A Dissertation
on

GUI BASED PRESSURIZER WATER REACTOR SIMULATOR USING PYTHON

Submitted in the partial fulfillment of the requirements of the degree of

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In

NUCLEAR SCIENCE & ENGINEERING

By

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CERTIFICATE

This is to certify that the Major project (AP-811) report entitled " **GUI BASED PRESSURIZER WATER REACTOR SIMULATOR USING PYTHON** *" is a bonafide work carried out by* **Mr. DIPANKAR GOLDER** *bearing Roll No.* **2K14/NSE/09***, a student of Delhi Technological University, in partial fulfilment of the requirements for the award of Degree in* **Master of Technology** *in* "**Nuclear Science & Engineering**"*.As per declaration given by the student this work has not been submitted to any other university/institute for the award of any degree or diploma.*

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First and foremost I would like to thank my parents for their blessings, support and guidance throughout my academic career.

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I thank all my friends to keep me cheerful and make me smile whenever I feel low.

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

PLACE: DIPANKAR GOLDER

DATE: (2K14/NSE/09)

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Abstract

This Thesis consists on the pressurized water reactor (PWR) simulator by using python language. The main purpose of this thesis is educational simulator, there are required simplifications and assumptions complete in this models, which may not replicate any exact vendor's plan or performance.

This thesis is write with the statement that the nuclear reactors, how it works and classification of nuclear reactor. But mainly focus on each and every individual components of pressurizer water reactor.

The simulator model of PWR shown can be studied to understand the internal operation of PWR such as movement of control rod, variation of temperature and its effect on output power of the reactor. In this simulation model I have mainly concentrated on the effect of variation of temperature on the output power depending upon the movement of control rod. Assigning the movement of control to a program is difficult task. That is making a program to understand the mechanical motion of control rod has been typical. For this in the program the logic was given so that when control rod moves up the previous position gets completely deleted and if we again move the control rod up then then the previous increment of control rod gets deleted. The reverse process will be happening when we move the control rod down.

We can say that understanding the motion of water, control rod and variation in temperature is affecting the output power and this can be clearly understood in this thesis. In future this work can be extended by introducing some other complex parameter such as stress or combination of complex parameters such as temperature and stress etc. introducing these things can make understanding of internal operation of PWR simulator more easier.

CHAPTER 1

INTRODUCTION

1.1 PURPOSE

This Thesis consists on the pressurized water reactor (PWR) simulator by using python language. The main purpose of this thesis is educational simulator, there are required simplifications and assumptions complete in this models, which may not replicate any exact vendor's plan or performance.

This thesis is write with the statement that the nuclear reactors, how it works and classification of nuclear reactor. But mainly focus on each and every individual components of pressurizer water reactor, description generally found in nuclear engineering books. .

.The manual cover fundamental NPP plant operations, similar to plant load moving, and trips and recuperation e.g. turbine excursion and reactor scram. Also, it covers plant reactions to breakdown events. Some breakdown events lead to reactor scram or turbine trip. Other serious breakdowns lead to accident situation bringing about incitation of the uninvolved center cooling security system

It should be specified that the components and processes modeled in the simulator represent realistic PWR characteristics. In any case, with the purpose of the simulator,, there are important improvements and suppositions made in the models, which may not reflect a particular merchant's configuration or execution.

In particular, the reactions showed by the simulator, under mishap circumstances, ought not be utilized for security analysis purposes, in spite of the way that they are reasonable with the purpose of educational training.

Most importantly, the responses manifested by the simulator, under accident situations, should not be used for safety analysis purposes, despite the fact that they are realistic for the purpose of educational training. As such, it is appropriate to consider that those simulator model responses perhaps only provide first order estimates of the plant transients under accidents scenarios.

1.2 Historical background

Pressurized water reactors were mainly designed for submarines. The research and growth works were performed by Westing house Bettis Laboratories and Knolls Atomic Power Laboratory. As a result of this initial research and growth work, a commercial PWR was designed and developed for nuclear power plant applications. Eventually, several commercial PWR suppliers emerge: Wilcox, Westinghouse and Combustion Babcock Engineering in the USA; Framatone in France and Siemens in Germany. Subsequently, Agip Nucleari in Italy and Mitsubishi in Japan became PWR licensees.

Over the past three decades, many PWRs were in service, accumulating thousands of reactor years of operating experience. In recent years, new generations of advanced PWR nuclear power plants have been developed, building upon the past success, as well as applying lessons learned from past operating experience. The advanced PWR design incorporates efforts by utilities, and the regulators to establish standardized solutions to meet their requirements. This is because the advanced PWR design has to be suitable for deployment in many countries. As well, the design has to be economical. In this context, important programmed in the development of advanced PWRs were initiated in the mid 1980s in the USA. In 1984, the Electric Power Research Institute (EPRI), in cooperation with US Department of Energy (DOE), and with the participation of US nuclear plant designers, and several foreign utilities, initiated a programmed to develop utility requirements to guide the advanced PWR design. As a result of this effort, utilities requirements were established for large PWRs having ratings of 1200 MW(e) to 1300 MW(e), and for mid-size PWRs in the 600 MW range. The effort for advanced PWR design was led by Westinghouse for the AP The effort for advanced PWR design was led by Westinghouse for the AP-600 and AP-1000design, which received NRC certification in 1999. Westinghouse indicates that the AP-600and AP-1000 designs.

.CHAPTER 2

LITERATURE REVIEW

2.1 FISSION AND FUSION:

Nuclear fusion is the reaction in which two or more nuclei combine, forming a new element with a higher atomic number(more protons in the nucleus). The energy released in fusion is related to $E = mc^2$ (Einstein's famous energy-mass equation). On Earth, the most likely fusion reaction is Deuterium–Tritium reaction. Deuterium and Tritium are isotopes of hydrogen.

${}^{2}_{1}$Deuterium + ${}^{3}_{1}$Tritium = ${}^{4}_{2}He + {}^{1}_{0}n$ + 17.6 MeV

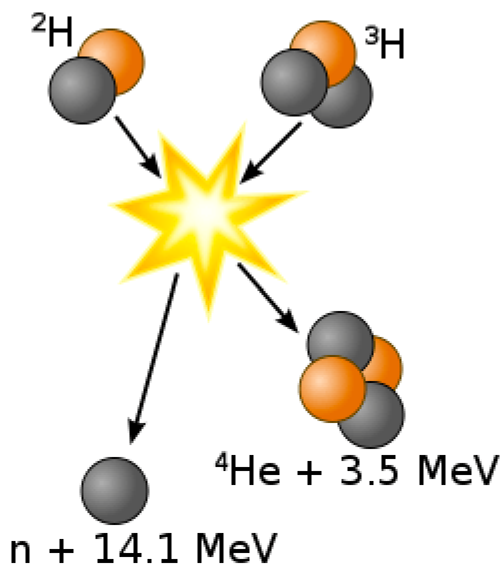

Fig 1.1 Fission Reaction

Nuclear fission is the splitting of a massive nucleus into photons in the form of gamma rays, free neutrons, and other subatomic particles. In a typical nuclear reaction involving ${}^{235}U$ and a neutron:

$$ {}^{235}_{92}U + n = {}^{236}_{92}U $$

followed by

$$ {}^{236}_{92}U = {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3n + 177 \text{ MeV} $$

2.1.1FISSION VS FUSION

Atoms are held together by two of the four fundamental forces of nature: the weak and strong nuclear bonds. The total amount of energy held within the bonds of atoms is called binding energy. The more binding energy held within the bonds, the more stable the atom. Moreover, atoms try to become more stable by increasing their binding energy.

The nucleon of an iron atom is the most stable nucleon found in nature, and it neither fuses nor splits. This is why iron is at the top of the binding energy curve. For atomic nuclei lighter than iron and nickel, energy can be extracted by combining iron and nickel nuclei together through nuclear fusion. In contrast, for atomic nuclei heavier than iron or nickel, energy can be released by splitting the heavy nuclei through nuclear fission.

The notion of splitting the atom arose from New Zealand-born British physicist Ernest Rutherford's work, which also led to the discovery of the proton.

2.1.2 CONDITION FOR FUSSION AND FUSION

Fission can only occur in large isotopes that contain more neutrons than protons in their nuclei, which leads to a slightly stable environment. Although scientists don't yet fully understand why this instability is so helpful for fission, the general theory is that the large number of protons create a strong repulsive force between them and that too few or too many neutrons create "gaps" that cause weakening of the nuclear bond, leading to decay (radiation). These large nuclei with more "gaps" can be "split" by the impact of thermal neutrons, so called "slow" neutrons.

Conditions must be right for a fission reaction to occur. For fission to be self-sustaining, the substance must reach critical mass, the minimum amount of mass required; falling short of critical mass limits reaction length to mere microseconds. If critical mass is reached too quickly, meaning too many neutrons are released in nanoseconds, the reaction becomes purely explosive, and no powerful release of energy will occur.

Nuclear reactors are mostly controlled fission systems that use magnetic fields to contain stray neutrons; this creates a roughly 1:1 ratio of neutron release, meaning one neutron emerges from the impact of one neutron. As this number will vary in mathematical proportions, under what is known as Gaussian distribution, the magnetic field must be maintained for the reactor to function, and control rods must be used to slow down or speed up neutron activity.

Fusion happens when two lighter elements are forced together by enormous energy (pressure and heat) until they fuse into another isotope and release energy. The energy needed to start a fusion reaction is so large that it takes an atomic explosion to produce this reaction. Still, once fusion begins, it can theoretically continue to produce energy as long as it is controlled and the basic fusing isotopes are supplied.

