BAG-MOLDING OF PLYWOOD

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BAG-MOLDING OF PLYWOOD

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Bag-molding of plywood and laminated veneer members probably had its origin in the vacuum-bag process that was introduced in the furniture industry several years ago (see fig. 1, A). While the vacuum-bag process depended upon atmospheric pressure and ordinarily only room temperature to set the glue between the plies, the newer techniques employ higher fluid pressures and varying degrees of heat.

Misnomers, such as "plastic plywood" and "plastic planes," have been applied to structures of molded plywood that are actually made from wood bonded with synthetic resin adhesive. By weight, these structures are probably about 80 percent wood and 20 percent resin. Except for variations in shape, the product is essentially the same as flat-press plywood.

Molded plywood is produced by several techniques often referred to specifically as the Duramold, Vidal, Aeromold, or vacuum-bag processes. Other terms sometimes used in describing the technique are "bag-molding," "autoclave-molding," or "tank-molding." Perhaps the most inclusive is the term "fluid-pressure molding." A number of published descriptions of bag-molding processes are listed at the end of this report.

The fundamental procedure is the same for all processes in common use. In principle the technique consists of attaching temporarily by staples, tape, clips, or some other means, superimposed layers of strips or sheets of glue-coated veneers to a mold of the desired shape, and molding these into a unit structure by the application of heat and fluid pressure through a flexible, impermeable bag or blanket. All the processes are relatively simple and provide a means by which plywood of simple or compound curvature, and of constant or varying thickness, in any arrangement of plies can be produced. Naturally, flat plywood can also be made by bag-molding, but due to the critical bag materials required in most operations, it is recommended that the technique be limited to the production of strategic molded parts that can be manufactured by no other practical means. In general, parts that fall in this category will have one or more of the following characteristics: Appreciable compound curvatures; variable thickness; single curvature bends approximating or exceeding 180° when pieces are too thick to be steam bent from flat plywood; parts too large to be made practicably by mating dies; quantity too small to justify mating dies.

The same principles of balanced construction that apply to flat plywood are applicable to molded plywood. For maximum resistance to warping all plywood should be symmetrical about the center plane of thickness. In this connection symmetry involves species, number of plies, thickness of plies, and direction of grain. In theory, a symmetrically constructed panel with alternate plies laid at 90°, with respect to direction of grain, would have maximum dimensional stability. In practice, however, a construction with alternate plies at 90° to each other is often impossible in pieces of pronounced compound curvature.

It is likewise impossible to make flat strips of veneer conform to appreciable compound curvature before the application of fluid pressure. Fluid pressure forces the veneer to conform to the surface of the mold; therefore, the greater the compound curvature at right angles to the grain of the strips, the narrower the strips must be to avoid wrinkles.

Equipment

The manufacture of bag-molded plywood of aircraft or boat quality requires the use of considerable equipment. Means of supplying fluid pressure and heat must be provided. Normally, an autoclave or cylindrical pressure tank 3- to 12-foot diameter and 10 to 60 feet in length, which will withstand an internal working pressure of 30 to 120 pounds per square inch, is used. In figure 1, C and E, the use of an autoclave in bag-molding is illustrated diagrammatically. Occasionally, the means of supplying heat and pressure is combined with the mold as illustrated in figure 1, B and D. A mold capable of withstanding the desired internal fluid pressure is then required and the bag is inflated by the pressure fluid.

All bag-molding of aircraft or boat quality plywood requires heat. This can often be supplied most economically by steam, either directly or indirectly by heating water or air, hence a boiler or an adequate supply of steam from an existing steam line is required. When air is used for a steam-air mixture, or to provide pressure on hot water, or as a combined heating-pressure medium, a compressor and receiver are required. The size and capacity of the compressor and the steam generator depend entirely upon the size and number of autoclaves or units being operated. Obviously, to charge a pressure tank of perhaps 1,000 cubic feet capacity to working pressure and temperature in about 10 minutes requires a large-sized boiler and compressor.

A vacuum pump may be used either to induce air pressure or to check the bag over an assembly for leaks. Vacuum alone produces insufficient pressure for most bag-molding operations and therefore is used only for single curvature veneering operations in furniture work and is not recommended for aircraft plywood.

Any operation involving the use of veneer presupposes the use of some of the ordinary veneer trimming tools, such as a saw, clipper, shaper or router, as well as a glue spreader, and veneer conditioning racks.

In some bag-molding operations careful control of the moisture content of the veneer throughout the process is desirable. Adequate air conditioning equipment is then an additional requirement.

