ANALISIS DESAIN SUMBER ELEKTRON LINAC KATODA LaB_6 MENGGUNAKAN CST DAN SIMION

Oleh

Elin Nuraini

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INTISARI

Penelitian ini membahas desain dan simulasi sumber elektron berbasis katoda LaB_6 untuk sistem akselerator linier (LINAC). Optimasi dilakukan pada konfigurasi elektroda Pierce menggunakan CST Studio Suite, sedangkan validasi hasil dilakukan dengan SIMION. Kajian mencakup rentang tegangan ekstraksi 20–50 kV dengan variasi sudut Pierce 66°–68° serta jumlah partikel makro 500 dan 1000 partikel. Parameter utama yang dianalisis meliputi arus, *perveance*, *emittance*, dan diameter berkas elektron. Hasil simulasi menunjukkan bahwa sudut *Pierce* 67,5° memberikan performa optimum, dengan keseimbangan yang baik antara kemampuan ekstraksi arus dan kualitas fokus berkas. Pada tegangan 30 kV, CST menghasilkan arus 0,469 A, *perveance* $9{,}00\times10^{-8}$ A/V$^{3/2}$, *emittance* $\varepsilon_x = 1{,}11\times10^{-5}$ mm·rad dan $\varepsilon_y = 4{,}21\times10^{-6}$ mm·rad, serta diameter berkas 0,7408 mm. Validasi menggunakan SIMION dengan 1000 partikel memperoleh arus 0,4695 A, *perveance* $9{,}036\times10^{-8}$ A/V$^{3/2}$, *emittance* $\varepsilon_y = 8{,}4956\times10^{-4}$ mm·rad dan $\varepsilon_x = 7{,}9536\times10^{-4}$ mm·rad, serta diameter berkas 0,7942 mm. Arus dan *perveance* dari kedua perangkat menunjukkan kesesuaian yang sangat baik (deviasi <1%), sedangkan perbedaan *emittance* dan diameter berkas terutama disebabkan oleh perbedaan pendekatan numerik. Secara keseluruhan, konfigurasi Pierce dengan material katoda LaB_6 mampu menghasilkan berkas elektron yang stabil dengan *emittance* terkontrol, sehingga layak diterapkan pada sistem LINAC tegangan menengah (LINAC beroperasi pada rentang tegangan ratusan kiloVolt hingga mendekati satu Mega Volt) untuk aplikasi industri.

Kata kunci: katoda LaB_6, sumber elektron, LINAC, CST Studio Suite, SIMION.

Pembimbing I : Dr.Ing. Ir. Sihana, IPU

Pembimbing II :. Dr. Taufik

ANALYSIS OF THE ELECTRON SOURCE DESIGN FOR A LaB_6 CATHODE LINAC USING CST STUDIO SUITE AND SIMION.

Elin Nuraini

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ABSTRACT

This study presents the design and simulation of an electron source based on a LaB_6 cathode for a linear accelerator (LINAC) system. The Pierce-type electrode configuration is optimized using CST Studio Suite, and the simulation results are validated with SIMION. The analysis is carried out over an extraction voltage range of 20–50 kV with Pierce angles between 66° and 68°, and macro-particle counts of 500 and 1000, to evaluate key beam parameters such as current, perveance, emittance, and beam diameter. The simulation results indicate that a Pierce angle of 67.5° provides an optimum configuration, offering a good balance between high current extraction capability and low-emittance beam focusing quality. At 30 kV, CST simulations yield a current of 0.469 A, a perveance of 9.00×10^{-8} A/V$^{3/2}$, emittance values of $\varepsilon_x = 1.11\times10^{-5}$ mm·rad and $\varepsilon_y = 4.21\times10^{-6}$ mm·rad, and a beam diameter of 0.7408 mm. Validation using SIMION with 1000 macro-particles produces a current of 0.4695 A, a perveance of 9.036×10^{-8} A/V$^{3/2}$, emittance values of $\varepsilon_y = 8.4956\times10^{-4}$ mm·rad and $\varepsilon_x = 7.9536\times10^{-4}$ mm·rad, and a beam diameter of 0.7942 mm. The agreement between CST and SIMION in terms of current and perveance is excellent, with deviations below 1%, while the differences in emittance and beam diameter arise from the distinct numerical approaches adopted in each code. Overall, the Pierce electrode configuration combined with a LaB_6 cathode is shown to produce a stable electron beam with controlled emittance over the investigated voltage range, making this source suitable for medium-voltage (LINACs operate in the voltage range of hundreds of kiloVolts to nearly one Mega Volt) LINAC systems intended for industrial applications.

Keywords: LaB_6 cathode, electron source, LINAC, CST Studio Suite, SIMION.

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Supervisor : Dr.-Ing. Ir. Sihana, IPU

Co-supervisor : Dr. Taufik