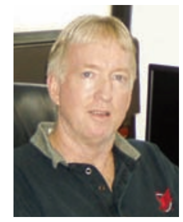
By: CLIFF KNIGHT, Owner/President
KnightHawk Engineering



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 microcracks found in the third 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 are looking bad. An unplanned shutdown would no doubt cost millions in profits and affect the company's bottom line.

There are many considerations in making this decision, which include but are 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 — What has been the morphology of the cracks from a historical prospective? Stress corrosion cracking for example. How is the endurance limit affected by the environmental conditions?

5. Fracture mechanics — The impeller experienced surge and 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. 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 affected by steady state operation. If the cracks were getting worse under steady state conditions it would likely fail quickly due to the revolutions per minute 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? 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. You can gain much valuable information, allowing for a better data based decision, rather than hip shooting. In any case, the work should be evaluated by a professional engineer competent in fracture mechanics on "real world" problems.

For more information, visit www.knighthawk.com or call (281) 282-9200. ●