PLASTIC BOAT CONSTRUCTION

Allan B. Hegg, Warsaw, Ind., assignor to Larson Industries, Inc., St. Paul, Minn., a corporation of Minnesota

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ABSTRACT OF THE DISCLOSURE

Self-buoyant boats constructed of reinforced plastic. An outboard runabout which, when loaded, will float in an upright position when filled with water has its forward deck and hull constructed as foam-core sandwich panels or laminates, and is provided with a pair of foam-core flotation tanks and an open center-well.

CROSS-REFERENCE TO RELATED APPLICATION

Ser. No. 730,418, filed May 20, 1968, by Allan B. Hegg, which discloses improvements in the preparation of foam-core sandwich panels or laminates, and the use of such sandwich panels to construct boats.

BACKGROUND OF THE INVENTION

Boats, particularly pleasure boats, are being made in increasing numbers from reinforced plastics such as glass reinforced polyester resins. Among the numerous advantages of such boats are their ease of maintenance and repair.

Many boats constructed of reinforced plastic are self-buoyant, but do not have sufficient excess buoyancy to support the added weight of equipment usually carried by such boats (e.g. outboard motors and gasoline tanks). Consequently, it is common practice to equip boats constructed of reinforced plastic with flotation tanks (e.g. placed under seats) to provide added buoyancy. However, such boats characteristically overturn (i.e. float bottom side up) when filled with water. Even if turned upright (e.g. as by a swimmer) such boats exhibit a marked tendency to "roll over." This is disadvantageous from the standpoint of human safety and because it causes loss of equipment (e.g. fishing tackle) to be lost from the boat.

SUMMARY OF THE INVENTION

Reinforced plastic boats can be constructed in such a way that they will be self-buoyant and remain upright when filled with water (i.e. swamped), even when heavily loaded (e.g. outboard motor, gasoline, etc.).

Boats constructed according to this invention are characterized by having their hull and forward deck constructed as sandwich panels or laminates comprising a core of foamed plastic (e.g. polyurethane foam) sandwiched between or surrounded by a plastic skin or shell (e.g. a glass reinforced polyester shell).

Another feature of boats constructed according to this invention is the use of two opposing longitudinal flotation tanks positioned in the bilge, each extending laterally from its respective side wall to a point short of the mid section or center of the hull. An open center well is defined by and between the two longitudinally extending flotation tanks in the bottom of the hull. The center well serves as a wet bilge.

Another feature of this invention is the method of constructing the longitudinal flotation tanks in the bilge.

Among the several advantages of the present invention are sufficient buoyancy in the boats of this construction to support or float the boat and its usual added gear (e.g. outboard motor and gasoline tank) in an upright position when filled with water. Other advantages include improved quietness of operation (i.e. a noticeable reduction of the typical sounds common to reinforced plastic boats of conventional design) and increased strength.

THE DRAWINGS

FIG. 1 is a perspective view of an outboard runabout having a forward deck and a dihedral bottom of clincher design.

FIG. 2 is a fragmentary sectional view illustrating the foamed-core laminate construction used for the hull and forward deck.

FIG. 3 is a plan view of the boat of FIG. 1 with the deck and motor well assembly removed to show the location of the longitudinally extending flotation tanks and the bilge tunnel.

FIG. 4 is a cross-sectional view of the boat shown in FIG. 1 as taken along lines 4—4 in the direction of the arrows.

FIG. 5 is a cross-sectional view illustrating a modification of the flotation tank construction shown in FIG. 4.

DETAILED DESCRIPTION

The present invention is directed to boats of improved construction which are strong, quiet and self-buoyant. Boats made according to the preferred form of the present invention will float stably in an upright position when filled with water, even when heavily loaded (e.g. outboard motor and full gasoline tank).

The present invention is hereinafter described with reference to the drawings.

(a) The boat construction

FIG. 1 is a perspective view of an outboard runabout constructed of reinforced plastic. The boat comprises a hull (generally designated by the numeral 1) and a forward deck 2 carried by hull 1. For ease of construction and added strength, deck 2 is integrally formed with side rails 3 and 4 and motor well 5. Hull 1 is comprised of side walls 6 and 7, transom 8 and a dihedral bottom 9. As shown in FIG. 1, bottom 9 is of clincher design. The mid section of hull 1 is the vertical plane which passes through keel 10 (i.e. the plane of symmetry).

According to this invention, hull 1 and forward deck 2 are constructed as foam-core sandwich panels or laminates comprising a core of foamed plastic sandwiched between or surrounded by plastic skins or shells.

