Need for Analyzing Cooling Water Networks

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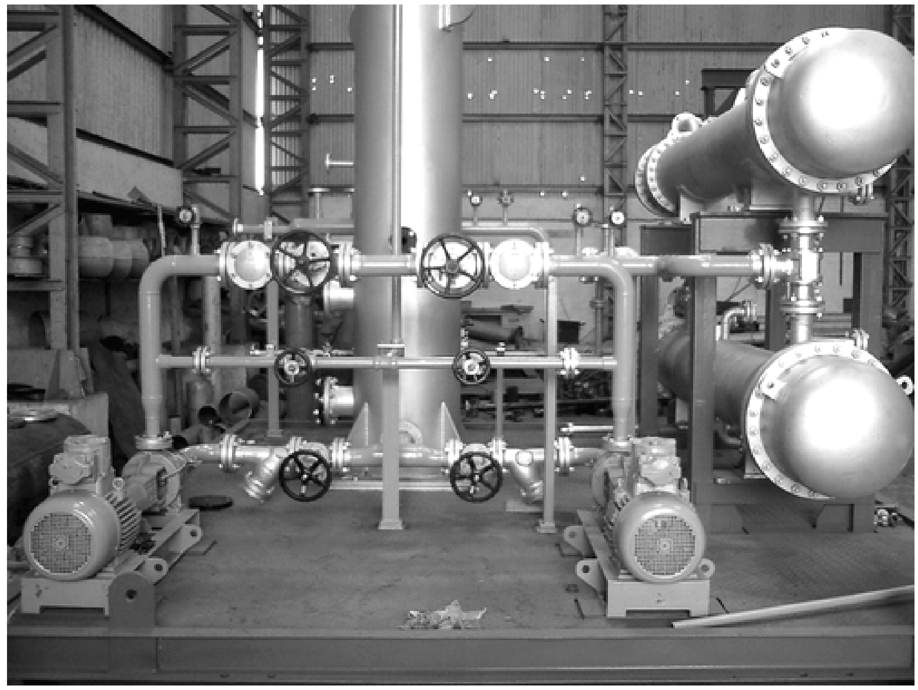

Cooling water system is one of the most important utilities in the process industry, which if not given due attention, can cause problems during startups. The author illustrates design specifications for cooling systems which can reduce costs, optimize operations and ensure smoother startups.

One of the most commonly used utilities in the process industry is the cooling water system. Yet important as it is, the humble cooling water network tends invariably to be overshadowed in the context of other more important critical equipment. If it is not given adequate attention during design, it may lead to underutilization of the cooling water system and cause problems during startups. These problems are more often highlighted during revamps and expansions.

In a cooling water system, the cooling tower provides the cooling required for the process heat exchangers and the cooling water pumps overcome the resistances (pressure drops) in the system.

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Another important aspect that affects pressure drops is the equipment and pipeline layout. Generally, all heat exchangers are located in the plant as per the process and layout requirements. Having finalized the layout, one normally calculates the highest pressure drop in the system and accordingly selects the pumps to deliver the required flow and head.

Design Specifications

Now let us look at where we provide design margins.

In sizing pipelines, one has to consider the total flows required and make a provision for design margin of say 10% on flow or the values agreed in the design basis. More often than not while sizing pipelines, the velocities considered are slightly conservative. Thereafter, one needs to take the closest commercially available higher size, for e.g. If the calculated value is 6.8", one may end up selecting an 8" line. So invariably, this results in a cooling water piping network with varying pressure drops and margins in various sections of the plant.

In the course of designing heat exchangers, one may end up with exchangers with pressure drops much lesser than the allowable pressure drop due to allowances for fouling and overdesign requirements of the process. This despite one wanting or having specified a fixed pressure drop across the exchanger.

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But what happens actually is because of the overdesign in pipelines and exchangers along with the layout requirements, one ends up getting more flow than desired in some exchangers and less flow than desired in others. Although not preferred, one attempts to manage small flow corrections at site by throttling flow using valves. Throttling flows using globe valves is possible for smaller exchangers but cumbersome for larger exchangers, and also not recommended. Another method of flow correction is using flow restriction orifices. Doing these orifice calculations at site is difficult (inserting orifice in one flow path changes the flows in other paths). Inserting orifices in big lines/ FRP lines is also troublesome after the lines have been erected.

Now software tools like PIPENET®, pipeflow etc are available for analysis of networks and using these tools, one can actually create a model of the actual plant with pipe sizes, pipe lengths, bends, elevations, exchangers etc.

