REMAINING LIFE ASSESSMENT

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In order to obtain a good estimate of the rotor blades and disk lives, the rotor blade and disk operating temperatures are required. The rotor blade airfoils can conservatively be estimated to be at the relative total temperature of the flowpath gas through the blades. The blade root and disk attachments can be estimated from a combination of the heat flow from the blades to the disk and from the blade root and disk exposed surfaces into the disk cavities. This leaves heat flow from the disk to the rotor shaft and cavities.

A simple schematic of a single stage power turbine or expander can be seen in Figure 1

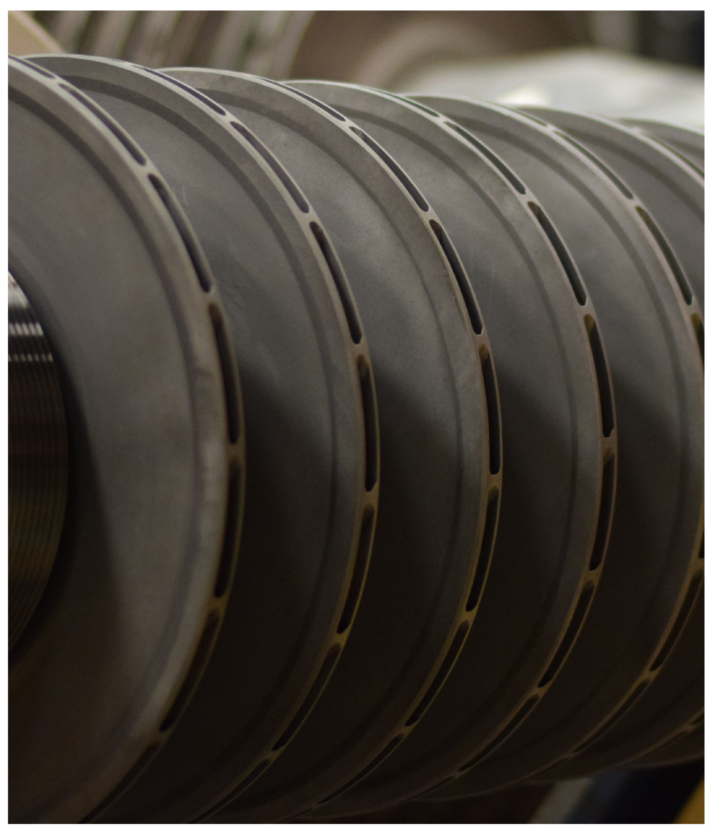
The calculated heat flow from the disk to the cavity (or from the cavity to the disk) is not particularly difficult, provided all of the flows and temperatures are defined. However, due to the complex thermal interactions and interdependencies in the disk cooling system, there can be a degree of uncertainty associated with the calculated disk temperatures that requires experienced judgment in the analysis. Of course, accurate measurements of actual disk or cavity temperatures will greatly reduce the uncertainty.

