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C2Po1E-04 [28]: The Modeling and Design of an MRI-Compatible Heat Exchanger for a Cryosurgical Probe

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Cryo-ablation is a breast cancer treatment method that utilizes a small probe in precise locations within the body to freeze and destroy unwanted cancer tissue. Recently there has been a growing interest in combining cryo-ablation with magnetic resonance imaging (MRI). The challenge of combining these two technologies is that MRI devices require the absence of metals, and traditional heat exchangers used in cryoprobes are typically composed of thermally conductive metals that tend to disrupt the magnetic field produced by an MRI, impairing its functionality. Subsequently, it becomes of interest to develop a heat exchanger composed of thermally conductive MRI-compatible materials. Furthermore, this can now be accomplished with additive manufacturing, utilizing thermally conductive ceramics such as zirconium or silicon. This report presents the results of a thermal modeling effort to characterize and design a non-metallic Joule-Thomson cryoprobe for cryo-ablation. The model is comprised of a Joule-Thomson valve, as well as a discretized recuperative heat exchanger that includes the effects of axial conduction, pressure drop, and fluid properties for single components and mixtures. The operating temperature for this device is 150 K, which is a viable temperature for cryo-ablation while also adhering to size constraints.

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