GAS TURBINE ENGINE WITH AN ARRANGEMENT FOR MEASURING THE SHAFT ROTATION SPEED

Inventor: Robert THIES, Schwielowsee (DE)
Assignee: ROLLS-ROYCE DEUTSCHLAND LTD & CO KG, Blankenfelde-Mahlow (DE)

Filed: Nov. 16, 2010

Foreign Application Priority Data
Nov. 17, 2009 (DE) .................... 10 2009 053 339.7

Publication Classification
Int. Cl. F01D 25/00 (2006.01)
U.S. Cl. ........................................... 415/118

ABSTRACT
A gas turbine engine includes an arrangement for measuring shaft rotation speed, including a laser source (10) for directing a laser beam (11) onto portions of rotor blades to either be reflected from or interrupted by the rotor blades to create light impulses as a function of the rotor rotation rate. A receiver diode (12) receives the light impulses and generates voltage impulses corresponding to the rotor or shaft rotation rate. An evaluation unit associated with the receiver diode measures the number of the voltage impulses generated per unit of time and calculates therefrom the rotation speed of the engine shaft connected to the rotor. The measurement arrangement is arranged in the engine housing to be easily accessible for mounting, maintenance and adjustment, it is functionally reliable under robust engine operation and can detect the rotation of a low pressure shaft and connected fan.
GAS TURBINE ENGINE WITH AN ARRANGEMENT FOR MEASURING THE SHAFT ROTATION SPEED

[0001] This application claims priority to German Patent Application DE102009053397.7 filed Nov. 17, 2009, the entirety of which is incorporated by reference herein.

[0002] The invention relates to a gas turbine engine with an arrangement for measuring the shaft rotation speed, which engine has bladed rotors and stators associated therewith, the rotors connected to an engine shaft inside an engine housing section.

[0003] In turbo fan engines it is necessary for controlling the function of the engine during its operation to have precise knowledge of the rotation speed of the low pressure shaft which is connected with the fan. As is known, the speed of the low pressure turbine shaft is measured with a phonic wheel which comprises a ferromagnetic toothed wheel rotating with the low pressure shaft and an electromagnet, arranged at a very small distance from the teeth, which is flowed through by an intermittent current. The rotation rate of the low pressure turbine shaft is determined on the basis of a counting of the voltage change impulses generated as a function of the rotation speed of the toothed wheel. Such a measurement system is described for example in U.S. Pat. No. 4,866,987 A.

[0004] The application of this measurement principle on the low pressure shaft of the engine is disadvantageous in so far as the ferromagnetic toothed wheel and the associated sensor are arranged in the interior of the engine and consequently are only accessible with difficulty from the exterior, and the adjusting of the—very small—distance necessary for achieving exact measurement results, between the toothed wheel and the electromagnet is a problem. Owing to the difficult access to the measurement arrangement, it is necessary to arrange several sensors on the periphery of the toothed wheel in order to guarantee in every case the generation of a speed signal. A further disadvantage is that the measurement arrangement, resting on the phonic wheel, can not be arranged in the foremost region of the low pressure shaft for space reasons, and therefore a failure of the fan shaft section of the low pressure shaft, caused by fracture or shearing off, can not be detected. This disadvantage is compensated for by a thicker dimensioning of this shaft region.

[0005] The present invention is based on the problem of constructing a rotation speed measurement device for an engine shaft, connected with a rotor, and arranging it in the engine so that the rotation rate of the entire engine shaft can be reliably monitored with little expenditure.

[0006] In the measurement of the shaft rotation speed in a gas turbine engine which has bladed rotors and stators associated therewith, connected to an engine shaft inside an engine housing section, there is arranged a laser source, arranged in the engine, directed onto the blade tips or longitudinal edges of the blades or reflecting surfaces/mechanisms mounted on the blades, for the generation of a laser beam and for the generation of light impulses brought about by reflection or by interruption on passing through between the blades as a function of the rotor rotation rate, and a receiver diode receiving the light impulses for the generation of voltage impulses. The number of voltage impulses is a measurement for the rotor- or shaft rotation rate, wherein there is associated with the receiver diode an evaluation unit for counting the voltage impulses and for calculating the rotation speed of the engine shaft which is connected with the respective rotor. The integration of such a measurement arrangement into the engine makes the measurement arrangement easily accessible and facilitates its mounting, maintenance and adjustment. As close, high-precision adjustment as possible of the distance of the measurement arrangement from the blades is, however, not necessary, the measurement device can also measure in a functionally reliable manner the rotation speed of the shaft connected with the respective rotor in the robust engine operation, for example with an extension or vibration of the blades. In the measurement of the rotation speed of the low pressure shaft of a turbo fan engine, with a measurement carried out on the blade tips of the fan, the rotation speed of the low pressure shaft can be detected as a whole, i.e. also the part of the low pressure fan connected directly with the fan, and also a shaft fracture occurring in this region can be identified.

[0007] In further development of the invention the laser source and the receiver diode for receiving a light beam reflected from the blades are arranged angled to each other in an engine housing section adjoining the blades, so that the reflected light beams impinge onto the receiver diode.

[0008] In a development of the invention, the laser source and the receiver diode are arranged in a wall recess of the respective engine housing section.

[0009] In further development of the invention, the bladed rotor is the fan of the engine, connected with the low pressure shaft, and the engine housing section is the fan housing surrounding the fan.

[0010] In further development of the invention, the respective laser source and the respective receiver diode are arranged on an engine housing section and on a stator and are aligned to each other so that the light impulse, respectively passing through between two adjacent rotor blades, impinges onto the receiver diode.

