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COOLED TURBINE NOZZLE FOR HIGH TEMPERATURE TURBINE

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ABSTRACT OF THE DISCLOSURE

A hollow vane body has internal partitions dividing the vane interior into a plurality of radially extending regions including a centrally disposed plenum and separate passages intermediate the central plenum and the leading and trailing edges and the convex and concave side walls. A heat transfer fluid is introduced into the centrally disposed plenum and selected ones of the surrounding passages, from which the fluid is directed in an effective and efficient manner to adequately cool all portions of the vane body.

This invention relates to cooled stator structure for high temperature turbomachines and, more particularly, to a turbine nozzle diaphragm assembly having improved means for controlling and directing the flow of cooling fluid throughout the assembly. The invention especially relates to a turbine vane construction by which cooling fluid is distributed through the interior and over the exterior surfaces of the vane in an efficient and adequate manner.

It is well known that the efficiency of a gas turbine engine is related to the operating temperature of the turbine and that the efficiency may be increased, in theory, by increasing the operating temperature. As a practical matter, however, the maximum turbine operating temperature is limited by the high temperature capabilities of the various turbine elements. Since the engine efficiency is thus limited by temperature considerations, turbine designers have expended considerable effort toward increasing the high temperature capabilities of turbine elements, particularly the airfoil shaped vanes upon which high temperature combustion products impinge. Some increase in engine efficiency has been obtained by the development and use of new materials capable of withstanding higher temperatures. These new materials are not, however, generally capable of withstanding the extremely high temperatures desired in modern gas turbines. Consequently, various cooling arrangements for vanes have been devised for extending the upper operating temperature limit by keeping the vane material at the lower temperatures which it is capable of withstanding without pitting or burning out. As used herein, the term "vane" is a generic term referring to airfoil-shaped elements used in high temperature turbomachines. As such, the term applies not only to those members popularly known as vanes, but also to other airfoil shaped members commonly known as blades, buckets, etc.

Cooling of vanes is generally accomplished by providing internal flow passages within the vanes to accommodate the flow of a cooling fluid, the fluid typically being compressed air bled from either the compressor or the combustor. It is also well known that the engine efficiency theoretically possible is reduced by the extraction of cooling air. It is therefore imperative that cooling air be utilized effectively, lest the decrease in efficiency caused by the extraction of the air be greater than the increase resulting from the higher turbine operating temperature. In other words, the cooling system must be efficient from the standpoint of minimizing the quantity of

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cooling air required. It is also essential that all portions of the turbine vanes be cooled adequately. In particular, adequate cooling must be provided for the leading and trailing edges of the vanes, these portions being most adversely affected by the high temperature combustion gases.

It has been found that cooling configurations available in the past have tended to have deficiencies with respect to the foregoing requirements. Cooling systems which use minimum quantities of cooling air commonly fail to cool adequately all portions of the vane. As a result, a critical portion such as the leading edge may crack, burn out, or pit after a relatively short operating period. On the other hand, those systems which adequately cool all portions of the vane, including the leading and trailing edges, commonly require too much air for efficient overall engine performance, the reason being that the cooling air is not used efficiently. For example, an inefficient arrangement may direct the cooling air through the interior of the vane in a manner which results in the creation of low convection heat transfer coefficients or rates of heat transfer. Other characteristics, such as inadequate heat transfer area, can also prevent effective use of the cooling air.

The airfoil-shaped vanes are not, of course, the only turbine elements exposed to the high temperature combustion products. It will therefore be obvious to those skilled in the art that it may be desirable in practice to provide suitable cooling arrangements for other high temperature elements such as, for example, the circumferential band structures commonly used to interconnect the ends of nozzle vanes in a turbine diaphragm assembly. Similarly, cooling provisions may be required for ancillary turbine structure such as seals, shrouds, etc. With respect to the cooling of such elements, it will be appreciated that the above discussion relative to adequate and efficient use of cooling air is applicable to these elements as well as to vanes.

It is therefore an object of this invention to provide for high temperature turbomachines an improved vane structure by which cooling fluid is utilized in a highly efficient manner.

It is another object of this invention to provide for high temperature turbomachines an improved vane structure by which all portions of the vane are cooled adequately.

A further object of this invention is to provide an improved turbine nozzle diaphragm assembly having improved means for controlling and directing the flow of cooling fluid throughout the assembly in an adequate and efficient manner.

A still further object of this invention is to provide the foregoing objects in gas turbine structure that is durable and dependable in operation and relatively simple and inexpensive to manufacture.

Briefly stated, in carrying out the invention in one form, a hollow vane for use in a high temperature turbomachine includes partition means dividing the hollow interior of the vane into a plurality of radially extending heat transfer regions, the regions including a centrally disposed plenum, a leading edge plenum between the central plenum and the leading edge of the vane, and passage means between the central plenum and the side walls of the vane downstream of the leading edge. A cooling fluid such as air is supplied from one end of the vane to the central plenum and the passage means. From the central plenum, the cooling fluid is directed into the leading edge plenum as high velocity jets which impinge on the interior wall surfaces of the leading edge plenum to generate high rates, or coefficients, of convection heat transfer at the leading edge. The cooling fluid flowing through the passage means provides effective convection cooling of the mid-chord region of the vane, the