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Thorium, a safety valve fuel for nuclear power generation

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ABSTRACT

Every new science and technology .especially that is not conventional is prone to meet with risks fear and distrust for which public confidence has to be developed by proper awareness. Nuclear energy is one such example. Nuclear energy is a promising alternative to other traditional energy sources, renewable or nonrenewable. The apathy to nuclear power plant resulting out of nuclear power plant disasters needs to be tackled by paying attention to ***'Thorium, a safety valve fuel for nuclear power generation'.*** *This presentation is a modest attempt to highlight this aspect. India's efforts in this direction on the use of thorium as a nuclear fuel are also presented.*

Keywords: Thorium, Fuel, Nuclear Power

INTRODUCTION

Currently we need energy sources for production of electricity. Without electricity no computers, no television and no washers and a lot of apparatus would not work. The energy sources can be broadly classified as Conventional/Renewable energy sources: e.g., Coal, oil, natural gas, sun, water and wind. Non renewable sources: e.g., Fossil fuels that draw on finite resources and Nuclear energy. Due to the consequence of depletion of renewable and nonrenewable energy resources one has to go for solar, water and wind energy. Although currently these energy sources are promising yet they are not enough to meet the present day consumption [1]. In view of this, the nuclear power is the only solution of self sufficiency. There is a misapprehension about the disastrous effects of nuclear power. The nuclear power plant disasters at Three Mile Island, Chernobyl and Fukushima have made all of us aware of the dangers inherent in using uranium to generate power. In the heat of these catastrophes thorium as a safer alternative to uranium has been overlooked. The mass media has given no attention to thorium. But this may change as the countries in the world over are attempting to harness thorium as safer substitute energy fuel for uranium. In this article an attempt is made to highlight switching from uranium to thorium as our alternative energy fuel which could lead to cheaper, safer and more sustainable nuclear power.

DISCUSSION ON THORIUM

Thorium is a natural radioactive element with the symbol Th and atomic number 90. It was discovered in 1828 and named after Thor, the Norse God of thunder. Virtually in nature, all thorium is found to exist in a single isotopic form as thorium 232 and it decays by emitting an alpha particle. Thorium has a half life of 14.05 billion years. It is estimated to be about four times more abundant than uranium in the earth's crust (1) and is a byproduct of the extraction of rare earths from monazite sands.

Thorium was formally used commonly as the light source in gas mantles and as an alloying material. But these applications have declined due to concerns about its radioactivity. Monazite is the most common and commercially important thorium bearing mineral. It is chiefly obtained as a sand containing up to 12% of thorium phosphate which is separated from other sands by physical and mechanical means. Monazite is concentrated by weathering in to economically workable deposits in beach sands in coastal tracts of Australia, Brazil, Ceylon, Malaysia and India.

World Monazite resources are estimated to be 12 million tones, 2/3 of which are in heavy mineral sands deposits on the south and east coasts of India. Estimated world thorium resources are given in Table 1[2].

Table 1. Estimated world thorium resources
(Reasonable assured and inferred resources recoverable up to $ 80/kg. Th.)

Country	Tones	% of total
Australia	489,00 0	19
U.S.A.	400,000	15
Turkey	344,000	13
India	319,000	12
Venezuela	300,000	12
Brazil	302,000	12
Norway	132,000	5
Egypt	100,000	4
Russia	75,000	3
Green land	54,000	2
Canada	44,000	2
South Africa	18,000	1
Other countries	33,000	1
World total	2, 61,000	

The Monazite content in Indian beach sands [3, 4] is given in Table 2.

Table 2. Monazite content in Indian beach sands

Place/Area	% content
Orissa state	
Cuttack and Ganjam Districts	2.5
Chilka Lake and Chicacole River	Minor amounts
Andhra Pradesh	
Visakhapatnam and Bhimunipatnam	3.0
Kerala & Tamil Nadu	3.0

It is seen from the Table .2 that the beach sands of A.P., Kerala and Tamil Nadu are very rich in Monazite content

Advantages of thorium as fuel over uranium :