The most common form of fusion, which occurs in stars, is called "D-T fusion," referring to two hydrogen isotopes: deuterium and tritium. Deuterium has 2 neutrons and tritium has 3, more than the one proton of hydrogen. This makes the fusion process easier as only the charge between two protons needs to be overcome, because fusing the neutrons and the proton requires overcoming the natural repellent force of like-charged particles (protons have a positive charge, compared to neutrons' lack of charge) and a temperature — for an instant — of close to 81 million degrees Fahrenheit for D-T fusion (45 million Kelvin or slightly less in Celsius). For comparison, the sun's core temperature is roughly 27 million F .

Once this temperature is reached, the resulting fusion has to be contained long enough to generate plasma, one of the four states of matter. The result of such containment is a release of energy from the D-T reaction, producing helium (a noble gas, inert to every reaction) and spare neutrons than can "seed" hydrogen for more fusion reactions. At present, there are no secure ways to induce the initial fusion temperature or contain the fusing reaction to achieve a steady plasma state, but efforts are ongoing.

A third type of reactor is called a breeder reactor. It works by using fission to create plutonium that can seed or serve as fuel for other reactors. Breeder reactors are used extensively in France, but are prohibitively expensive and require significant security measures, as the output of these reactors can be used for making nuclear weapons as well.

2.2 Nuclear reactor:

A nuclear reactor previously known as an atomic pile. Nuclear reactor is a device that used to initiate and control a nuclear chain-reaction. Nuclear reactors are used at nuclear power plant for inpropulsion of ships and electricity generation Heat comes from nuclear fission is passed to a working liquid (gas or water), which goes through steam turbines. These either drive a ship's propellers or turn electrical generators. Nuclear reactors main principle is steam generation it can be used for district heating or industrial process.. A few reactors are utilized to produced isotopes for industrial and medical use, or for production of weapons-grade plutonium. Some reactors are used just for exploration. Today there are around 450 atomic power reactors that are used to produce power in around 30 nations around the world.

The world's first atomic reactors worked normally in a uranium store around two billion years back. These reactors were enrich uranium ore bodies and moderated by rainwater. The seventeen known at Oklo in west Africa, each under 100 kW thermal and together expended around six tons of that uranium. It is expected that these were not unique worldwide.

Today, reactors got from designs initially developed for pushing submarines and naval ships generate around 85% of the world's atomic electricity. The principle outline is the pressurized water reactor which has water at more than 300°C under pressure in its primary cooling/heat exchange circuit, and produces steam in a secondary circuit. The less various boiling water reactor (BWR) makes steam in the primary circuit over the reactor core, at comparative same temperatures and pressure. Water is used both coolant and arbitrator in PWR and BWR, to slow neutrons. Since water boils at 100°C, they have strong steel pressure vessels or tubes to enable the higher working temperature.

2.3 COMPONENTS OF NUCLEAR REACTOR

There are several components of nuclear reactors are :-

a) Fuel: Uranium is the basic fuels. Pellets of uranium oxide are arranged in tube to from fuel.

b) Moderator: Material in the core which shows down the neutrons released from fission so that they cause more fission. It may generally heavy water or graphite.

c) Control rod: It is used control the rate of reaction. Special control rod are used to enable the core to sustain a low level of power efficiency.

d) Coolant: It is used to transfer the heat it. In light water reactor water is used as coolant.

e) Pressure tube: It is made up of steel and used for hold the fuel and transfer the coolant through surrounding moderator.

f) Steam generator: Part of cooling system where the high pressure primary coolant bringing heat from reactor is used to make steam for the turbine. It is also Known as heat exchanger.

g) Containment: It is made by steel or concrete.It protects from radiation which may occurs in case of any serious malfunction inside.

2.4 Classification of Nuclear Reactor brief description are given below

2.4.1 NUCLEAR REACTOR CLASSIFICATION BY NUCLEAR REACTION

Nuclear reactor are two types by nuclear reaction A) Nuclear fission , B) Nuclear fusion.
Nuclear fusion also two types i) Thermal reactor, ii) Fast neutron. Given blew about this description.

2.4.1.1 A. NUCLEAR FISSION

All nuclear power reactors are mainly based on nuclear fission. They normally use uranium and its produce plutonium as nuclear fuel, though a thorium fuel cycle is also possible. Fission reactors is divided into two classes, depending on the neutrons energy that manage the fission chain reaction.

- **Thermal reactors:**Thermal reactor is the most common nuclear reactor. In thermal reactor use thermal neutrons to carry on the fission of their fuel. All present reactors are of this kind These contain neutron moderate neutrons until their neutron temperature is thermalized, that is, until their kinetic-energy approaches the normal kinetic-energy of the particles. Thermal neutrons or slow neutrons have a far high cross-section of fissioning the fissile cores uranium-235, plutonium-239, and plutonium-241, and a fairly lower possibility of neutron capture by uranium-238 compared with the fast neutrons that originally come out from fission .It allowing use of natural uranium or low-enhanced uranium fuel. The moderator is often the coolant, more often u water under high pressure and to increase the boiling point . These are encompassed by a reactor vessel, instrumentation to screen and control the reactor, radiation protecting, and a containment building.

- **Fast-neutron reactors:** Fast neutron reactors utilize fast neutrons to bring about fission in their fuel. They don't have a neutron modaretor and utilize less-moderating coolants. It requires the fuel which is more highly about 20% or more enriched in fissile material to maintain chain reaction. The fissile material relatively lower possibility of fission against capture by U-238 . Fast reactors can possibly create less transuranic waste since all actinides are fissionable with fast neutrons, but they are very difficult to build and more costly to work. Generally speaking, fast reactors are less regular than thermal reactors in many applications.

2.4.1.2 B. NUCLEAR FUSION

Nuclear fusion power is a technology, by and large with hydrogen as fuel. While not appropriate for power creation, Farnsworth-Hirsch fusors are used to deliver neutron radiation.

2.4.2 NUCLEAR REACTOR CLASSIFICATION BY MATERIAL

Nuclear reactor again classified three types by moderator material such as.

2.4.2.1 WATER MODERATOR REACTORS

Water moderator reactors are divided by two types i) Heavy-water reactors, ii)Light-water moderated reactors

2.4.2.1.1 HEAVY-WATER REACTORS

Pressurezed heavy water reactor also known as CANDU , it is a Canadian design These reactor are heavy-water moderator and cooled pressurizer water reactors. Rather than using a large pressure vessel as in a PWR , the fuel is contained in several pressure tubes. PHWRs are energized with enriched uranium and are thermal neutron reactor outlines. PHWRs can be refueled while at full power, which makes them exceptionally proficient in their using of uranium. This PHWRs have been built, Argentina, Canada, China, India, , Romania, South Korea and Pakistan. India operates some number of PHWRs.

2.4.2.1.2 LIGHT WATER REACTOR

Light-water reactors use normal water to moderate and cool the reactors. At the point when at working temperature, if the temperature of the water increases and its density drops, and less neutrons going through it are slowed back to trigger further reactions. That negative feedback balances out the reaction rate. Graphite and heavy water reactors have a tendency to be more completely thermalized than light water reactors. Because of the additional thermalization, these sorts can use unenriched uranium/natural fuel.

2.4.2.2 B. LIGHT ELEMENT-MODERATORS

Light element-moderated reactors also divided two types i)Molten salt reactors, ii)Liquid metal cooled reactors.

2.4.2.2.1 MOLTEN SALT REACTORS

These dissolve the fuels in fluoride salts, or use fluoride salts for coolant. These have many safety features, high efficiency and a high power density suitable for vehicles. Notably, they have no high pressures or flammable components in the core. The prototype was the MSRE, which also used the Thorium fuel cycle. As a breeder reactor type, it reprocesses the spent fuel, extracting both Uranium and transuranics, leaving only 0.1% of transuranic waste compared to conventional once-through uranium-fueled light water reactors currently in use. A separate issue are the radioactive fission products, which are not reprocessable and need to be disposed of as with conventional reactors.

2.4.2.2.2 LIQUID-METAL FAST–BREEDER REACTOR (LMFBR)

This is a reactor design that is cooled by liquid metal, totally unmoderated, and produces more fuel than it consumes. They are said to "breed" fuel, because they produce fissionable fuel during operation because of neutron capture. These reactors can function much like a PWR in terms of efficiency, and do not require much high-pressure containment, as the liquid metal does not need to be kept at high pressure, even at very high temperatures. BN-350 and BN-600 in USSR and Super phoenix in France were a reactor of this type, as was Fermi-I in the United States. The Monju reactor in Japan suffered a sodium leak in 1995 and wasre started in May 2010. All of them use/used liquid sodium. These reactors are fast neutron, not thermal neutron designs. These reactors come in two types: i)Lead-cooled ii) Sodium-cooled

2.4.2.3 GRAFITE-MODERATOR REACTORS

These are generally graphite moderated and CO_2 cooled. They can have a high thermal efficiency compared with PWRs due to higher operating temperatures. There are a number of operating reactors of this design, mostly in the United Kingdom, where the concept was developed. Older designs (i.e. Magnox stations) are either shut down or will be in the near future. However, the AGCRs have an anticipated life of a further 10 to 20 years. This is a thermal neutron reactor design. Decommissioning costs can be high due to large volume of reactor core.

2.4.3 NUCLEAR REACTOR CLASSIFICATION BY COOLANT

Nuclear reactors again classified three types by coolant A) Boiling water reactor, B) Pressurized water reactor and C) Pool types reactors.

