A gas turbine with at least one stationary stator blade and at least one rotor blade that can be rotated during operation is provided. The gas turbine has at least one optical waveguide embedded into a first rotor blade. The optical waveguide is oriented such that thermal radiation of a region of the first stator blade can be detected by the optical waveguide. An analyzing device is designed to analyze the thermal radiation and to ascertain the temperature of the region of the first stator blade, the temperature being ascertainable along a path from which the radiation is emitted during the rotation of the first rotor blade.
GAS TURBINE WITH PYROMETER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the U.S. National Stage of International Application No. PCT/EP2012/060209 filed May 31, 2012, and claims the benefit thereof. The International Application claims the benefit of German Application No. DE 102011077908.6 filed Jun. 21, 2011. All of the applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

[0002] The invention relates to a gas turbine having at least one stationary stator blade and at least one rotor blade which can be rotated during operation.

BACKGROUND OF INVENTION

[0003] Work on the efficiency of modern gas turbines never stops. An increased efficiency can always be achieved in this case by an increased operating temperature. Here, the operating temperature continuously approaches the limits of the thermostability of the blade materials being used.

In order to avoid overloading, the temperature of individual components of a gas turbine is monitored. By way of example, pyrometers are used for this purpose which detect the thermal radiation of individual components, lead it to a detector and evaluate it there, thus determining the temperature of the component. A multiplicity of temperature measurement points and temperature measuring devices are used so as to be able to measure local variations in the temperature.

[0004] Owing to their fixed position relative to the burners, the stationary blades, called stator blades, have larger inhomogeneities in the temperature distribution than the rotor blades, which rotate during operation. The temperature distribution in the stator blades is therefore of great interest. To date, the temperature of the stator blades has been measured in a pointiform manner with the aid of a limited number of stationary thermocouples.

SUMMARY OF INVENTION

[0005] It is an object of the present invention to specify a gas turbine in the case of which the temperature distribution in the stator blades can be more accurately detected.

[0006] This object is achieved by a gas turbine as described herein.

[0007] The gas turbine according to an embodiment comprises at least one stationary stator blade and at least one rotor blade which can be rotated during operation. Also present is at least one optical waveguide, which is embedded in a first rotor blade and is aligned such that the thermal radiation of a first stator blade can be detected by the optical waveguide.

[0008] The gas turbine according to an embodiment also comprises an evaluation device for evaluating thermal radiation. The evaluation device is configured to determine the temperature of at least the first stator blade, it being possible to determine the temperature along a path from which the thermal radiation is detected in the course of the rotation of the first rotor blade and thus of the optical waveguide.

[0009] The region of the stator blade whose thermal radiation is recorded is in this case a function of the optical waveguide and of the distance of the optical waveguide end from the stator blade.

[0010] Differently put, in an embodiment the pyrometer, which is represented by the optical waveguide, rotates together with a rotor blade and is directed toward a stator blade. The temperature of the stator blade can therefore advantageously no longer be determined only at fixed points at which thermal elements are provided, but at any point on a circular track which results from the movement of the rotor blade relative to the stator blade. The temperature distribution of the stator blade can thus be detected much more accurately than previously.

[0011] In one refinement and development of an embodiment, the first rotor blade comprises a photodetector for converting the thermal radiation into electrical signals. In this case, the photodetector is expediently coupled to the optical waveguide in order to be able to detect the thermal radiation, which comes from the first stator blade, after passage through the optical waveguide. The photodetector can, for example, be fed in this case by wireless energy transfer. Alternatively, the photodetector can be fed by means of a battery. The pyrometer is advantageously implemented thereby substantially in the rotor blade itself. The data determined can then be recorded and/or passed on by telemetry or by a recording data plotter.

[0012] In a further refinement and development of an embodiment, the optical waveguide is guided into the shaft of the first rotor blade and terminates there. It is possible through this configuration for the recorded thermal radiation to be output in the direction of stationary parts of the gas turbine. Said radiation can be more simply recorded and further processed there. It is then advantageous when the end of the optical waveguide in the shaft is provided with a collimator. In accordance with an advantageous refinement of an embodiment, it is possible hereby for the emerging thermal radiation to be emitted in an axial parallel beam. This enables the radiation to be recorded as far as possible without attenuation after traversing a short air gap.

[0013] In an advantageous refinement of an embodiment, the radiation coming from the collimator is detected with the aid of a detection device, wherein the reception range of the detection device is formed over so large an area that substantially all radiation coming from the collimator can be detected. The comparatively large area of the configuration of the detection device enables the thermal radiation to be detected and further processed without attenuation. The accuracy of the measurement is thereby ensured.

[0014] In order to separate the detection device from the ambient light, and thus to reduce or to avoid a recording of the ambient light, it is advantageous to provide a cover or sleeve in the region of the detection device.

