IPB Reactor Calorimetry Coefficient of Performance (COP) Note

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Definition

P : power deposit to the core either by DC or Q-pulse in watts, since there is no precise measurement of power be deposited to the core in Q-pulse, we assume P is Q Pi Filter power (Pi) minus termination thermal power ($term$) deposited by the heatsink water stream divided by a efficiency, and efficiency is measured by passing core.

$$P = Pi - term/efficiency \tag{1}$$

$Hpdrop:$ heater power drop after power deposit to the core in watts

V_1 : voltage measured at the core entrance when Q-pulse

$V_{2:}$ voltage measured at the core exit when Q-pulse

$V^2 = (V_1 - V_2)^2$ when Q-pulse or voltage drop when DC

COP Estimation

$$C = \frac{Hpdrop}{V^2}[watts/volts^2], [watts/volts^2] = 1/[ohms] \tag{2}$$

Where C is constant at any given core temperature of power DC or Q-pulse, gas hydrogen or helium.

$$R = \frac{V^2}{P}\ [volts^2/watts], [volts^2/watts] = [ohms] \tag{3}$$

Where R is constant at any given core temperature for power DC.

$$M = \frac{Hpdrop}{P} \tag{4}$$

Where M is constant of power DC, and estimated constant of Q-pulse at any given core temperature

$$cop = \frac{Hpdrop_{Q}(P) - Hpdrop_{DC}(P)}{P} \tag{5}$$

For any given V_{DC}^2,

$$\begin{aligned} cop &= \frac{Hpdrop_{Q} - Hpdrop_{DC}}{P} = \frac{C_Q V_{DC}^2 - C_{DC} V_{DC}^2}{P_{DC}} \\ &= \frac{C_Q V_{DC}^2 - C_{DC} V_{DC}^2}{V_{DC}^2 / R_{DC}} = (C_Q - C_{DC})\, R_{DC} \end{aligned} \tag{6}$$

For any given P,

$$cop = \frac{Hpdrop_{Q} - Hpdrop_{DC}}{P} = M_Q - M_{DC} \tag{7}$$

Assume helium (he) generates no extra heater vs. hydrogen generates extra heater

$$cop = \frac{Hpdrop_{h2Q} - Hpdrop_{heQ}}{P} = M_{h2Q} - M_{heQ} \tag{8}$$