Sandwich panels of this type can be prepared by a filling process which comprises, for example, forming two nestable hull-shaped shells or skins of reinforced plastic on two separate molds, placing the smaller of the two reinforced polyester shells inside the larger shell, holding the two shells in a spaced relationship (e.g. separated by ½") and then blowing a foam producing agent between the two shells. On hardening, the foam producing agent will form a rigid or flexible cellular plastic core between the two shells. The cellular core can have open or closed cells. Any exposed edges of the core can be sealed or enclosed by using additional plastic of the type used to form the hard shells (e.g. reinforced polyester).

However, the use of two separate molds for forming the inner and outer skins or shells of sandwich panels, particularly in the manufacture of boats, is generally uneconomical. Consequently, it is more common to prepare sandwich panels of this type by a process of superposition (i.e. the orderly fabrication of layers). According to this process, a reinforced plastic skin or shell is formed in a conventional female hull mold. Subsequently, one or more layers of plastic foam are formed in place on the inside of this outer skin or shell. Finally an inner reinforced plastic skin or shell is formed in place over the last applied layer of foam.

The sandwich panels which result from these various processes are illustrated in FIG. 2. The outer skin or shell can consist of a polyester gel coat 11 backed with one or
more layers of reinforced polyester 12 (e.g. polyester reinforced with glass fibers). The inner shell can consist of one or more layers of reinforced polyester 13. Sandwiched between and bonded to the outer and inner shells is a foamed plastic core 14 (e.g. rigid polyurethane foam).

The preparation of foamed-core sandwich panels and certain improvements in them are disclosed in our co-pending application Ser. No. 730,418, filed May 20, 1968 (M & G—155).

Regardless of the method of construction used to form the foamed sandwich hull, it has been found that substantial advantages are obtained (e.g. advantages in the fatigue life of the hull) if the inner and outer shells are firmly bonded to each other along or near the chine and also along the bottom of the hull between the chine and keel (e.g. bonded along a longitudinal line spaced 40—80% of the distance from the chine to the keel). Such firm bonds can be obtained by directly bonding the two shells together (e.g. as by the use of a polyester glue) or, less preferably, through the use of spacers or fasteners (e.g. plastic or metal rods attached to both shells). Since boat hulls are preferably formed by a process of superposition, it is convenient to form these points or lines of attachment between the inner and outer shells as a part of the process of forming the floatation tanks and wet bilge tunnel (hereinafter described).

Turning now to FIG. 3, another feature of the present invention is the use of two opposed longitudinal floatation tanks 15 and 16 which are positioned in the bilge. Each of the floatation tanks (e.g. floatation tank 16) extends laterally from its respective side wall to a point short of the mid section of the hull. Desirably, each floatation tank will extend more than half way (e.g. 60—80%) from its respective side wall to the mid section. Floatation tanks 15 and 16 together with the bottom of the hull, define an open center well 17 which serves as a wet bilge and provides stability to the boat when it is filled with water. Center well 17 can be partially covered (e.g. with a wooden catwalk) to provide a stable walking surface for the occupants of the boat and one which is at the same level as the tops of floatation tanks 15 and 16.

The construction of floatation tanks 15 and 16 and center well 17 is shown in more detail in FIG. 4. FIG. 4 is a cross-sectional view of the boat of FIG. 1 taken along the line 4—4 in the direction of the arrows.

Turning now to FIG. 4, the hull 1 comprises side walls 6 and 7 and a dihedral bottom 9 which is of clinker design. The two floatation tanks, generally designated by the numerals 15 and 16, are formed in place by the following procedure.

First, the outer shell of hull 1 is formed. This shell comprises side walls 6 and 7 and bottom 9. Typically, this outer shell is formed in a female hull mold by the sequential application of a polyester gel coat followed by one or more layers of glass reinforced polyester. Next, a cover 18 for each floatation tank (e.g. 16) is positioned within this outer shell. Cover 18 can be made of reinforced plastic, wood, etc. As shown in FIG. 4, the cover 18 for floatation tank 16 is in a substantially right rectangular shape (i.e. shaped having a horizontal portion and a vertical portion. If desired, cover 18 can be formed from several component pieces or can be partially or completely assembled or formed in the hull. The free horizontal rim of cover 18 should abut the outer shell of hull 1 at or near the conjunction of side wall 6 and bottom 9 (i.e. at chine 20). Desirably, the point of abutment will be at chine 20. The free vertical rim of cover 18 should abut the bottom 9 of hull 1 at a point short of the mid section of hull 1 and preferably beyond a point midway between side wall 6 and the mid section (i.e. beyond the midpoint between chine 20 and keel 10).