2.4.3.1 BOILING WATER REACTOR (BWR):

.Boiling water reactor like a pressurizer water reactor without the pressurizer and steam generator. BWR is a single loop circulation system and its control rods from below .In BWR uranium oxide act as fuel. Water turns into steam and drives the turbine. Not at all like a PWR, there is no primary and secondary loop. The thermal productivity of these reactors can be higher. They can be more straightforward, and even possibly more steady and safe. The most up

2.4.3.2 PRESSURISED WATER REACTOR (PWR):

PWR reactors use a pressurzer, reactor vessel ,contain control rods, nuclear fuel, moderator, and coolant. PWR is cooled and moderated by high-pressure water. The hot radioactive water that leaves the pressure vessel is looped through a steam generator, which turn warms an secondary loop of water to steam that can run turbines. They are the larger part of current reactors. This is a thermal neutron reactor outline, the most current of which are the VVER-1200, Advanced PWR and the European Pressurized Reactor.\

2.4.3.3 POOL TYPE REACROR

Pool-type reactors, also called swimming pool reactors, are a type of nuclear reactor that has a core (consisting of the fuel elements and the control rods) immersed in an open pool of usually water. Some sodium-cooled reactors like the BN-600 have sodium pools instead.

The water acts as neutron moderator, cooling agent and radiation shield. The layer of water directly above the reactor core shields the radiation so completely that operators may work above the reactor safely. This design has two major advantages: the reactor is easily accessible and the whole primary cooling system, *i.e.* the pool water, is under normal pressure. This avoids the high temperatures and great pressures of nuclear power plants. Pool reactors are used as a source of neutrons and for training, and in rare instances for process heat but not for electrical generation.

2.4.4 NUCLEAR REACTOR CLASSIFICATION BY GENERATION

- **Generation I reactor** : Generation 1 reactors are early prototypes non commercial power producing and research reactors.
- **Generation II reactor :** Generation II reactor are most current nuclear reactor, its time between 1965–1996
- **Generation III reactor :**Generation II reactors are evolutionary improvements of existing designs 1996-now .
- **Generation IV reactor** : possibly it will come 2030 now technology is under process

CHAPTER 3

REPORT ON PRESENT INVESTIGATION

3.1 PRESSURIZER WATER REACTOR:

PWR reactors use a pressurzer, reactor vessel ,contain control rods, nuclear fuel, moderator, and coolant. PWR is cooled and moderated by high-pressure water. The hot radioactive water that leaves the pressure vessel is looped through a steam generator, which turn warms an secondary loop of water to steam that can run turbines. They are the larger part of current reactors. This is a thermal neutron reactor outline, the most current of which are the VVER-1200, Advanced PWR and the European Pressurized Reactor.

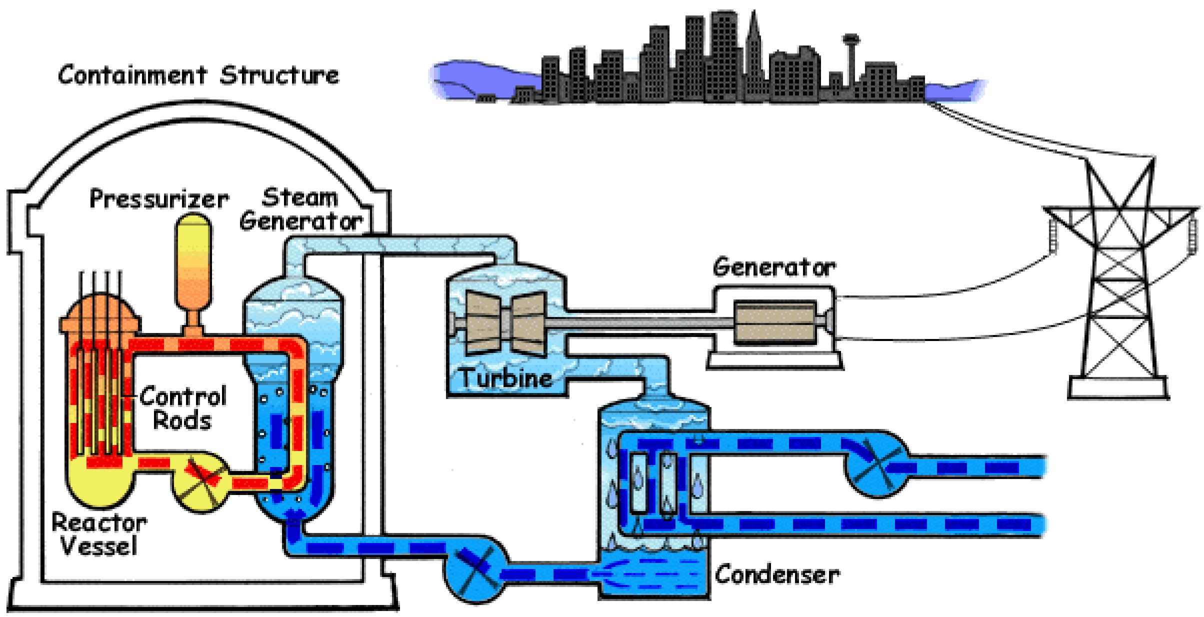

Fig 3.1 PWR Reactor

3.1.1 FUEL

In a high temperature, sintering furnace the uranium dioxide(UO2) powder is fired after enrichment . Hard, ceramic cylindrical pellets, which are created through the process, are now clad in zirconium metal alloy named zircaloy which is correction resistant and is backfilled with helium to detect leakages and to aid heat conduction zircaloy has a favorable mechanical property and also has a low absorption cross section, this is why it is chosen. The fuel rods which well finished, are now grouped in fuel bundles and then the reactor's core is built by using this fuel bundles. There are 200 to 300 rods in each fuel assembly of PWR and a large reactor consists of 150-250 such assemblies along with 80-100 tones of uranium. The normal dimension of fuel rods bundle is 14*14 to 17*17 and length is 4meter.900 to 1600MWe are produced by a typical PWR.

18 to 24 months are needed for a complete cycle of refueling for most commercial PWRs. Each fueling replaces one third of the core approximately, though in now a days refueling time is reduced to a few days by modern refueling scheme and the periodicity of refueling also becomes short.

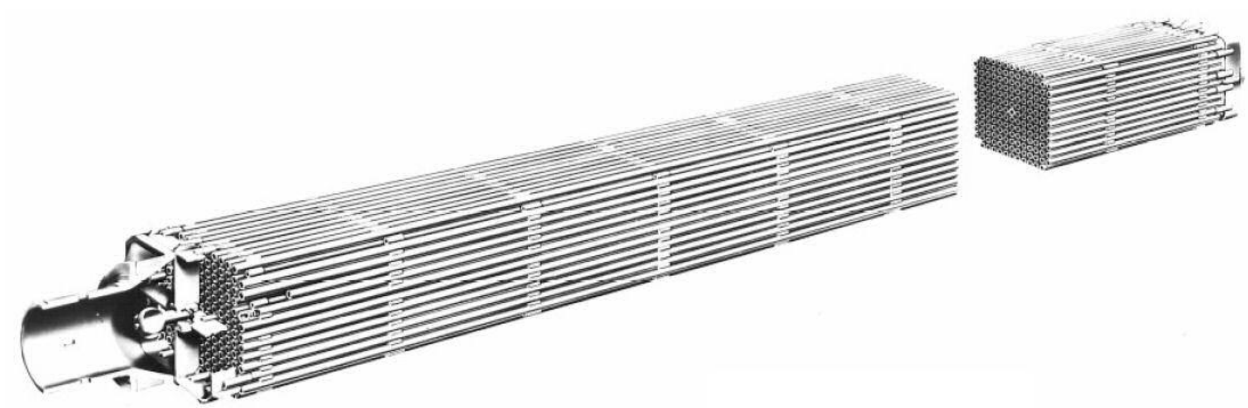

Fig.3.1.1 Fuel rods

3.1.2 MODERATOR:

There are some PWR reactors such as all thermal reactors, which need the fast fission neutrons to be slow for interacting with the nuclear fuel and sustain chain reaction. The neutrons of the coolant water undergo several collisions with the H2 atoms in the water in PWRs. In this process it losses some speed. The process, called moderating of neutrons, will occur when there will be more dense water will be present. When the temperature increases, the water will expand and there will be more gaps between the molecules of water which reduce thermalization and thus reduce the slow down process of neutrons and hence the reactivity reduce in the reactor. If there isa large increase in reactivity the chain reaction will be slowed down by the moderation process

, which will produce less amount of heat. PWR reactors become very stable for this property called negative temperature coefficient of reactivity. When the coolant gets hot, the reactivity decreases and shut down slightly to compensate. This entire process is called self regulating. In this way the plan is controlled by itself for a certain temperature set by the control rod's position.

In PWR there is extra room for increased moderation so PWRs are maintained in under moderated state. Because it there will be any moderation near saturation, density of the moderator will decrease, which could cause reduction moderation slightly and making the void coefficient positive.

3.1.3 REACTOR VESSEL:

The reactor core, and all related supporting devices, are housed inside the reactor vessel. The main components are the reactor vessel, the reactor core, the core barrel, and upper internals package .The reactor vessel is a tube shaped vessel with a hemispherical base head and a removable semi-circular top head. The top head is removable to consider the refueling of the reactor. There will be one cold leg or inlet nozzle and one hot leg or outlet nozzle for every reactor coolant loop system .The reactor vessel is made by a manganese molybdenum steel , and all surfaces that come into contact with reactor coolant are cladding with stainless steel to expand consumption resistance .The core barrel slides down within the reactor vessel and houses the fuel. Around the base of the core barrel, there is a lower core support plate on which the fuel congregations sit. The core barrel and all of the lower internals really hang inside the reactor vessel from the internals support edge. On the outer side of the core barrel will be irradiation specimen holders in which tests of the material utilized to manufacture the vessel will be set. At intermittent time intervals, some of these sample will be uninvolved and tried to perceive how the radiation from the fuel has influenced the strength of the material. The package site of the upper internals is on top of the fuel. It contains the aide sections to direct the control rods when they are pulled from the fuel. The package of upper internals is keeps the core from attempting to move up amid operation because of the force from the coolant moving through the assemblies.