1. Thorium is three times more abundant in nature than uranium.
2. Unlike uranium, thorium is not fissile and is a fertile material. It can be used in conjunction with fissile material as nuclear fuel.
3. Thorium fuels can breed fissile uranium -233. When thorium -232 struck by neutrons it absorbs neutron and it becomes thorium-233, which is unstable and decays to protactinium -233 and then uranium -233. Uranium -233 is long lived can be easily unloaded and easily separated from the remaining thorium.
4. It is to be remembered that uranium -233 when bombarded with high energy neutrons it undergoes fission and releases energy. On the other hand in the case of uranium, it is uranium -238 turned to uranium -239 by high-fly neutrons that produce all the high radio- active waste products. In the case of uranium -233 fission, far fewer number of highly radioactive long lived by products are produced as waste. The thorium nuclear waste only stays radioactive for 500 years instead of 10,000years as in the case of uranium -238 fission [5,6]. Further the waste products of thorium are 1000 to 10,000 times less than that of uranium -238. It means it leaves little waste when compared to uranium.
5. Thorium -232 emits only low level alpha particles when compared to uranium -238 and hence exposure to radiation is less dangerous.

6 With thorium fueled reactors there is no risk of explosion. No matter how many thorium nuclei can be packed together as they will not on its own undergo fission. On the other hand in the case of uranium reactors one must take utmost care in shutting down the reactor in order to prevent explosion.

7. Uranium reactors produce plutonium -239 as fission product which makes much better bomb fuel that can be used for the destructive purpose of preparation of bomb. On the other hand thorium fueled reactors cannot melt down and do not produce reliable fuel for bombs. Hence thorium -232 can be used as fuel only for the peaceful purpose of power generation.
8. A ton of thorium produces as much electricity as 200 tons of uranium or 3-5 million tons of coal. By using only currently known resources of thorium, we would have enough to power the whole planet 10,000 years [7].

Thus thorium is more advantages as a reactor fuel [8] than uranium. Thorium based reactors are safer because the reaction can easily be stopped and also because the operation does not have to take place at extreme pressures compared to uranium based reactors. Hence thorium fuel is referred to as safety valve [9] fuel in reactor operation.

Uranium -233 a man made fissile isotope with half life 160,000 years is well suited for use in nuclear reactors. After thorium - 232 is converted Uranium - 233 can be unloaded and then fed to the core of another reactor to be used as fuel. The number of neutrons produced in the fission reaction is not sufficient for a self sustained chain reaction. A particle accelerator could be used to provide the necessary neutrons for fission to occur in thorium fueled reactors. A nuclear reactor making use of such an outside neutron source would be known as an 'An Accelerator Driven System (ADS)'. If the accelerator is turned off, the nuclear reaction would cease. Thus by using a 10 MW proton beam from an accelerator which produces spallation neutrons on interaction with bismuth-lead coated in the core of the nuclear reactor ,

we can produce 1500MW heat and thus 600MW electricity. There are several proposals to develop a proto type reactor of this kind which is sometimes popularly called an energy amplifier.

In view of this, a lot of international interest developed in building a thorium power plant. Many countries have the technology including US, Germany, China and India. India, which has about a quarter of the world's total reserves, has already planned its nuclear power program [10- 13] eventually to use thorium, phasing out uranium. It is to be noted that the only uranium -233 fueled reactor in the world is 'Kamini 'operating since 1996 at Indira Gandhi Atomic Research Centre, Kalpakkam. This is a 30 kw experimental reactor facility. This reactor is adjacent to a fast breeder test reactor in which thorium oxide is irradiated producing uranium -233 for Kamini. In 2002, India's Nuclear Regulatory Agency issued approval to start construction of 500 mega watt electric proto type fast breeder reactor which should be completed this year (2012) [10].In the next decade construction will begin on six more of these breeder reactors. Design work is also complete for India's first Advanced Heavy Water Reactor (AHWR) which will involve a reactor fueled primarily by thorium that has gone through a series of tests in full scale replica. The biggest hold up at present is finding a place for suitable location for the plant [10] which generates 300MW of electricity. Because of its abundant resources of thorium and domestic lack of uranium, India has been the only country with a sustained effort to use thorium as fuel in large scale nuclear power generation. India's 20 years goal is to generate 75% nuclear power from thorium used fuel which will be reprocessed to recover fissile material.

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