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# Analysis of Nuclear Power Plant and its Evolution in India

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***Abstract*— Nuclear power plant is the fourth largest energy source in India. Nuclear power has the potential to create the large amount of energy and the best way to assemble large amount of renewable energy. In India nuclear power plant contribute 2% of total power generation, we proceed to path to increase the percentage of renewable energy source. There are 437 nuclear power reactors in operation, and 69 nuclear power reactors under construction in 31 countries around the world. The new techniques introduced in nuclear power which consumed many man power and generate huge amount of electricity with focusing very less nuclear waste. As India are developing country and its large amount of electricity which can easily available by nuclear power.**

***Keywords*— Elements, Growth, Power, Nuclear evolution, Nuclear power plant, Nuclide, Reactor, Uranium fuel**

## I. INTRODUCTION

The first time electricity generates ever on September 3, 1948 at the X- 10 Graphite Reactor in Oak Ridge, Tennessee in the United States, and was the first nuclear power plant to power a light bulb.

In Nuclear [1] power plant, nuclear reactor is the heat source which used to generate steam which dives from the steam turbine collected to an electric generator which produces electricity.

In nuclear power plant enormous amount of heat is released, from the splitting of radioactive atoms emblematically uranium, to induce power and supreme electricity.

Nuclear energy is attracting new interest around the world as countries look for low-carbon alternatives to fossil fuels to increase the diversity of their sources of energy and improve security of supply. The nuclear reactor provided the one sixth of electricity of actual needs. Mainly nuclear reactor was built in seventies and eighties. These nuclear reactors were known as first and second generation nuclear reactors. Third generation nuclear reactor were developed in nineties had some advance technology than previous one. Now days effort is Underway on the fourth generation, which improve use of natural resources and produce very less radioactive waste. India leads to increase the nuclear power strength grooming year by year till 2017, there are 21 working reactor and 7 nuclear power plant.

In this paper we mainly focus on nuclear reactor it's functioning in India and its generation of nuclear reactors.

The rest of paper is mainly structured as follow, section II describe all elements of nuclear power plant with their diagrammatic representation in Fig.1. In section III, we study the notation of nuclear reaction. Section IV, describe reaction, which occurs in nuclear reactor such as alpha, beta and gamma reaction. Section V, enclose overall evolution of nuclear power plant its generation and its demand in India in various aspects. In section VI, we conclude that nuclear energy is one of best renewable energy source.

## II. THE ELEMENTS OF NUCLEAR POWER PLANT

Nuclear power plants are about to similar to coal burning power plant. Both have the same principle of making steam which rotate turbine, which in turn drives a generator, leads to producing electricity. Both processes could only differentiate on the basis of fuel which used to heat water and create steam. The Nuclear power plants use the splitting of radioactive atoms, called nuclear fission, as its source of heat.

### *A. Fuel*

Normally uranium used as fuel, mainly UO2 or metallic uranium [2]. Uranium undergoes fission at very slow rate; this rate of decay is too slow so we used this in power generation for long time. There are so many type of isotopes of uranium but the best to generating power is uranium-235

 

(U-235). In nature these isotopes present only in 1%. The highly skilled and trained nuclear chemist work with uranium and increase quantity of uranium-235 (U-235), so will be used as fuel and follow nuclear fission and produce electricity.

*B. Nuclear Reactors*

They have unique role in nuclear power plant as they initiate and control over all chain reaction which responsible for electricity generation. They catalyze the bombarding of neutrons on uranium atoms in nuclear fission. Bombardment causes increase in kinetic energy of molecules which changes into heat and simultaneously absorption of gamma rays creates during fission and by the ensuing radioactive decay of fission materials. The first nuclear reactor formed at Oklo in Gabon, Africa.

*C. Containment Buildings*

It is a solid structure building of dome shaped. Commonly made by steel, which encloses and protects the overall nuclear reaction. They designed specially to block the escape of radiation at high pressure during the server malfunction inside the nuclear reactor. They behave as last barrier in between the reactor and surrounding environment.

