Technical Comments

Comment on "Thermodynamic Design Fundamentals of High-Performance Insulation"

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Folkman and Lee (Ref. 1, p. 958) state that 25% is the maximum perforated area in two adjacent multilaminar insulation sheets which will allow no radiation passage. Consider a unit area square in two adjacent barrier sheets. Let four holes be located at the corners of the square in one sheet and one hole be located at the center of a diagonal in the adjacent sheet. With alignment of the two barrier sheets, the maximum diameter with a single-size hole pattern and no radiation passage is $2^{1/2}/2$ and the fractional open area per sheet is $\pi/8$.

If square holes are used, the limiting case is established by placing the center hole corners at the midpoints of the unit square sides. The side of the limiting square hole is $2^{1/2}/2$ and the fractional open area is $\frac{1}{2}$. This limit may also be approached with a circular hole pattern by using strategically placed groups of holes of successively smaller diameters. The diameters of the three largest holes of the pattern relative to the unit area square are $2^{1/2}/2$, $[2 - 2^{1/2}]/2$, and $[5(2)^{1/2} - 6]/14$. In the preceding discussion, exact hole location in the sheets and exact sheet alignment are assumed.

Reference

[1] Folkman, N. R. and Lee, T. G., "Thermodynamic Design Fundamentals of High-Performance Insulation," *Journal of Spacecraft and Rockets*, Vol. 5, No. 8, Aug. 1968, pp. 954–959.

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Reply by Authors to J. W. Powers

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In the preceding comment on Ref. 1, Powers points out that the maximum perforated area in two adjacent multilayer insulating sheets which will allow no radiation through two adjacent sheets can be greater than the 25% stated in Ref. 1. In theory, this is certainly true if square holes or various size circular holes are used.

Since the question of maximum perforated area has arisen, it is of interest to examine the practical aspects. From strictly a manufacturing standpoint, any hole with a square corner can be eliminated since square corners are highly susceptible to tearing. Several sizes of circular holes also complicate the manufacturing process.

For any practical application, any perforated insulation that even approaches the maximum area will result in direct radiation through two sheets. This will occur since most multilayer insulations are structurally unstable and considerable shifting of adjacent sheets takes place.

The third aspect which must be examined is that of performance. If Fig. 7 of Ref. 1 is extrapolated to 25% perforated area, it can be seen that the heat flux through the insulation may be 4 or 5 times higher than an unperforated blanket. This is a severe penalty and this amount of perforations is probably not required even for the most severe decompression.

From the foregoing arguments, it can be seen that the maximum perforated area, although interesting from a theoretical standpoint, is hardly a factor in the design of a practical insulation system.

Reference

[1] Folkman, N. R. and Lee, T. G., "Thermodynamic Design Fundamentals of High-Performance Insulation," *Journal of Spacecraft and Rockets*, Vol. 5, No. 8, Aug. 1968, pp. 954–959.

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