A foundation supported turbine structure includes a centrally guided inner casing within which is mounted the rotor and stationary guide blading and an outer casing which is spaced from the inner casing. The inner casing is supported by cantilever arms secured to the foundation and which extend laterally inward through openings provided in the outer casing corresponding support points for the inner casing at opposite sides thereof. The outer casing includes support feet which are secured to the foundation and a bellows unit surrounds each cantilever arm at the pass-through opening in the outer casing for providing a fluid-tight connection.
LOW-PRESSURE STEAM TURBINE CASING

This invention relates to an improved construction for a turbine casing of double-shell construction with the outer casing separate from the inner casing, the inner casing being supported on the foundation by means of supporting arms and the outer casing being joined to the supporting arms.

Casings for the low-pressure sections of steam turbines are known in which the inner casing is supported on brackets or feet forming part of the outer casing. With low-pressure sections of large dimensions this gives rise during operation to increased deformation corresponding to the size. In other words, there is no assurance that the inner casing will remain exactly centralized and thus damage to the rotor can easily occur.

One remedy consists in stiffening the outer casing so that deformation remains relatively small, irrespective of the operating conditions at the inner casing bearing points. However, this leads to massive and expensive forms of construction for the turbine outer casings which, in the case of the low-pressure section, have essentially to provide only an enclosing membrane with respect to the atmosphere. In addition, transport problems are greatly increased as the size of turbine units rises.

A large-capacity steam turbine comprising welded inner and outer casings has been proposed in which the inner casing is separate from the outer casing and is supported on the turbine foundation via the lower portion of the inner casing by means of supporting members located on the long side of the casing and in a manner allowing expansion, keys able to move relative to the turbine foundation being provided at the ends of the lower portion of the inner casing to allow it to expand in the axial direction. In addition, with this form of construction the supporting members holding the inner casing on the foundation and the keys at the ends have to be connected to the outer casing by way of flexible, stranded means of shaft compensation.

The arrangement of supporting members on the hot inner casing and connected to the casing incurs many dangers. For example, even the slightest change of angle between the contact surface of the supporting member and the inner casing causes displacement of the inner casing relative to the rotor, or of the two axes, thus creating the risk that the moving blades will rub on the inner casing. Such changes of angle can also be caused by non-uniform temperature distribution. This is more probable under the circumstances stated above because, owing to the form of construction described, the distance between the bearing points of the supporting members located on the inner casing must increase.

The principal object of the present invention is to provide a low-pressure steam turbine casing whose inner casing is completely independent of the movements and forces exerted by the outer casing, and at the same time avoiding the disadvantages described above.

This objective is achieved by means of a supporting arm in the form of a cantilever beam on two supports, the cantilevered portion supporting the inner casing, which has a central guideway, in a manner allowing expansion.

This has the advantage of small bending forces on the supporting arm because the distance between the bearing points on the turbine foundation and on the inner casing can be shortened. Consequently, account has to be taken only of displacement of the inner casing due to its expansion. This can be coped with both at standstill temperatures of 0° to 30° C, and also at operating temperatures of 20° to 50° C, and is moreover approximately equally effective in any radial direction. As a result, the inner casing remains perfectly centralized relative to the moving blades and rotor in any operating condition.

In another version the outer casing is rigidly fixed to the supporting arm. This can be done simply by welding, but also by means of rigid, but detachable connections. This version has proved beneficial, especially in the case of smaller turbines, because in this manner space is saved and the casing consists of few parts. However, it must be noted that the supporting arms then also have to take the weight of the outer casing. In addition, with this version the outer casing can be constructed purely as an enclosing membrane, bringing the advantage of an extremely lightweight structure.

In another version the outer casing is itself supported on the turbine foundation, in which case the outer casing is connected to the supporting beam by way of a flexible membrane.

In this manner the supporting arms are also relieved of the weight of the outer casing. This leads to savings in materials and costs because the individual parts of the casing are simpler and are easier to handle during manufacture and transport.

In a particular form of the invention, the supporting arm for the inner casing is rigidly joined to the foundation, being either of prestressed and/or reinforced concrete, or comprising a beam integral with the turbine foundation. This construction has the advantage that no auxiliary supports for the inner or outer casing are required during erection or dismantling, and in addition flexure of the supporting arms can be further reduced by virtue of the direct connection.

The invention will now be described in more detail with reference to the accompanying drawings, in which:

FIG. 1 shows a cross-section through a steam turbine casing.

FIG. 2 is a plan view of a part of the low-pressure steam turbine casing as shown in FIG. 1, and

FIG. 3 shows a section at the bearing points of the supporting arm.

In FIG. 1 the casing 1 of the low-pressure section of a steam turbine is shown schematically in cross-section. The casing 1 comprises essentially an inner casing 2 and an outer casing 3. The two casings 2 and 3 are separated from each other in such a way that the forces of mass and movement of the outer casing 3 cannot act on the inner casing 2, and vice versa. For this purpose a bellows 6 is fixed at one end to the supporting arm 4, and at the other end to the outer casing 3 at frame 16, the joints being rigid and steamtight.

The supporting arm 4 rests on the turbine foundation by way of two bearings 8 and 9, one which, namely bearing 8 closer to the cantilevered portion 5, is subjected to compressive forces, while the other bearing 9 is loaded in tension. This can be achieved simply by means of anchor bolts 18 and 19, not shown in FIG. 1, set in the turbine foundation 7.

