

Heated Plate Materials

The heated wall was carefully designed and fabricated to provide a detailed temperature field for use as CFD boundary conditions and three heat flux sensors to provide system response quantities (SRQ). The plate surface can safely reach 180°C and provide up to 3300 W, or 6300 W/m² of heating. Like the thermocouples, the thin-film heat flux sensors are embedded into the plate as close to the surface as possible to reduce errors.

The heated plate has three heat flux sensors embedded just under the surface. They are at positions $x = 14.91, 76.5, 138.1$ cm from the leading edge, centered in the z direction. They are model 20457-3 made by RDF Corporation and have a thermal resistance of 81 m²K/W. The sensors are 2.5 cm² square and return a voltage that corresponds to a heat flux with a calibrated sensitivity provided by the manufacturer. The heat flux has an uncertainty of 5% of reading. The Cirlex sheet surrounds the heat flux sensors to provide uniform thermal resistance. The thermal resistance of the HFS is 0.00211 m²K/W and the Cirlex (Kapton laminate that surrounds the HFS) is 0.00212 m²K/W. The thicknesses of the HFS and Cirlex are 0.013 in and 0.010 in respectively, so the resulting thermal resistance of the two layers is 0.00293 m²K/W for HFS and epoxy and 0.00302 m²K/W for Cirlex and epoxy. Therefore, the resistance of the Cirlex area is about 3% higher than the HFS area. A thermal circuit analysis can be found attached to this document.

The six silicone rubber heaters, driven with three power supplies, sit under the heated plate and are capable of maintaining the plate at 150°C with the mean velocity at 4.6 m/s. The power supplies are controlled independently based on the plate temperature to maintain an approximate isothermal condition.

The surface is electroplated with nickel to reduce radiative heat transfer (emissivity~0.04) and oxidation. The surface aluminum is alloy 2024 since its thermal properties are more accurately known compared to the common alloy 6061. An analysis showing how we estimated the surface emissivity is attached to this document.

The Teflon sides keep the heated plate 12.7 mm away from the Lexan walls to provide enough thermal insulation to keep them at safe temperatures. They also have embedded thermocouples.

The thermal epoxy in the plate assembly is Dow Corning 3-6751 and is 1.0 mm thick.