Molds

The forming of any piece of bag-molded plywood requires a mold of some type. Molds, sometimes called forms, dies, or mandrels, are broadly classified as male or female. Male molds as illustrated in fig. 1, A, B, and C are the desired shape on convex surfaces, while female molds (fig. 1, D and E) have the proper shape on concave surfaces.

Common mold materials are wood (solid or plywood), metal (steel, cast iron, or low-temperature alloys), plastic materials, and cements. The choice of mold materials will depend largely on the shape of the item to be molded, the quantity desired, availability, advantages and disadvantages of considered materials.

Wood molds are normally of the male type and have the obvious advantage of presenting a tacking surface often necessary in temporarily attaching the strips of veneer. Male wood molds may be grooved to allow the insertion of stiffeners to be glued to the molded plywood in a single operation. Wood molds are prone to distort somewhat after repeated heating and cooling, particularly if they are allowed to become wet. A mold may become wet as a result of leaks in the bag. The temperature penetration in wood molds is relatively slow as the mold is usually several inches thick, and the molded plywood must be heated essentially from the bag side.

Metal molds, usually of greater cost than those of wood, may be less expensive to use because of their long life and stability. In common practice, metal molds are female in type. The smoother surface of the piece being molded is on the convex side of the piece.

Some attempts have been made to use concrete, cements, and casting resins in mold construction, but to date these materials have proved practicable in relatively few uses.

Bags or Blankets

The purpose of the bag is to provide a flexible impervious barrier between the fluid under pressure and the mold. The piece being molded is pressed between this flexible bag and the rigid surface of the mold and the full fluid pressure is applied at right angles to the surface of the bag regardless of the shape. The pressure at certain glue joints may be slightly less than the full fluid pressure by the amount necessary to shape the veneer.

Bags are classified as full bags or half bags (blankets). A full bag is a complete envelope of impervious flexible material (fig. 1 A and C) clamped shut at one end or side and having a connection, usually called a bleeder, to allow the entrapped air to escape to the atmosphere. It may be completely closed, similar in principle to a basketball bladder (fig. 1, B and D), having only a tube connection for inflation. A half bag, or blanket, is a sheet which normally fits the mold without wrinkling and is sealed by some temporary means to the edges of the mold (fig. 1, E). The bleeder may be attached to the mold or to the bag. Full bags are normally used over male molds and half bags are used on female metal molds.

Most bag-molding operations at present require bags made of specially compounded natural or synthetic rubber.[1] The useful life of a bag depends largely on the heating medium used, the temperature of the cycle, the size of the bag, and the care used in handling. It may be as short as 10 hours or as long as 200 hours of operation.

Because of the present critical supply problem with all rubber products, attempts are being made to find suitable substitute bag materials. Some of these show promise and preliminary tests have shown that certain low-cost materials may be used for one operation.

Glues

It is possible to use a variety of glues for bag-molding; however, typical bag-molded parts require long assembly periods, and have definite use requirements that normally limit the choice of glues to the hot-setting resin types. Glues most generally preferred are those that are dry at the time the veneer is assembled on the mold and may be pressed at any time within 7 days after application.

The molding of curved parts often requires that the flat strips of veneer slip slightly during molding. Some glues aid this slipping by acting as a lubricant while passing through the plastic stage when heated. This peculiar characteristic and the somewhat critical relation between temperature, time, and pressure in the curing of the glue makes close cooperation between operator and glue supplier advisable. Specially compounded glues are available which have been developed for bag-molding.[2] These glues have been formulated to produce good bonds at the normal moisture contents and temperatures used in hot-pressing plywood at fluid pressures of 30 to 100 pounds per square inch commonly used in bag-molding.

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[1] See partial list of bag material manufacturers in appendix.

[2] See appendix for partial list of suppliers of glues for bag-molding.

APPENDIX

Partial List of Manufacturers of Rubber Bag Materials or Bags

1. E. I. duPont deNemours & Co., Inc., Fabrikoid Division, Fairfield, Conn.
2. Firestone Rubber & Latex Products Co., Fall River, Mass.
3. Goodyear Tire & Rubber Co., Akron, Ohio.
4. B. F. Goodrich Co., 450 S. Main St., Akron, Ohio.
5. Tyer Rubber Co., 100 Railroad Ave., Andover, Mass.
6. Voit Rubber Co., Los Angeles, Calif.

