KNIGHTHAWK TECH NOTES

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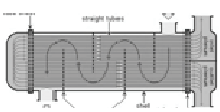
# "Blindly Using the ASME Code"

You are working in one of the largest ethylene plants in the world and production is sold out. It is Friday evening and about quitting time and the A operators call you to the control room. The operators point out a sudden outlet temperature drop on the tube side of a heat exchanger with constant inlet temperature. It is a sure sign there has been another tube failure. This has been the third failure in two months since the replacement heat exchangers were installed.

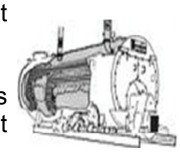
The inlet tubesheet is a high heat flux design and requires special design work to get the job done right. The company got bids from all major heat exchanger companies and, of course, the cheapest bidder got the job. The engineering contractor issued specifications requiring finite element modeling of the inlet tubesheet. The inlet tubesheet design has a strength weld with the fit to be rolled. The maintenance and process conditions were reviewed and showed no indication of a maintenance or operations problem. So, after a thorough review, the fingers started pointing at design.



There were several problems with the analysis of the transfer line exchanger.

1. The waterside shell heat transfer coefficient was incorrectly calculated. It did not consider the magnetite layer that forms and was far too high for the application. In addition, the waterside film coefficient was not a function of heat flux as it should be.
2. The second problem with the design was the gas side heat transfer coefficient was incorrectly calculated. It did not properly consider turbulent entry effects that greatly increase the local heat flux. The calculations also did not consider the "jetting" effect of the flow entering the TLE. This can increase the local heat flux as much as 15%.
3. In addition, the designer improperly specified the length of blow down. Operations did follow the procedure but it was dead wrong. The transient pressure/momentum conditions at blow down would cause local "flashoff" and lead to film boiling.
4. However, the worst part of the design was the analysis of the rolled and welded joint. The engineering company, an expert in finite element analysis and the new Codes, improperly modeled the unit as a homogenous unit. A rolled and welded tube to tubesheet joint does not act like a solid unit. In fact, over time, the joint will loosen up and "gaps" will form. This leads to crevice corrosion and boiling. The expected life of a unit can be reduced as much as 15 years. In finite element analysis, there are many procedures applied. Most of them are based on experience and some are based on guidance within the rules.

In the end, the problem with these units was poor design. While the units looked good on paper, their design was based on improper interpretation and implementation of the rules and therefore, did not meet Code.



When KnightHawk models high heat flux waste heat boilers, we consider the following.

1. Waterside heat transfer film coefficients based on the magnetite layer and local heat flux. KnightHawk varies the film coefficients based on local conditions.
2. KnightHawk bases the gas side film coefficients on a computational fluid dynamics model to ensure the local entry coefficients are correctly calculated.
3. KnightHawk executes a detailed thermosyphon model to ensure the circulation ratio meets specification. KnightHawk's program considers two-phase flow conditions with slip.
4. Most importantly, KnightHawk models the rolled and welded joint as it was built and as it behaves in the unit. The results are realistic and meet production conditions.

It is notable that the top three vendors in high heat flux transfer line exchangers do not use rolled and welded joints. They all use gapless welds to prevent the degradation of the unit over time.

High heat flux inlet tubesheets should be reviewed and approved by a Professional Engineer who is competent in the field.

## *Cliff's Notes:*

KnightHawk has evaluated over 500 high heat flux systems and performed design audits on every major unit in every major application. KnightHawk has also patented equipment to improve the design. KnightHawk can perform the complete computational fluid dynamics of the gas and waterside. In addition, KnightHawk can develop the most complex realistic non-linear elastic plastic model that includes creep. We typically look at 4 to 5 major systems per year. In addition, KnightHawk has its own field-tested software for complex parallel downcomers and risers.

On a side note, the Saints won the super bowl. What can I say, I am a lifelong Saints fan and it finally happened. Yeah…….2010 is off to a good start for KnightHawk. We have just received a major "green" project in Arizona, looking at ground-breaking large scale heat recovery systems in the solar industry.

*Cliff Knight*

## *KnightHawk Project Update*

- Turbocharger Failure Analysis - Railroad
- Turboexpander Failure Analysis - Gas Plant
- Gear Drive Failure Analysis - Petrochemical
- Vessel Failure Analysis - Refinery
- Reactor Failure Analysis - Petrochemical
- Main Oil Pump Failure Analysis- Petrochemical
- Gas Turbine Failure Analysis - Refinery
- CFD Ethylene Furnace - Petrochemical
- TLE Failure Analysis - Petrochemical
- Oxidizer Failure and Redesign - Petrochemical
- Inlet Cone Design for TLE's – Petrochemical
- Bearing Design - Heavy Manufacturing
- Vaporizer Design - Petrochem
- Mechanical Equipment Design - Off Shore
- Transient Fluid Dynamics - Petrochemical
- Waste Heat Boiler Failure - Petrochemical
- Liquids & Solids Separation Technology Development - Coal
- Vessel Nozzle Fitness for Service - Power
- Waste Heat Boiler FFS- Petrochemical
- Titanium Tower FFS Analysis- Petrochemical
- Flange Leak - Off Shore
- Thermosyphon Analysis - Petrochemical
- Waste Heat Boiler Audit - Petrochemical Middle East