"Computer Modeling and Burnup Analysis in Light Water Nuclear Reactors"

Presented by

Basma Mahmoud Mohammed Fouad

A Thesis Submitted
to
Faculty of Science

In Partial Fulfillment of the
Requirements for
the Degree of
Master of Science
(Nuclear Physics)

Physics Department
Faculty of Science
Cairo University

(2010)

"نمذجة بالحاسب الآلي و تحليل إحتراق الوقود في مفاعلات الماء الخفيف"

إعداد

بسمة محمود محمد فؤاد

رسالة مقدمة

إلي

كلية العلوم

كجزء من متطلبات الحصول علي درجة

الماجيستير

(الفيزياء النووية)

قسم الفيزياء

كلية العلوم

جامعة القاهرة

(2010)

المستخلص

أسم الطالب: بسمة محمود محمد فؤاد

عنوان الرسالة : **"نمذجة بالحاسب الآلي و تحليل إحتراق الوقود في مفاعلات الماء الخفيف"**

الدرجة : **ماجيستير فى الفيزياء**

الغرض من هذه الرسالة هى دراسة سلوك وقود الثوريوم/ يورانيوم المتباين فى مفاعلات الماء الخفيف المضغوط. تهدف هذه الرسالة الى دراسة التحليلات النيوترونية و الأحتراق لوقود الثوريوم/ يورانيوم باستخدام برنامجى الحاسب الألى MCNPX , WIMS-D5 . يعتمد تصميم المفاعل على نموذج يسمى بالوحدات المتكاملة للبذرة و الغطاء بحيث تشغل وحدات البذرة المحتوية على وقود اليورانيوم و وحدات الغطاء المحتوية على وقود الثوريوم/يورانيوم الحجم الكلى لقلب مفاعلات الماء الخفيف المضغوط و المصممة على شكل لوحة شطرنج. وقد وجدت تطابقات مرضية بين نتائج النموذج الحالى و نتائج حالات قياسية متماثله.

توقيع السادة المشرفون:

أ. د هشام محمد محمد منصور

أ. د مصطفى عزيز عبد الوهاب

أ.د. جمال عبد الناصر

رئيس مجلس قسم الفيزياء

كلية العلوم – جامعة القاهرة

Appendix A

The Multiplication Factor (K_{eff})

The ratio of the number of fission neutrons in one generation divided by the number of fission neutrons in the preceding generation.

Burnup

The total energy released in fission by a given amount of nuclear fuel released per unit mass of the fuel and is measured in megawatt days per kilogram.

Thermal energy group

The neutrons whose energies are smaller than 0.625 eV.

Epithermal group (Resonance group)

The neutrons which have energies between 0.625 eV to 5.53 KeV.

Fast group

The neutrons which have energies between 5.53 KeV to 20 MeV.

Reflective Boundary

It is an imaginary surface; where any particle hitting this reflecting surface is specularly (mirror) reflected. Reflective surfaces are valuable because they can simplify a geometry setup (and also tracking) in most problems.

CHAPTER 1

INRTODUCTION

CHAPTER 2

METHODOLOGY

CHAPTER 3

RESULTS AND DISCUSSION

CHAPTER 4

CONCLUSIONS

REFERENCES

APPENDIX

ABSTRACT

Student Name: **Basma Mahmoud Mohammed Fouad**

Title of the thesis: **Computer Modeling and Burnup Analysis in Light Water Nuclear Reactors**

Degree: **Master of Science**

The purpose of this thesis is to study the feasibility of the Thorium/Uranium fuel cycle in heterogeneous Pressurized Water Reactors (PWR) core design. This thesis focuses on the neutronic and burnup analysis of the Thorium/Uranium fuel using the computer codes MCNPX and WIMS-D5. The design is based on the Whole Assembly Seed and Blanket (WASB) concept, in which the individual seed (Uranium) and blanket (Thorium-Uranium) units occupy one full-size PWR assembly in a checkerboard core configuration. The results of the present models are compared with the solution of the benchmark problems. Satisfactory agreement is obtained.

Keywords: Thorium Fuel cycle, Whole Assembly Seed and Blanket, Neutronic calculations

Supervisors: Signature:

1- **Prof. Dr. Hesham Mohammed Mansour**

2- **Prof. Dr. Moustafa Aziz Abd El Wahab**

Prof. Dr. Gamal Abd El Naser

Chairman of Physics Department
Faculty of Science- Cairo University

APROVAL SHEET FOR SUMISSION

Thesis Title: **Computer Modeling and Burnup Analysis in Light Water Nuclear Reactors**

Name of candidate: **Basma Mahmoud Mohammed Fouad**

This thesis has been approved for submission by the supervisors:

1- Prof. Dr. Hesham Mohammed Mansour

Signature:

2- Prof. Dr. Moustafa Aziz Abd El Wahab

Signature:

Prof. Dr. Gamal Abd El Naser

Chairman of Physics Department
Faculty of Science- Cairo University

Cairo University
Faculty of Science

To WHOM IT MAY CONCERN

This is to certify that: Basma Mahmoud Mohamed Foad

Has attended and passed successfully the following postgraduate Courses as a partial Fulfillment of the requirements of the degree of Master of Science:

1. **Advanced Quantum mechanics,**
2. **Group Theory,**
3. **Quantum Field Theory,**
4. **Theories of Nuclear interactions,**
5. **Molecular Spectroscopy,**
6. **Statistical and electrodynamics**

This certificate is issued at his own request.

Date of birth: 15/10/1981

Place of birth: El-Sharkya

Controller

9 G.M. Nasr 2010

6

ACKNOWLEDGMENT

I would like to give my appreciations to

- Prof. Dr **Hesham Mansour**, for his kind supervision and patience. He has been a great source of knowledge, encouragement and *guidance.*
- Prof. Dr **Moustafa Aziz**, for his supervision and continuous help, support and valuable guidance during this work.

I would like to express my deep appreciation to Prof. Dr **Esmat Amin** for her kind and enthusiastic help in both WIMS-input and computerization.

I would like also to thank all my friends in the National Center of Nuclear Safety and Radiation Control.

I am also grateful to my family, for their support and love.

TABLE OF CONTENTS