Cover 18 is then bonded to the outer shell of hull 1 along the lines of abutment between hull 1 and the horizontal and vertical rims of cover 18. This can be performed by applying a tape or ribbon of glass fabric saturated with polyester resin along the seams or lines of abutment. Such overlapping tapes are shown by the numerals 21 and 22 in FIG. 4.

The foregoing procedure is repeated for purposes of installing a cover for floatation tank 15. Like parts are indicated by like numerals.

Then a foam producing agent is blown under the covers (e.g. 18) of tanks 15 and 16 to thereby fill the tanks with plastic foam 19.

After the covers for floatation tanks 15 and 16 are firmly bonded in place to the outer shell of hull 1 and after the floatation tanks have been filled with foam 19, the covers 18 can be coated, if desired, with one or more layers of reinforced plastic (e.g. glass reinforced polyester). This is desirable if wooden covers have been used, but is generally unnecessary when reinforced plastic covers are used, except to cover or close the openings used for blowing foam producing agents into the floatation tanks.

Next, the side walls 6 and 7 are covered on the inside with a blanket of foamed plastic (23 and 24). Foamed plastic cores 23 and 24, usually formed of polyurethane, can be premolded and glued in place or, more preferably, formed in place by the spray application of one or more layers of a foam producing agent.

Desirably, the foamed plastic cores will be thicker above the water line of the boat than below. This increased thickness of the plastic core is shown in FIG. 4. Compare, for example, the thickness of the core 23 at the gunwale and at the chine.

Next, foamed panels 23 and 24 are covered or coated with an inner skin (25 and 26) of reinforced plastic (e.g. glass reinforced polyester).

If desired, the bottom of center well 17 can also be of foamed core construction, using techniques previously described.

The foamed core construction of deck 2 can be performed in the same manner as that of hull 1. As a matter of convenience, hull 1 and deck 2 will ordinarily be fabricated separately and joined together after the foamed core construction of deck 2 is completed.

Alternative procedures can include the use of preformed foamed cores for the floatation tanks (with or without the prebonding of such cores to their respective covers, e.g. 18). Also, the foamed cores for the floatation tanks can be formed in the hull and all or part of their respective covers applied or formed afterwards.

(b) Plastics for the shells or skins

Suitable plastics are known in the art. Although all plastics do not serve with equal effectiveness, their selection is within the skill of the art. Among the many plastics are ABS resins (i.e. acrylonitrile-butadiene-styrene resins) and unsaturated polyester resins. Unsaturated polyester resins are in widespread use in the manufacture of boats and are preferred because of their good qualities, low cost, and ease of application.

The commercially important polyester molding resins are the polycondensation products of dicarboxylic acids and dihydric alcohols. Occasionally, these polyester resins are chemically modified with minor amounts of mono- and polyfunctional materials (e.g. isoseryl acid and pentane-thiol). The polyesters commonly used in the manufacture of boats are unsaturated polyesters characterized by ethylenic unsaturation (i.e. the structure >C==C<). Ethylenic unsaturation can be and frequently is introduced into polyester resin molecules by the use of maleic or fumaric acid or maleic anhydride in the manufacture of the resin. Unsaturated polyester resins can be cross-linked and hardened through the double bond of the ethylenic unsaturation using compatible monomers which also contain ethylenic unsaturation (e.g. styrene) Polyester resins, when catalyzed (e.g. catalyzed with benzoyl peroxide) will cure or harden at room temperature.
Although a variety of reinforcing materials are known, in the art (e.g. paper, nylon, metal filaments, etc.), glass fibers are the most common. The selection of suitable reinforcing materials (e.g. chopped glass fibers, woven fabrics, etc.) is within the skill of the art.

Suitable foam producing agents are those which produce open and closed cell plastic foams such as those which produce polyurethane, polyester and polystyrene foams. Such agents are known in the art. Polyurethane foams are preferred as is known in the art, polyester foams are a particular species of polyurethane foams and are produced by the reaction between polyesters of relatively high acid or hydroxyl numbers and di- or polyisocyanate cross-linking agents such as hexamethylene-diisocyanate and toluenediisocyanate, aided by suitable blowing agents.

Because the cellular plastic foams used in this invention are preferably completely encapsulated or enclosed between nonporous skins or a skin (e.g. glass reinforced polyester skins) either open or closed cell foams can be used. Closed cell foams are preferred because of the added safety factor which they provide in circumstances under which the surrounding skin or shell is or may be punctured or ruptured.

The present invention is further illustrated by the following examples.

EXAMPLE I

A sixteen-foot outboard runabout of cinker design is constructed substantially as shown in FIGS. 1-4.

