KNIGHTHAWK TECH NOTES

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"Will the Fracture last……?"

You are the maintenance reliability engineer at one of the largest smelting facilities in the world. The main air compressor once again went through a surge and/or stall event due to failed inlet

guide vanes. When you arrive at the control room you find all is stable, but you are reminded of micro-cracks found in the 3rd stage impeller and wonder if the end is near. The plant does not have a planned outage scheduled for the next six months.

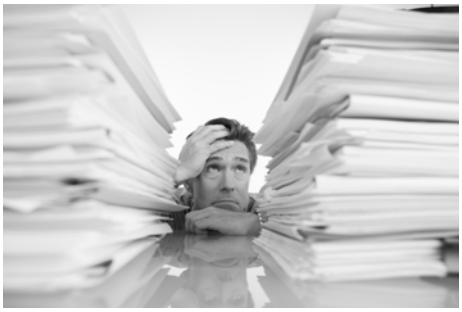
The plant manger asks you whether the plant should shut down and inspect the impeller. He asks that you and your team make this critical decision as soon as possible so the shutdown plans can be made if things or looking bad. An unplanned shutdown would no doubt cost millions in profits and affect the company bottom line.

There are many considerations in making this decision which are but not limited to the following:

1. Operations History – The actual run history may be considered. Does it have a history of cracks and what has been the mean time between failures with these cracks?
2. Risk Management – What are the safety and/or environmental risks associated with a failure.
3. Mechanical Design – Where are the cracks located? What is the impeller blade loading? What is the mean stress in the affected area?
4. Metallurgical and materials
   a. What has been the morphology of the cracks from a historical prospective? Stress corrosion cracking for example.
   b. How is the endurance limit affected by the environmental conditions?
5. Fracture mechanics – The impeller experienced surge/shock conditions and there is a question as to how the cracks would be affected.

The real question is whether or not the existing cracks will grow or not. Well, since the compressor is still running it is very likely that the cracks did not grow much if any, or in a way that was effected by steady state operation. If the cracks were getting worse under steady state conditions it would likely fail quickly due to the rpm of the impeller. Also, if the cracks were directly tied into any reverse loading from normal operation it would have already failed. Based on this line of thinking, one might rule out any major short term effect. Not so fast, there could be longer term effects involved in the crack propagation. This could be due to the sustained loading from the centrifugal load.

A fracture mechanics model should be considered when looking at the likelihood of failure. The question would be whether the analysis should be under elastic or plastic conditions. It is important to understand how the environmental conditions are affecting the cracks. Is it brittle or more ductile or in other words what is the fracture toughness estimated to be?



The solution methodology for this problem would rely heavily on the fracture mechanics, metallurgical, and detailed finite element models. The uncertainty of the environment would also be considered in the problem.

The end result of the work is that a safe and logical decision can be based on analysis and risk assessment of the results. Much valuable information can be gained, allowing for a better data based decision, rather than hip shooting. In any case the work should be evaluated by a professional engineering competent in fracture mechanics on "real world" problems.

Cliff's Notes: KnightHawk has worked many fracture mechanics problems both in static and rotating equipment. Our team is a one stop shop for both the materials and metallurgical analysis and specialty engineering to develop the numerical models. There is nothing that beats the practical experience of solving real world problems in the field and KnightHawk has one of the best reputations in the business for solving the most complex problems. KnightHawk has worked Class 1 Nuclear problems to complex challenges for DARPA (Defense Advanced Projects Agency) and I am confident we can help with yours.

I hope everyone has had a wonderful 4th of July. Our thoughts and prayers are still and will continue to be with those affected by the oil spill. And they are always with our soldiers fighting in Iraq and Afghanistan.

God Bless you and we look forward to working with you to solve your toughest challenges.

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KnightHawk Project Update

- Coupling Failure – Gas Pipe Line
- Bolting Failure – Automotive
- Centrifugal Compressor Failure Analysis – Petrochemical
- Gear Drive Failure Analysis - Petrochemical
- Cryogenic Tank Fit for Service – Petrochemical
- Flare System Analysis – Petrochemical
- Reactor Failure Analysis – Petrochemical
- Oxidizer Redesign – Petrochemical
- Water Pump Failure Analysis – Nuclear Power
- Flow Meter Failure Analysis – Petrochemical
- Gasifier Equipment Design – Power
- Pump Vibration Analysis – Petrochemical
- Reverse Engineering – Manufacturing
- High Temperature Molten Salt Tank Design – Green Energy
- Tool Failure Analysis – Offshore
- CFD Ethylene Furnace – Petrochemical
- TLE Fit for Service Analysis - Petrochemical
- Oxidizer Redesign – Petrochemical
- Inlet Cone Design for TLE's - Petrochemical
- Bearing Design – Heavy Manufacturing
- Vaporizer Design – Petrochemical
- Mechanical Equipment Design – Off Shore
- Transient Fluid Dynamics – Petrochemical
- Waste Heat Boiler Failure – Petrochemical
- Liquids & Solids Separation Technology Development – Coal
- Furnace Feed Header Analysis – Petrochemical