A HYDROELECTRIC TURBINE COMPRISING A PASSIVE BRAKE AND METHOD OF OPERATION

Field of the invention

This invention relates to a hydroelectric turbine, in particular when employed at tidal sites, which turbine includes a brake, preferably a passive brake which becomes operational following a predetermined level of bearing wear, in order to avoid damage to the turbine.

Background of the invention

The environmental impact of the industrialisation of the planet, in particular the use of fossil fuels to supply our energy needs, is at the stage when it can no longer be ignored, and as a result significant resources are now being directed into alternative forms of energy generation. The most promising of these new forms of alternative energies are solar power, wind power, thermal power and tidal power. Tidal power appears to provide the most consistent and predictable form of power, although harnessing tidal power is arguably the most difficult of the above power sources, given the harsh submarine conditions in which hydroelectric turbines must be located in order to generate electricity.

Hydroelectric turbines are generally located on the seabed in areas of high tidal flow which give rise to extremely difficult working conditions. Access to the turbines once located on the seabed is difficult, time consuming and dangerous, and is preferably kept to a minimum. In the addition it is extremely difficult to monitor the condition of the various working parts of the turbines, for example monitoring for excessive bearing wear which may result in damage to the turbine, requiring costly repairs and down time in the electrical generating capacity of that turbine.

It is therefore an object of the present invention to provide a hydroelectric turbine and a method of operating same, which will avoid damage to the turbine in the event of excessive bearing wear.

Summary of the invention

According to a first aspect of the present invention there is provided a hydroelectric turbine comprising a stator and a rotor; at least one set of bearings supporting the rotor within the stator; and a brake which is operable to apply a braking force to the rotor upon a predetermined level of wear of the at least one set of bearings, wherein the brake comprises one or more sections of brake pad having a braking surface positioned radially inboard of a bearing surface of the at least one set of bearings with respect to the direction of wear of the bearing.

Preferably, the brake is a passive brake.

Preferably, the or each section of brake pad is formed integrally with the at least one set of bearings.

Preferably, the at least one set of bearings comprises journals and bearing blocks.

Preferably, the journals are mounted to the rotor and the bearing blocks are mounted to the stator.

Preferably, each section of brake pad is located within one of the bearing blocks.

Preferably, a braking surface of the one or more sections of brake pad is recessed from a bearing surface of the bearing block.

Preferably, each section of brake pad is flanked on both sides by a section of bearing block.

Preferably, the brake is operable to apply the braking force to the rotor regardless of the circumferential position on the turbine at which the predetermined level of wear of the at least one set of bearings occurs.

Preferably, sections of brake pad are disposed around substantially the entire circumference of the turbine.

Preferably, the at least one set of bearings comprising at least one radial bearing and at least one thrust bearing, the brake being operable to apply the braking force to the rotor upon a predetermined level of wear of either the radial bearing or the thrust bearing.

According to a second aspect of the present invention there is provided a method of preventing damage to a hydroelectric turbine, the turbine comprising a stator and a rotor and at least one set of bearings therebetween, and a brake comprising one or more sections of brake pad having a braking surface positioned radially inboard of a bearing surface of the at least one set of bearings with respect to the direction of wear of the bearing, the method comprising the step of: automatically applying a braking force to the rotor in response to a predetermined level of wear of the at least one set of bearings through contact of the braking surface with the stator or rotor following wearing of the bearing surface to the level of the braking surface.

Preferably, the method comprises applying sufficient braking force to the rotor to substantially arrest rotation of the rotor.

Preferably, the method comprises applying the braking force to the rotor regardless of the position on the turbine at which the predetermined level of bearing wear occurs.

Brief description of the drawings

Figure 1 illustrates schematic sectioned view of hydroelectric turbine according to a preferred embodiment of the present invention; and

Figure 2 illustrates a perspective view of a bearing block forming part of the hydroelectric turbine illustrated in figure 1.