The outer shell of the hull is prepared in a female hull mold as follows. First, a 15 mil polyester gel coat is applied over the inner hull-defining surface of the mold. Next, a 45 mil layer of polyester resin reinforced with continuous, non-oriented glass fibers is applied over the gel coat. Next, a woven fiber glass mat, saturated with polyester resin, is applied over the previous layer of reinforced polyester.

Next, two substantially right angular shaped reinforced polyester glass covers (about 80 mils thick) for the flotation tanks are placed in this outer shell. Each is provided with several holes for foam injection. The covers are positioned in the hull as shown in FIGS. 3 and 4 so that their horizontal rims abut the outer shell of the hull at the hard chines 20 and their vertical rims abut the bottom 9 of the hull at points about 60-80% of the distance from the chines 20 to the keel 10. Each of the covers 18 is then fastened in place by applying a six inch wide strip of glass cloth saturated with polyester over the seams (i.e. cloth strips 21 and 22).

Next, a polyurethane foam producing mixture is injected into the center of each flotation tank 15 and 16 to thereby fill the tanks with closed cell, rigid polyurethane foam 19 having a density of about 3-3.5 lbs. per cu. ft. The holes used for foam injection are then sealed using polyester resin saturated glass patches.

Meanwhile, a deck and transom assembly 2-5 is prepared as shown in FIG. 1. The outer shell 27 of this assembly is prepared in a female mold by the sequential application of a 15 mil polyester gel coat, a 10 mil layer of polyester reinforced with glass cloth, and a 45 mil layer of polyester reinforced with chopped glass fibers. Next, the interior or underside of the front deck portion of the outer shell 27 of deck and transom assembly 2-5 is coated with two layers (each ½-¾ inch thick) of polyurethane foam by spray application. The underside of the rear deck (i.e. the motor well or splash well as it is sometimes called) is also coated with a single ½-¾ inch layer of polyurethane foam by spray application.

Finally, the polyurethane foam coatings on the front and rear decks are covered with a 45 mil layer 28 (see FIG. 4) of polyester resin reinforced with chopped glass fibers. Adhesion of this inner polyester skin is enhanced if the polyurethane foam is first coated with a thin primer coating of polyester resin within 1-60 seconds (e.g. 10-30 seconds) after the polyurethane foam producing agent has been applied to the decks and before the foam has hardened (i.e. while it is still foaming).

Deck assembly 2-5 is then bonded to hull 1 by the use of a glass-reinforced polyester adhesive.

Then, the interior of side walls 6 and 7 of hull 1 are sprayed with several layers of a foam producing agent to produce polyurethane foam blankets or cores 23 and 24, each extending upwardly from the flotation tanks to the gunwales as shown in FIG. 4. Then, foam blankets 23 and 24 are covered with inner shells 25 and 26 of glass reinforced polyester (about 45 mils thick).

The resulting boat is then completed in a conventional manner by, for example, the installation of a windshield, running lights, and steering wheel.

The amount of foam used in manufacturing this boat is sufficient to provide a total buoyancy in excess of that required to float the boat when loaded to its BIA (Boating Industries Association) capacity, that is, in this case, the amount of foam above the water line of the boat is greater than the amount of foam below the water line. This compensates for the buoyancy of the boat's bottom which may otherwise cause the boat to roll over or "bottom-up" when swamped.

When the boat just described is loaded to its BIA capacity with dead weight (sand), a 35 horsepower outboard motor and a full ten gallon gasoline tank, and the n intentionally swamped, it will float upright and continue to do so for in excess of 24 hours.

EXAMPLE II

Similar results will be obtained if the procedure of Example I is repeated with the following modifications:

(a) the polyurethane core and inner polyester shell are omitted from the stern deck 5;
(b) the deck assembly 2-5 is not bonded to hull 1 until the hull is completed (including the foam application to the side walls); and
(c) a different technique is used to install flotation tanks 15 and 16.

In this illustrative example, described with reference to FIG. 5, the flotation tanks 15' and 16' are formed in place by positioning two 1 x 3-inch hardwood rails 29 in the bottom of the hull 1', one above each of the lines of the bottom where the covers of the flotation tanks would normally abut bottom 9' of the hull 1'. The rails 29 are held above the bottom 9' of hull 1' and generally parallel thereto at a height approximately coplanar with the chines 20'. Then a ten-inch wide glass cloth 30, saturated with polyester resin, is draped over each rail 29 and bonded with the length thereof to both the rail 29 and bottom 9' of the hull 1' immediately below the rail 29, thereby forming the vertical portions of each of the two flotation tanks 15' and 16' (i.e. as longitudinal ribs).

