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Heat transfer — it is involved in most every industrial problem

Heat transfer is what many of us remember as the awful subject we tried to avoid in college. Heat transfer is the study of the transportation of thermal energy when a temperature difference is present. Many researchers have devoted their careers to the study of heat transfer in many specific applications. Much of this research has provided a basis for real-world solutions.

Many times we desire to calculate the thermal conditions in static and rotating equipment for process and mechanical concerns. One can rarely look up a real-world problem in a heat-transfer handbook and directly solve the problem. The process of performing heat-transfer calculations most often involves the engineer calculating a heat-transfer film coefficient, which is essentially the coefficient that characterizes the transport of heat from a fluid medium to a solid over time and a surface.

So what do you do to calculate film coefficients in the real world? Providing that you or someone you know does not have a heat transfer reference to fit your situation, you will need to use one of the following methodologies:

1. Absolute analysis — This is sometimes called the university analysis and should only be used when you have lots of time, as you must conduct the research and derive the equations that fit the specific situation you are calculating.

2. Bracketed analysis — The bracketed analysis is like a ship firing a shell short and long for targeting purposes. After a few shots the gunner can close in on the location of the target. This thought process can apply to heat transfer as well. Most often in heat transfer we are looking for the worst-case situation. This methodology involves calculating using hand-derived or computer simulations to establish the lower and upper bound on process conditions and geometric responses and using that information to determine the operating range of a heat-transfer film coefficient.

3. Relative approach — This approach involves the establishment of the film coefficient based on known conditions and similar geometry. This might be at different operating or process conditions. It might also involve field data acquisition. Film coefficients are back-calculated based known conditions. Nondimensional parameters may be established and the condition of interest is evaluated. The trick for this methodology is to ensure that all parameters are accounted for. Many times this requires advanced experience in heat transfer. This technique is probably the most advanced and accurate for real-world industrial problems.

4. Computational fluid dynamics (CFD) — Using this tool one can model the fluid and solid sections of the area of interest and extract the heat transfer conditions. This is accurate, provided the engineer is experienced in CFD modeling. Many CFD users with more than 15 years of experience and a proven track record will tell you that you can get 10 engineers modeling the same problem in CFD and get 10 different answers. It is a good tool when used by an experienced person.

5. Field data acquisition — This involves measuring field parameters such as flows, pressures and temperatures in order to extract the hard data required to calculate the local film coefficient. Unfortunately, it is often difficult to take the measurements.

Watch out for the gremlins in heat transfer. A few tips are:

- Real-world gaps between parts that are calculated to be homogenous.
- Material properties varying with temperature.
- Calibration of field data acquisition equipment. Not necessary to the analyzer but ensures the accuracy of the probes in the process or mechanical component.
- Units — Heat transfer involves many different units and makes sure your units are consistent.
- Seek out a heat-transfer engineer with lots of gray hair to review your results, it will pay off.

Heat-transfer analysis is valuable in failure analysis and the design of rotating and static equipment. Many times, for projects that involve heat transfer-driven stress analysis, the correlations may vary the results as much as 50 percent and thus lead to false or incorrect conclusions.

As always, when performing or using heat-transfer analysis, have a professional engineer that is competent in heat and mass transfer to review and approve the results and conclusions of any analysis.

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