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Electron Beam Properties Emitted From Deuterium Plasma Focus: Scaling Laws

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Abstract:

The Lee model is extended to study and characterize the electron beams emitted from plasma-focus devices. It is then first applied to characterize the electron beams emitted from low and high-energy plasma focus operated with deuterium gas. The numerical experiments on NX2 device at 15 torr of deuterium give the following results: electron fluence = $5.7 \times 10^{22} \text{ m}^{-2}$, electron flux = $16 \times 10^{29} \text{ m}^{-2} \text{ s}^{-1}$, the relativistic kinetic mean energy of the electron = 56 keV, electron number = 2×10^{16} , electron current = 91 kA, and damage factor = $2.7 \times 10^{12} \text{ W} \cdot \text{m}^{-2} \text{ s}^{0.5}$. Then, the effect of pressure on the beam characteristics is studied. The energy of the beam at pinch exit changes from around 57.1 (1.0% of the stored energy E_s) to 176.1 (6% E_s) with

characteristics is studied. The energy of the beam at pinch exit changes from around 57 J (1.9% of the stored energy E_0) to 170 J (0.7% E_0) with maximum value of 180 J (6.1% E_0 at 15 torr, and these results are compared with the measured values 3.2% E_0 on NX2. Scaling trends are suggested for electron beam characteristics. The energy fluence and the power flow density (energy flux) have a variation $4.3 - 265 \times 10^7 \text{ J} \cdot \text{m}^{-2}$ and $2.2 - 19 \times 10^{15} \text{ W} \cdot \text{m}^{-2}$, respectively. The electron beam current ranges from 12 to 700 kA being 9%-35% of I_{peak} . The energy beam YEB scales on average as $\text{YEB} = 6.55 \times E_0^{1.45}$ at energies in the 1 to 500 kJ regions (YEB in J and E_0 in kJ), and $\text{YEB} = 1 \times 10^{-6} I_{\text{pinch}}^{3.53}$ and $\text{YEB} = 2 \times 10^{-6} I_{\text{peak}}^{3.14}$ (I_{peak} and I_{pinch} in kA and YEB in J). These results provide much needed benchmark reference values and scaling trends for electron beams of a plasma focus operated in deuterium gas.

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