank to a desired shape for the exterior fuselage surface. The rough-cut blank of commercial polyurethane foam 10 is generally cut to be undersized by an amount equal to the thickness of a fiberglass skin of specified thickness as shown in FIG. 4 on the finished machined exterior surface 14. The finished undersized core 12 is shown in FIG. 2. In a particular application, the surface of the fuselage was cut to thirty-three thousandths of an inch below the size desired.

Next, as shown in FIG. 3, alternating layers of resin and reinforcing fabric, preferably fiberglass cloth, are laid onto the cut exterior surface of the finished undersized core 12 to create a fiberglass cloth and resin build-up 13. Polyester resin has been found to be preferred to other types of resins because it sets-up more quickly. Applying a dry layer of fiberglass cloth over the surface of the core material is preferred. Then, polyester resin is painted onto the surface of the fiberglass cloth with a paint brush and smoothed with a plastic squeegee. When the polyester resin becomes tacky, but before it sets, another layer of fiberglass cloth is laid over the polyester resin and all the wrinkles are smoothed out of the fiberglass cloth. A successful way to remove wrinkles has been to use a squeegee. This process is repeated until the desired number of layers of fiberglass cloth and polyester resin are applied. It has been found that, after cutting the surface of the core material thirty-three thousandths of an inch below the final size desired, four layers are preferred. Four layers of fiberglass cloth and polyester resin build the surface of the fuselage back up thirty-thousandths of an inch, or three-thousandths of an inch below the desired size of the finished fuselage surface. Then, about twenty-thousandths of an inch of resin is applied to the last layer of fiberglass cloth. Machining the resin layer only, not the layers of resin and fiberglass cloth, is preferred and results in a very hard finished surface. Once the final twenty-thousandths of an inch layer of polyester resin has hardened, seventeen-thousandths of an inch of the final layer of resin is cut off using the NC machine. This process leaves the finished machined exterior surface 14 of proper size and shape. Extra machining can also be done at this point to create slots for wing spars or stabilizers and pockets for hardware or any other needed items. FIG. 5 illustrates where the typical slot for a wing spar 15 could be machined.

After one side of the half of the fuselage is completed, a jig 16 is constructed to rotate the workpiece 180°. The construction of jigs is well known to those skilled in the art. Generally, it is beneficial to construct the jig 16 with a heavier density of foam than was used to construct the fuselage. It has been found that using a 15 lb. density polyurethane foam is preferred when constructing the fuselage from 4 lb. foam. One way to construct a jig 16 has been to cut the surface of a blank sheet of 15 lb. polyurethane foam to approximately fit the contour of the fuselage. Then, a layer of tape is placed over the model fuselage surface. The tape is sanded and washed with solvent, such as acetone or alcohol, and then body putty is used to pot the jig to the surface of the fuselage. Pin holes 17 are then drilled into the jig at positions which match the location of set pins 18 of the NC table 11. The workpiece is then rotated 180°, and the drilled pin holes 17 in the jig 16 are used to align the workpiece precisely in the proper location.

Another computer program is executed to excavate the core of the workpiece to produce a shell. The thickness of the shell is chosen in advance for compatibility with the fiberglass skin to furnish the required strength, weight, and internal volume. FIG. 7 shows the excavated core 19. During operations from this side, slots and pockets can also be machined for bulkheads, firewalls, sting or balance attachments mounts, hard points for locating pins, or other hardware. FIG. 8 shows the possible locations for a pocket for a balance mount 20 and a hole for an alignment dowel 21.

Finally, the process is inverted and repeated to fabricate the other half of the fuselage. All hardware, stiffeners, and internal structures are fitted and installed in one half of the excavated core 19, and then the two halves are located and bonded together. The completed fuselage 22 is shown in FIG. 9. The fuselage is then sanded and painted and ready for installation of wings, stabilizers, canards, landing gear, or other attachments.

