KNIGHTHAWK TECH NOTES

PHONE: (281) 282-9200 • FAX: (281) 282-9333

WEBSITE: www.knighthawk.com

April, 2017 *Issue 17.02*

"Transient Loadings – They may be the Peak Loadings!"

Often in a process, data is taken and averaged over a matter of minutes or even hours. The fact is a detrimental transient forcing function may be present that is causing you all the problems. But you just can't see it or have no proof. You may need to capture the field data on a millisecond basis to help a qualified team to determine the root cause.

Many times when we are designing static and rotating equipment, it starts with a specifications sheet that lists the performance expectations and requirements. Most often it is the case that any startup or shutdown requirements are not listed. For static equipment this could be heat up rates or sequencing of process feeds to the equipment. For rotating equipment it could be ramping conditions through critical speeds. Many times, during a startup of a plant, opportunities for relatively high transient loadings are present. Let's discuss a few examples to "home in" on some design considerations.

The first example is the heat up rate of thick walled reactors and heat exchangers. When these components heat up localized thermal gradients produce stresses. If the firing rate of the equipment is too quick, the thermal gradient induced can cause detrimental stress to the vessel. You might wonder how this can happen if the peak temperature is not reached. Well, the key is to look at the transient heat transfer. The firing rate will be dependent on the process fluid conditions, geometry, and materials. Many times the surface on the "hot side" will heat up fast and the outer surfaces will remain colder due to thermal lag. Because of this, the transient thermal gradient can be higher than steady state. Another situation involves the startup of rotating equipment. Many times a compressor or turbine is "false loaded" to bring the system on line. During these periods there can be performance issues that can affect the equipment. Dynamic stresses during startup can be higher than normal. Also, for compressors there can be transient loads involving the loss of cooling on intercoolers. Sometimes, the process fluid properties change during startup due to yield achieved. This can also lead to response changes in the equipment. Sometimes polymer equipment has polymer-lubricated bearings that interacts with heat, speed, and differential pressure and it affects the bearing performance.

Most of the startup issues discussed are not analyzed during the process and detailed design phase of the plant. In the past, many of these situations were too difficult to analyze, so trial and error and experience was used to determine startup procedures. This is no longer the case for many applications. Where in the past transient process and mechanical analysis was very rare, it is now conducted on a regular basis. The reason is due to faster computers, better numerical methods, and economical solution methodologies.

The solution methodology for startup analysis of static equipment might be as follows:

1. Develop a finite element (FE) model of the equipment.
2. Calculate the transient heat transfer film coefficients, that is film coefficient versus time.
3. Perform a transient heat transfer FE analysis
4. Perform a transient stress FE analysis.

The solution methodology for simulation of intercooler failure for a compressor might be as follows:

1. Set up parameters of compressor performance model.
2. Evaluate the transient heat transfer in the intercooler.
3. Forward step the compressor performance model in time simulating the loss of cooling.

Remember the peak stresses are not always the steady state stresses. Don't let it "bite" you. New methodologies and tools can tell you what you need to know to operate your equipment safely and reliably.

Cliff's Notes:

KnightHawk is frequently contracted to perform root cause failure analysis where there is limited data and it just seems impossible to figure out what the root cause is. To do this work, KnightHawk will typically do a Phase 1 engineering assessment. Phase 1 is generally a lump sum cost. Phase 2 will contain the detailed work required to determine the root cause. KnightHawk has perfected a root cause methodology involving multidiscipline analysis. Also, don't forget, we have a metallurgical and materials lab to look at the failed parts to characterize the failure. In addition we have a field services group to look at vibration, dynamic pressure, flow and acoustics. Again, we are a one stop shop.

I hope everyone had a Blessed Easter and are enjoying the spring weather.

Take care and God Bless,

Cliff Knight

cknight@knighthawk.com

KnightHawk Project Update

- Rotordynamics of a centrifugal compressor
- Steam Turbine Failure Analysis
- Failed tank investigation
- Finite Element Analysis of reactor jacket
- Check Valve Testing
- Thermal Oxidizer Feed Mixing CFD
- Rail Car Pressure Containment FFS
- Heat Exchanger Rerate Analysis
- Furnace Ethane Feed Optimization
- Pipe stress analysis of large bore piping system
- Coker Furnace Outlet Piping Non-Linear Creep Stress Analysis
- Vessel Code Calculations
- Heat Exchanger Diaphragm Failure
- Storage Rack System FFS
- Fan Vibration Field Services
- Reverse Engineering of Medical Devise
- PMI and Materials Consulting
- Boiler Tube Failure Analysis
- Silo Rerate Analysis
- Brittle Fracture Analysis