With these tools, it is possible to create a model and analyze the network and optimize the pipe sizes. Spool pieces can be provided in possible problem areas, and one can size the orifices and know the flow

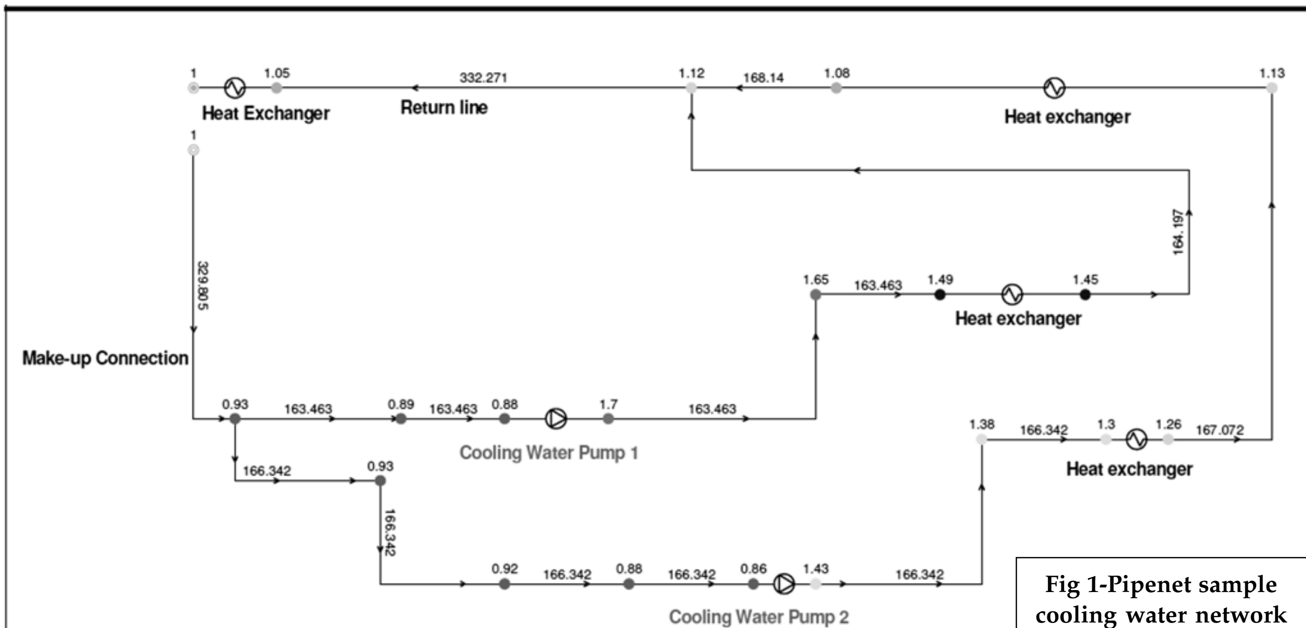

Fig 1-Pipenet sample cooling water network

"PIPENET® results in this paper have been used with the permission of Sunrise Systems Ltd of the United Kingdom."

passing through all the consumers. For some cases, it may even be worthwhile to consider temperature control valves. This method of analyzing and fine tuning the cooling water network can also help in understanding operations during turndown and also provide suitable solutions to save power in the design stage itself. One can thus analyze whether it is feasible to shut off one pump and still meet process requirements or whether providing a variable frequency drive (VFD) for the cooling water pumps is a possible solution. Alternatively, one can evaluate whether one needs the motor to be sized for end of the curve for this operation.

Analyzing these flows during turndown is also important, as reducing flow in some exchangers with large overdesign can actually increase fouling due to lower velocities. It is common that velocities in exchangers located at grade are higher than exchangers located at a higher elevation. Sometimes, one is also constrained to use cooling water on the shell side of exchangers and it is important to ensure that one doesn't end up with low velocities in such exchangers. This enables one to analyze the network and ensure that maldistribution of flow does not result in increased fouling in exchangers due to low velocities.

For older plants where one needs to add capacity, creating a model is the right way to optimize and decide on the additional cooling water requirements. Existing pumps can be analysed with regard to their capabilities and one can check for the possibility of using a larger impeller and evaluate the power required from the pump curves. The requirement for new pumps can be analysed and their capacity specified. It may sometimes be necessary to check the actual flows in the existing plant using a strap-on ultrasonic meter.

Case Study

In a recent project involving a complex cooling water system, a special client request was addressed. The client wanted to know how much flow would result from operating both the pumps (2 X 100%) instead of one. Accordingly, the cooling water piping network,

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equipment and, control valves were modeled with Cv, and the actual pump curves, and came to the interesting conclusion that due to the system resistance, we would get only 20% additional flow if we operated (2 x 100%) pumps instead of one.

Fig 1 (PIPENET 1.40 by Sunrise systems) is an example of how a simplified closed loop cooling water network model looks like. Pipenet has tools like pump, pipe, filters, orifice plate, control valve etc which enables the user to realistically model cooling water systems. The software has an inbuilt library of standard pipes and different fittings like elbow, valve, tee etc which can be selected.

Elevations can also be entered as well as pump curves which gives a realistic picture of pump operation. It is possible to also account for temperature and pressure changes taking place in the heat exchangers which form part of the cooling water system. This network analysis is also useful for chilled water networks.

Conclusion

Current trends indicate that cooling water networks are growing in size and complexity and this necessitates use of network analysis to reduce costs, optimize operations and ensure smoother start ups.