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Header flow maldistribution — Can it hurt you, do you know it?

You are walking out into Complex B just recently built, at your petrochemical complex. Complex A has been running for several years with no problems. In fact, it was running so good that management elected to duplicate Complex A for the design of Complex B. But as always the new plant offered an opportunity to debottleneck a few areas and realize maximum capacity and efficiency of the unit.

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This makes the bean counters happy and it just squeaks the project by for approval. Here comes the project team all ready to achieve goals and objectives. In the process a header feeds four boilers. One of the boilers has failed and you are wondering how this can be, it is a sister unit with all the same major equipment.

Your materials group has said the problem is low cycle thermal fatigue causing the failures and your process group says everything is OK. The material is the same as what is being used in Complex A. All the experts in every area are telling you there are no problems and the unit should not fail. Some experts are concluding that it must be the operators letting the process swing through a transient too rapidly. The operators are angry because they know they have been operating the plant correctly and the plant manager is breathing down your neck just as everyone is telling you there is nothing wrong with the design.

Although Complex A and B are sister units, the only difference is the feed rate has changed by only 10 percent but it is still within the boilers name plate, with room to spare. What could be the problem? While sitting in your front office watching the sprinkler system come on it hits you. You have always observed some of your sprinkler heads being starved because of an insufficient header size. What about the feed header at Complex B?

Well, as it turns out, the problem was caused by a header maldistribution due to the header configuration and flow. Process calculations showed that based on the frictional pressure drop the header should be OK. But computational fluid dynamics (CFD) showed the dynamic head recovery in the header was high enough to cause a maldistribution. Once a certain flow was reached this maldistribution would starve certain parts of the system, causing overheating.

Header design is important for all kinds of process equipment, such as pumps, compressors and heat exchangers. There are general rules for sizing that work well depending on fluid velocities and density, but be sure to perform the following steps:

- Lay out the design in accordance with normal process guidelines.
- Position the inlet in the most strategic and symmetrical location.
- Calculate the frictional pressure drop and the dynamic head. Make sure the dynamic head is not a detrimental player.
- Perform a CFD study of the header to validate the design. Make any changes required. The CFD study will account for total flow conditions including local inertia effects.
- Have the design reviewed by a professional engineer competent in header design.

KnightHawk Engineering (KHE) has found the maldistribution present involving selective linear exchangers and primary quench exchangers in ethylene units. In these projects it is important to consider the thermosyphon and thermodynamic stability of the system. KHE has its own proprietary software that considers parallel two-phase flow in thermodynamic systems. This is used in conjunction with computational fluid dynamics to determine if a problem exists.

As always a design should be reviewed by a registered professional engineer competent in the field.

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