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Preparation for Heat Transfer Analyses

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A significant amount of information is required in order to perform a heat transfer analysis on any type of component. By accumulating this information before you start into the analysis, the calculation itself can be completed in a smooth and efficient manner. This will hold true for a simple 1D hand calculation or a complex 3D finite element model. The following provides a checklist for accumulating the types of information you will need to provide the analyst in order to successfully complete the project.

1. Problem Definition: The most important information to have before starting the analysis project is a clear understanding of how the component is used and how the result will be used. This will determine the type of analysis that is needed. A component that must withstand severe transient thermal gradients which control stresses at life limiting locations will require a complex transient model. The airflow required to maintain the bulk temperature of a component, such as a motor, below a set value can be accomplished with a steady state hand calculation.

2. Component Description/Geometry: As a minimum, you will need the volumes and surface areas of the parts in question. Additional information that may be needed includes surface finish and contact pressures at mating surfaces. Also, as the parts become more complex the component geometry can be used to identify simplifications that can be made to the model. For example, a small fillet radius that may be important to the stress analysis will have no significant impact on the heat transfer and will complicate the generation of mesh to represent the part.

3. Materials and Properties: All materials used in the component must be identified in order to determine the thermal properties. The properties normally required are conductivity, specific heat, mass and surface emissivity. All materials must be considered. A coat of paint or oily dust can significantly change the emissivity and can provide sufficient insulation to slow the transient response.

4. Flow Systems: Most heat transfer problems involve some type of fluid flow system that can move heat energy into or out of the component. This can range from free convection cooling to complex pumped flow networks with separate heat exchangers. To complete the analysis, the heat transfer medium has to be identified (e.g. air, water, oil) and the flow network must be laid out and flow rates identified or calculated.

5. Heat Sources and Sinks: All sources and sinks need to be identified. The primary sources are usually easy, but more subtle sources may be present. Friction, as a heat source, should always be accounted for when moving parts or viscous flows are involved. In rotating components, pumping and windage can be significant. Solar heating and radiation to the night sky should be determined for any component operating outdoors.

6. Types of Heat Transfer: Four types of heat transfer define the system to be analyzed. These are conduction, forced convection, free convection and radiation. This step requires information from all of the above steps and is generally the most challenging part of the analyst's job when setting up boundary conditions.

The items given above are by no means an exhaustive listing of all details that are required by the heat transfer analyst, but it does cover the types of information required. Also, the dividing line between what is provided and what must be determined as part of the analysis becomes obscure in items 4 – 6. In item 4, the internal flows generally have to be determined by the analyst. In Item 5, friction, pumping and windage are calculated based on the component geometry, dynamics, and coolant flows. Item 6, setting up boundary conditions, is normally completely the job of the analyst.

By providing as much of the information covered above as possible, you will create a situation where you are paying your analyst to do analysis and not to search for information that should already be available.

About the author:

George Moore, PE has performed detailed heat transfer analysis on military and commercial jet engines for more than six years. Prior to that, he spent thirteen years modeling and analyzing heat transfer and fluid flow loss of coolant scenarios of US Naval nuclear power plants for the Bechtel Bettis laboratory (formerly operated by Westinghouse Electric).