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(54) IMPROVEMENTS IN OR RELATING TO CONTROLLABLE PITCH AXIAL FLOW FANS

(71) We, WOODS OF COLCHESTER LIMITED, of Tufnell Way, Colchester, Essex, CO4 5AR, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to controllable pitch axial flow fans, that is to say fans of the kind comprising a rotatable impeller incorporating a hub carrying a plurality of blades extending generally radially from the hub and arranged to drive the air in an axial direction when the fan is operating, and in which the blades can themselves be rotated in use of the fan to a limited extent relative to the hub, for adjusting their pitch angle; the invention relates more particularly to the impellers of such fans.

The blades of fans of this kind are usually restrained from radially outward motion by rolling bearings and it is an object of this invention to reduce the adverse effects of centrifugal force on such bearings.

According to the present invention an impeller for a controllable pitch axial flow fan has a blade rolling bearing provided with a bearing cage arranged so that during rotation of the impeller the centrifugal force acting on the bearing cage is taken on an outer bearing race of the blade bearing.

In carrying out the invention the bearing cage may be formed from a relatively low mass material such as an acetal resin or nylon impregnated with graphite. Preferably the blade bearing contains a lubricant having a density substantially the same as the density of the material of the bearing cage. Conveniently, the bearing cage may comprise an annular member provided with a multiplicity of axially extending pockets each of which is arranged to retain a ball of the blade bearing.

The annular member may be substantially

channel shaped in cross-section having a multiplicity of circumferentially spaced openings in its base, each of which constitutes a said pocket which retains a ball of the ball bearing, and the member being arranged so that the base of the channel or the ends of its said walls abut the surface of the outer race which is provided with a groove along which the balls roll. Alternatively, the annular member may be substantially H-shaped in cross-section having the cross-arm of the H formed with a multiplicity of circumferentially spaced openings, each of which constitutes a said pocket which retains a ball of the ball bearing, and the member being arranged so that the ends of the side arms of the H abut the flat surface of the outer race which is provided with a groove along which the balls roll. The sides of the openings which extend through the base of the channel or through the cross arm of the H, as the case may be, are preferably part spherical in shape.

The blade bearing may be enclosed by a housing which acts to retain a lubricant in the blade bearing in accordance with the invention forming the subject of Patent Application No. 5311/77 (Serial No. 1,512,560).

In such a case, the housing is preferably formed from metal and is channel shaped in cross-section having the mouth of the channel directed radially inwards towards the impeller axis, the depth of the channel being such as to ensure that the balls and the cage are always covered with lubricant despite the effects of centrifugal force during use of the fan impeller.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a side elevation of a fan impeller in accordance with the invention;

Figure 2 is a fragmentary sectional elevation of one of the blade assemblies shown in Figure 1;

Figure 3 is a plan view of a thrust bearing cage shown in Figure 2;

Figure 4 is a section taken on the line IV—IV in Figure 3, looking in the direction of the arrows;

Figure 5 is a section, similar to Figure 4, but showing another form of thrust bearing cage; and

Figure 6 is an enlarged section of the thrust bearing assembly shown in Figure 2.

Referring in the first instance to Figures 1 to 4 and 6, the fan impeller comprises a hollow domed hub 1 mounted on a drive shaft 2 and carrying around its periphery a plurality of radially extending blades 3. Each blade 3 comprises an aerofoil portion 4 projecting outwards from a circular root portion 5 which fits within an opening 6 in the wall of the hub 1. The root portion 5 of each blade 3 is secured, as by screws 7, to a blade carrier 8 located within the hub 1 and supported by a thrust bearing 9 disposed between a flange 10 on the blade carrier 8 and a flange 11 extending inwards from the opening 6.

The thrust bearing 9 comprises a number of hardened steel balls 12 interposed between an annular inner race 13 adjacent the flange 10 and an annular outer race 14 adjacent the flange 11. The balls 12 are arranged to roll in shallow annular grooves 15 provided in the facing surfaces of the races 13 and 14 and are equidistantly spaced around the grooves 15 by an annular bearing cage 16 having a relatively low mass and formed from a suitable plastics material such as acetal resin or from nylon impregnated with graphite. The bearing 9 contains a lubricant having a density substantially the same as that of the material of the bearing cage 16. Each ball 12 lies within a part-spherical pocket 17 in the form of an opening which extends axially through the base of the annular cage 16 which has a substantially channel shaped cross-section, the cage 16 being interposed between the surfaces of the races 13 and 14 which are provided with the grooves 15, so that base 18 of the channel or the ends of its side walls 19 abut the surface 29 of the outer race 14. The bearing 9 is enclosed by an annular housing 20 which acts to retain the lubricant in the bearing and to prevent ingress of abrasive particles. The housing 20 is of metal and is channel shaped in cross-section, the depth of the channel being sufficient to ensure that the balls 12 and the cage 16 are always covered with lubricant despite the effects of centrifugal force during use of the fan impeller.