*D. Control Rods*

They are part of nuclear reactor. They used to handle the rate of fission. Control rods made up of elements which have the natural neutron absorbing properties, which are grouped into control rod assemblies. Some Common elements used to make control rods such as boron, cadmium, and other elements known for their tendency to absorb neutrons.

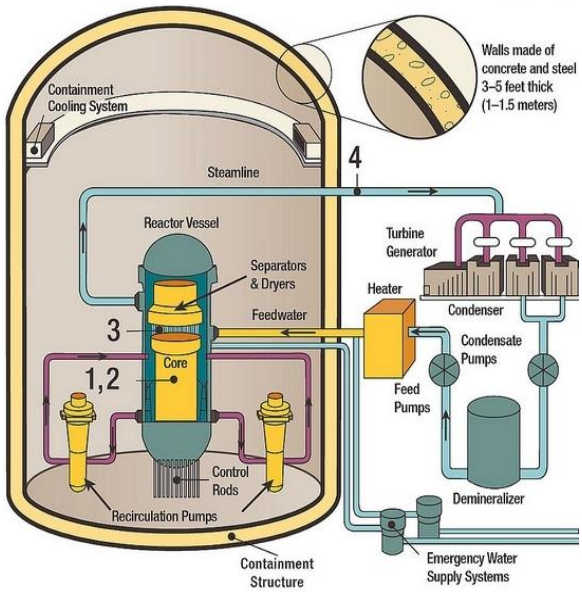


Fig .1 Component of nuclear power plant [3]

*E. Turbines*

Turbine is the rotatable stick, which part of rotor system to make and control the kinetic energy from steam coming into turbine. Turbine generator then converts this energy into electricity.

*F. Generators*

Generator converts mechanical energy of rotating turbine into continuous flow of electron leading to an electric current by applying its magnetism and mechanical power.

*G. Feed water Pumps*

Feed water pump plays an important role to control flow of water. It draws water, pressurizes it and force feed water to convert it in steam and forwarded to steam generator to produced mechanical energy which then converted into electricity.

*H. Steam Generators*

Uranium atom have enormous amount of potential energy, when uranium atom undergoes fission then this potential energy released in form of heat. These heat absorbed by steam generator which convert water into steam which fed through a steam line to the turbine, where rapid expansion is used to drive the turbine.

*I. Cool Water Condensers*

These condensers help to remove air form the water by converting it into pure steam and give the maximum power and most optimal efficiencies.

*J. Cooling Towers*

In nuclear reactor we are dealing with hot water, so cooling tower cooled large amount of water so it reused and released back into the environment.

*K. Fuel Rods*

Fuel rods are the long rods in which uranium enriched short pellets (typically 2.5 cm long) are arrange subsequently to make fuel bundles. Now these bundles are used as a fuel in nuclear reactor.

## III. REACTION MECHANISM OF NUCLEAR FISSION REACTION IN NUCLEAR POWER PLANT

A chemical reaction in which two nuclear particles assort with each other to produced two or more nuclear particle or $^{\gamma}$-rays (gamma rays). Due to which at least one nuclide (atom have specific no. of protons and neutrons) transformed into

 

another is called nuclear reaction, if there is no change in nuclide then the nuclear reaction called nuclear scattering.

Most know nuclear reaction is nuclear fusion of light elements of sun and stars which generate energy. The natural nuclear reaction also occurs in cosmic ray and matter. The nuclear fission is most notable man controlled nuclear reaction which occurs in nuclear reactor. Nuclear reactors are manmade or sometimes not, devices which lead up and govern the nuclear reaction. The world's first nuclear reactor operated about two billion years ago.

Standard nuclear notation shows (see fig.2) the chemical symbol, the mass number and the atomic number of the isotopes.

