New microwave sensor for blade tip monitoring

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Abstract (max. one page)

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A novel solution for blade tip monitoring purpose consists of a microwave sensing system which works on principles that are similar to a short range radar system, providing accurate and robust measurement within the harsh turbine environment. As a key part of the system, the sensor sends a continuous microwave signal towards the target (i.e. the rotating turbine blades) and receives the reflected signal. The parameters of interest are both the amplitude and phase of the signal, in and out of the resonance. At resonance the EM field is radiated by the sensor and interacts with the tip of the blade, while out of resonance the EM field is not able to detect the blade, yielding a reference signal. From this information, the system is able to perform tip clearance measurement.

From a measurement system stand point and given the environmental conditions, the sensor has to provide sharp resonance and frequency stability versus temperature. From a mechanical reliability stand point, the sensor has to be hermetically sealed and be able to withstand harsh environmental conditions such as vibration, corrosive gases and large temperature range, typically from -30°C to over 1000°C depending on sensor location. In addition, the sensor is required to be compact in order to avoid perturbing the performance of the turbine.

A microwave sensor for tip clearance measurement in large frame turbines has already been developed by Meggitt Sensing Systems. It consists of a patch antenna, operating at 6 GHz [1].

In this work we present a new microwave sensor to perform tip clearance measurement in smaller turbines (aero-derivatives, aero-engines). Performing measurements in small turbines such as the ones encountered in aero-derivatives and aero-engines requires further miniaturization of the sensors and increased spatial resolution. Scaling down the existing 6 GHz patch antenna would lead to a fragile sensor, due to its design complexity.

The new sensor consists of a microwave resonator being able to meet the different above-mentioned requirements. The selected sensor design presented in this study consists of a resonant cylindrical waveguide cavity made of high temperature resistant materials, fed by a coaxial line and protected by a ceramic cap. This technology represents a good compromise between miniaturization and robustness of the probe. The proposed design was validated through software simulation and prototypes were built and tested. Measurements agree well with simulated results. In addition, tests on isothermal aging, thermal cycling up to 900°C and vibration have been carried out with success. Finally the sensor has been successfully tested on turbines for tip clearance measurement at a power load ranging from 1 MW to 20 MW.

[1] US 7,283,096 B2 Geisheimer et al., Oct. 16, 2007.