The cantilever portion 5 is provided with a bearing 10 which rests on the inner casing 2 by means of flange 11. As indicated symbolically, bearing 10 is movable. This allows compensation of expansion due to heating.
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of the inner casing 2, a central guideway 14 for the inner casing 2 being provided so that the inner casing 2 remains in a central position. Through the configuration of the supporting arm 4 on a steam turbine casing 1, it is possible to influence favorably the bending characteristics and moment curve of the support and the casing. The outer casing 3 comprises an upper part 12 and a lower part 13. With a casing constructed according to the invention, these parts are to be considered only as an enclosing membrane and are subjected only to forces of internal vacuum, external atmospheric pressure and their own weight. Because of this, the parts can be made extremely light in weight.

FIG. 2 shows a partial view of the low-pressure casing 1 of a steam turbine, the long side of the inner casing 2 resting on the cantilevered portion 5 of supporting arm 4. Here there are two bearing points 10. The feet 15 of the outer casing 3 are anchored to the foundation 7 by means of bolts 17, the feet 15 being fixed to the supporting frame 16 of the outer casing 3. The upper part of the outer casing 3 is connected to the lower part 13 by means of the steamtight, bolted flanges 20 and 21. Between the outer casing 3 and the supporting arm 4 there is a flexible, sealing joint, here represented by the bellows 6. One end of this is connected to frame 16, and the other end to the cantilever 5 of supporting arm 4, forming a steamtight joint. The supporting arm 4 is fixed to the turbine foundation 7 rigidly by means of the bearings 8 and 9 provided with the anchor bolts 18 and 19.

The supporting arm 4 is directly connected to the inner casing 2 solely by way of bearing 10, or bearing points 10'. The flow of heat from the inner casing 2 to the supporting arm 4 is thus greatly restricted, although the supporting arm 4 is still cooled by the exhaust steam. Even in the case of nonuniform temperature distribution, therefore, the support of the inner casing cannot become distorted or twisted. The central or almost coaxial position of the rotor relative to the inner casing 2 is thus permanently maintained.

FIG. 3 shows an assembly of the supporting arm 4 in cross-section, viewed at the line A—A in FIG. 2. For reasons of clarity, a part of the supporting arm 4 fixed to the turbine foundation 7 has been omitted. Bearing 8 is provided with a centering device 26 which engages a key 27 mounted on the supporting arm 4. Another bolt 18 fixes the supporting arm 4 to the turbine foundation 7.

The outer casing 3, comprising upper part 12 and lower part 13, with supporting frame 16, is fixed to the turbine foundation 7 by means of brackets 15 attached to the frame 16, foundation bolts 17 being used for this purpose. Bellows 6, forming a steamtight joint, is fitted between supporting arm 4, or its cantilevered portion 5, and the frame 16 of outer casing 3. The upper part 12 and lower part 13 are rigidly joined together at flanges 20 and 21.

The cantilevered portion 5 of supporting arm 4 has at its end a bearing plate 22. To this is fixed a slide plate 23 on which the plate 24 can slide in any direction. The plate 24 has a spherical surface 28 which engages in a matching piece 25 set in flange 11. When the inner casing expands, flange 11 will move radially relative to slide plate 23, whereupon the plate 24, centered and guided by the spherical surface 28, will follow the movement in an omni-directional manner. The bearing 10, comprising the components stated above, will thus move uniformly, the central position of the turbine being determined by the central guide 14 indicated in FIG. 1.

The invention is not restricted to the casing of the low-pressure section of a steam turbine, and when suitably modified could also be used in a high-pressure or intermediate-pressure section. Furthermore, a casing constructed in accordance with the invention could also be applied to other fluid flow machines without thus forfeiting the advantages described.

In another form of the invention the supporting arm 4 serves at the same time as a steam inlet. For this purpose, a crossover pipe or a live steam line 30 can be located in the supporting arm 4, which has the form of a hollow beam. The line must then be provided with insulation. Among the advantages of this is the fact that the incoming flow enters at the lower part of the inner casing 2 of the steam turbine without reducing the steam exhaust area between outer and inner casing.

With this version it may prove expedient not to fix the supporting arm 4 to the turbine foundation 7 by means of rigid bearing points 8 and 9, but to provide these with flexible supports appropriate to expansion of the supporting arm 4 and, the forces of reaction created by the crossover pipe.

1. A foundation supported turbine structure wherein the turbine casing is of the double-shell type comprising an inner casing within which is mounted the rotor and stationary guide blading and an outer casing spaced from said inner casing, central guide means for said inner casing for accommodating thermal expansion thereof, support means for said inner casing comprising cantilever arms carried by the foundation and extending laterally inward therefrom through openings provided in said outer casing to corresponding support points for said inner casing at opposite sides thereof, each said support point for said inner casing on said cantilever arm including a bearing structure mounted for omni-directional sliding movement on said arm in a horizontal plane, and means for supporting said outer casing at least indirectly by said foundation.

2. A foundation supported turbine structure as defined in claim 1 wherein said means for supporting said outer casing includes means securing said outer casing directly to said foundation.

3. A foundation supported turbine structure as defined in claim 1 and which further includes a flexible bellows surrounding each of said cantilever arms, one end of said bellows being connected in a seal-tight manner to the cantilever arm and the other end thereof being connected in a seal-tight manner to said outer casing at the pass-through opening for said arm.

4. A foundation supported turbine structure as defined in claim 1 wherein at least one of said cantilever support arms for said inner casing is hollow so as to also provide a fluid inlet pipe.

5. A foundation supported turbine structure as defined in claim 1 wherein the bearing structure located at each said support point for said inner casing on said cantilever arm and which is mounted for omni-directional sliding movement on said arm is a horizontal plane includes a fixed slide plate at the inner end of said cantilever arm, and a movable plate slideable omni-directionally on said fixed plate, the upper side of said movable plate including a spherical surface engaged with a complementary spherical surface on a horizontal flanged part of said inner casing.