Adjustment of the pitch angle of the blades 3 is brought about by means of an arm 21 extending transversely from the carrier 8 and supporting at its end a pin 22 carrying a roller 23 which locates within a channel 24 in the periphery of a common actuating disc

25. The disc 25 surrounds and is rotationally fast with the drive shaft 2 but is also capable of axial movement relative to the drive shaft 2. Any convenient control arrangement, for example mechanical, electrical or pneumatic, may be employed for adjusting the axial position of the disc 25, and it will be seen that axial movement of the disc 25 will be converted into a simultaneous rotation of all the blades 3 about their respective axes. One or more counterbalance weights 26 may be provided on the blade carrier 8 to oppose inherent blade turning moments.

Referring now to Figure 5, this shows an alternative form of the annular cage 16 having a substantially H-shaped cross-section and part-spherical pockets 17 in the form of openings which extend through the cross arm 27 of the H parallel to its side arms 28. The cage 16 is interposed between the surfaces of the races 13 and 14 which are provided with the grooves 15, so that the ends of the side arms 28 abut the flat surface 29 of the outer race 14. As before the cage 16 is formed from a relatively low mass material such as an acetal resin or nylon impregnated with graphite, and the bearing 9 contains a lubricant having a density substantially the same as that of the material of the bearing cage 16.

Since the mass of the annular cage 16, whether it be channel shaped or H shaped in cross-section, is much less than that of a conventional steel cage, the effects of centrifugal force are correspondingly reduced. This reduced centrifugal load is taken on the flat surface of the outer race 14 which the base 18 of the channel or the ends of the side arms 28 of the H abut, rather than on the balls 12 as occurs with a conventional steel cage, thus eliminating a known source of fretting. Moreover, because the densities of the lubricant and the material of the bearing cage 16 are substantially the same, the contact pressure between the flat surface of the outer race 14 and the base 18 of the channel or the side arms 28 of the H-section is further reduced, thus further reducing the torque required to turn the blades 3 to adjust their pitch angles. Also, the sliding motion which occurs between the balls 12 and the cage 16 when the pitch angle of the blade 3 is adjusted, takes place at a relatively low contact pressure and against the material of the cage 16 which has a relatively low coefficient of friction. Furthermore, the provision of the housing 20 ensures that the balls 12 and the cage 16, together with the bearing surfaces of the races 13 and 14, are always covered with a lubricant, preferably a suitable grease, despite the effects of centrifugal force during use of the fan impeller.

WHAT WE CLAIM IS:—

1. An impeller for a controllable pitch



Figure 3 is a plan view of a thrust bearing cage shown in Figure 2;

Figure 4 is a section taken on the line IV—IV in Figure 3, looking in the direction of the arrows;

Figure 5 is a section, similar to Figure 4, but showing another form of thrust bearing cage; and

Figure 6 is an enlarged section of the thrust bearing assembly shown in Figure 2.

Referring in the first instance to Figures 1 to 4 and 6, the fan impeller comprises a hollow domed hub 1 mounted on a drive shaft 2 and carrying around its periphery a plurality of radially extending blades 3. Each blade 3 comprises an aerofoil portion 4 projecting outwards from a circular root portion 5 which fits within an opening 6 in the wall of the hub 1. The root portion 5 of each blade 3 is secured, as by screws 7, to a blade carrier 8 located within the hub 1 and supported by a thrust bearing 9 disposed between a flange 10 on the blade carrier 8 and a flange 11 extending inwards from the opening 6.

The thrust bearing 9 comprises a number of hardened steel balls 12 interposed between an annular inner race 13 adjacent the flange 10 and an annular outer race 14 adjacent the flange 11. The balls 12 are arranged to roll in shallow annular grooves 15 provided in the facing surfaces of the races 13 and 14 and are equidistantly spaced around the grooves 15 by an annular bearing cage 16 having a relatively low mass and formed from a suitable plastics material such as acetal resin or from nylon impregnated with graphite. The bearing 9 contains a lubricant having a density substantially the same as that of the material of the bearing cage 16. Each ball 12 lies within a part-spherical pocket 17 in the form of an opening which extends axially through the base of the annular cage 16 which has a substantially channel shaped cross-section, the cage 16 being interposed between the surfaces of the races 13 and 14 which are provided with the grooves 15, so that base 18 of the channel or the ends of its side walls 19 abut the surface 29 of the outer race 14. The bearing 9 is enclosed by an annular housing 20 which acts to retain the lubricant in the bearing and to prevent ingress of abrasive particles. The housing 20 is of metal and is channel shaped in cross-section, the depth of the channel being sufficient to ensure that the balls 12 and the cage 16 are always covered with lubricant despite the effects of centrifugal force during use of the fan impeller.

