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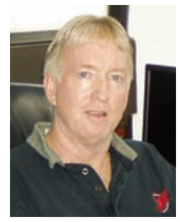

Bulk flow through process equipment — Is it really the case?

You are sizing a pump, compressor, turbine, heat exchanger, reactor, pressure vessel, furnace coil, etc., and almost always a flow rate is involved. Most often you will use the bulk flow. Bulk flow represents the average flow conditions. Bulk flow conditions are frequently not the culprit when handling challenging design or failure analysis issues. If something failed due to a problem with bulk flow conditions it is most likely due to a gross mismatch of application. When a boxer in a ring is fighting, he is not worried about the average force of his opponent's punch. He is worried about the transient impulse that could knock him out. In industry we use bulk flow analysis typically for design and for first checks in failure analysis and troubleshooting. When and how do we decide to go further? Well, you might ask, what do you mean go further? Further means to consider actual flow fields that might even be transient.

The best way might be to look at a few examples.

Pump cavitation: There was a process pump in operation and experienced what was believed to be cavitation. The net positive suction head requirements were found to be met. The pump was operating within its performance ranges. The cavitation appeared to occur at different times of the day. The fluid was pumped into an air to process fin-fan exchanger. Finally the actual flow field was evaluated and determined that a local low-pressure zone downstream of an inlet guides vain caused flashing. The lower fin-fan efficiency due to the air heating up in the daytime led to the flashing. This was determined from computational fluid dynamics.

Pipe vibration: A piping system was vibrating. Bulk flow analysis and conditions showed that there should be no two-phase flow. The vibration was believed to be flow induced. A popping noise was present, suggesting two-phase flow conditions. The problem was found to be again a low flow zone causing flashing of the process. This was determined through computational fluid dynamics.

Erosion problem: A mechanical component was experiencing erosion. It made no sense because the bulk velocities were low. Not so! A computational fluid dynamics study revealed that local flow conditions caused the velocity to be four times the bulk flow. Since erosion is a function of velocity squared, the component eroded.

Vessel hot spot: A vessel had a hot spot. Heat transfer conditions were calculated based on bulk flow. Local flow conditions led to a high heat flux in a local area of the vessel. Again the problem was solved based on computational fluid dynamics analysis.

A question was asked earlier: "When do you decide to go further?" Well it is when you have applications with known problems; bulk flow analysis does not solve the problem, or just good old engineering judgment.

Typical transient load conditions that may occur in static and rotating equipment include, but not limited to:

- Fluid flashing.
- Acoustical vibration.
- Thermal gradients.
- Choke flow.
- Two-phase flow develops unexpectedly.
- Structural resonance.
- Foreign matter entering the equipment.

Over the past nearly 20 years KnightHawk has analyzed many types of process equipment that have failed. It has been rare that there was a direct design issue when properly following codes. It has been a transient that was in the process that was not accounted for in the design of the equipment.

Designers can now model numerically and predict the response of the furnace.

It is typical to have a review to determine all the process conditions that may exist for equipment. It may take the form of mechanical and process reviews such as HAZOPs. In any case it is recommended that any new piece of equipment that is critical to an operation be audited by a professional engineering team competent in that equipment.

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