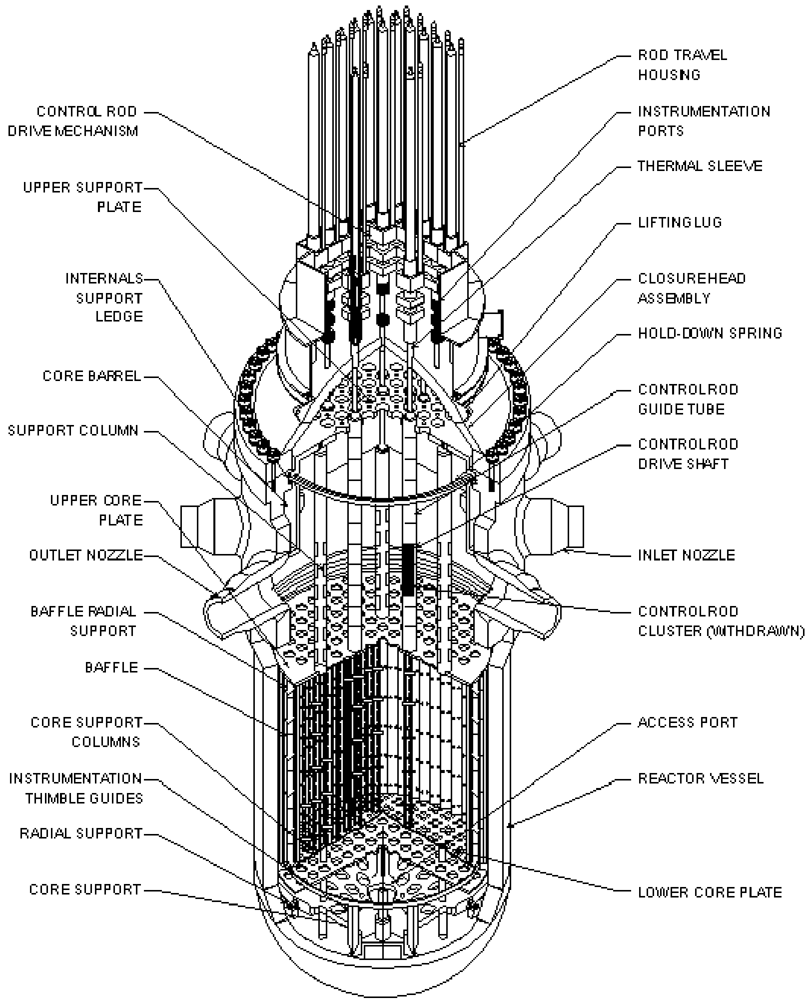

Fig 3.1.3 PWR Reactor vessel

The stream way for the reactor coolant through the reactor vessel would be:

• The coolant enters the reactor vessel at the cold nozzle(inlet nozzle) and hits against the core barrel.

• The core barrel compels the water to downward in the space between the core barrel and the reactor vessel.

• After achieving the base of the reactor vessel, the stream is rotated toward the upward to go through the fuel gatherings.

• The coolant streams all around and through the fuel gatherings, and heat remove which is generate by the fission process.

• The now more smoking water enters the upper internals area, where it is steered out the hot nozzle (outlet nozzle) and goes ahead to the steam generator.

3.1.4 STEAM GENERATORS:

The reactor coolant streams from the reactor to the steam generator. Within the steam generator, the hot reactor coolant streams within the many tubes. The auxiliary coolant, or feed water, streams around the outside of the tubes, where it grabs heat from the essential coolant. At the point when the feed water absorbs heat , it begins to boil and from steam. Now, the steam generators utilized by the three Pressurized Water Reactor sellers contrast somewhat in their plans and operations.

In the Combustion Engineering and Westinghouse outlines, the steam/water blend goes through multiple stages. One stage causes the boil water to spin ,which sling the water to the outside. The water is then depleted back to be utilized to make more steam. The drier steam is running to the second stage of partition. The mixture is enforced to make some changes in direction In this stage. In view of the steam's capacity to change the direction and the water's failure to change, the steam leaves the steam generator, and the water is depleted back for reuse. The two stage procedure of moisture removal is so productive at remove the water that for each 100 pounds of steam that leaves the steam generator, the water substance is under 0.25 pounds. It is important to maintain the moisture content of the steam as low as possible to prevent damage to the turbine blading.

The Babcock & Wilcox design uses a once through steam generator . In this design, the flow of primary coolant is from the top of the steam generator to the bottom, instead of through U-shaped tubes as in the Westinghouse and Combustion Engineering designs. Because of the heat transfer achieved by this design, the steam that exits the once through steam generator contains no moisture. It is essential to keep up the moisture substance of the steam as low as could be expected under the damage to the turbine balding. The Wilcox and Babcock design PWR utilizes once through steam generator . In this design, the stream of essential coolant is from the highest point of the steam generator to the base, rather than through U-shaped tubes . As a result of the heat exchange accomplished by this design, the steam that leaves the once through steam generator contains no moisture. This is finished by heating the steam over the boiling point. In a Westinghouse steam generator, there is a single outlet for the primary coolant and a single outlet for the steam. The steam generator design is piped to the turbine, and the coolant is steered to the suction of the reactor coolant pumps .Given blew the figure of steam generator and also described the each parameter of steam generator .

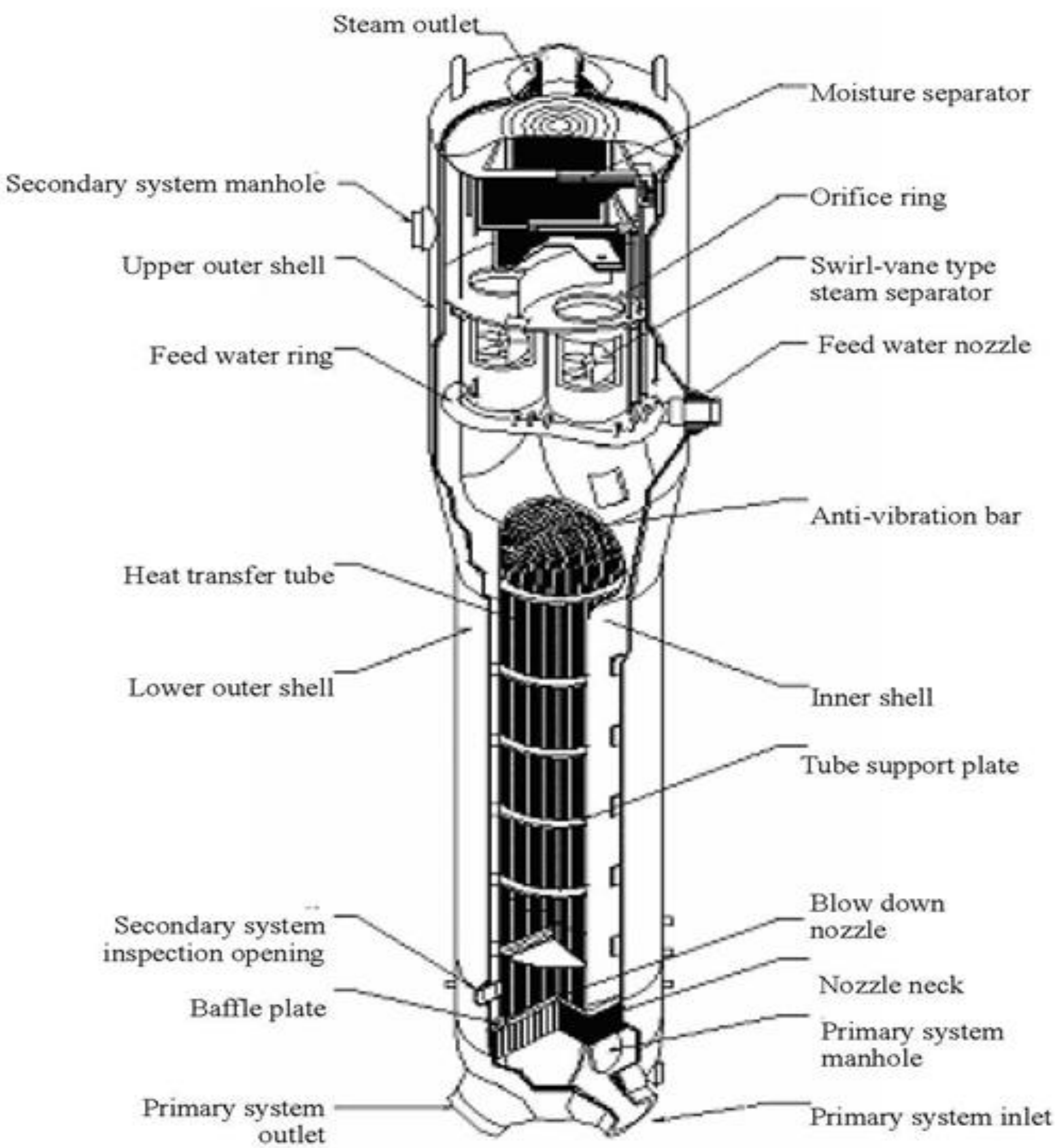

Fig 3.1.4 PWR steam generator

3.1.5 Design data of Steam Generator:

Type	U-tube steam generators with integral steam-drum
Height overall	20.62m
Upper shell OD	4.48m
Lower shell OD	2.44m
Operating pressure, tube side	15.5MPa
Design pressure, tube side	17.2MPa
Full load pressure, shell side	6.90MPa
Maximum moisture at outlet	0.25%
Design pressure, shell side	8.27MPa
Reactor coolant flow rate	4360kgs
Reactor coolant inlet temperature	325.8 degree/c
Reactor coolant outlet temperature	291.8 degree /c
Shell material	Mn-Mo steel
Channel head material with stainless steel	Carbon steel clad internally
Tube sheet material Inconel on primary face	Mo-Cr-Ni steel clad with
Tube OD	2.22cm
Average tube wall thickness	1.27
Steam generator weights	
• Dry weight in place	312.208kg
• Normal operation weight in place	376.028kg
• Flooded weight	509.384kg

3.1.6 REACTOR COOLANT PUMP :

Reactor coolant pump is mainly used to supply a flow of primary coolant. The objective of this pump is to remove heat, produced by the process called fission, using the flow of primary coolant . Even in the absence of a pump , natural circulation flow takes place through the reactor. However, for removing the generated heat , this flow isn't enough when the reactor is at power but the flow of natural circulation can easily remove the heat when the plant is shutdown.

