METHOD FOR DESIGNING A LOW-PRESSURE TURBINE OF AN AIRCRAFT ENGINE, AND LOW-PRESSURE TURBINE

The present invention relates to a turbine, in particular a low-pressure turbine of a gas turbine, in particular of an aircraft engine.

BACKGROUND

Gas turbines, in particular aircraft engines, are made up of multiple subassemblies, namely among other things a compressor, preferably a low-pressure compressor and a high-pressure compressor, a combustion chamber, and at least one turbine, in particular a high-pressure turbine and a low-pressure turbine. The compressors and the turbines of the aircraft engine preferably include multiple stages which are positioned axially one behind the other in the flow direction. Each stage is formed by a stationary vane ring and a rotating blade ring, the stationary vane ring having multiple stationary guide vanes and the rotating blade ring having multiple rotating blades. Each stage is characterized by a characteristic quantity which indicates the number of guide vanes to the number of rotating blades ratio within the stage. This characteristic quantity is also referred to as the vane-to-blade ratio (V/B).

The low-pressure turbine of an aircraft engine in particular is a noise source not to be disregarded. The low-pressure turbine emits noises in particular at frequencies which are an integral multiple of the so-called blade-passing frequency (BPF). The blade-passing frequency of a stage is the frequency at which the rotating blades of the stage rotate past a stationary guide vane of the respective stage.

For minimizing the noise emission of the low-pressure turbine of an aircraft engine, it is known from the related art to establish the vane-to-blade ratio of downstream stages of the low-pressure turbine at a value of approximately 1.5 in order to muffle the noise of the blade-passing frequency. Despite these measures known from the related art, the low-pressure turbines of aircraft engines known from the related art still emit a high noise level under noise-critical operating conditions, in particular during the landing approach or during taxiing on the tarmac of an airport.

An object of the present invention is to create a novel turbine, in particular a low-pressure turbine of a gas turbine, in particular of an aircraft engine.

The present invention provides a turbine, in particular a low-pressure turbine of a gas turbine, in particular of an aircraft engine, having multiple stages positioned axially one behind the other in the flow direction of the turbine, each stage being formed by a stationary guide vane ring having multiple guide vanes and a rotating blade ring having multiple rotating blades, and each stage being characterized by a vane-to-blade ratio characteristic quantity which indicates the number of guide vanes to the number of rotating blades ratio within a stage. According to the present invention, at least one stage of the turbine is designed in such a way that its vane-to-blade ratio characteristic quantity under noise-critical operating conditions of the turbine is between a lower cut-off limit for mode $k=-1$ of the blade-passing frequency (BPF) of this stage and an upper cut-off limit for mode $k=-2$ of the blade-passing frequency (BPF) of this stage.

The design principle according to the present invention for a turbine of an aircraft engine makes it possible to noticeably minimize the noise level emitted by the turbine. The noise emission in the range of the blade-passing frequency (BPF) may be clearly reduced with the aid of the present invention.

According to a preferred refinement of the present invention, at least one of the stages of the turbine is designed in such a way that its vane-to-blade ratio characteristic quantity in noise-critical operating conditions of the turbine is between a lower cut-off limit for mode $k=-1$ of the double blade-passing frequency (2BPF) of this stage and an upper cut-off limit for mode $k=-2$ of the double blade-passing frequency (2BPF) of this stage.

With the aid of this preferred refinement of the present invention, it is also possible to minimize the noise emission with frequencies which correspond to the double blade-passing frequency.

According to another preferred refinement of the present invention, at least one of the stages of the turbine situated upstream in the flow direction is designed in such a way that its vane-to-blade ratio characteristic quantity under noise-critical operating conditions of the turbine is between a lower cut-off limit for mode $k=-1$ of the blade-passing frequency (BPF) of this stage and an upper cut-off limit for mode $k=-2$ of the blade-passing frequency (BPF) of this stage, and, furthermore, at least one of the stages of the turbine situated downstream in the flow direction is designed in such a way that its vane-to-blade ratio characteristic quantity under noise-critical operating conditions of the turbine is between a lower cut-off limit for mode $k=-1$ of the double blade-passing frequency (2BPF) of this stage and an upper cut-off limit for mode $k=-2$ of the double blade-passing frequency (2BPF) of this stage.

BRIEF DESCRIPTION OF THE DRAWING

Exemplary embodiments of the present invention are explained in greater detail on the basis of the drawing without being limited thereto.

FIG. **1** shows a diagram for illustrating the design according to the present invention of the vane-to-blade ratio of the stages of a turbine with regard to modes $k=-1$ and $k=-2$ of the blade-passing frequency (BPF), and

FIG. **2** shows a diagram for illustrating the design according to the present invention of the vane-to-blade ratio of the stages of a turbine with regard to modes $k=-1$, $k=-2$, and $k=-3$ of the double blade-passing frequency (2BPF).

DETAILED DESCRIPTION

The present invention is described in greater detail in the following with reference to FIGS. **1** and **2**.

The present invention relates to a design principle for the stages of a turbine, namely a low-pressure turbine of an aircraft engine. Such a low-pressure turbine includes multiple stages which are situated axially behind each other in the flow direction of the low-pressure turbine. Each stage is formed by a stationary guide vane ring and a rotating blade ring. The guide vane ring has multiple stationary guide vanes. The rotating blade ring of each stage has multiple rotating blades. The present invention relates to a design principle with which the vane-to-blade ratio of the stages of a low-pressure turbine may be adapted in such a way that the low-pressure turbine emits a noise level as low as possible, i.e., under noise-critical operating conditions of the turbine or the aircraft engine. Such noise-critical operating conditions are, for example, a landing approach of an aircraft or movement of the aircraft on the tarmac of an airport. The noise emitted is characterized by frequencies which are integral multiples of the blade-passing frequency (BPF).

According to the present invention, at least one stage of the low-pressure turbine is designed in such a way that under