Partial List of Suppliers of Bag-Molding Glues

American Cyanamid Co.
Plastics Div.
30 Rockefeller Plaza
New York City

Bakelite Corp.
230 Grove St.
Bloomfield, N. J.

Carbide & Carbon Chemicals Corp.
30 E. 42nd St.
New York City

Casein Co. of America
Bainbridge, N. Y.

Catalin Corp.
1 Park Ave.
New York City

E. I. duPont deNemours & Co.
Plastics Dept.
Arlington, N. J.

Durez Plastics & Chemicals, Inc.
1181 Walck Road
North Tonawanda, N. Y.

Lauxite Corp.
Lockport, N. Y.

Monsanto Chemical Co.
Plastics Div.
Springfield, Mass.

Perkins Glue Co.
Lansdale, Pa.

Plaskon Co., Inc.
2112-24 Sylvan Ave.
Toledo, Ohio

Resinous Products & Chemical Co.
222 W. Washington Sq.
Philadelphia, Pa.

Shawinigan Products Corp.
350 Fifth Ave.
New York City

Partial List of Articles on Molded Plywood

1. ANONYMOUS.
   1940. MOLDED AIRPLANES FOR DEFENSE. Mod. Plastics 17(11):25-31, 78,80,82, illus.

2. ________
   1941. FLETCHER BASIC TRAINER: AN ALL-PLYWOOD SKIN-STRESSED AIRPLANE. Aero Digest 38(2):165-166, illus.

3. ________
   1941. NEW PLASTIC PLANE: SUMMIT AERONAUTICAL JOB PRODUCED UNDER VIDAL PROCESS PATENTS. Business Week (593):36-37, illus.

4. ________
   1941. THE MORROW VICTORY TRAINER. Aero Digest 39(6):231,235, illus.

5. ________
   1941. TWIN MOTORED PLASTIC PLYWOOD PLANE. Mod. Plastics 19(2): 52-53, 110, 112.

6. ________
   1942. MOLDING PLASTIC-PLYWOOD. Mod. Plastics 19(11):46-49, 112,114,116, illus.

7. ________
   1942. MOULDED AIRCRAFT UNITS: USE OF RESIN-BONDED PLYWOOD AS A STRUCTURAL MATERIAL: A SURVEY OF PROGRESS. Aircraft Prod. 4(4):312-315, illus.

8. ________
   1942. VICTORY TRAINER. Mod. Plastics 19(5):42-43, illus.

9. BARNES, JOHN S.
   1943. MAKING PLYWOOD WITH MULTIDIRECTIONAL PRESSURE. Mech. Engin. 65(1):17-20, illus.

10. CHRISTIAN, PAUL
    1942. AIRPLANES AND BATHTUBS, COOKED TO ORDER. Sat. Evening Post 215(3):12-13,36,39, illus.

11. FAIRCHILD, SHERMAN M.
    1943. DETAILS OF DURAMOLD FABRICATION. Aero Digest 42(2):232, 235, illus.

12. HAWTHORNE, RANDOLPH
    1941. MOLDING THE LANGLEY AIRPLANE: A NEW PLASTIC BONDED PLYWOOD PLANE. Aviation 40(11):75-76, 154,156, illus.

Partial List of Articles on Molded Plywood (continued)

13. MARHOEFER, L. J.
1942. DESIGN CONSIDERATIONS FOR PLYWOOD STRUCTURES. Aviation 41(11):114-117, 340; (12):146-149, 314, illus.

14. MILLER, EUGENE
1942. THE VIDAL PROCESS FOR MOLDED STRUCTURES. Aviation 41(10): 124-127, 299, illus.

15. MOON, HAROLD P.
1941. DEVELOPMENT OF A PLASTIC MOLDED AIRPLANE. Aviation 40(1): 44-45, 140,144, illus.

16. PERRY, THOMAS D.
1941. AIRCRAFT PLYWOOD AND ADHESIVES. Mod. Plastics 18(8): 53-58, 82,84,86, illus.

17. ________
1943. FLEXIBLE PRESSURE IN VENEER AND PLYWOOD WORK. Presented at Spring Meeting, Wood Industries Division, Am. Soc. Mech. Engrs., Apr. 26-28, 1943.