The reactor coolant out from the steam generator outlet and goes into the pump through the suction side . There is an increase in velocity which is transferred into pressure, in the discharge. There is a pressure difference between the inlet pressure and the pressure of the reactor coolant at the discharge of the pump which is 90psi approximately.

Leaving the pump, the coolant enters the reactor vessel .From the cold leg side of the vessel, the coolant moves through the fuel and thus it collect some extra heat and then it goes into the steam generators.

Motor, hydraulic section and the seal package are the main components of this type of pump. The electric motor which is used , is air cooled and large in size.

It produces horsepower at the range 6000 to 10,000. For removing heat the sufficient amount of flow is provided by using this huge amount of power (100,000 gallon/min. per pump approx).

In the pump , there is two hydraulic section .One is impeller and the other one is discharge volute. By using a long shaft the pump impeller is joined to the motor.

There is a seal package, which is placed between the hydraulic section and the motor. This prevents water leaking up the shaft into the atmosphere. Leaked water is collected and sent to the seal leak of system due to the collection in various parts of the system.

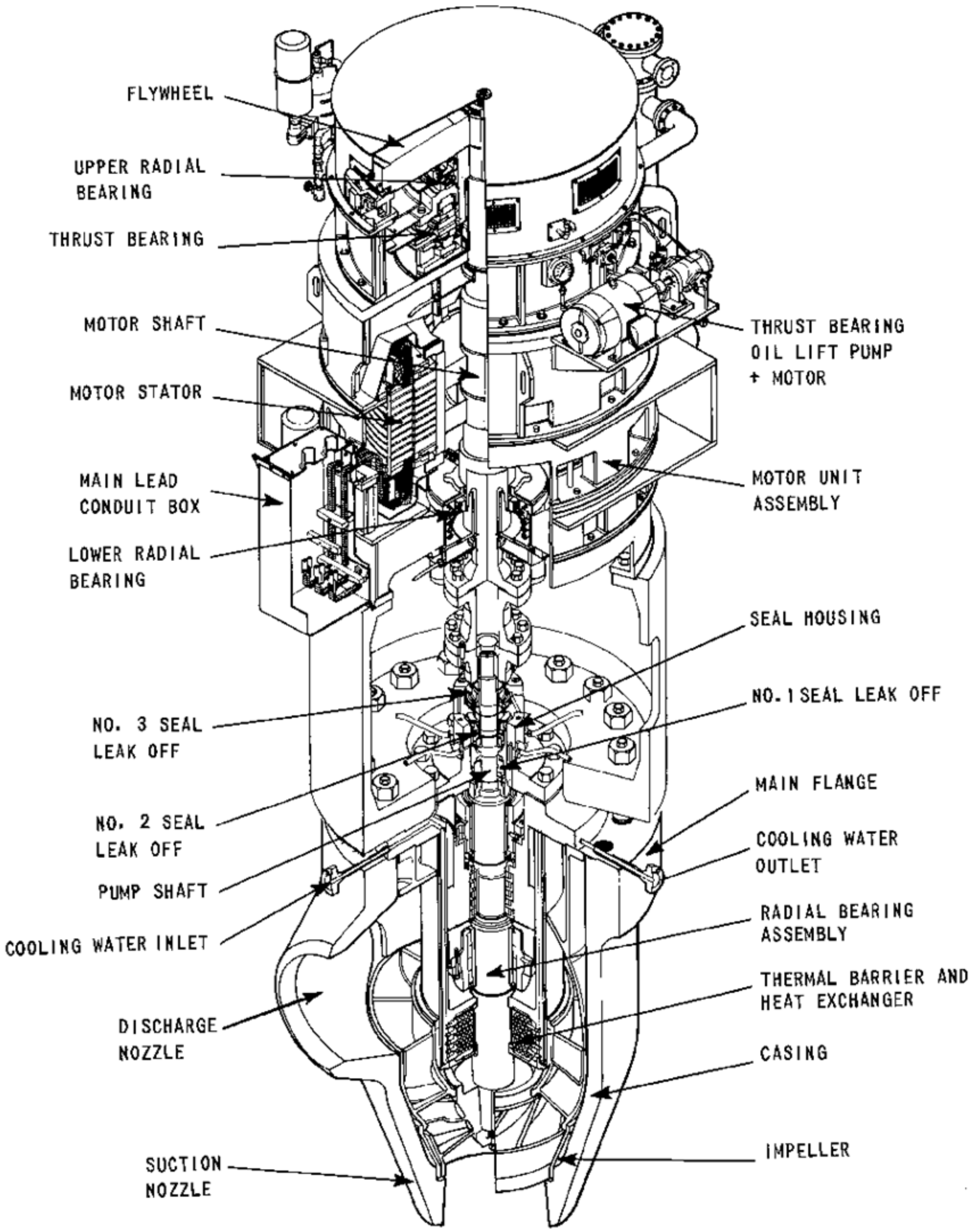

Fig 3.1.6 PWR coolant pump

3.1.7 PRESSURIZER:

The pressurizer is the part in the reactor coolant system. Pressurizer gives a method for controlling the system pressure. Pressure is controlled by the utilization of pressurizer shower, electrical heaters, safety valves and power operated relief valves .

The pressurizer works with a mixture of steam and water in balance. If pressure begins to move away from the preferred value , the different components will activate to take pressure back to the normal operating point. The reason for the pressure deviation is generally associated with a vary in the temperature of the reactor coolant system. If the temperature of reactor coolant is start to increase ,the reactor coolant density will decrease and the water will consume more room event that reactor coolant framework temperature begins to build, the thickness of the reactor coolant will diminish, and. Since the pressurizer is connected with the reactor coolant system by the surge line, the water will spread out into the pressurizer. This will bring about the steam in the highest point of the pressurizer to be compressed, and consequently, the pressure to increase.

The inverse effect will happen if the reactor coolant system temperature decreases. The water will turn out to be more dense , and will possess less space. The pressurizer level will decrease, which will bring about a pressure decrease . For a pressure decrease or increase, the pressurizer will work to take pressure back to normal

For example, if pressure starts to increase above the desired set point, the spray line will allow relatively cold water from the discharge of the reactor coolant pump to be sprayed into the steam space. The cold water will condense the steam into water, which will reduce pressure (due to the fact that steam takes up about six times more space than the same mass of water). If pressure continues to increase, the pressurizer relief valves will open and dump steam to the pressurizer relief tank. If this does not relieve pressure, the safety valves will lift, also discharging to the pressurizer relief tank. If pressure starts to decrease, the electrical heaters will be energized to boil more water into steam, and

therefore increase pressure. If pressure continues to decrease, and reaches a predetermined set point, the reactor protection system will trip the reactor.

The pressurizer relief tank is a large tank containing water with a nitrogen atmosphere. The water is there to condense any steam discharged by the safety or relief valves. Since the reactor coolant system contains hydrogen, the nitrogen atmosphere is used to prevent the hydrogen from existing in a potentially explosive environment

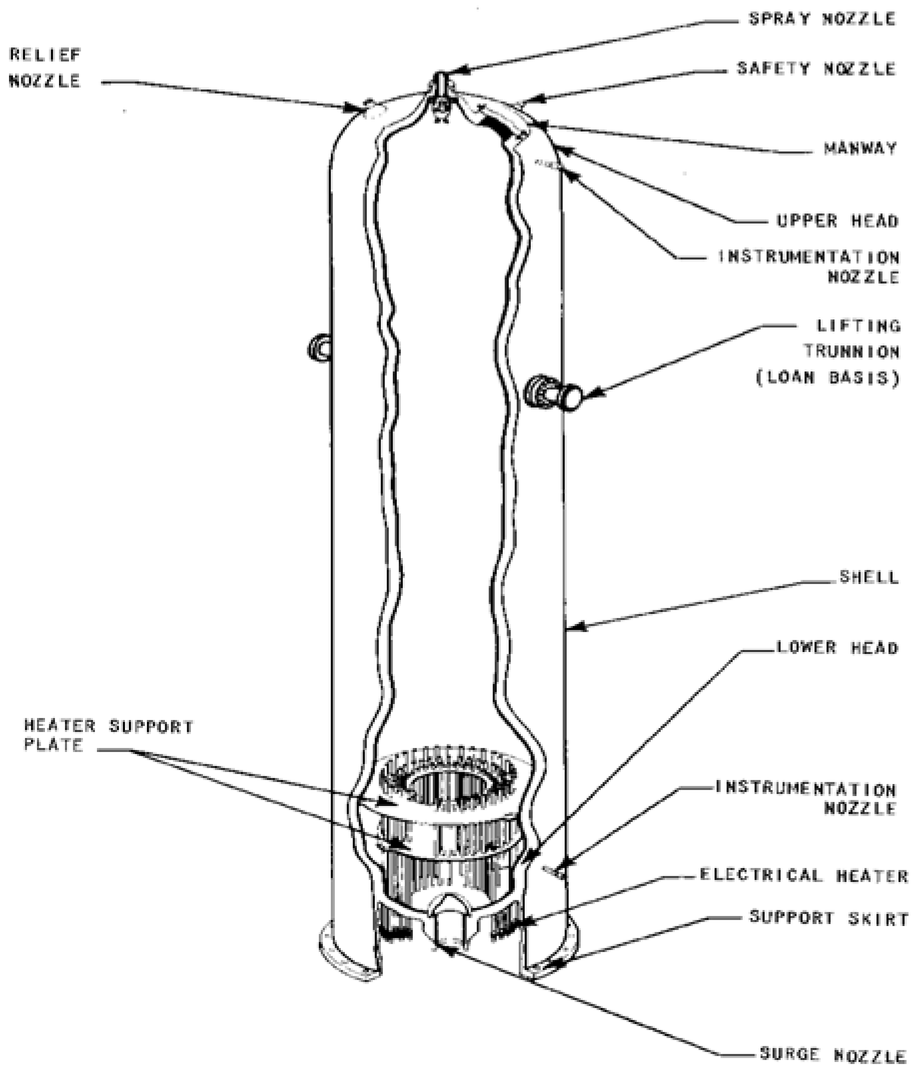

Fig 3.1.7 PWR pressurizer

3.1.8 TURBINE GENERATION SYSTEM

The PWR plant is separated completely into the primary system and the secondary system. Since the steam generated in a steam generator does not contain the radioactivity, the turbine-generator system is essentially the same to that of the conventional thermal power plant. But, as the generated steam is a low-pressure saturated one, it is necessary to use much more steam compared with the conventional thermal power plant and 4 pole turbines (1, 500 or 1,800 rpm) are used due to large turbines.

