Sit Back, Enjoy the Glide

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This article is the fourteenth in a series exploring refrigeration and heat pump concepts without using jargon

Last month, we thought a bit about the effect water has on ammonia when they are mixed, and it was noted that ammonia refrigeration systems have been known to carry on working even when as much as 25% of the liquid in the system is water. The effect of the water is to move the boiling point of the ammonia, so that in an evaporator the temperature shifts as the liquid turns to gas.

This effect is known as "glide." It is tolerable in an evaporator where the outlet is intended to be a mixture of liquid and gas, for example, in a pumped circulation system. But, it can be disastrous if the flow control is dependent on superheat produced at the end of the evaporator.

The thermostatic expansion valve—from the Greek words "thermos," meaning "hot" (if you don't drop it*) and "statos," meaning "standing," so "thermostatic" = "keeps it hot"—or its modern electronic equivalent measures the inlet pressure and the outlet temperature of the evaporator and adjusts the refrigerant flow rate to make sure there is only gas in the evaporator outlet. This is good news for the compressor, which doesn't suffer from unsquashable liquid in the place where gas squashing takes place, and also good news for the evaporator manufacturer who gets to sell a larger evaporator to provide the necessary heat exchange surface to do this superheating.

*This joke is courtesy of Flanders and Swann, English music hall comedians of the 1950s, from whom I learned all the important bits of thermodynamics.

It is not such good news for system efficiency, particularly if the only way to get a large enough temperature difference to do the superheating is by lowering the evaporating temperature, but that's another story (see "The Temperature Lift" in March 2012). There are two drawbacks to this approach. First, it assumes that the pressure is the same all the way through the evaporator. Second, it assumes that the temperature is the same all the way through the evaporator.

In fact, there needs to be a little bit of pressure drop to make the refrigerant move in the right direction, but this is not usually enough to cause a problem. The boiling temperature of the refrigerant usually follows the pressure (see "Temperatures, Pressures, and Refrigerants" in April 2012), and so it drops a little bit as the pressure reduces. A traditional mechanically operated thermostatic valve can usually control steadily if there is at least 10 degrees F (5.5 K) superheat. A good electronic valve can manage to keep steady at about half this level.

If the refrigerant is actually a cocktail of two or more chemicals then sometimes the boiling temperature does not follow the pressure, but slides from one condition to another as the fluid boils. This is called "glide" and can make your head hurt. Glide happens because the components of the mixture evaporate at different rates, so the proportions of the cocktail change. The pressure drops slightly on the way through the evaporator but the boiling temperature rises a lot. If a standard mechanical valve is set to maintain 10 degrees F (5.5 K) difference between the boiling point at the coil inlet and the actual temperature at the coil outlet, this might not be enough to allow the valve to do its stable control thing. The result is unsquashable liquid in the compressor.

For example, a coil with liquid entering at –15°F (–26°C) that has a pressure drop equivalent to 1 degrees F (0.5 K) and is set to control the superheat to 10 degrees F (5.5 K) will have an outlet temperature of –5°F (–21°C) and the superheat will actually be 11 degrees F (6 K) on normal refrigerant. If there is also an 8 degree F (4.4 K) glide in the refrigerant because it is a cocktail, then the actual superheat at the coil outlet will only be 3 degrees F (1.6 K) and a mechanical expansion valve will not be able to control accurately. If the pressure reading is taken at the coil outlet and a "true" superheat value is being measured, as is the case with some electronic valves, then it will work OK, but with mechanical valves this is not possible due to the way the valve cleverly balances internal pressures to vary the amount of opening.

In principle it is possible to use "glide" to your advantage, provided the heat exchanger can be designed to give maximum benefit from the inlet temperature to the stuff being cooled. This would allow the compressor to operate at a higher inlet pressure, but this is tricky in practice, so it's not normally done, even with "wide glide" refrigerants.

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