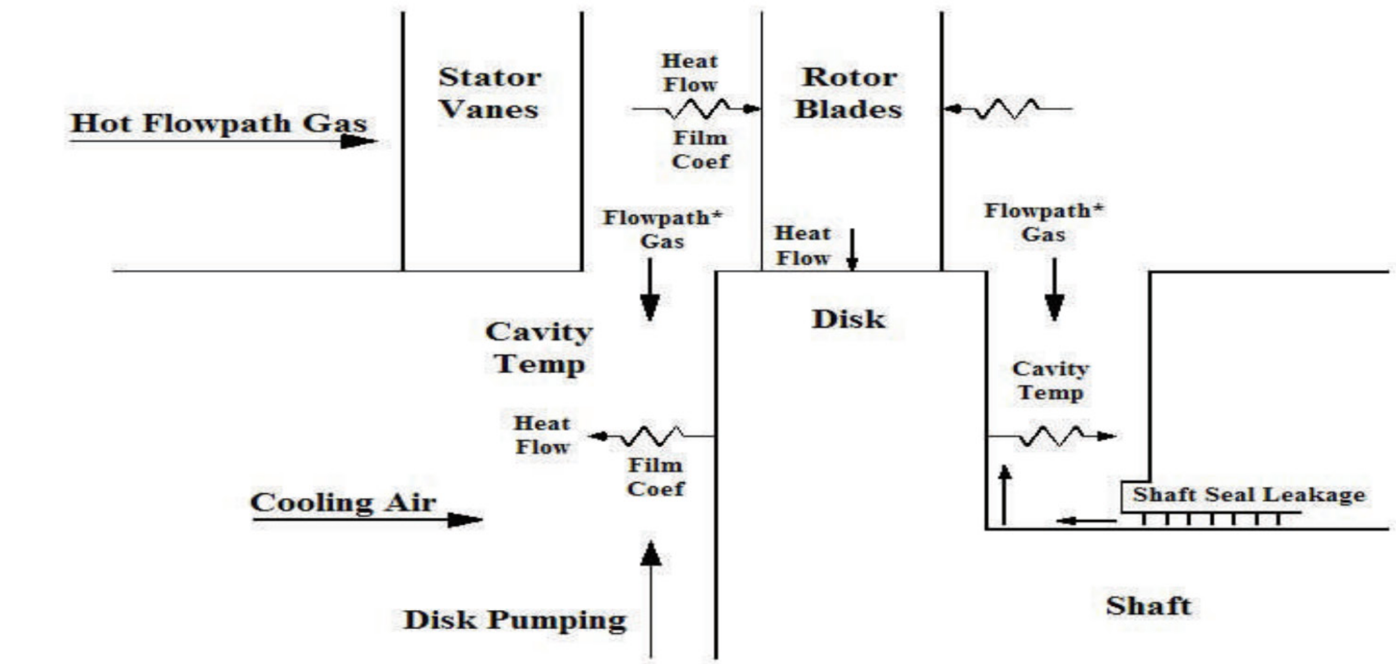
One of the more interesting aspects of the disk cavity thermal system is the effect of disk pumping. A disk rotating in a fluid is going to "pump" the fluid. That is, as a disk starts to spin, a film of fluid will start to flow along the disk due to viscous drag. However, in this case, instead of the fluid slowing the disk, the disk accelerates the fluid. At the same time, as the viscous drag is pulling the fluid in a circular direction (with the disk surface) inertial (mass) forces are adding a radial component to the fluid flow.

As the disk pumping action pulls fluid from the base of the disk, the pressure at the base starts to decrease and this causes fluid from the slightly higher pressure area away from the disk surface to flow to the disk base and, ultimately, up the disk face. In a system with no disk rim sealing, like that shown in Figure 1, the pumped flow enters the flowpath. If there is no source of fluid in the cavity to make up for the lost flow, the required flow is drawn in from the flowpath. Therefore, with no (or worn) seals, hot gas flow will enter the disk cavity at the same time cooler gas is leaving the cavity.

If fluid from some other source (cooling flow, for example) enters the cavity, that flow will also enter the "pumped" system and flow from the flowpath to the cavity will decrease. If the added flow equals or exceeds the disk-pumping requirement, no flowpath gas will enter the cavity.

The disk pumping rate, cavity fluid temperatures and disk surfaces temperatures all affect the heat flow from the disk to (or from) the cavity and all are necessary to estimate the disk film heat transfer coefficients used in the analysis. Therefore, the calculation of the disk temperature profile is an iterative process with each step yielding a better estimate (until the step-to-step temperatures no longer change).





* Leakage from Flowpath (Disk Pumping - Cooling Air). If the Cooling Air Flow Rate exceeds the Disk Pumping Flow Rate then there is No Leakage from the Flowpath.

Figure 1: A Simple Schematic of a Single stage power Turbine or Expander

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