[0015] In one refinement of an embodiment, the detection device is a waveguide, in particular an optical waveguide with a comparatively large cross section, or a bundle of optical waveguides. The optical waveguide/waveguides serves/serve to pass on radiation in a stationary part of the gas turbine to a photodetector. The use of optical waveguides as detection device enables the detector to be implemented in a thermally less stressed region of the gas turbine.

[0016] Alternatively, the detection device can also directly be the photodetector. Said photodetector is then preferably provided with a sufficiently large detector area in order, in turn, to provide as far as possible for attenuation-free recording of the thermal radiation.
In one advantageous refinement and development of an embodiment, a lens collimator is provided in the region of the end of the optical waveguide reaching the first stator blade. Alternatively, the optical waveguide can be configured in a tapered fashion at its appropriate end. It is thereby possible to control the region of the surface of the stator blade from which thermal radiation is recorded.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Preferred, but in no way limiting exemplary embodiments of the invention are now explained in more detail with the aid of the figures of the drawing, in which the features are schematized. In the drawing:

**FIG. 1** shows a section of one gas turbine. This means that only parts of the components are schematized. The gas turbine comprises a rotor blade and stator blades. The rotor blade is arranged rotatably on a shaft. The stator blades are arranged fixed to the housing and do not rotate during operation.

A glass fiber is embedded in the rotor blade. It runs therein from an end situated on the surface of the rotor blade into the shaft. The end situated on the surface of the rotor blade points in the direction of the stator blades. Provided at the end of the optical waveguide there is a lens collimator.

The other end of the glass fiber lies on a surface of the shaft. The glass fiber terminates there with a second collimator. The second collimator is configured in this case such that the output radiation emerges in an axial parallel beam. The radiation thus output enters a photodetector whose receiving surface has a large area by comparison with the cross section of the glass fiber.

FIG. 2 shows variants of the termination of the glass fiber, which points in the direction of the stator blades. Thus, as indicated in this exemplary embodiment, the glass fiber can be terminated with the lens collimator. A further possibility and alternative consists in terminating the glass fiber in such a way that the glass fiber has a tapered end. A further alternative consists in using a glass fiber of lower aperture. Said end then has no special configuration.

During operational running, a region of a stator blade emits thermal radiation in accordance with its temperature. In this case, the region is small by comparison with the size of the stator blade. The thermal radiation enters the glass fiber via the lens collimator. It is led there up to its other end and enters the photodetector through the second collimator and the following air gap. The electrical signals initiated by the radiation are evaluated, and the temperature of the region is thereby determined.

The rotor blade rotates during operational running. The glass fiber necessarily co-rotates in this case. The region of the stator blade that is under consideration thereby travels around the shaft on a circular track. Since said movement is relatively quick, it is possible at practically any time to consider the temperature of each region of the stator blade which lies on the circular track. All that this requires is to wait until the rotor blade has passed once over the desired region. The temporal resolution of the evaluation in this case determines which angular section of the circular path will ultimately be regarded as region.

1. A gas turbine, comprising at least one stationary stator blade and at least one rotor blade which can be rotated during operation, at least one optical waveguide, which is embedded in a first rotor blade and is aligned such that thermal radiation of a region of the first stator blade can be detected by the optical waveguide, and an evaluation device for evaluating the thermal radiation, which is configured to determine the temperature of the region of the first stator blade, it being possible to determine the temperature along a path from which the thermal radiation emanates in the course of the rotation of the first rotor blade.

2. The gas turbine as claimed in claim 1, wherein the first rotor blade comprises a photodetector for converting the thermal radiation into electrical signals.

3. The gas turbine as claimed in claim 2, wherein the photodetector is fed by wireless energy transfer.

4. The gas turbine as claimed in claim 1, wherein the optical waveguide is guided into the shaft of the first rotor blade and terminates there.

5. The gas turbine as claimed in claim 4, wherein the end of the optical waveguide in the shaft is provided with a collimator.

6. The gas turbine as claimed in claim 5, wherein the collimator is configured to emit the emerging radiation in an axial parallel beam.

7. The gas turbine as claimed in claim 4, wherein the radiation coming from the collimator is detected with the aid of a detection device, wherein the reception range of the detection device is formed over so large an area that substantially all radiation coming from the collimator can be detected.

8. The gas turbine as claimed in claim 7, wherein the detection device has a cover or sleeve to prevent ambient light from scattering.

9. The gas turbine as claimed in claim 7, wherein the detection device is an optical waveguide or a bundle of optical waveguides for passing on the radiation to a photodetector.

10. The gas turbine as claimed in claim 7, wherein the detection device is a photodetector.

11. The gas turbine as claimed in claim 1, wherein a lens collimator is provided in the region of the end of the optical waveguide pointing toward the first stator blade.

12. The gas turbine as claimed in claim 1, wherein the optical waveguide is tapered at its end.