[0011] In still further development of the invention, the laser source and the receiver diode are mounted respectively lying opposite on a stator arranged downstream and arranged upstream of a rotor, and namely such that either the light impulses passing through between the rotating rotor blades or light impulses reflected from the rotor blades impinge onto the receiver diode.

[0012] Furthermore, it is also conceivable that the laser source and the receiver diode are arranged jointly on a stator situated upstream or downstream from the rotor, so that the receiver diode can receive light impulses respectively reflected from the rotor blades.

[0013] In development of the invention, the receiver diode is a photodiode or an optical sensor. Preferably, a filter for filtering out intrusive light is associated with the receiver diode.

[0014] An example embodiment of the invention is described in further detail with the aid of the drawings, in which are shown:

[0015] FIG. 1 is a diagrammatic illustration of a turbo fan engine;

[0016] FIG. 2 is a sectional view in the region of the fan with a measurement device arranged in the fan housing for determining the rotation speed of the low pressure shaft;

[0017] FIG. 3 is a detailed illustration of the measurement device according to FIG. 2; and

[0018] FIG. 4 is a detailed illustration of an alternative embodiment of the measurement device.
The turbofan engine, illustrated in highly simplified form in FIG. 1, comprises downstream of the combustion chamber 1 a high pressure turbine 3, connected with the high pressure shaft 2 (rotor surrounded by engine housing section 15), via which a compressor 4 is driven, and a low pressure turbine 6, connected with the low pressure shaft 5 of the turbofan engine, for driving the fan 8 rotating inside a fan housing 7. The high pressure and the low pressure turbine and the compressor comprise respectively a bladed rotor surrounded by an engine housing section 15. The fan 8 has a plurality of fan blades 9, fastened at regular intervals on the periphery of a hub. In the illustrations according to FIGS. 2 and 3 the fan housing 7 illustrated with—for simplicity’s sake—only one fan blade 9. A measurement device for detecting the rotation speed of the low pressure shaft 5 is integrated into the fan housing 7 in the region of the engine housing section surrounding the blade tips 13, which measurement device comprises a laser source 10, for the generation of a laser beam 11, and a photodiode 12. During the rotation of the fan, the laser beam 11 is directed from the laser source 10 toward the respective blade tip 13 and is then reflected from the blade tip 13 as light beam 14 toward the photodiode 12. The laser source 10 and the photodiode 12 are arranged angled to each other inside a recess 16 constructed in the engine housing section 15, here the fan housing 7. The light beam 14 reflected from the respective blade tip 13 generates a voltage impulse, which is detected by a counter/evaluation unit 17. The number of voltage impulses generated per unit of time is a measurement for the rotation rate of the fan and hence also of the rotation rate of the low pressure shaft, which, based on the fan parameters, is calculated and indicated in the counter/evaluation unit 17.

The measurement arrangement which is thus constructed and integrated into the engine is easily accessible and can be maintained and adjusted in a simple manner. In addition, such a high-precision adjustment of the gap width is not necessary as with the phonic wheel, so that also a vibration or an extension of the fan blades in operation do not impair the measurement process. An essential advantage of the measurement arrangement formed according to the present example embodiment of the blade tips of the fan blades and the laser source and the photodiode is that the low pressure shaft of a turbofan engine is monitored over its entire length and also a fracture of the part of the low pressure shaft (fan shaft) adjoining the fan is detected, so that the fan shaft can be dimensioned smaller and weight can be saved.

The invention is not restricted to the previously described preferred embodiment. Rather, numerous modifications are conceivable within the framework of the claims. This means that the measurement arrangement comprising a laser source and a receiver diode can also be integrated into the housing of the low pressure turbine for measuring the rotation speed of the low pressure turbine shaft or into the high pressure turbine housing or the compressor housing for measuring the rotation speed of the high pressure shaft and can be mounted on the housing or on the stator or only on the stator. The light beam impulses generated by the rotation of the rotor and detected by the receiver diode can be generated by reflection on any part of the blades or respectively reflection means mounted on the rotor blades, or by interruption of the laser beam. For instance, the laser source 10 and the receiver diode 12 can be aligned with respect to each other so that the laser beam 11 is directed to pass between the rotor blades 9 toward the receiver diode such that the rotating rotor blades 9 interrupt the laser beam 11 to create the light impulses 14 impinging onto the receiver diode 12. See FIG. 4 which shows such an embodiment with modified versions of the laser source 10 and the receiver diode 12. Various reflecting mechanisms, refracting mechanisms and lenses can be used to direct and control the laser beam and light beam. Various features of the various embodiments disclosed herein can be combined in different combinations to create new embodiments within the scope of the present invention.
the rotating rotor blades interrupt the laser beam to create the light impulses impinging onto the receiver diode.

6. The gas turbine engine of claim 1, wherein the laser source and the receiver diode are mounted respectively lying opposite on a stator arranged downstream and upstream of a rotor, wherein light impulses either passing through between the rotor blades or reflected therefrom impinge onto the receiver diode.

7. The gas turbine engine of claim 1, wherein the laser source and the receiver diode are mounted jointly on a stator situated one of upstream and downstream from the rotor so that the receiver diode respectively receives light impulses reflected from the rotor blades.

8. The gas turbine engine of claim 1, wherein the receiver diode is at least one of a photodiode and an optical sensor.

9. The gas turbine engine of claim 1, and further comprising a filter associated with the receiver diode for filtering out intrusive light.

10. The gas turbine engine of claim 1, wherein the bladed rotor is a fan of the engine, the engine shaft is a low pressure shaft and the engine housing is a fan housing surrounding the fan.

11. The gas turbine engine of claim 2, wherein the bladed rotor is a fan of the engine, the engine shaft is a low pressure shaft and the engine housing is a fan housing surrounding the fan.

* * * * *