Partial List of Patents on Molded Plywood Technic

1. ALLWARD, GEORGE A.
1942. AIRCRAFT WING STRUCTURE. (U. S. Patent No. 2,273,919).

2. CLARK, V. E.
1941. AIRCRAFT WING STRUCTURE. (U. S. Patent No. 2,258,134).

3. TEAGUE, MONROE M.
1937. FLUID PRESSURE VENEER PRESS. (U. S. Patent No. 2,073,290).

4. VERHEY, WILLIAM
1940. METHOD OF MAKING PLYWOOD SHELLS. (U. S. Patent No.2,223,587).

5. VIDAL, EUGENE L. and MARHOEFER, L. J.
1942. METHOD OF FORMING VENEER STRUCTURES. (U. S. Patent No. 2,276,004).

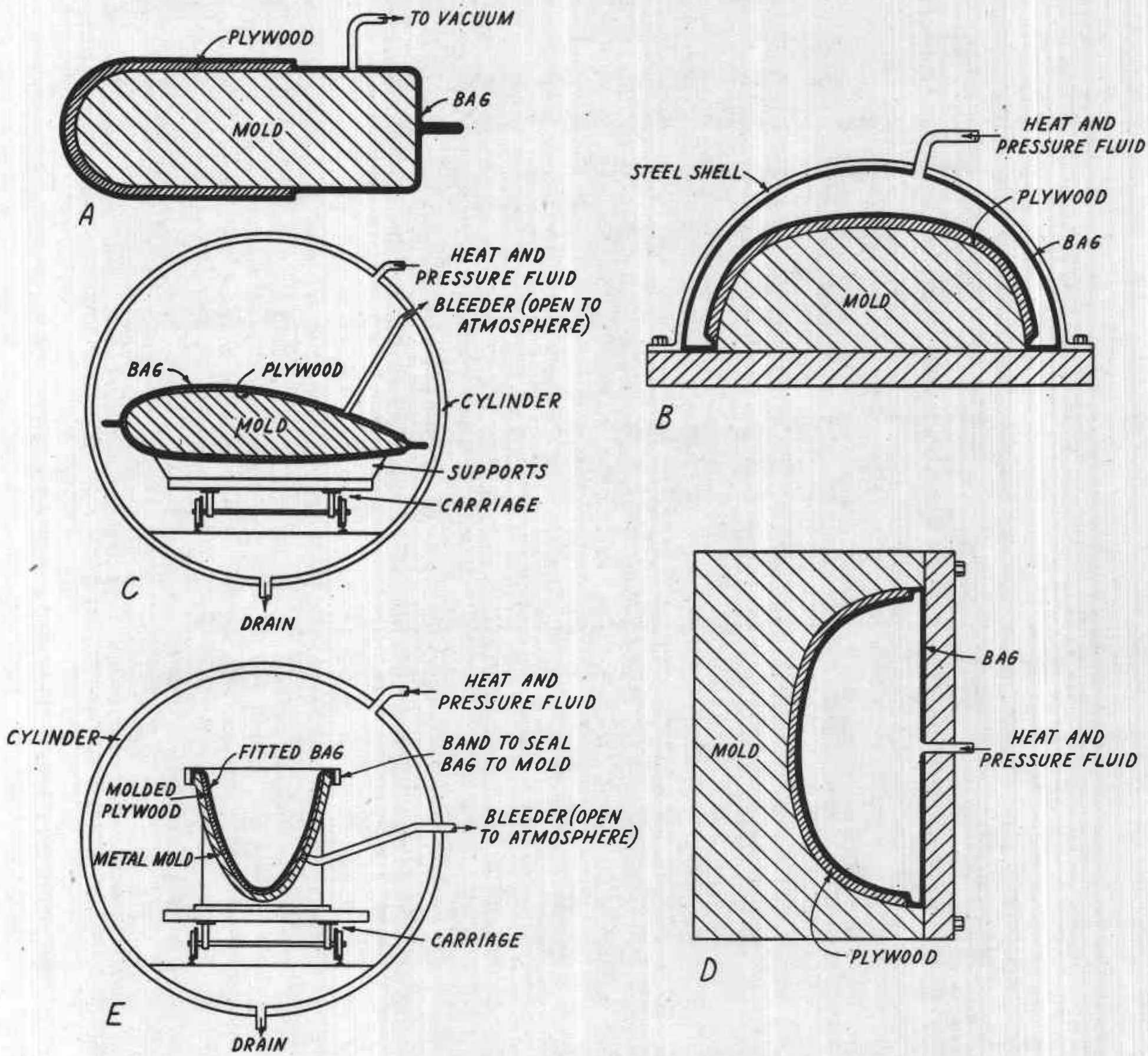

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Figure 1.--Five methods of forming bag-molded plywood.