

STUDY OF BORON NEUTRON CAPTURE
THERAPY COMPONENTS AT THERMAL
COLUMN FOR NUCLEAR REACTOR

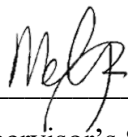
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DOCTOR OF PHILOSOPHY

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.




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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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“In the name of Allah, the most Gracious and the most Merciful”

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ABSTRAK

Kajian penyelidikan ini memberi tumpuan kepada penggunaan konkrit barit colemanite, pelindung pelbagai lapisan, dan kollimator untuk komponen terapi penangkapan neutron boron (BNCT). Kajian ini bertujuan untuk menggunakan konkrit barit colemanite sebagai perisai utama, mengaplikasikan dan menggunakan pelindung berbilang lapisan untuk pengatup rasuk dan penyumbat rasuk, dan mengoptimumkan pengeluaran fluks neutron terma dan separa terma sambil meminimumkan neutron laju dan fluks gamma dengan menggunakan kollimator dalaman dan luaran. Konkrit konvensional yang umumnya dijadikan sebagai perisai utama BNCT memerlukan lebih ketebalan dan kurang berkesan terhadap radiasi neutron dan gamma. Oleh demikian, konkrit komposit digunakan untuk meningkatkan sifat perisai dan mengurangkan ketebalan. Kajian ini menggunakan kaedah DOE untuk campuran konkrit dan mengkaji kesan colemanite sebagai agregat halus dan sebagai pengisi dalam campuran konkrit barit colemanite ke atas kesan ciri mekanikal dan ciri perisai konkrit. Konkrit barit colemanite diuji terhadap ciri mekanikal dan ciri sinaran. Pengujian kemerosotan, halaju ultra nadi, dan kekuatan mampatan digunakan untuk ciri mekanikal, manakala pengujian penghantaran neutron dan gamma adalah untuk ciri sinaran. Kajian ini menunjukkan bahawa colemanite sebagai pengisi dengan 1.85%, barit 46.95%, dan kandungan air yang lebih rendah sebanyak 4.65% berjaya mencapai kekuatan mekanikal Gred 40, perisai neutron dan perisai gamma yang lebih tinggi, dan keliangan yang tinggi berbanding perisai konkrit konvensional. Tambahan pula, berdasarkan simulasi Monte-Carlo N Particle, pelindung berbilang lapisan menggunakan konkrit barite colemanite, plumbum, dan polietilena boron 30% untuk penyumbat rasuk dan bidai rasuk didapati lebih cekap dalam melindungi radiasi berbanding dengan pelindung lapisan tunggal, dengan penyerapan radiasi lebih daripada 90%. Sementara itu, ketebalan perisai juga dapat dikurangkan dengan ketara hasil penggunaan pelindung berbilang lapisan yang hanya memerlukan kurang 60 cm berbanding perisai satu lapisan konvensional. Di samping itu, kajian yang menggunakan simulasi dan pengukuran Monte-Carlo N Particle menggunakan kadmium rod dan kerajang emas pada reaktor 250kw mencadangkan penggunaan kollimator dalaman dan luaran untuk memaksimumkan fluks neutron terma dan separa terma dengan 2 dan 1.2 kali lebih tinggi daripada pengukuran awal. Penyelidikan ini menyimpulkan bahawa konkrit barit colemanite adalah bahan pelindung utama yang sesuai untuk kemudahan penyelidikan nuklear dan penggunaan perisai berbilang lapisan dan kollimator dapat meningkatkan prestasi komponen BNCT di turus terma untuk reaktor nuklear.

ABSTRACT

This research study focuses on the use of barite colemanite concrete, multi-layer shielding, and collimators for boron neutron capture therapy (BNCT) components. The study aims to use barite colemanite concrete as primary shielding, implement the use of multi-layer shielding for beam shutters and beam stoppers, and optimize thermal and epithermal neutron flux while minimizing fast neutron and gamma flux using internal and external collimators. Conventional concrete as primary shielding for BNCT requires greater thickness and is less effective towards neutron and gamma radiation, thus composite concrete is used to improve shielding properties and reduce thickness. The study uses the DOE method for concrete mix and studies the effects of colemanite as fine aggregate and as filler in barite colemanite concrete mix to study effect on mechanical and shielding properties. The barite colemanite concrete testing with mechanical and shielding testing. The slump, ultra-pulse velocity, field-emission electron scanning, and compressive strength tests are used for the mechanical properties, while neutron and gamma transmission tests are used to determine shielding properties. The study found that barite colemanite concrete with 1.85% colemanite as filler, 46.95% barite, and a lower water content of 4.65% achieved mechanical strength of Grade 40, higher neutron and gamma shielding properties, and high porosity compared to conventional concrete shielding. Furthermore, based on Monte-Carlo N Particle simulation, the multi-layer shielding using barite colemanite concrete, lead, and 30% borated polyethylene for beam stoppers and beam shutters was found to be more efficient in shielding radiation compared to single-layer shielding, with more than 90% radiation absorption. The thickness of shielding was significantly reduced with the use of multi-layer shielding to less than 60 cm compared to conventional single-layer shielding. In addition, the study using Monte-Carlo N Particle simulation and measurement using rod cadmium and gold foil at 250kw reactor proposed the use of internal and external collimators to maximize thermal and epithermal neutron flux with 2 and 1.2 times higher from preliminary measurement. This research concludes that barite colemanite concrete is a suitable primary shielding material for nuclear research facilities and that the use of multi-layer shielding, and both internal and external collimators can improve the performance of BNCT components at the thermal column for nuclear reactors.

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