3 – 5mm Microgroove Heat Exchangers in Frost-Developing Conditions

Webinar Questions and Answers

1. What is it about smaller diameter tubes that results in a higher airside HTC?

You can refer to our first webinar on small diameter tube heat exchangers for a more in-depth discussion. In short, HTC is inversely proportional to diameter because the thermal boundary layer is smaller in small diameter tubes. https://youtu.be/siHwksYWQXk

2. Are the sample coils 1 row and/or do they have the same physical depth?

Both the 3mm and 5mm samples are 2-row coils. The depth of the 5mm coil is larger than that for the 3mm. More geometry information is available in the Purdue paper on this topic: https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3106&context=iracc

3. Are the tests and results presented based on a plain fin? What about other fin types?

Yes, the samples constructed only had plain fins due to the manufacturing limitations for the 3mm coil. Other fin types, especially with enhancements, would certainly impact the air side pressure drop and frost performance. We have published heat transfer and pressure drop correlations for these small diameters (3-5mm) for wavy, slit, and louver enhancements.

4. Do you have a comparison of refrigerant pressure drop?

These tests and designs were solely developed for airside heat transfer evaluation, not refrigerant testing. Fluid side pressure drop was not measured, as it was not relevant to the study. Certainly 3mm tubes will have higher pressure drop than 5mm for the same flow rate, however, this can be overcome by increasing the number of circuits while maintaining similar mass flux in the tubes.

5. Why did you opt to decrease fin spacing for the 3mm rather than increase the number of rows and keep the fin spacing the same?

We developed optimized designs that achieved better performance than the 5mm design and required only 2 rows. Generally adding rows is more costly than adding fins because it significantly increases the number of copper tubes, so these 2 bank designs are more desirable.

6. Have you ever measured the variability of fins distance for the same type of coil?

Yes. Actually, this was an issue with a previous set of 3mm prototype coils and so we had additional samples made. In general, our experience is that mass-manufactured coils are fairly consistent in fin spacing. Prototyping can be a different scenario given the limitations in manufacturing at much lower scales.

7. I recall that you said you had a higher capacity with 3mm, but at a higher fin density. Did you evaluate the 3mm coil at the same fin density, which would result in better frost performance?

No, we were limited in the number of 3mm sample coils we could produce and further wanted comparable surface area and refrigerant mass flux. Testing alternate samples with varying geometry would be welcomed to provide further input on the potential of 3mm and 5mm copper tube fin heat exchangers.

8. Would ramping up airflow after defrost provide any benefit by removing more of the adhering condensate?

Possibly. This approach was not specifically tested as a part of this effort, but we have seen that approach used in other projects and actual systems.

9. Is the electric reheat located upstream of the frosted coil or downstream?

We did not use electric reheat in our experiments to provide defrosting. Defrosting was conducted using a flow of warm glycol through the coil. (There may be some confusion since the test schematic shows electric heat used to precisely control glycol and air temperatures).

10. Any idea about the reliability and lifetime of the coating?

We have not performed these tests as part of this work. Our colleagues at EPRI published some research on ice adhesion, corrosion, and adhesive testing of coatings here: https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3254&context=iracc

11. How do you apply the coating on the entire heat exchanger? At what point in the assembly was the coating applied?

The coating was applied on fully constructed heat exchanger samples, not on individual fins or fin sheets. OTS provided the full coils to NEI, who used their proprietary methods to apply the coating to each sample.

12. Regarding slide 26:
    a. Were each of these 3 tests conducted by different coils?

No. These results are for the same coil, tested at 3 different times.

b. Does the order (left to right or right to left) of the plots correspond to the chronological order the coil was tested?

No. The middle (blue) line was the first test, followed by the first (red) line and then the last (green).

13. Have you conducted any tests with multi-row coils?

All of the samples for the presented results were 2-row coils. No other samples were made for this project.

14. What is the effect of circuiting on frost formation? Will circuiting in 5mm affect frosting compared to circuiting 3mm?

We did not focus on the impacts of circuitry or the location of initial frost development. We sought to operate coils with small fluid delta-Ts to avoid hot and cold spots. Circuitry should not inherently impact frost formation, but obviously a design with high pressure drop may see more localized frosting on cold spots than a design with less pressure drop and more uniform surface temperatures.