KNIGHTHAWK TECH NOTES

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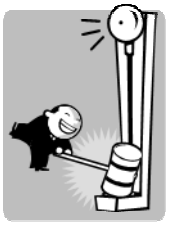
May, 2009 ***Issue 9.4***

"Refractory - Is It Working For You?"

Many types of process heat transfer static equipment require some form of refractory to isolate the metallic structural component from high heat. A typical installation would be a reactor with internal temperatures greater than 2000 °F. The metal temperature of the structural component might have a maximum design temperature of less than 650 °F. A typical refractory installation will consist of three or more refractory layers. Heat transfer paste or heat transfer paper will be installed between the refractory and the wall of the vessel. Analysis of the heat transfer to obtain a real world solution can be challenging.



Typical calculations involve determination of the heat transfer coefficients on the refractory hot face and the environmental ambient conditions outside the pressure vessel. Most often the refractory companies can provide detailed material properties such as thermal conductivity to calculate the heat load through the refractory. One consideration is the gaps between the reactor and the wall. During the cyclic life of a refractory it moves within the vessel. The heat transfer paste and/or paper might not always cover the full range of movement over time. The movement might be in a ratcheting manner that could cause overstress of the refractory in time or lead to local hot spots within the vessel. Sometimes the refractory might crack to relieve its overload and still have useful life.

Some of the challenges in the heat transfer calculations involve what is called "gap heat transfer"; this is just like it sounds - the heat transfer through the gaps. Radiation, conduction, and convection through these gaps transport heat.

The finite element method can be employed to calculate the "real world picture" of a refractory problem. A sensitivity study can be conducted on the gap elements to determine the operating range for the physical properties of the gap elements. Measurements taken in the field can be used to calibrate the physical properties of the "gap" interface elements. These gaps traditionally have always been the "fly in the ointment" when it comes to the development of a successful heat transfer model with refractory.

The other side of the coin is the structural analysis of the refractory. This too can be accomplished using the finite element method. The response of refractory is not the same as metal. It exhibits movement as a complete unit consisting of several types of refractory and "gaps" that can behave anisotropicly. This simply means that things aren't the same in all directions. Like many structures, thermal expansion is a factor in refractory design. Typically it will not grow as much as metal and therefore the "gaps" get bigger. Sometimes expansion joints must be incorporated into the design to account for the differences between the growth of the metal structures and the refractory. It is sometimes a practice to use supports like a spring and expansion joint to insure the refractory will not be overstressed.

While a good refractory design will work for you. A good design will incorporate the metal, supports, gaps, all refractory materials, and any heat transfer interface material in the gaps.

A methodology for installation of refractory should include the following:

1. Make sure the refractory is designed for the process. Considerations would be, but not limited to, corrosion and hot erosion of the hot face. Make sure the fluid velocities are calculated. Testing in pilot units or actual production units would be advisable.
2. Perform a rough heat transfer analysis of the system.
3. Perform preliminary sizing of the heat transfer internals.
4. Make sure embedded anchors can "take the heat".
5. Perform a structural analysis to account for the expansion and heat transfer. Don't forget about seismic analysis as you would not want the refractory to loosen up during a seismic event.
6. Final detailed heat transfer analysis.
7. Final structural analysis.

The analysis should be reviewed by a professional engineering competent in refractory systems.

Cliff's Notes:

Our team has a long history of analyzing and designing refractory systems where the heat transfer and structural integrity is challenging. Call us and we can explain how we can help you by lessening your challenge.

I hope everyone had a great spring break. In Houston, I believe we have had our last cool days before the hot humid summer sets in. So try to stay cool, have a great time, and don't forget to enjoy your family.

Cliff Knight

KnightHawk Project Update

- Hot Oil Heat Exchanger Failure – Refining
- Transfer Line Exchanger Analysis –Petrochemical
- Skid Design – Off Shore
- Vessel Failure – refinery
- Reactor Failure – Petrochemical
- Compressor Failure – Petrochemical
- Reverse Engineering Pump – Off Shore
- Fan Vibration – Nuclear
- Open Faced Compressor Impeller – Gas Plant
- Metallurgical Analysis of Failed Valve Parts – Petrochemical
- Turboexpander Failure Analysis – Gas Plant
- Bearing Design – Heavy Manufacturing
- Mechanical equipment design – Off Shore
- Gear Drive Failure – Petrochemical
- Valve Failure – Petrochemical
- Structural Dynamics – Petrochemical
- Ring Header Failure Analysis & Redesign – Petrochemical
- Gasifier Process Analysis – Petrochemical
- Reactor Fit for Service – Petrochemical
- Furnace Failures – Petrochemical
- Waste Heat Boiler Failure – Petrochemical
- Casting Failure High Temp Application – Petrochemical
- Compressor Reverse Engineering & Analysis – Offshore
- Rotordynamics Analysis – Offshore
- Surge Drum Vibration Analysis – Petrochemical
- Clinker Grinder Design Assessment – Petrochemical
- Compress wreck – Offshore
- Syngas Heat Exchanger Design Assessment – Petrochemical
- Thermosyphon Analysis - Petrochemical
- Pump Impeller Reverse Engineering – Manufacturing
- Fire Tube Boiler FFS – FFS -1/ API 579
- Pump Impeller Metallurgical Failure Analysis – Manufacturing
- Flange Leak Analysis – Off Shore
- Fitness for Service Waste Heat Boiler – Petrochemical
- Thermosyphon Analysis - Petrochemical
- Vessel Fluid Dynamics