VARIABLE GEOMETRY GUIDE VANE FOR A GAS TURBINE ENGINE

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates generally to aircraft gas turbine engines and particularly to a turbine inlet guide vane therefor.

2. Background Art

The operation of turbofan gas turbine engines is well known. Such engines include a serial arrangement of a fan, low and high-pressure compressors, a combustor, and high and low-pressure turbines. Air admitted into the inlet of the engine is compressed by the engine's compressor. The compressed air is then mixed with fuel in the engine's combustor and burned. The high-energy products of combustion of the burned air fuel mixture (often referred to a "hot gas" or "working fluid") then enter the turbine which extracts energy from the mixture in order to drive the compressor and fan. That energy extracted by the turbine above and beyond that necessary to drive the compressor and fan, exits the engine at the core engine exhaust nozzle thereof, producing thrust which powers the associated aircraft. A significant and usually much larger amount of additional thrust is produced by the fan which is driven by the low-pressure turbine, taking in ambient air and accelerating the air to produce the additional thrust.

In two-spool gas turbine engines, the high-pressure compressor and high-pressure turbine rotors are mounted on a first high-pressure shaft, while the low-pressure compressor and low-pressure turbine rotors are mounted on a second, low-pressure shaft which is received within the interior of the first shaft, concentric therewith. The two shafts are supported on several sets of bearings which in conventional engines are attached to and supported by various frame assemblies.

It is a continuing goal of gas turbine engine designers to reduce the weight of such engines without sacrificing the thrust output thereof. Recently, there has been an effort to reduce the weight of such engines by reducing the physical size thereof, making up for any reduction in flow area through the engine by an increase in shaft operating speeds. Thus, as modern engines become more compact for the amount of thrust they produce, there becomes less and less room within the interior of the engine to accommodate such structures as these individual bearing frames.

Recent innovations in gas turbine engines architecture have resulted in "mid-turbine frame" arrangements. In such mid-turbine frame arrangements, the most downstream bearing for the high pressure turbine is moved from radially inwardly of the engine's combustor, a location which, due to the compactness of modern engines, is no longer large enough to accommodate the bearing, to a location downstream thereof between the low and high pressure turbines. The most downstream bearing for the low pressure turbine shaft is moved in an upstream direction, closer to the high pressure shaft bearing so that both bearings may be supported by a single frame assembly and housed within a single bearing housing, thereby reducing engine weight substantially.

Such a mid-turbine frame arrangement requires a strut to transmit mechanical bearing loads from the bearing frame to the engine's case, typically, where the case attaches to a mount by which the engine is connected to an associated pylon and also to accommodate aerodynamic vibratory loading as well. This strut must therefor extend through the hot gas path between the high and low-pressure turbines where it is exposed to gas temperatures as high as 2000° F. or higher. Those skilled in the art will appreciate that accommodating

such high heat loads in those struts is critical. While making such struts hollow to accommodate the flow of cooling air therethrough may suggest itself, hollowing out such struts will necessarily weaken them, thereby detracting from the struts' ability to carry the high mechanical loads placed thereon by the bearings. Increasing the mass of the struts to handle such high mechanical bearing loads and accommodate the high thermal loading thereof as well, would necessarily severely increase the strut's weight and therefore be contrary, the goal of reducing the weight of the engine.

Also disposed within the hot gas path between the high and low-pressure turbines are inlet guide vanes. These are aerodynamic structures which turn the exhaust from the high-pressure turbine to an optimal direction for entry into the low-pressure turbine. Since such guide vanes only accommodate aerodynamic loading (both steady state and transient) from the gases passing through the turbine and not the much higher mechanical loading from the bearings as do the struts described hereinabove, such guide vanes tend not to be as mechanically robust as the struts.

It is the current practice to use separate struts and low-pressure turbine inlet guide vanes since the performance requirements of the two are so different. Using separate struts and inlet guide vanes imposes a significant restriction on the flow of working fluid from the high to the low-pressure turbine and adds significant weight to the engine. Accordingly, a combined strut and low-pressure turbine inlet guide vane would be desirable but, heretofore, the diverse load (aerodynamic and mechanical) and temperature handling requirements of those two components have rendered the integration thereof into a single component difficulty if not impossible to achieve.

DISCLOSURE OF THE INVENTION

The present invention comprises a variable geometry inlet guide vane which provides the necessary working gas flow alignment while accommodating the extreme mechanical loading from a mid-turbine bearing frame in a light weight and compact assembly.

The guide vane of the present invention includes an internal mechanical load carrying spar which effectively transmits bearing loads through the hot gas path to an engine mount, spaced internally from a lightweight variable geometry, aerodynamic shell which provides the necessary directional alignment of gas flow to an associated turbine or compressor throughout varying engine operating conditions (aerodynamic and vibrating loads). A gap between the spar and the shell may accommodate cooling airflow therethrough to cool the guide vane from the extreme heat loads present in gas flow when the guide vane is employed in conjunction with a turbine. The gap also accommodates an actuation mechanism which connects to the interior of the shell and when actuated, adjusts the aerodynamic shape of the shell. In the preferred embodiment the actuation mechanism comprises a cam-actuated, four bar linkage grounded to the spar and attached at, at least one output link thereof, to the interior of the shell. Movement of the output link adjusts the position of an associated portion of the aerodynamic shell, thereby adjusting the shape thereof to optimize load balancing between the pressure and suction surfaces thereof and to "tune" the shape of the shell to varying operating conditions of the engine to enhance the performance thereof.

To reinforce the spar and thereby minimize the mass required to accommodate thereof mechanical load, the spar is provided with stiffeners around its periphery to which the linkage may be grounded.