Let, If the initial nuclei are denoted by a and b, and the product nuclei are denoted by c and d, the reaction can be represented by the equation:

$$a + b \rightarrow c + d$$

The form a (b, c) d is equivalent to a + b producing c + d. Light particles are often abbreviated in this shorthand, typically p means proton, n means neutron, d means deuteron, α means an alpha particle or helium-4, β means beta particle or electron, γ means gamma photon, etc.

Atomic mass by 4 and become the element two atomic numbers less. Since an atom loses two protons during alpha decay, it changes from one element to another.

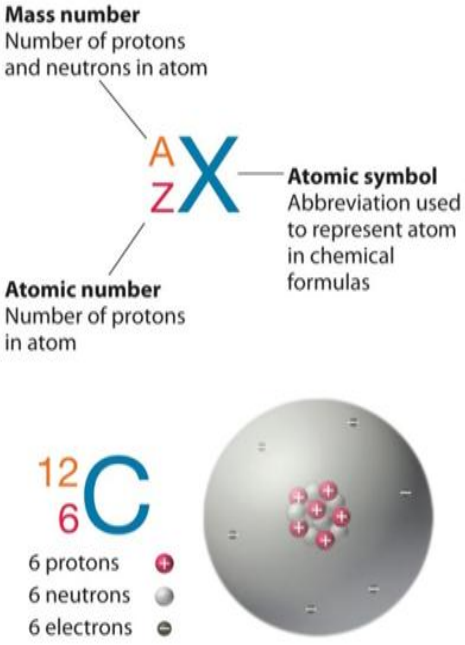


Fig. 2 Notation of nuclide [4]

## IV. TYPES OF NUCLEAR REACTION

*A.Alpha decay*

Alpha decay is a radioactive decay of an atomic nucleus, which is accompanied by the emission of an alpha particle. An atom that undergoes alpha decay will reduce its example, after undergoing alpha decay, an atom of uranium (with 92 protons) becomes an atom of thorium (with 90 protons). In the alpha decay of a nucleus, the change in binding energy appears as the kinetic energy of the alpha particle and the daughter nucleus. [5]

*B. Beta decay*

radioactive process in which a beta particle is emitted from the nucleus of an atom, raising the atomic number of the atom by one if the particle is negatively charged, lowering it by one if positively charged. [6]

*C. Gamma decay*

Gamma decay is emission of electromagnetic radiation from an unstable nucleus gamma radiation often occurs after a nucleus has emitted alpha and beta particle. [7]

$${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$$

$${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + 2\,{}^{1}_{0}n$$

Fig. 3 Nuclear fission of uranium nuclide [8]

In nuclear fission reaction U-235 absorbs thermal neutron, forms highly excited U-236 compound nucleus motion may produce a neck and Coulomb force may stretch it out. Fission occurs free neutrons are ejected fragment undergo subsequent decay, these decay show in fig 4. In nuclear reaction different type of reaction occurs that are alpha decay, beta decay, positron elimination, electron capture, gamma emission and spontaneous fission [9]

## V. EVOLUTION OF NUCLEAR POWER IN INDIA

Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity, so if the India has 21 nuclear reactors in operation in 7 nuclear power plants [an], having an installed capacity of 6780 MW and producing a total of 30,292.91GWh of electricity while 6 more reactors are under Construction expected to generate an additional 4,300 MW.

**Different generation of nuclear power plant, which especially depend on modified reactor**

*A. Generation I*: The 1st generation reactors titled as "Early prototypic reactors". Reactors were developed in 1950-60s and very few are still running today. [10]

 

*B. Generation II*: Generator II reactors "active safety systems" was often being used. They developed in mid of 1960s. Many electrical and mechanical operation on command used in "safety system" which mainly controlled and operate by electricity only, if not they shut down. Today about 90% of overall nuclear power generate by generation II reactors.

