

Helium-Gas Cooling of Stainless-Steel Walls of Shielding Vessels

Robert J. Weggel, Magnet Optimization Research Engineering, LLC
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Fig. 1 plots the deposited power density (DPD) vs. axial position and azimuthal angle in the bore tube of the most-upstream inner shielding vessel in Target Magnet IDS120j. The mean inner radius of the flange is 10.5 cm; its axial extent is from -100 cm to zero; azimuthal angles range from 15° to 345° in increments of 30° . The solid red curve of Fig. 1 plots the DPD, assuming a bore-tube density of 7.85 g/cm³, along the line where it is highest, the azimuthal angle defined by Nick Souchlas as 255° . The curve fit (solid black curve) of Fig. 1 extrapolates the DPD, assuming it to be axially symmetric. The maximum value of DPD is 67 W/cm³; the integral under the curve is $3,376$ W/cm²—i.e., $3,376$ W per cm of azimuthal extent for a bore-tube of 1-cm wall thickness. A square-wave approximation to the curve would have an axial extent of $3,376/67 = 50.4$ cm.

A computer program accepts as input this 67 -W/cm³ DPD (uniform) and 50.4-cm length of heated zone to assess the feasibility of cooling the bore tube. Cooling with helium gas turns out to be challenging. Helium even with a velocity of 211 m/s and pressure of 10 atm can cool a bore tube only 9.14 mm thick, if cooling is from one side only and the temperature rise in the bore tube is limited to 80°C . The required thickness of helium layer is 6.1 mm. The bulk, boundary-layer and conduction temperature rises are 60°C , 18°C and 2°C , respectively. The hot-spot temperature rise in a bore tube 1 cm thick would be 92°C .

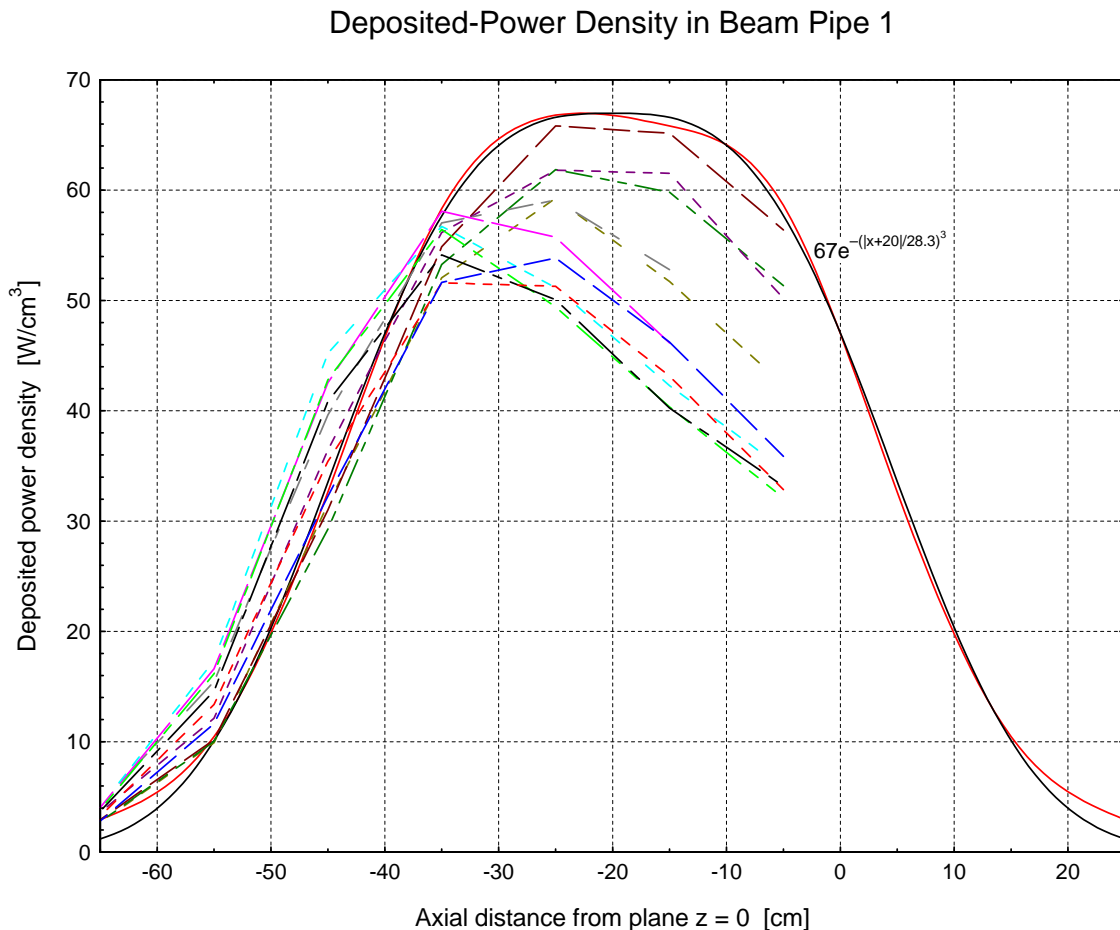


Fig. 1: Deposited-power density In beam pipe 1.