Detailed description of the drawings

Referring now to the accompanying drawings there is illustrated a hydroelectric turbine, generally indicated as (10) which is intended to be located on the seabed or the like in order to generate electricity in response to the tidal or other flow of water through the turbine (10). The turbine (10) comprises a ring shaped stator which in use is fixed to a suitable base (not shown) or the like, and within which is mounted for rotation a rotor (14). The stator (12) is provided with an annular array of coils (not shown) while the rotor is provided with a corresponding annular array of magnets mounted around the exterior circumference thereof. Rotation of the rotor (14) within the stator (12) results in relative movement between the coils and magnets, generating an EMF in order to provide the electrical power output from the turbine (10). In the preferred embodiment illustrated the turbine (10) comprises an open centre turbine, although it will be appreciated from the following description that the invention could be applied to other forms of hydroelectric turbine.

The turbine (10) further comprises bearings in the form of a pair of radial bearings (16) and a pair of thrust bearings (18). The radial bearings (16) bear the weight of the rotor (14) and prevent unwanted radial movement of the rotor (14) within the stator (12). The thrust bearings (18) bear the axial load applied to the rotor (14) by the tidal flow of water against the rotor (14). Thus this load will reverse as the tide reverses. In the preferred embodiment illustrated both the radial and thrust bearings (16, 18) each comprise an annular journal (20) circumscribing the rotor (14) and secured thereto by any suitable means. The journal (20) may be formed from any suitable material, for example stainless steel. The bearings (16, 18) further comprise an annular array of bearing blocks (22) which run on the corresponding journals (20). The bearing blocks are mounted to the stator (12) by any suitable means. The bearing blocks (22) may be formed from any suitable material, for example a material having a sufficiently low co-efficient of friction but which is hard enough to provide an acceptable rate of wear. It will be appreciated that the position and number of the bearings (16, 18) may be altered as required.

Referring in particular to Figure 2 there is illustrated one of the bearing blocks (22) in isolation from the turbine (10). The bearing block (22) is substantially U shaped having a recessed central portion (24) flanked by a pair of shoulder sections (26) which stand proud of the central section (24). Mounted within the central section (24) is a brake pad (28). A

braking surface (30) of the brake pad (28) is positioned radially inwardly of a bearing surface (32) of the bearing block (22), with respect to the direction in which the bearing block (22) will wear during use. As described in detail above, the radial and thrust bearings (16, 18) each comprise a circular array of the bearing blocks (22) in end to end alignment with one another. It should however be appreciated that not every bearing block (22) need be provided with the brake pad (28) therein. For example every second bearing block (22) in the radial and thrust bearing (16, 18) may be provided with the brake pad (28) therein. For bearing blocks (not shown) without the brake pad (28) it is preferred that the central section (24) is not provided and so those bearing blocks will have a continuous bearing surface. Further alternatively brake pads (28) may only be provided in a number of the bearing blocks (22) around the circumference of the turbine (10).

During use the rotor (14) spins within the stator (12), and the journals (20) of the radial and thrust bearing (16, 18) run on the corresponding bearing blocks (22), slowly causing wear to the bearing blocks (22) as they are formed from a softer material than the journals (20). As the bearing blocks (22) wear the bearing surface (32) will slowly recede towards the braking surface (30) of the brake pad (28). Thus it will be appreciated that eventually the bearing blocks (22) will wear so much that the brake pad (28) will be exposed from within the central section (24), thus contacting the respective journal (20). A wear line (L) indicates the level of wear of the bearing block (22) which will result in exposure of the respective brake pad (28). As the brake pad (28) comprises a material having a significantly higher co-efficient of friction then the bearing blocks (22), contact between the brake pad (28) and the respective journal (20) will result in slowing and eventually a full stop of the rotor (14). This will ensure that the radial and thrust bearing (16, 18) do not wear to a level which could result in damage to the turbine (10), for example if the rotor (14) were to foul the stator (12), which could result in damage to the coil/magnets of the turbine (10).

