ABSTRACT

A fan assembly including a fan hub engaged with a driving means for rotation, a streamlined hub cover and a plurality of fan blades attached to the fan hub. The fan blades have an exterior fiberglass skin, filled with high-density polyurethane foam, and a reinforcing steel spar positioned within the exterior skin. The spar is fabricated in a tapered "H" cross section to provide maximum strength without impairing the efficiency of an optimum airfoil.

8 Claims, 4 Drawing Figures
This invention relates to fans, and more particularly to axial flow fans or cooling towers. Although disclosed for use on water-cooling towers, the instant fan blades and assemblies are readily applied to dry-surface heat exchangers and other similar devices, depending upon the air flow movement for cooling.

A conventional cooling tower installation, of the type applicable to the present invention, is illustrated in U.S. Pat. No. 3,345,048, assigned to the same assignee as the instant invention. Airflow, induced by a cooling tower fan, enters the tower through a set of louvers, and is drawn through the tower to cool falling and splashing water droplets and water films (on tower filling) by intimate contact with the air. Cooling is brought about by heat and mass transfer: by evaporation and sensible heat transfer from the water droplets and films.

More specifically, the invention pertains to an improved cooling tower fan blade structure. The conventional cooling tower fan blades have heretofore been constructed of cast or extruded aluminum, fabricated stainless steel, and cast or hollow molded plastic. Metals are subject to corrosion, stress cracking, pitting, and erosion. Several of these problems are also found in plastics. Metallic fan blades are subject to fatigue and skin cracking from vibration. Optimum blade helix form and blade widths cannot be used because of metal casting or fabrication limitations. The fan blade of the instant invention solves these and other problems that have plagued the industry.

The general purpose of this invention is to provide a fan blade having unique optimum design features and operating efficiency, and possessing the advantages of similarly employed prior art devices and none of the above-described disadvantages.

With these and other considerations in view, it is an important object of this invention to provide a cooling tower fan assembly which provides for long-term endurance under severe fatigue-loading conditions, is easily assembled, and needs little maintenance.

Another object is to provide a cooling tower fan blade which will resist corrosion, stress cracking, pitting and erosion.

A further object is to provide a cooling tower fan blade in which stresses are kept low enough to be within the endurance limits of the materials for the prevailing loading conditions; and the blade frequencies are well under the operating frequencies apt to be encountered in service.

To attain these and other objectives, the novel fan assembly of the present invention provides a fan hub engaged with a driving means for rotation, a streamlined hub cover and a plurality of fan blades attached to the fan hub. The fan blades have an exterior fiberglass reinforced polyester or epoxy resin skin, filled with a high density polyurethane foam, and a reinforcing steel spar positioned within the exterior skin. The spar is fabricated in a tapered "H" cross section. The fiberglass skin offers exceptional corrosion and abrasion resistance under severe cooling tower environments. Fiberglass fabrication techniques further allow the exacting design, complicated by blade helix and chord width variation, to be duplicated accurately and economically. The high density polyurethane foam reinforces the airfoil profile over the entire blade length, effectively transfers applied blade loads to the spar, and enhances the torsional stability and impact strength of the blade.

FIG. 1 is a fragmentary top plan view, partially broken away, of the fan assembly in accordance with the present invention;

FIG. 2 is an enlarged sectional elevational view of the fan blade to hub connection in accordance with the present invention;

FIG. 3 is an enlarged top plan view, partially broken away, of the fan blade in cross section with the instant invention; and

FIG. 4 is a sectional view taken along line 4-4 of FIG. 3 showing the interior construction of the fan blade.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the improved fan assembly 10, comprises a fan hub 30 secured to a driven shaft 35, fan blade support arms 40 and fan blades 50 rigidly secured to the blade supports 40. Shaft 35 is the conventional output shaft of an electric motor, speed reducer, gear motor or similar power source, not shown.

The shape of a fan blade is determined by the desired air-moving capability. The blade theoretically should increase in width proceeding from the outer tip towards the hub. The leading and trailing edges would resemble two hyperbolic envelopes approaching infinity at the fan center of rotation. The blade angle generally increases from relatively flat at the tip to a greater angle at the fan center and an average angle in between. An airfoil (or family of airfoils) is utilized thru the blade length to obtain the desired lift and drag characteristics for given performance, and yet provide geometrical blade sections having sufficient strength to carry imposed loadings within suitable stress levels. The instant invention enables use of optimum airfoil sections thru the blade length, relatively unrestricted by the usual manufacturing limitations of casting or forming.

This invention deals primarily with the structural fabrication of the fan blades 50. As can be seen in FIGS. 3 and 4, fan blade 50 consists of an exterior skin 52, a filler means 54 and a reinforcing spar 56. Exterior skin 52, having upper and lower skin portions 57 and 58 respectively, is a fiberglass airfoil of synthetic resin laminate (i.e., polyester or epoxy resin) consisting of an exterior gel-coat (highly filled and pigmented polyester resin) and a synthetic resin/glass mat. fiberglass offers exceptional corrosion and abrasion resistance under severe cooling tower environments. fiberglass fabrication techniques further allow the exacting design to be duplicated accurately. The open area or cavity within exterior skin 52 is filled with a high density (5-15 pounds/cu. ft.) rigid polyurethane foam. The foam increases the blade stiffness and reinforces the airfoil profile over the entire blade length.