What is claimed ad new and desired to be secured for Letters Patent is:

NUMERICAL CONTROL FABRICATION TECHNIQUE FOR COMPOSITE DYNAMIC MODELS

Abstract of the Disclosure

In a method of fabricating an article such as a dynamic model or a part thereof, a computer-driven machining means, such as a numerically controlled machine, is used to cut a core material such as a rigid foam into a desired shape and to a size specification that is slightly smaller than the final size desired to the article. Alternating layers of a polymer resin such as polyester and a reinforcing fabric such as fiberglass cloth are then applied to the surface of the core material, causing a build-up of layers of polymer resin and reinforcing fabric to a point at which the item being fabricated is oversized from that desired. Finally, a computer-driven machining means is used to cut the article being fabricated to exact size and shape specifications, leaving a desired thickness of reinforcing material.

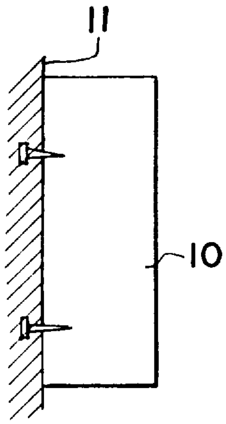

FIG. 1

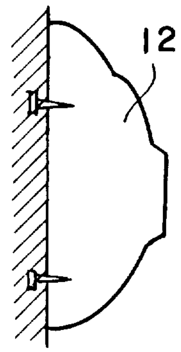

FIG. 2

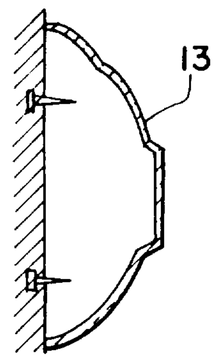

FIG. 3

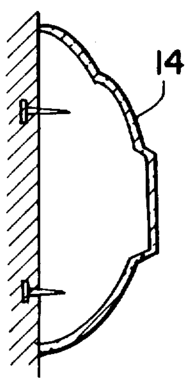

FIG. 4

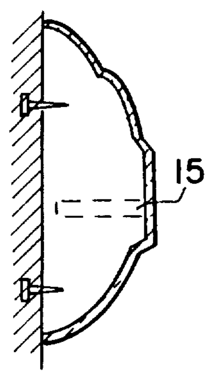

FIG. 5

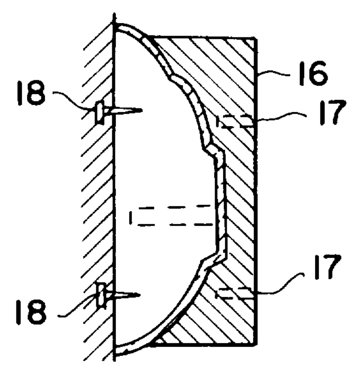

FIG. 6

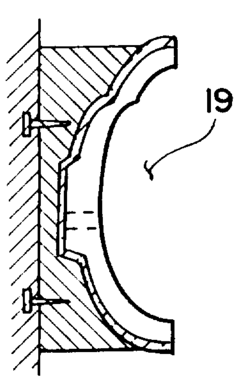

FIG. 7

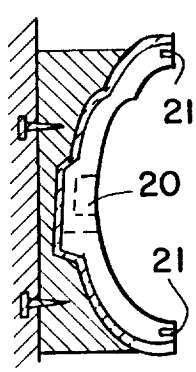

FIG. 8

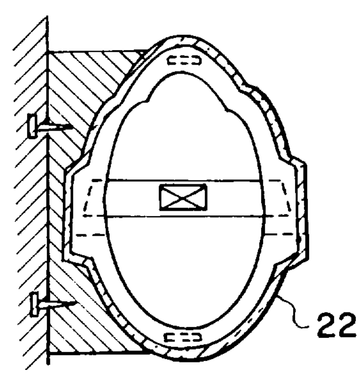

FIG. 9