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Transient local flow instability

It is another day at the plant. You are a production engineer responsible for a process unit at a world-class production facility, and once again your area has been discussed at the morning meeting. During a certain period of operation the critical turbo expander trips on high vibration, and this expander has even experienced a blade failure on one occasion. You have had the equipment looked at by your internal group as well as several consultants, and no problems with equipment have been identified. Your team has checked the alignment, balanced the machine, and so on and so forth. By all accounts the equipment should not be behaving in this manner, but "it is what it is." The boss wants the problem solved, and so you put together an investigative team.

In this problem the machinery engineers have looked at the equipment and you are quite certain some phenomena is going on. The question in your mind is, "Who needs to be on the team?" The answer lies in capturing all of the physics that governs the machine. In this particular case the piping design, mechanical equipment design, materials, process and process control are all factors. Therefore, a good team for this situation may look like this:

1. Process engineer
2. Production engineer
3. Metallurgical and materials engineer
4. Mechanical piping engineer
5. Machinery engineer
6. Controls engineer
7. Operators
8. "Troubleshooter"
9. Investigative facilitator

Several investigative techniques are available, but in general the facilitator executes a particular one. At KnightHawk we have our own, which we use in-house for failure investigations, that we call the integrated systems approach. One of the "wild cards" in the investigation is the troubleshooter. This is typically an individual who has worked many investigations and has a gift for handling multidiscipline physics. Some of the key items the group would look at include the following:

1. It is important to look at time history data. In this case multiple events are to be considered, so trying to identify a correlation, or pattern, between the events is important.

2. Characterization of the fracture surface is important. In the only case of failure with this equipment the fracture had striations indicating fatigue, and then ductile overload when the blade tip broke off.

3. Next it's important to consider where the equipment is running on the performance curves, so a process analysis is important.

The key to the investigation is the equipment had experienced high cycle fatigue. This suggests a forcing function is present, and could possibly raise the question of a transient event. The unit runs smoothly most of the time, so it is important to identify what can cause a transient event, and how its effects can get to the impeller. After the team explores this for a period of time, it is discovered a control valve upstream of the turbo expander may be the culprit. During every event with this equipment a process change had occurred upstream, and the control valve oscillated to correct for this change, ensuring the turbo expander had the right process feed conditions. The other issue found was the inlet piping had an elbow too close to the inlet. Even under the best conditions uniform flow was not entering the expander. Therefore, any disturbance upstream, such as an oscillating control valve, could cause pressure pulses that would lead to detrimental transient pressure/momentum conditions. As it turned out, this was the root cause of the problem described in this case study. A contributing factor to the problem was poor inlet pipe conditions. A relatively easy fix would solve the problems identified in this example.

To validate the cause of the problem, dynamic pressure transducers should be installed near the control valve and at the turbo expander. The dynamic event would be captured and conclusive evidence of the problem obtained. The fix should also be validated in the same way.

These types of problems are often complex and challenging and should be reviewed and approved by a professional engineer with experience in these type problems.

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