Next, the entire space on the bottom of hull 1' outboard of each of these two longitudinal ribs is filled with polyurethane foam 19' up to a level coplanar with the chines 20'. Next, each of these polyurethane cores 19' is separately covered with ½-inch thick plywood 31 which is bonded to its respective side wall 6 (or 7) in the same manner as the covers 18 of Example I. The plywood panels 31 are bonded to their respective rails 29 with adhesive and screws 32 to thereby produce flotation tanks 15' and 16' similar to those of FIG. 4, but which differ in the materials and method of construction thereof.

Tests conducted using outboard runabouts constructed according to this invention (of a "deep V" design) have demonstrated the advantages of this invention in terms of safety, strength and quietness. In one test, such a boat was intentionally swamped in a lake by permitting water to fill
the boat through holes drilled in the bottom of the boat. The boat floated upright. A frogman then climbed aboard over the side of the boat, started the outboard motor, and drove away with water running out of the holes. During this test, the water in the wet bilge or bilge tunnel provided ballast which, with the aid of the added buoyancy of the foam above the water line, kept the boat in an upright position.

The results of this and other tests have shown that, in addition to providing the potentially life-saving safety feature of upright flotation when swamped, boats of this construction are stronger than comparable boats of conventional design and are quieter in operation (i.e. engine noises and vibrations from wave pounding are damped). It is believed that the increased strength of boats constructed according to a preferred form of this invention is due, in part at least, to the use of laminated side walls and flotation tanks which are generally triangular in cross section and which are joined at their apices (i.e. at chine).

What is claimed is:

1. Boats which float in an upright position when filled with water which comprise:
   (a) a hull having an outer shell of reinforced plastic which forms the side walls and bottom of said hull;
   (b) a forward deck disposed above said side walls and carried thereby;
   (c) two laterally spaced longitudinal flotation tanks positioned in the hull, each tank extending longitudinally along the bottom of the hull to thereby define a center well between them; and
   (d) said forward deck and side walls and flotation tanks being constructed as foamed-core laminates or sandwich panels having inner and outer shells and a core of foamed plastic sandwiched between said inner and outer shells, the volume of said foamed-core laminates or sandwich panels being larger above the waterline than below.

2. Boats of claim 1 wherein said foamed plastic is polyurethane foam.

3. Boats of claim 2 wherein said reinforced plastic is glass reinforced polyester.

4. Boats of claim 2 wherein said boats are runabouts and have a dihedral or V bottom of carvel or clinker design.

5. Boats of claim 3 wherein:
   (a) The outer shell of the hull is also the outer shell of the side walls and the flotation tanks;
   (b) The inner and outer shells of said deck, side walls and flotation tanks are all constructed of reinforced polyester resin; and
   (c) The inner shells of each of said flotation tanks are bonded directly to the outer shell of said hull at:
      (1) the conjunction of their respective side walls and the bottom; and (2) along the bottom of the hull at a point short of the mid section thereof.

6. Boats of claim 5 wherein:
   (a) said laminated side walls and said flotation tanks are generally triangular in cross-section and are joined together by their apices at the chine;
   (b) said foamed-core laminated side walls are generally triangular in shape, the base of said triangle being above the waterline;
   (c) said inner shell of said flotation tanks is substantially right angular in shape and is bonded along the bottom of the hull by a glass fabric tape saturated with polyester resin; and
   (d) said forward deck is bonded to said side walls by a glass reinforced polyester adhesive.

7. In the process of fabricating a reinforced plastic boat hull having flotation tanks positioned therein, the improvement which comprises:
   (a) positioning a substantially right angular shaped cover for a flotation tank longitudinally in the outer shell of said hull so that the free horizontal rim of the cover abuts said hull at the conjunction of a side wall and the bottom of said hull, and the free vertical rim of the cover abuts the bottom of said hull at a point short of the mid section of said hull;
   (b) bonding said cover to said hull along the lines of abuttment; and
   (c) filling the cavity formed between said cover and said hull with plastic foam.

8. Improved process of claim 7 wherein said cover is assembled in said hull and said plastic foam is formed in place before the cover is completely assembled.

9. Improved process of claim 8 wherein said cover is made partly of wood and partly of glass reinforced polyester.

10. Improved process of claim 7 wherein said cover is a unitary glass reinforced polyester resin cover and said plastic foam is formed in place after the cover is bonded to said hull.

11. Improved process of claim 10 wherein said plastic foam is rigid, closed-cell polyurethane foam and the side walls of said hull are thicker above the water line of said boat hull than below.

12. Improved process of claim 11 wherein said bonding is performed by taping said cover to said hull along the line of abuttment with a polyester resin saturated fiberglass mat.

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