Fig. 2 plots the DPD vs. radius and azimuthal angle in the flange at the upstream end of the innermost shielding vessel in Target Magnet IDS120j. The inner radius of the flange is 12 cm; its O.R. is 48 cm; its mean axial position (midplane) is -96 cm. The solid red curve of Fig. 2 plots the DPD, assuming a flange density of 7.85 g/cm^3 , along the ray of highest DPD, the azimuthal angle defined by Nick Souchlas as 315° . The curve fit (solid black curve) of Fig. 2 extrapolates the DPD to the minimum flange radius of 12 cm, predicting a maximum DPD of 187 W/cm^3 . A square wave with the same area under the curve would have an extent of 5.9 cm.

A computer program accepts as input this 187-W/cm^3 DPD (uniform) and 5.9-cm length of heated zone to assess the feasibility of cooling the flange. Cooling with helium gas turns out to be feasible only if the flange is partitioned into multiple flanges. Helium even with a velocity of 172 m/s and pressure of 10 atm can cool a flange only 5.4 mm thick, if cooling is from one side only and the temperature rise in the bore tube is limited to 80°C . The required thickness of helium layer is 3.4 mm. The bulk, boundary-layer and conduction temperature rises are 24°C , 54°C and 2°C , respectively.

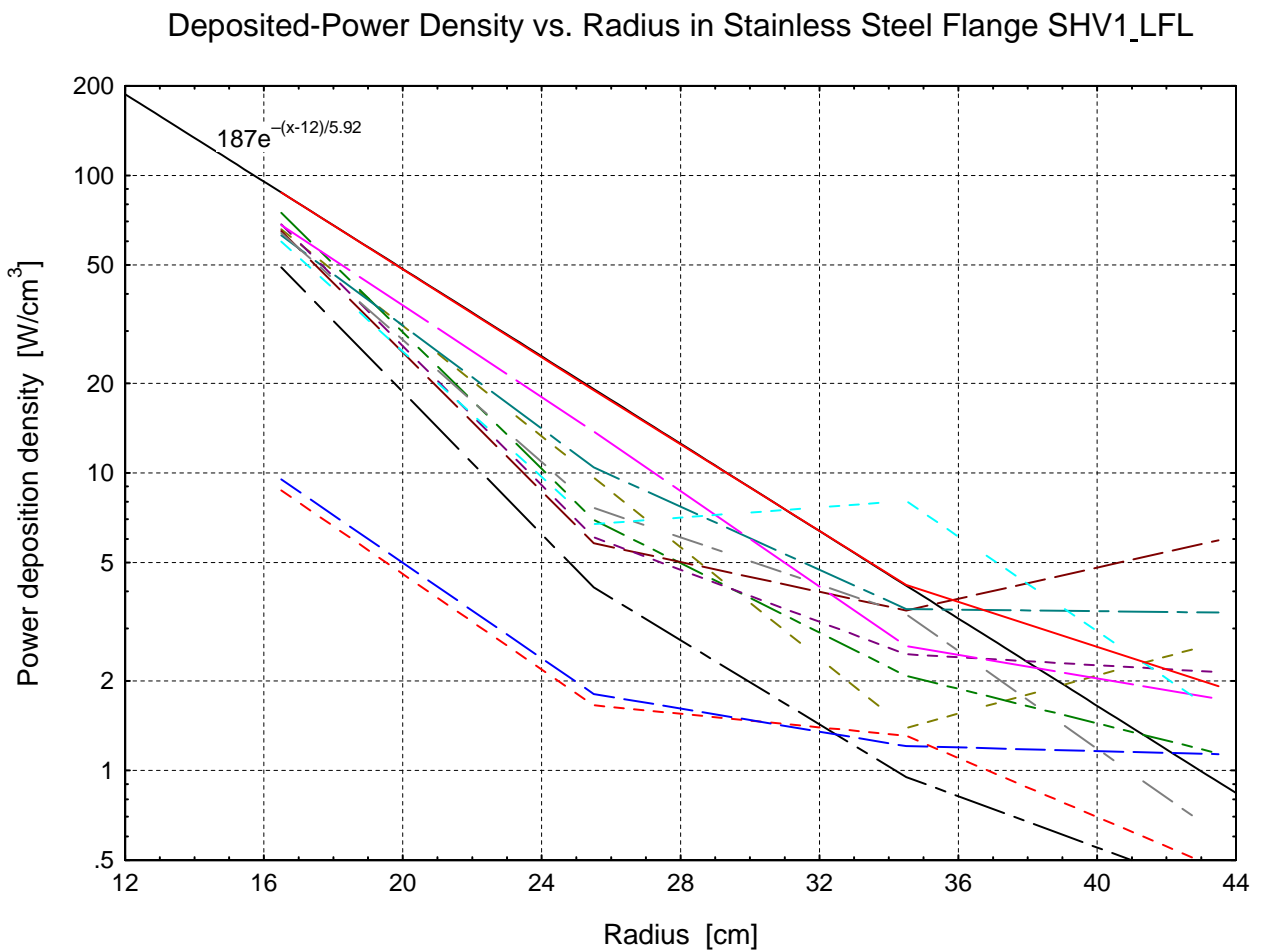


Fig. 2: Deposited-power density vs. radius in stainless-steel flange SHV1_LFL.