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Thermal performance of the multilayer insulation systems for cryogenic applications

Multilayer insulation (MLI) technique is a robust passive thermal protection system being used in space cryogenics exploration programs as well as on the ground programs also. It is used as an excellent thermal insulator. Radiation, solid conduction and gas conduction are the significant modes of heat transfer in a cryostat. MLI technique used to degrade mainly the radiation heat load, by placing the reflective layers called radiation shields in the vacuum space
between the two walls (hot and cold boundary surfaces) of the cryostat to achieve
multiple radiation reflection. The method of achieving the multiple radiation
reflection by placing the reflective layers, is the basic principle of MLI technique. These radiation shields are coated with highly reflecting metals to reflect the incident radiation. Therefore, solid conduction may be introduced here due to adjacent radiation shields. To reduce the solid conduction, spacers are the low thermal conductivity materials that are placed side by side near the radiation shields, so that thermal contact between the radiation shields can be removed and so the chance of the solid conduction is also reduced. Hence, MLI systems are a combination of the radiation shields and the spacers. These spacers themselves are in contact with the radiation shields, therefore, a significant amount of solid conduction is found through these spacers. The heat load due to gas conduction is introduced because of non-perfect vacuum condition. The current work is an attempt to find the best MLI system, which is usually asked before designing the cryostat. This work discusses the effect of perforated double-Aluminized Mylar (DAM) with Dacron, unperforated DAM with Silk-net and perforated DAM with Glass-tissue on the performance of MLT technique, as the reflective layer as well as spacer materials. After that, we have discussed the effect of layer density and the number of layers on the heat load, by which the optimal layer density is observed for all three combinations. Knowing the key parameters of MLI, we have compared the heat load generation in spherical as well as cylindrical cryostats and found the effect of layering near the inner and outer wall of the cryostat.

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