

Sudan University of Science and Technology

College of Graduate Studies

A comparative Study of the Types of
Light-Water Reactors

أنواع مفاعلات الماء الخفيف (دراسة مقارنة)
A thesis Submitted in A partial Fulfillment
of the Requirement for the Degree of
Master of Science in Nuclear Physics

By

Morteda Hassan Osman Elhaj

Supervised by

Dr. Ibrahim Mohammed El Faki

February 2007

C

قال تعالى: (وَيَسْأَلُونَكَ عَنِ الرُّوحِ قُلِ الرُّوحُ مِنْ أَمْرِ رَبِّي وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا) صدق الله العظيم

(الإسراء : 85)

Dedication

I dedicate this thesis
To my Parent,
My Family And
All my friends for their love,
Support and long-term
Sacrifices.

Morteda

Acknowledgement

- Praise to Allah who gave me health and patience to accomplish this work.
- I am so grateful to Dr: Ibrahim Elfaki for his comments and suggestions during the revision of this thesis.
- I wish to express my sincere appreciation to Dr: Rahama Osman in the Administration of the Educational Development in Gabbas Schools for his helpful, suggestions and encouragement.
- I wish to thank the staff of the Sudanese Atomic energy committee.
- My thanks to every one who help me.

ABSTRACT

The main purpose of this project is the study of light water reactors (LWR) and the comparison between its types the pressurized water reactor and the boiling water reactor.

The research aims to study the future of nuclear power and its development besides the effective factors that affect its progress. The study covers briefly the usage of electric power in Sudan and future plans for its development.

The comparison presents the advantages and disadvantages of the pressurized water reactor and the boiling water reactor.

The research showed the importance of nuclear power as one of the most essential sources of future of energy and plans for its development.

الخلاصة

الهدف من هذه الأطروحة هو دراسة مفاعلات الماء الخفيف والمقارنة بين نوعيها مفاعل الماء المضغوط ومفاعل الماء المغلي, كما تهدف لدراسة مستقبل الطاقة النووية والعوامل المؤثرة عليها. أيضا تطرقت الأطروحة بإيجاز إلى الطاقة الكهربائية المستخدمة في السودان والخطط المستقبلية لتطويرها.

إن المقارنة التي قام بها الباحث أوضحت إيجابيات وسلبيات مفاعل الماء المضغوط و مفاعل الماء المغلي . كما أوضحت الأطروحة أهمية الطاقة النووية كواحدة من أهم مصادر الطاقة في المستقبل والخطط التي وضعت لتطويرها.

List of Contents

No.	Subject	No. of Page
	الآية	II
	Dedication	III
	Acknowledgement	IV
	Abstract (English)	V
	Abstract (Arabic)	V1
	List Of Contents	VII
	List Of Abbreviation	X
	List Of Tables	XI
	List Of Figures	XII
	Chapter One	
	Nuclear Reactor Concept	
1.0	Introduction	1
1.1	Radioactivity	2
1.2	Interaction Involving Neutrons	2
1.3	The Fission Process	3
1.4	Nuclear Reactor	5
1.5	Nuclear Power	6
1.6	Reproduction Constant	6
1.7	Safety And Waste Disposal	9
	Chapter Two	
	Light Water Nuclear Reactor (LWR)	
2.0	Introduction	10
2.1	Pressurized – Water – Reactor (PWR)	12
2.2	(PWR) Reactor Design	16
2.2.1	Coolant	16
2.2.2	Moderator	16
2.2.3	Fuel	17
2.2.4	Control	19
2.3	Boiling Water Reactor (BWR)	21
2.3.1	BWR Control Power	25
2.3.2	BWR Safety	25
2.4	Advanced Boiling Water Reactor	27
2.5	Economic Simplified Water Reactor (ESWR)	28
	Chapter Three	

No.	Subject	No. of Page
	Future Nuclear Power Development	
3.0	Introduction	29
3.1	Advanced (LWR) Programme	30
3.1.1	Principles ,Objective And Target	30
3.1.2	Safety	31
3.2	International Nuclear Congress' 93	36
3.3	The Future Plans For Electricity Power Generation in Sudan	42
3.4	Power Generation Project	42
3.5	Generation	44
	Chapter Four	
	Discussion And Conclusion	
4.0	Introduction	45
4.1	Advantages Of PWR	45
4.2	Disadvantages Of PWR	45
4.3	Advantages Of BWR	47
4.4	Disadvantages Of BWR	47
4.5	Conclusion	48
4.6	Future work	49
	References	50

List of Abbreviation

No.	Abbreviation	Meaning
1	LWR	Light Water Reactor
2	PWR	Pressurized Water Reactor
3	BWR	Boiling Water Reactor
4	HTGR	High Temperature Gas-Cooled Reactor
5	CANDU	Canadian Deuterium Uranium
6	LMFBR	Liquid Metal Fast Breeder Reactor
7	ABWR	Advanced Boiling Water Reactor
8	LOCA	Loss-of Coolant Accident
9	ESBWR	Economic Simplified BWR
10	IC	Isolation Condensers
11	PCCS	Passive Containment Cooling System
12	GDCS	Gravity Driven Cooling System
13	PCS	Primary Cooling System
14	SCS	Secondary Cooling System
15	SG	Steam Generator
16	MCP	Main Coolant Circulation pump
17	RPV	Reactor Pressure Vessel
18	GE	General Electric
19	KWU	Kraft Work Union
20	URD	Utility Requirements Document
21	PSA	Probabilistic Safety Assessment

List of Tables

No. of Table	Content	Page
--------------	---------	------

1	Key ALWR Polices	32
2	Top Tier ALWR Plant Design Requirements	33
3	Four Energy Scenarios (A, B1, B and C) Of The World Energy Council Supply Assumptions	37
4	Nuclear Power Plants In Commercial Operation	41
5	Power Stational Grid 2001	43
6	Volumetric Power Densities And Linear Fueling Ratings For LWR Reactor Systems.	48

List of Figures

No. of figure	Content	Page
1.1	Schematic Of Nuclear Fission	4
1.2	Cross-Section Of Reactor Core	8
2.1	Diagram Of PWR	11
2.2	Diagram Of BWR	11

No. of figure	Content	Page
2.3	Pressurized Water Reactor	13
2.4	First Generation PWR	15
2.5	Modern PWR	15
2.6	PWR Fuel Bundle	18
2.7	PWR Reactor Vessel	20
2.8	Boiling Water Reactor	21
2.9	Dual Cycle BWR	24
2.10	Early Direct Cycle BWR (Natural Circulation)	24
3.1	Energy Supply Scenario B Of The World Energy Council.	39
3.2	World uranium production 1998	39
3.3	Fuel For Electricity Generation (Percent)	40
3.4	World – Wide Trend Of Fuel Burn- Up	41