It will be appreciated that brake pads (28) need not be provided in both the radial and thrust bearings (16, 18), although it is preferred. Similarly it will be understood that brake pads (28) do not need to be provided in both radial bearings (16), or both thrust bearings (18), although again it is preferred. Similarly it is to be understood that the positions of the journals (20) and bearing blocks (22) could be reversed, such that the bearing blocks (22) are positioned on the rotor (14) and the journals (20) are positioned on the stator (12). Alternatively the journals (20), particularly if formed from a material with a higher wear rate

than the bearing blocks (22), could be provided with the brake pads (28) recessed therein. It is also possible that both the journals (20) and the bearing blocks (22) would be provided with brake pads (28) therein.

As mentioned above it is not necessary that brake pads (28) are positioned around the entire circumference of the radial and thrust bearings (16, 18). However it is preferred that brake pads (28) are provided around substantially the entire circumference of said bearings (16, 18). As bearing wear occurs, in particular at one point around the circumference of the stator (12), it will then be possible for the rotor (14) to move closer to the stator (12) at that point of increased wear. This will mean that the magnets and coils of the turbine (10) will be brought into closer proximity with one another, and could eventually contact one another resulting in damage thereto. By providing the brake pads (28) around substantially the entire circumference of the rotor (14) and stator (12), the possibility is avoided of the rotor (14) and stator (12) getting too close to one another at any position around the circumference of the turbine (10). The positioning of the brake pads (28), in particular the position of the braking surface (30), is chosen such that rotation of the rotor (14) will be arrested prior to the point being reached at which the proximity of the rotor (14) to the stator (12) could result in damage to the turbine (10).

The provision of the brake pads (28) thus avoids the possibility of damage to the turbine (10) during operation, and will as a result reduce the maintenance requirements on the turbine (10).

Claims

1. A hydroelectric turbine comprising a stator and a rotor; at least one set of bearings supporting the rotor within the stator; and a brake which is operable to apply a braking force to the rotor upon a predetermined level of wear of the at least one set of bearings, wherein the brake comprises one or more sections of brake pad having a braking surface positioned radially inboard of a bearing surface of the at least one set of bearings with respect to the direction of wear of the bearing.

2. A hydroelectric turbine according to claim 1 in which the brake is a passive brake.

3. A hydroelectric turbine according to claim 1 or 2 in which the or each section of brake pad is formed integrally with the at least one set of bearings.

4. A hydroelectric turbine according to any preceding claim in which the at least one set of bearings comprises journals and bearing blocks.

5. A hydroelectric turbine according to claim 4 in which the journals are mounted to the rotor and the bearing blocks are mounted to the stator.

6. A hydroelectric turbine according to claim 3 or 4 in which each section of brake pad is located within one of the bearing blocks.

7. A hydroelectric turbine according to any of claims 4 to 6 in which a braking surface of the one or more sections of brake pad is recessed from a bearing surface of the bearing block.

8. A hydroelectric turbine according to any of claims 6 to 8 in which each section of brake pad is flanked on both sides by a section of bearing block.

9. A hydroelectric turbine according to any preceding claim in which the brake is operable to apply the braking force to the rotor regardless of the circumferential position on the turbine at which the predetermined level of wear of the at least one set of bearings occurs.

10. A hydroelectric turbine according to any preceding claim in which sections of brake pad are disposed around substantially the entire circumference of the turbine.

11. A hydroelectric turbine according to any preceding claim in which the at least one set of bearings comprising at least one radial bearing and at least one thrust bearing, the brake being operable to apply the braking force to the rotor upon a predetermined level of wear of either the radial bearing or the thrust bearing.

12. A method of preventing damage to a hydroelectric turbine, the turbine comprising a stator and a rotor and at least one set of bearings therebetween, and a brake comprising one or more sections of brake pad having a braking surface positioned radially inboard of a bearing surface of the at least one set of bearings with respect to the direction of wear of the bearing, the method comprising the step of:
automatically applying a braking force to the rotor in response to a predetermined level of wear of the at least one set of bearings through contact of the braking surface with the stator or rotor following wearing of the bearing surface to the level of the braking surface.

13. A method according to claim 12 comprising applying sufficient braking force to the rotor to substantially arrest rotation of the rotor.

14. A method according to claim 12 or 13 comprising applying the braking force to the rotor regardless of the position on the turbine at which the predetermined level of bearing wear occurs.