KNIGHTHAWK TECH NOTES

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Complex Heat Transfer Coefficients – They can be "Tricky"

In a major industrial complex there are many types of equipment. Most are broken down into on of two categories which are static (fixed) and rotating equipment. Much of the equipment operates at a high temperature and whether it is process or mechanical analysis, heat transfer is involved. Some of the equipment is well insulated and the process is such that the temperature is uniform and local thermal gradients are limited. For example, a storage tank may have a constant temperature. During startup of the tank the metal is heated up per Code and there are no real issues. But there are other situations where the thermal gradients are horrendous.

Take for example the analysis of the inlet to Transfer Line Exchangers (TLE). Usually the temperature is about 1550 ° F on the gas side and depending on the steam temperatures the shell side temperature might be around 625 °F. Now for many years, well before LSU won its first BCS national championship in football, there have been all sorts of correlations that have been developed. The correlations address the complex entry from the TLE inlet cone where the gas flows into the tubesheet. For the most part the correlations have been accurate. But the calculations assume uniform turbulent flow entering the far field. That is rarely or never the reality of the real problem. Sometimes "jet flow" will occur and it will hit the center of the tubesheet or a swirl action will occur from upstream elbows. The actual flow field can change the heat transfer film coefficient by as much as 40%. Therefore the local heat flux calculations that could lead to high strain are not accounted for. Well, computational fluid dynamics (CFD) comes to the rescue; not so fast. The algorithms that capture the local boundary conditions are no better than the programmer and theory used. The CFD solutions have to be tested against the "old timer" methods. In this case they must match the solution with the uniform turbulent flow in the "far field" that serves as a boundary.

Another example is in rotating equipment. This example involves the calculation of polymer lubricated bearings in gear pumps. This is about as complex as it gets. The heat flux is a function of shaft position, rpm, bearing unit load, and a few other items. But the real problem is the flux is highly local and dissipates over a short area. To make matters worse, the problem is non-Newtonian and the viscosity is a function of shear rate and local temperature. The exact solution to the problem is a non-linear iterative solution that includes the shaft location in the iteration. This problem has been approached with traditional and dimensional algorithms and the solutions are simply not correct.

One method that one may consider to handle complex heat transfer is as follows:

1. Perform the traditional hand calculations based on the information you have.
2. Develop a CFD model to compare to the hand calculations that are from the "old timer" methods. The CFD solution should be pretty close.
3. Next move to the a complex problem. Execute the problem with both hand calculations and CFD. The CFD should be more accurate, but in case you have diverged to a false solution you will catch it with the rough hand calculations.
4. Try to correlate the numerical model to a real world solution where data has been taken.
5. Always check, check, and recheck the solution.
6. Run a sensitivity analysis on the solution to determine the governing factors.
7. For the hand calculations an equation solver can be quit handy for iterative solutions with variable properties.

As with all complex work have the work reviewed and approved by a competent professional engineer in heat transfer.

KnightHawk Project Update

- Combustion CFD Analysis – Power
- Equipment Hydrotesting – Oil & Gas
- Clamping Connector Analysis – Petrochemical
- 3 Phase Separator CFD – Oil & Gas
- Critical Pipe Stress – Petrochemical
- Vertical Cast Transporter Failure – Nuclear Power
- Transient Fluid Dynamics – Petrochemical
- Valve Reverse Engineering – Oil & Gas
- Transfer Line Exchanger – Petrochemical
- Brittle Fracture Analysis – Petrochemical
- Fit for Service Analysis – Petrochemical
- Pipeline Hydro Testing – Oil & Gas
- Well Bore Flow Analysis – Oil & Gas
- Tensile Testing – Manufacturing
- Pump Vibration Analysis – Petrochemical
- Riser Stack Analysis – Offshore
- Gas Pipeline Coupling Failure – Oil & Gas
- Reciprocating Compressor Re-Design – Petrochemical
- Compressor Skid Pipe Stress – Petrochemical
- Pump Vibration Analysis – Petrochemical
- Vessel Destructive Testing – Oil & Gas
- Corrosion Analysis – Gas Pipeline
- Centrifugal Pump Rotor Reverse Engineering – Petrochemical
- Creep Tensile Testing – Communications
- Gasifier Equipment Design – Power
- High Temperature Molten Salt Tank Design – Green Energy

Cliff's Notes: KnightHawk Engineers have the expertise, tools, and equipment to get the job done. We have addressed complex heat transfer problems throughout industry in both static and rotating equipment.

We hope all of you got though the spring unaffected by the tornado weather patterns we are seeing. We are finally getting plenty of rain in Houston. I've even seen a few alligators in my canal behind my house that has kept the eco in balance (More gators, less ducks).

Take care and God Bless,

Cliff Knight

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