3.1.9 EMERGENCY CORE COOLING SYSTEM:

There are mainly two objective of emergency core cooling system (ECCS). One is to minimize the of the fuel by providing core cooling. By injecting huge amount of cool, borated water into the reaction cooling system, the minimization of the fuel damage is done. The second objective is to supply extra neutron poisons by using the some borated source of water to ensure the shutdown of the reactor. Another name of the water source is refueling water storage tank (RWST).

There are four separate system in the emergency core cooling system to inject large amount of borated water. In the order of descending pressure the systems are :-

I)High pressure injection system.

ii) Intermediate pressure injection system.

iii) The cold leg accumulation.

iv) The low pressure injection system.

To provide enough amount of flow each system consists of two pumps, even one pump is shown in the diagram. These systems also operate when power supply is lost due to this reason plant emergency power system is used to give power to these system.

When there is an emergency actuation signal, the high pressure injection system automatically takes water from refueling after storage tank and deliver it into the reaction coolant system.

The objection of this system is to deliver water to the core in emergency condition means when the pressure of the reactor coolant system remains high.

The function of intermediate pressure injection system is also same as that of the high pressure injection system except that here the primary pressure stays, high, such as small to intermediate size primary breaks.

The cold leg accumulators contain huge amounts of borated water and pressurized nitrogen gas bubble and it can be operated without any electric power. When the primary system pressure drops significantly the borated water is forced out of the tank by nitrogen delivered into the reactor system. The emergency condition in which the system gets activated is when the primary pressure drops rapidly line large primary breaks.

The low pressure injection system operates during large breaks which comes low pressure in reactor coolant system. It takes water from sump and pump it through heat exchanger for cooling , and then send it to the reactor for core cooling .This system is used for core cooling means when the refueling water tank becomes empty then this method of cooling is used.

3.2 ADVANTAGES OF PWR:

PWR reactors are very stable due to their tendency to produce less power as temperatures increase; this makes the reactor easier to operate from a stability standpoint.PWR turbine cycle loop is separate from the primary loop, so the water in the secondary loop is not contaminated by radioactive materials. PWRs can passively scram the reactor in the event that offsite power is lost to immediately stop the primary nuclear reaction. The control rods are held by electromagnets and fall by gravity when current is lost; full insertion safely shuts down the primary nuclear reaction

- PWR reactors are extremely steady because of their tendency to deliver less power as temperatures raise, it makes the reactor easy to work from a stability stance.
- Pressurized Water Reactor (PWR) turbine cycle loop is isolated from the essential loop, so the water in the auxiliary loop is not tainted by radioactive materials.
- PWRs can inactively scram the reactor if offsite force is lost to instantly stop the essential nuclear reaction. The control-rods are held by electromagnets and fall by gravity when electricity is lost, full insertion securely close down the essential nuclear reaction.

- PWR technology is favored by countries trying to build up and nuclear naval force, the solid reactors fit well in nuclear submarines and ships.

3.3 DISADVANTAGES OF PWR:

The coolant water must be very pressurized to remain liquid at high temperatures. This requires high quality piping and an heavy-pressure vessel and subsequently expands construction costs. The higher pressure can raise the consequences of lost coolant accident. The reactor pressure-vessel is manufactured from flexible steel at the same time, as the plant is worked, neutron flux from the reactor causes this steel to end up less bendable. Inevitably the flexibility of the steel will achieve limits controlled by the pertinent evaporator and weight vessel principles, and the weight vessel must be repaired or supplanted. This won't not be practical or economic, thus decides the life of the plant

Extra high pressure components, for example, steam generators, pressurizer, reactor coolant pumps and so on are additionally required. This additionally expands the capital expense and many-sided quality of a PWR power plant.

The high temperature water coolant with boric corrosive broke up in it is destructive to carbon steel but not stainless steel , this can bring about radioactive erosion products to rotate in the primary coolant loop. This confines the lifetime of the reactor, as well as the frameworks that sift through the erosion products and modify the boric corrosive concentration add essentially to the radiation exposure and to the general expense of the reactor . In one time, this has brought about serious consumption to control rod drive mechanisms when the boric corrosive arrangement leaked through the seal between the component itself and the primary system

Only 0.7% uranium-235 is natural, the isotope essential for reactors. This makes it important to enhance the uranium fuel, which essentially builds the expenses of fuel production. It is a very serious proliferation for requirement of PWR’s enrich fuel .

3.4 PYTHON LANGUAGE:

Python is a high level computing language which is widely used in general-purpose, dynamic programming, interpreted language . Its outline theory accentuates code comprehensibility, and its syntax permits programmers to express ideas in less lines of code than possible in language, for example, java or C++. The language gives develops expected to empower clear projects on both a little and vast scale.

Python is Interpreted: Python is prosecute at runtime by the mediator. You don't have to order your system before executing it. This is like PERL and PHP.

Python is Interactive: You can really sit at a Python incite and cooperate with the translator directly to compose your projects.

Python is Object-Oriented: Python hold Object-Oriented style or procedure of programming that embodies code inside items.

Python is a Beginner's Language: Python is an extraordinary language for the learner-level programmers and backings the improvement of an extensive variety of uses of application. But our programmer based on Python Tkinter and discus on it.

Tkinter

Without Tk Python would be less alluring to numerous clients. Tk is called Tkinter in Python, or to be exact, Tkinter is the Python interface for Tk. Tkinter is an acronym for "Tk interface". Tk proved as very successful in the 1990's, because it's toolkits is very useful and easier to learnTk was created as a GUI augmentation for the Tcl scripting language by John . Tk demonstrated as to a great degree effective in the 1990's, on the grounds that it is less demanding to learn and to use than different toolboxs. So it is no big surprise that numerous developers needed to utilize Tk autonomously of Tcl. That is the reason ties for heaps of other programming languages have been created, including Perl, Ada (called TASH), Python (called Tkinter), Ruby, and Common Lisp.

Tkinter provides the following widgets:

- Canvas
- Button
- Frame
- checkbutton
- combobox
- entry
- label
- labelframe
- listbox
- menu
- menubutton
- message
- notebook
- tk_optionMenu
- panedwindow
- progressbar
- radiobutton
- scale
- scrollbar
- separator
- sizegrip
- spinbox
- text
- treeview
- window