The blades are reinforced with a high-strength alloy steel spar 56. Spar 56 has an "H" shape cross section and tapers as it extends towards the tip of the blade. As seen in FIGS. 3 and 4, the adjacent legs slant towards each other and taper in width and depth progressing outward from the hub to provide maximum spar section within the exterior skin. All combined loads are carried by the spar over the entire blade length. The spar 56 may be both mechanically interlocked and chemically bonded to the foam filler 54 to provide a common action between the steel reinforcement and the skin. The "H" cross section spar provides maximum strength and stiffness for bending moments from air and blade weight loadings, and centrifugal forces and superior resistance to torsional loadings. The "H" section enables use of thin efficient airfoils not encumbered by requirements of a thick blade just to cover the spar. Generally, the thicker the blade the greater the aerodynamic drag—and ultimately the greater the horsepower to operate the fan. Thus use of this spar results in manufacturing and operating economies.

FIG. 5 is a fragmentary top plan view, partially broken away, of the fan assembly in accordance with the present invention;

FIG. 2 is an enlarged sectional elevational view of the fan blade to hub connection in accordance with the present invention;

FIG. 3 is an enlarged top plan view, partially broken away, of the fan blade in cross section with the instant invention; and

FIG. 4 is a sectional view taken along line 4-4 of FIG. 3 showing the interior construction of the fan blade.

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Welded to the inner edge of spar 56 is a flange 44 for attachment to the fan hub. Support arm 40 extends outwardly from fan hub 30 and has a flange 42, at its outer end, for field attachment to flange 44. As seen in FIG. 2, flanges 42 and 44 are bolted together in a conventional manner to insure a rigid attachment of blade 50 to hub 30. Conventional tangentially
slotted bolt holes, not illustrated, may be provided in flange 44 to allow easy assembly and fan pitch adjustment.

A streamlined fiberglass reinforced polyester or epoxy resin hub cover 20 may be fastened to the hub through angle brackets 60 at each hub arm 40 in a conventional manner as shown in FIG. 2. Hub cover 20 provides an effective seal against back flow of air at the fan center, to improve fan performance. Cover 20 also provides a smooth fairing to seal air losses at the inner or widest portion of the fan blades. fiberglass provides a great flexibility in fabricated forms, and can be produced in aerodynamically clean shapes and can be readily balanced.

It will be understood from the foregoing description that this invention provides an efficient solution to long standing problems connected with the operation of a conventional cooling tower. By means of this novel design and construction, blades may be fabricated for large diameter fans, i.e., 10 to 36 feet in diameter, without excess structural support or power requirements. The fan blades of the instant invention resist corrosion, stress cracking, pitting and erosion while providing long term endurance under severe fatigue loading conditions. In short, the novel reinforced fiberglass blades are corrosion resistant and may be driven with low operating horsepower and require minimum field service and replacement.

Although an embodiment constructed in accordance with the present invention has been described with the requisite particularity, the disclosure is, of course, only exemplary. Consequently, numerous changes in details of construction, in size, configuration, and arrangement of components and materials and in modes of application will be apparent to those familiar with the art and may be resorted to without departing from the scope of the invention as set forth in the following claims.

What is claimed is:
1. A fan blade, comprising:
   a. a fiberglass exterior skin, including upper and lower skin portions, defining a cavity therebetween;
   b. a spar, having a longitudinally extending "H" section, located within said cavity and spaced from said exterior skin, extending for substantially the full span of said exterior skin to carry substantially the full load imposed on the blade; and
   c. filler means, substantially filling said cavity, effective to transfer applied blade loads to said spar.
2. A fan blade as defined in claim 1, wherein said filler means is a polyurethane foam.
3. A fan blade as defined in claim 1, wherein said upper and lower skin portions comprise polyester resin reinforced with fiberglass mat.
4. A fan blade as defined in claim 1, wherein said upper and lower skin portions comprise epoxy resin reinforced with fiberglass mat.
5. A fan blade as defined in claim 1, wherein said spar is fabricated in a longitudinally tapered "H" section.
6. A fan blade, comprising:
   a. an exterior skin, of generally airfoil shape, including an upper and lower skin portion defining a cavity therebetween, said exterior skin being synthetic resin reinforced with fiberglass mat;
   b. a tapered longitudinally extending spar, having an "H" cross section, located within said cavity and spaced from said exterior skin, extending for substantially the full span of said cavity, to carry substantially the full load imposed on the blade;
   c. filler means of polyurethane foam substantially filling said cavity effective to transfer applied blade loads to said spar; and
   d. connecting means attached to one end of said spar for attachment to a fan hub.
7. A fan blade as defined in claim 1, wherein the adjacent legs of said "H" section slant towards each other and taper in width and depth progressing outward from said hub.
8. A fan assembly for a cooling tower, comprising:
   a. a fan hub engaged with and rotated by a driving means;
   b. streamlined fiberglass hub cover means positioned so as to shroud the back flow area at the fan center; and
   c. a plurality of fan blades attached to said fan hub;
   d. said fan blades including a hollow exterior fiberglass skin of generally airfoil shape; a spar, having a longitudinally extending "H" section, located within said exterior skin and spaced therefrom extending for substantially the full span of said exterior skin, to carry substantially the full load imposed on said blades into said fan hub; and filler means, substantially filling said open area, effective to transfer applied blade loads to said spar.

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