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Two-phase flow — A vibration culprit?

Your plant has been experiencing slugging problems in one of the plant process units. The slugging occurs at random and no one is sure of the source. Sometimes it takes the form of random vibration that comes and goes. The process is continuous and it makes no sense at all why it would come and go after the entire unit runs a steady 98 percent of design capacity and there are no upsets. This slugging causes pressure waves up and down the system that affect the process control. The operators are having to fight the system to get back to where it needs to be. Leaks in the system have occurred and sometimes failure has occurred where the unit had to be shut down. All of the experts have been called in to fix the problem. The mechanical group has run one vibration study after another and no problems are ever found. Metallurgical analysis of all of the failures reveals bending fatigue and subsequent ductile overload. Everyone is frustrated as to the source of the problems. You are in the conference room and the plant manager tells you to solve the problem and now you are under the gun.

You bring all of the players into one room. The results of each group are as follows:

1. Metallurgy is OK.
2. Mechanical design is OK.
3. Process is OK and operating within design limits.
4. Control is OK.

At this time you are shaking your head. Everything has been evaluated and still nothing is found. As you look at the problem, you go back to the basics. First, the vibration and slugging does not happen all the time so you now convince yourself it must be some sort of transient event. But the equipment is operating under steady state conditions and this puzzles you as to the source of the problem. You are beginning to believe you have a real mystery on your hands. Now it's time to hit this hard. You go back and talk to the operators again and find out this problem goes and comes during certain times of the year. Furthermore, you find out this happens during the day on hot days. Now you finally have something to work with. At this point you have set things up with the operators to call you when things start to rock and roll. Sure enough you are called in and can finally see what is happening.

Through execution of a field study, you find out the vibration is caused by a slipstream injection off a process that is being cooled by fin fan coolers. The coolers were slightly undersized when the plant is running up to nearly 100-percent capacity, which is up from the normal 90 percent. During the higher flow process conditions and high ambient temperatures, a low pressure zone on the backside of a control value flashes out some constituents, causing a pressure pulse in the system that initiates the vibration and slugging.

What was described above occurs many times in industry. During the design and initial operation of the plant facility, it is difficult to consider all of the transient events that may or may not occur. A typical methodology for these types of problems is:

- Characterize the vibration through execution of a field study. This may be tricky if the event is transient.
- Capture the process conditions at the time of the event when and/or if possible. A historian temporarily set for high speed data capture is very useful here.
- Review the structural dynamics of the system. This includes all equipment, the piping and support systems.
- On hardware, control valves, mixers, orifices or check valves — upstream of the vibration — consider the local flow effects. In the case above, consider low flow zones leading to flashing.
- Perform a fluid dynamics study using computational fluid dynamics tools to identify low flow and recirculation zones.
- Calculate any driving forces.
- Perform a transient forced vibration analysis.

Typically, solutions are available from the structural end or the process side. The most economical way of fixing these problems is usually from the process side. In all cases, have a professional engineer competent in these problems review and confirm the study and proposed solution.

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