3.5 OUTLINE IDEA FOR DESIGNING THE PWR SIMULATOR:

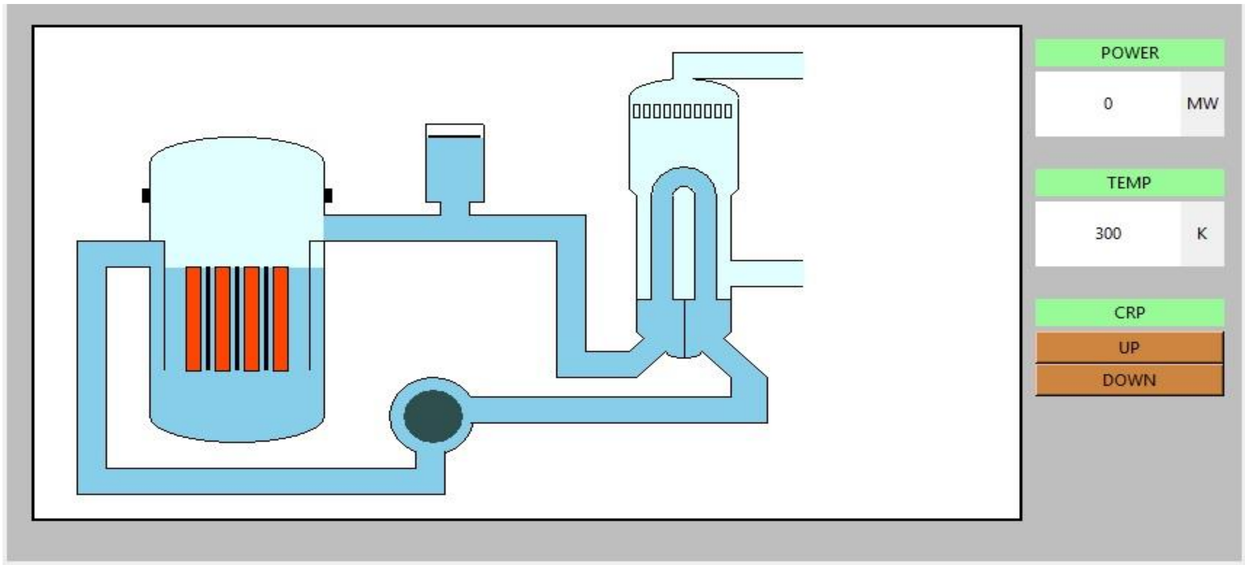

Fig 3.5 Outline of PWR simulator

Basically in this thesis we designed a simulation model for PWR reactor. Since this simulator should be user friendly, the graphical interface must be designed properly. For this purpose we have decided to use python as it is user friendly and well suited for graphical designs. As we have seen earlier that TKinter module can be integrated in python language for designing the GUI stuff. This TKinter can be obtained inbuilt in python. The outline idea for designing this simulator is first we take a WINDOW where the actual programing begins. Inside this window a FRAME is defined inside which a CANVAS is taken where the outline of actual PWR simulator is designed. This Canvas can be named as we declare a variable name like C1. This canvas can be called anywhere in the programme with this variable name. The schematic view of this PWR simulator is as shown in the figure if previous page. We can see that this PWR simulator is composed of colors, lines, rectangular and circular structures. The color is defined in python using the values of RGBs. The intensity of R, G, B defines the type of color. In python we define the color or value of each of R, G, B using hex code preceded by #. Like a color can be defined by #FFFFFF which indicates white color where the Red component is FF, Green component is FF etc. to arrange any object inside the canvas there basic can be used which are grid, place and pack. The PWR structure can be created using three basic commands such as create rectangle(), create line(), create arc(). Anything that can be drawn on the canvas can be controlled if we use the option of tagging it.

3.6 PROGRAMMING

```
from tkinter import *

class PWR_Simulator:

    def __init__(self):

        window=Tk()

        f1=Frame(window)

        window.title("PWR Simulator")

        self.c1=Canvas(f1, width=850,height =430,bg="#bebebe")

        f1.pack()

        self.c1.pack()

        self.c1.create_rectangle(20,20,700,400,fill="white",width=2,tags="boundary")



        #color begins

        self.c1.create_rectangle(430,145,505,75,fill="#E0FFFF",outline="#E0FFFF",tags="clr1")

        self.c1.create_rectangle(460,60,474,75,fill="#E0FFFF",outline="#E0FFFF",tags="clr1")

        self.c1.create_rectangle(500,200,550,220,fill="#E0FFFF",outline="#E0FFFF",tags="clr1")
```

```
self.c1.create_arc(430,60,505,90,extent=90,start=100,fill="#E0FFFF",outline="#E0FFFF",tags=
"clr1")

self.c1.create_arc(430,60,505,90,extent=80,start=0,fill="#E0FFFF",outline="#E0FFFF",tags="cl
r1")
        self.c1.create_rectangle(435,255,500,130,fill="#E0FFFF",outline="#E0FFFF",tags="clr1")
        self.c1.create_rectangle(460,60,550,40,fill="#E0FFFF",outline="#E0FFFF",tags="clr1")

        self.c1.create_rectangle(100,205,220,320,fill="#87CEEB",outline="#87CEEB",tags="clr1")
        self.c1.create_rectangle(100,125,220,205,fill="#E0FFFF",outline="#E0FFFF",tags="clr1")

self.c1.create_arc(100,105,220,145,extent=180,start=0,fill="#E0FFFF",outline="#E0FFFF",tags
="clr1")

self.c1.create_arc(100,300,220,340,extent=180,start=180,fill="#87CEEB",outline="#87CEEB",t
ags="clr1")
        self.c1.create_rectangle(220,165,400,185,fill="#87CEEB",outline="#87CEEB",tags="clr1")
        self.c1.create_rectangle(380,185,400,290,fill="#87CEEB",outline="#87CEEB",tags="clr1")
        self.c1.create_rectangle(400,270,430,290,fill="#87CEEB",outline="#87CEEB",tags="clr1")
        self.c1.create_line(435,278,455,258,fill="#87CEEB",width=17,tags="clr1")
        self.c1.create_line(430,285,450,265,fill="#87CEEB",width=15,tags="clr1")
```

```
self.c1.create_line(380,283,435,283,fill="#87CEEB",width=15,tags="clr1")

self.c1.create_rectangle(435,255,500,230,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(445,230,460,150,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(475,230,490,150,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_arc(452.5,135,482.5,165,style="arc",extent=185,start=0,fill="#87CEEB",width=1
4,outline="#87CEEB",tags="clr1")


self.c1.create_line(483,260,513,290,fill="#87CEEB",width=17,tags="clr1")

self.c1.create_line(490,266,520,296,fill="#87CEEB",width=17,tags="clr1")

self.c1.create_rectangle(500,290,525,325,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(525,305,310,325,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_arc(265,290,325,350,extent=220,start=30,fill="#87CEEB",outline="#87CEEB",ta
gs="clr1")

self.c1.create_arc(263,290,323,350,extent=60,start=290,fill="#87CEEB",outline="#87CEEB",ta
gs="clr1")

self.c1.create_rectangle(283,330,303,380,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(303,380,70,360,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(50,380,70,185,fill="#87CEEB",outline="#87CEEB",tags="clr1")
```

```
self.c1.create_rectangle(50,185,110,205,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(300,165,320,155,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(290,155,330,106,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(440,260,495,230,fill="#87CEEB",outline="#87CEEB",tags="clr1")


self.c1.create_arc(455,265,480,275,extent=180,start=180,fill="#87CEEB",outline="#87CEEB",t
ags="clr1")

self.c1.create_rectangle(455,270,480,250,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_rectangle(455,265,485,250,fill="#87CEEB",outline="#87CEEB",tags="clr1")

self.c1.create_line(494,258,498,253,fill="#87CEEB",width=5,tags="clr1")

self.c1.create_line(443,259,438,254,fill="#87CEEB",width=5,tags="clr1")

#color ends




#building outline begins

self.c1.create_line(100,125,100,185,tags="bd1")

self.c1.create_line(100,205,100,320,tags="bd1")

self.c1.create_line(220,125,220,165,tags="bd1")

self.c1.create_line(220,185,220,320,tags="bd1")

self.c1.create_arc(100,105,220,145,style="arc",extent=180,start=0,tags="bd1")
```

```
self.c1.create_arc(100,300,220,340,style="arc",extent=180,start=180,tags="bd1")

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self.c1.create_line(320,165,400,165,tags="bd1")

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self.c1.create_line(380,185,380,290,tags="bd1")

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self.c1.create_line(400,270,430,270,tags="bd1")

self.c1.create_line(380,290,435,290,tags="bd1")

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self.c1.create_line(435,290,455,270,tags="bd1")

self.c1.create_line(480,270,500,290,tags="bd1")

self.c1.create_line(495,260,525,290,tags="bd1")

self.c1.create_arc(455,265,480,275,style="arc",extent=180,start=180,tags="bd1")

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self.c1.create_line(495,260,500,255,tags="bd1")

self.c1.create_line(435,255,435,150,tags="bd1")

self.c1.create_line(435,150,430,145,tags="bd1")

self.c1.create_line(430,145,430,75,tags="bd1")

self.c1.create_line(500,255,500,220,tags="bd1")
```

```
self.c1.create_line(500,200,500,150,tags="bd1")

self.c1.create_line(500,150,505,145,tags="bd1")

self.c1.create_line(505,145,505,75,tags="bd1")

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self.c1.create_line(460,40,550,40,tags="bd1")

self.c1.create_line(474,60,550,60,tags="bd1")

self.c1.create_line(500,200,550,200,tags="bd1")

self.c1.create_line(500,220,550,220,tags="bd1")

self.c1.create_line(500,290,500,305,tags="bd1")

self.c1.create_line(525,290,525,325,tags="bd1")

self.c1.create_line(500,305,320,305,tags="bd1")

self.c1.create_line(525,325,320,325,tags="bd1")


self.c1.create_arc(265,290,325,350,style="arc",extent=220,start=30,tags="bd1")

self.c1.create_arc(263,290,323,350,style="arc",extent=60,start=290,tags="bd1")
```

```
self.c1.create_line(283,347,283,360,tags="bd1")

self.c1.create_line(303,347,303,380,tags="bd1")


self.c1.create_line(283,360,70,360,tags="bd1")

self.c1.create_line(303,380,50,380,tags="bd1")

self.c1.create_line(70,360,70,205,tags="bd1")

self.c1.create_line(50,380,50,185,tags="bd1")

self.c1.create_line(50,185,100,185,tags="bd1")

self.c1.create_line(70,205,100,205,tags="bd1")


self.c1.create_line(300,165,300,155,tags="bd1")

self.c1.create_line(320,165,320,155,tags="bd1")


self.c1.create_line(300,155,290,155,tags="bd1")

self.c1.create_line(320,155,330,155,tags="bd1")

self.c1.create_line(290,155,290,95,tags="bd1")

self.c1.create_line(330,155,330,95,tags="bd1")

self.c1.create_line(290,95,330,95,tags="bd1")
```

```
self.c1.create_line(100,185,110,185,tags="bd1")

self.c1.create_line(110,185,110,285,tags="bd1")

self.c1.create_line(220,185,210,185,tags="bd1")

self.c1.create_line(210,185,210,285,tags="bd1")


self.c1.create_line(292,105,328,105,width=2,tags="bd1")


self.c1.create_line(435,230,445,230,tags="bd1")

self.c1.create_line(500,230,490,230,tags="bd1")

self.c1.create_line(460,230,475,230,tags="bd1")

self.c1.create_line(445,230,445,150,tags="bd1")

self.c1.create_line(460,230,460,150,tags="bd1")

self.c1.create_line(475,230,475,150,tags="bd1")

self.c1.create_line(490,230,490,150,tags="bd1")

self.c1.create_arc(460,142.5,475,157.5,style="arc",extent=185,start=0,tags="bd1")

self.c1.create_arc(445,127.5,490,172.5,style="arc",extent=185,start=0,tags="bd1")


self.c1.create_rectangle(433,80,437,90,tags="bd1")

self.c1.create_rectangle(440,80,444,90,tags="bd1")
```

```
self.c1.create_rectangle(447,80,451,90,tags="bd1")

self.c1.create_rectangle(454,80,458,90,tags="bd1")

self.c1.create_rectangle(461,80,465,90,tags="bd1")

self.c1.create_rectangle(468,80,472,90,tags="bd1")

self.c1.create_rectangle(475,80,479,90,tags="bd1")

self.c1.create_rectangle(482,80,486,90,tags="bd1")

self.c1.create_rectangle(489,80,493,90,tags="bd1")

self.c1.create_rectangle(496,80,500,90,tags="bd1")


self.c1.create_line(467.5,230,467.5,275,tags="bd1")


self.c1.create_arc(275,300,315,340,start=0,
extent=359,fill="#2f4f4f",outline="#2f4f4f",tags="bd1")


self.c1.create_rectangle(125,205,135,285,fill="#ff4500",tags="fr1")

self.c1.create_rectangle(145,205,155,285,fill="#ff4500",tags="fr1")

self.c1.create_rectangle(165,205,175,285,fill="#ff4500",tags="fr1")

self.c1.create_rectangle(185,205,195,285,fill="#ff4500",tags="fr1")
```

```
self.cr1py1=205

self.cr1py2=285


self.c1.create_line(140,self.cr1py1,140,self.cr1py2,width=3,tags="cr1")

self.c1.create_line(160,self.cr1py1,160,self.cr1py2,width=3,tags="cr1")

self.c1.create_line(180,self.cr1py1,180,self.cr1py2,width=3,tags="cr1")


self.c1.create_rectangle(95,145,100,155,fill="black",tags="bd1")

self.c1.create_rectangle(220,145,225,155,fill="black",tags="bd1")

#building outline ends


self.pl1=Label(f1,text="CRP",bg="#98fb98")

self.pl1.place(x=710,y=230,width=130)


bt1=Button(f1,text="UP",command=self.rodup,bg="#cd853f")

bt1.place(x=710, y=255,height=25,width=130)


bt2=Button(f1,text="DOWN",command=self.roddown,bg="#cd853f")

bt2.place(x=710, y=280,height=25,width=130)
```

```
self.start1=0

self.dx=0


self.pl1=Label(f1,text="POWER",bg="#98fb98")

self.pl1.place(x=710,y=30,width=130)

self.pl2=Label(f1,text="0",bg="white")

self.pl2.place(x=710,y=55,width=100,height=50)

self.pl3=Label(f1,text="MW")

self.pl3.place(x=810,y=55,width=30,height=50)


self.tl1=Label(f1,text="TEMP",bg="#98fb98")

self.tl1.place(x=710,y=130,width=130)

self.tl2=Label(f1,text="300",bg="white")

self.tl2.place(x=710,y=155,width=100,height=50)

self.tl3=Label(f1,text="K")

self.tl3.place(x=810,y=155,width=30,height=50)



self.power=0
```

```
    self.temp=300

    window.mainloop()

def displaypower1(self):

    self.pl2["text"]=str(self.power+20)
    self.power=self.power+20
    self.tl2["text"]=str(self.temp+50)
    self.temp=self.temp+50

def displaypower2(self):
    self.pl2["text"]=str(self.power-20)
    self.power=self.power-20
    self.tl2["text"]=str(self.temp-50)
    self.temp=self.temp-50
```

```
def rodup(self):
    if(self.cr1py2>207):
        self.displaypower1()


        self.c1.after(10)
        self.c1.update()
        self.c1.delete("cr1")
        self.c1.create_line(140,(self.cr1py1-2),140,(self.cr1py2-2),width=3,tags="cr1")
        self.c1.create_line(160,(self.cr1py1-2),160,(self.cr1py2-2),width=3,tags="cr1")
        self.c1.create_line(180,(self.cr1py1-2),180,(self.cr1py2-2),width=3,tags="cr1")
        self.cr1py1=self.cr1py1-2
        self.cr1py2=self.cr1py2-2



        if(self.cr1py2<285):
            self.start1=1
        if(self.cr1py2>=285):
            self.start1=0
```

```
        while(self.start1==1):

            self.c1.create_line(60,230-self.dx,60,220-self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(60,320-self.dx,60,310-self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(260-self.dx,370,250-self.dx,370,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(110-self.dx,370,100-self.dx,370,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(80+self.dx,195,90+self.dx,195,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(105,235+self.dx,105,245+self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(105,295+self.dx,105,305+self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(130,315-self.dx,130,305-self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(150,315-self.dx,150,305-self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")

            self.c1.create_line(170,315-self.dx,170,305-self.dx,arrow=LAST,width = 5,fill="blue",tags="ar1")
```

```
        self.c1.create_line(190,315-self.dx,190,305-self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(190,190-self.dx,190,180-self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(170,190-self.dx,170,180-self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(150,190-self.dx,150,180-self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(130,190-self.dx,130,180-self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(260+self.dx,175,270+self.dx,175,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(350+self.dx,175,360+self.dx,175,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(390,225+self.dx,390,235+self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(405+self.dx,280,415+self.dx,280,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(453,200-self.dx,453,190-self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(483,190+self.dx,483,200+self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")

        self.c1.create_line(513,290+self.dx,513,300+self.dx,arrow=LAST,width = 
5,fill="blue",tags="ar1")
```

```
        self.c1.create_line(470-self.dx,315,460-self.dx,315,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(360-self.dx,315,350-self.dx,315,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(530-self.dx,210,520-self.dx,210,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(495+self.dx,50,505+self.dx,50,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(440,120-self.dx,440,110-self.dx,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(458,120-self.dx,458,110-self.dx,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(476,120-self.dx,476,110-self.dx,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.create_line(494,120-self.dx,494,110-self.dx,arrow=LAST,width =
5,fill="blue",tags="ar1")

        self.c1.after(100)

        self.c1.update()

        self.c1.delete("ar1")

        self.dx=self.dx+2

        if(self.dx==20):

          self.dx=0
```

```
                self.c1.after(100)




def roddown(self):
    if(self.cr1py2>=285):
            self.start1=0
            self.c1.delete("ar1")
    if(self.cr1py2<285):
        self.displaypower2()
        self.c1.after(10)
        self.c1.update()
        self.c1.delete("cr1")
        self.c1.create_line(140,(self.cr1py1+2),140,(self.cr1py2+2),width=3,tags="cr1")
        self.c1.create_line(160,(self.cr1py1+2),160,(self.cr1py2+2),width=3,tags="cr1")
        self.c1.create_line(180,(self.cr1py1+2),180,(self.cr1py2+2),width=3,tags="cr1")
        self.cr1py1=self.cr1py1+2
        self.cr1py2=self.cr1py2+2
    PWR_Simulator()
```