*C. Generation III*: In mid 1990s advanced reactor developed, their designs integrate further unreceptive shelter systems which is to increase reactor safety by operating without human intervention or electrical power.

*D. Generation IV*: Latest nuclear reactor which will not operational before 2020. The closed fuel cycle will have used inside reactor with long-lived actinides. They mainly focused on the non-hazardous effect and non- radioactive waste. Many design of reactor will have based on fast neutron reactor.

**Six power plant of India**

1. Tarapur Atomic Power Station (TAPS),
2.Rajasthan Atomic Power Station (RAPS), Rajasthan
3. Kaiga Generating Station (KGS), Karnataka
4. Kudankulam Atomic Power Project, Tamilnadu
5. Kakrapar Atomic Power Station(KAPS), Gujarat
6. Narora Atomic Power Station (NAPS), Uttar Pradesh.

The growth in nuclear power plant can easily see from 2011 to 2016 in India. Statistical data shows different unit of electricity production in 2011 and 2016.

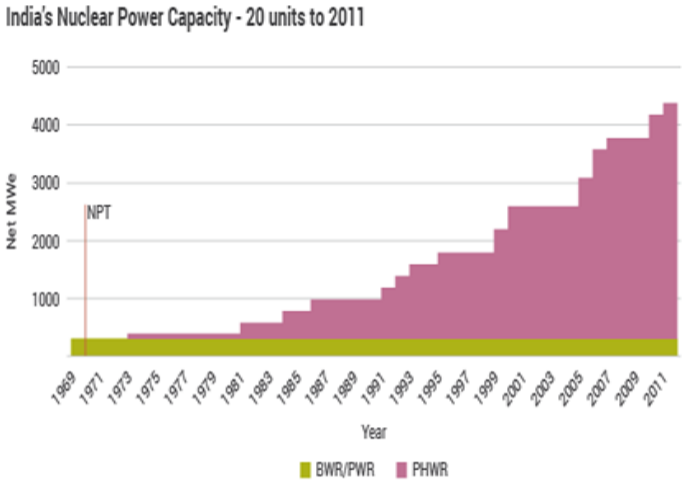


Fig .4 The increasing India's nuclear power growth from 1969 to 2011. [11]

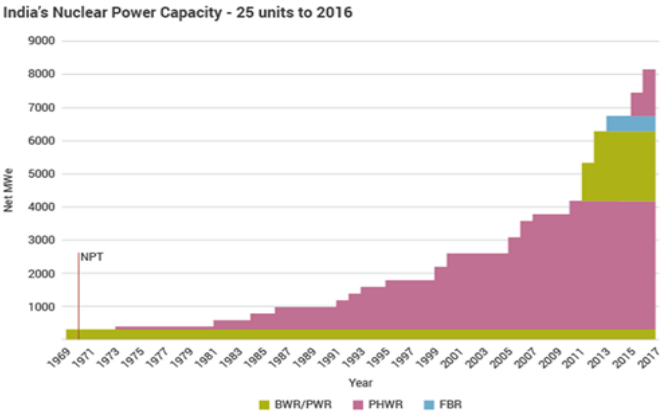


Fig. 5 The increasing nuclear power growth from 1969 to 2017 [12]

From the graph study it is clear that till 2011 India's nuclear power capacity at 20 units but in 2016 it became 25 units so, there is a continuous growth in production of nuclear energy as it is a very convenient renewable source of energy. [13]

## VI. CONCLUSION

Nuclear fission remains an important for our energy requirement and maintaining balance. They neither create any type of precursors to acid rain and global warming. Only they required a larger time and cost at a time, but they have the potential to generate enormous amount of energy and save our non-renewable resources so its energy demand increases. [13]. Indian nuclear power program is fully developed and has graduated in all facets of nuclear power technology.

The new techniques introduced in nuclear power which consumed many man power and generate huge amount of electricity with focusing very less nuclear waste. As India is developing country and its large amount of electricity which can easily available by nuclear power.

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