

PERANCANGAN SUMBER ION HIDROGEN NEGATIF (H⁻) UNTUK SIKLOTRON MEDIS SEBAGAI ALAT FASILITAS BORON NEUTRON CAPTURE THERAPY (BNCT)

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INTISARI

BNCT merupakan metode terapi kanker yang memanfaatkan reaksi tangkapan neutron thermal oleh atom boron-10 (¹⁰B). Neutron thermal banyak dihasilkan dari reaktor nuklir, akan tetapi pembangunan reaktor nuklir di rumah sakit tidak mudah. Dilakukan pendekatan teknologi akselerator berupa siklotron, salah satunya siklotron HM-30. Siklotron ini dapat menghasilkan neutron cepat 1.9×10^{14} n/detik Pada siklotron ini, sumber ion yang digunakan berupa ion H⁻ dengan arus 15 mA dan energi 30 keV.

Tugas akhir ini berupa perancangan dan optimasi sumber ion untuk mencapai kebutuhan siklotron medis sebagai fasilitas BNCT, dengan mengacu tahapan *engineering deign*. Proses perancangan dilakukan melalui beberapa bagian dari *requirements* hingga *embodiment design*. Proses analisis dilakukan dengan perhitungan secara komputasi terkait densitas ion pada siklotron HM-30 dan daya ionisasi sumber ion yang dibutuhkan terhadap arus yang dihasilkan.

Berdasarkan perancangan telah didapatkan parameter *embodiment design*, besar peluruhan densitas ion H⁻ pada siklotron, serta daya ionisasi pada sumber ion. Hasil kalkulasi peluruhan didapatkan densitas awal ion H⁻ $n_{0H^-} = 1.382 \times 10^{15} / m^3$ dan densitas akhir $n_{150H^-} = 2.983 \times 10^{12} / m^3$, dengan nilai peluruhan sebesar 4% per putaran. Didapatkan juga kebutuhan daya ionisasi sumber ion sebesar $P_{H^-} = 300 W$ dan $P_{H^-} = 312.5 W$ dengan efisiensi daya $\eta = 50 mA/kW$ dan $\eta = 48 mA/kW$. Perancangan hanya mencakup penentuan parameter operasi, target, komponen dan material yang digunakan, sehingga diperlukan penelitian lanjutan mengenai optimasi sumber ion.

Kata kunci: BNCT, Siklotron, Sumber Ion, Ion Hidrogen negatif

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DESIGN OF A NEGATIVE HYDROGEN ION (H⁻) SOURCE FOR A MEDICAL CYCLOTRON AS A FACILITY FOR BORON NEUTRON CAPTURE THERAPY (BNCT)

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ABSTRACT

BNCT is a cancer therapy method that utilizes thermal neutron capture reactions by boron-10 (¹⁰B) atoms. Thermal neutrons are produced from nuclear reactors but, it is very difficult to build nuclear reactor in hospital. An accelerator technology approach is carried out in the form of a cyclotron, one of which is the HM-30 cyclotron. This cyclotron can produce fast neutrons of $1.9 \times 10^{14} \text{ n/sec}$. In this cyclotron, the ion source used is H⁻ ion with a current of 15 mA and energy of 30 keV.

This final project focuses on the design and optimization of an ion source to meet the requirements of a medical cyclotron for BNCT (Boron Neutron Capture Therapy) facilities, following the stages of engineering design. The design process was carried out through several stages, from requirements definition to embodiment design. Analytical calculations were performed computationally to evaluate the ion density within the HM-30 cyclotron and the ionization power required by the ion source to achieve the desired output current.

The results of the design process yielded key parameters for the embodiment design, the expected decay of H⁻ ion density within the cyclotron, and the corresponding ionization power requirements for the ion source. Specifically, the initial H⁻ ion density was calculated as of $n_{0H^-} = 1.382 \times 10^{15} /m^3$ and final density after 150 turns of $n_{150H^-} = 2.983 \times 10^{12} /m^3$ with a decay rate of 4% per turn. The required ionization power for the ion source was determined to be $P_{H^-} = 300 \text{ W}$ and $P_{H^-} = 312.5 \text{ W}$ with a power efficiency of $\eta = 50 \text{ mA/kW}$ dan $\eta = 48 \text{ mA/kW}$. This design study is limited to the determination of operational parameters, performance targets, component selection, and material specification. Consequently, further research is recommended to advance the optimization of the ion source towards practical implementation.

Keywords: BNCT, Cyclotron, Ion Source, Negative Hydrogen Ion

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