Adjustment of the pitch angle of the blades 3 is brought about by means of an arm 21 extending transversely from the carrier 8 and supporting at its end a pin 22 carrying a roller 23 which locates within a channel 24 in the periphery of a common actuating disc

25. The disc 25 surrounds and is rotationally fast with the drive shaft 2 but is also capable of axial movement relative to the drive shaft 2. Any convenient control arrangement, for example mechanical, electrical or pneumatic, may be employed for adjusting the axial position of the disc 25, and it will be seen that axial movement of the disc 25 will be converted into a simultaneous rotation of all the blades 3 about their respective axes. One or more counterbalance weights 26 may be provided on the blade carrier 8 to oppose inherent blade turning moments.

Referring now to Figure 5, this shows an alternative form of the annular cage 16 having a substantially H-shaped cross-section and part-spherical pockets 17 in the form of openings which extend through the cross arm 27 of the H parallel to its side arms 28. The cage 16 is interposed between the surfaces of the races 13 and 14 which are provided with the grooves 15, so that the ends of the side arms 28 abut the flat surface 29 of the outer race 14. As before the cage 16 is formed from a relatively low mass material such as an acetal resin or nylon impregnated with graphite, and the bearing 9 contains a lubricant having a density substantially the same as that of the material of the bearing cage 16.

Since the mass of the annular cage 16, whether it be channel shaped or H shaped in cross-section, is much less than that of a conventional steel cage, the effects of centrifugal force are correspondingly reduced. This reduced centrifugal load is taken on the flat surface of the outer race 14 which the base 18 of the channel or the ends of the side arms 28 of the H abut, rather than on the balls 12 as occurs with a conventional steel cage, thus eliminating a known source of fretting. Moreover, because the densities of the lubricant and the material of the bearing cage 16 are substantially the same, the contact pressure between the flat surface of the outer race 14 and the base 18 of the channel or the side arms 28 of the H-section is further reduced, thus further reducing the torque required to turn the blades 3 to adjust their pitch angles. Also, the sliding motion which occurs between the balls 12 and the cage 16 when the pitch angle of the blade 3 is adjusted, takes place at a relatively low contact pressure and against the material of the cage 16 which has a relatively low coefficient of friction. Furthermore, the provision of the housing 20 ensures that the balls 12 and the cage 16, together with the bearing surfaces of the races 13 and 14, are always covered with a lubricant, preferably a suitable grease, despite the effects of centrifugal force during use of the fan impeller.

WHAT WE CLAIM IS:—

1. An impeller for a controllable pitch



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axial flow fan having a blade rolling bearing provided with a bearing cage arranged so that during rotation of the impeller the centrifugal force acting on the bearing cage is taken on an outer bearing race of the blade bearing.

2. An impeller as claimed in Claim 1, wherein the bearing cage is formed from a relatively low mass material such as an acetal resin or nylon impregnated with graphite.

3. An impeller as claimed in Claim 1 or Claim 2, wherein the bearing cage comprises an annular member provided with a multiplicity of axially extending pockets each of which is arranged to retain a ball of the blade bearing.

4. An impeller as claimed in Claim 3, wherein the annular member is substantially channel shaped in cross-section having a multiplicity of circumferentially spaced openings in the base, each of which constitutes a said pocket which retains a ball of the ball bearing, and the member being arranged so that the base of the channel or the ends of its side walls abut the surface of the outer race which is provided with a groove along which the balls roll.

5. An impeller as claimed in Claim 4, wherein the sides of the openings are part-spherical in shape.

6. An impeller as claimed in Claim 3, wherein the annular member is substantially H-shaped in cross-section and the cross arm of the H is formed with a multiplicity of circumferentially spaced openings each of

which constitutes a said pocket which retains a ball of the ball bearing, and the member being arranged so that the ends of the side arms of the H abut the surface of the outer race which is provided with a groove along which the balls roll.

7. An impeller as claimed in Claim 6, wherein the sides of the openings are part-spherical in shape.

8. An impeller as claimed in any preceding claim wherein the blade bearing contains a lubricant having a density substantially the same as the density of the material of the bearing cage.

9. An impeller as claimed in any preceding claim in which the blade bearing is enclosed by a housing which acts to retain a lubricant in the blade bearing.

10. An impeller as claimed in Claim 9, wherein the housing is channel shaped in cross-section, the depth of the housing channel being such as to ensure that the balls and the cage of the blade bearing are always covered with lubricant despite the effects of centrifugal force during use of the fan impeller.

11. An impeller having a blade rolling bearing provided with a bearing cage substantially as hereinbefore described with reference to the accompanying drawings.

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