CHAPTER 4

RESULT AND CONCLUSION

4.1 RESULTS

PWR reactors use a pressurzer, reactor vessel ,contain control rods, nuclear fuel, moderator, and coolant. PWR is cooled and moderated by high-pressure water. The hot radioactive water that leaves the pressure vessel is looped through a steam generator, which turn warms an secondary loop of water to steam that can run turbines. They are the larger part of current reactors. This is a thermal neutron reactor outline, the most current of which are the VVER-1200, Advanced PWR and the European Pressurized Reactor.

The simulator model of PWR shown can be studied to understand the internal operation of PWR such as movement of control rod, variation of temperature and its effect on output power of the reactor. In this simulation model I have mainly concentrated on the effect of variation of temperature on the output power depending upon the movement of control rod. Assigning the movement of control to a program is difficult task. That is making a program to understand the mechanical motion of control rod has been typical. For this in the program the logic was given so that when control rod moves up the previous position gets completely deleted and if we again move the control rod up then then the previous increment of control rod gets deleted. The reverse process will be happening when we move the control rod down.

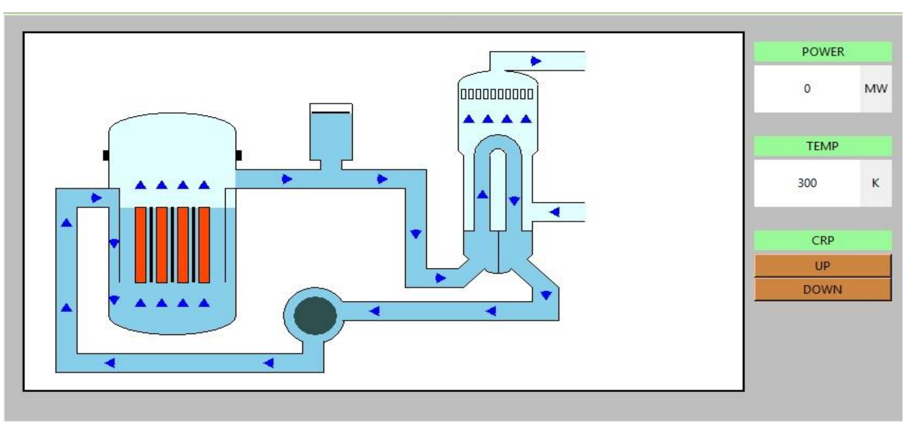

Fig 4.1(a) PWR simulator at power zero

The above figure shows the initiation of PWR operation. On the right hand side we can see the graphical user interface buttons. The 'up' button will begin the movement of control rod upwards and as the control rods moves up the rate of fission will increase resulting increase in temperature of water which will produce steam in another vessel. Thus the output power will increase. We can clearly see this increment in the output power as long as the control rod moves up. Now when we press the 'down' button the control rod moves down affecting the rate of fission in negative way. Thus the output power will decrease. These can be clearly seen the following figure.

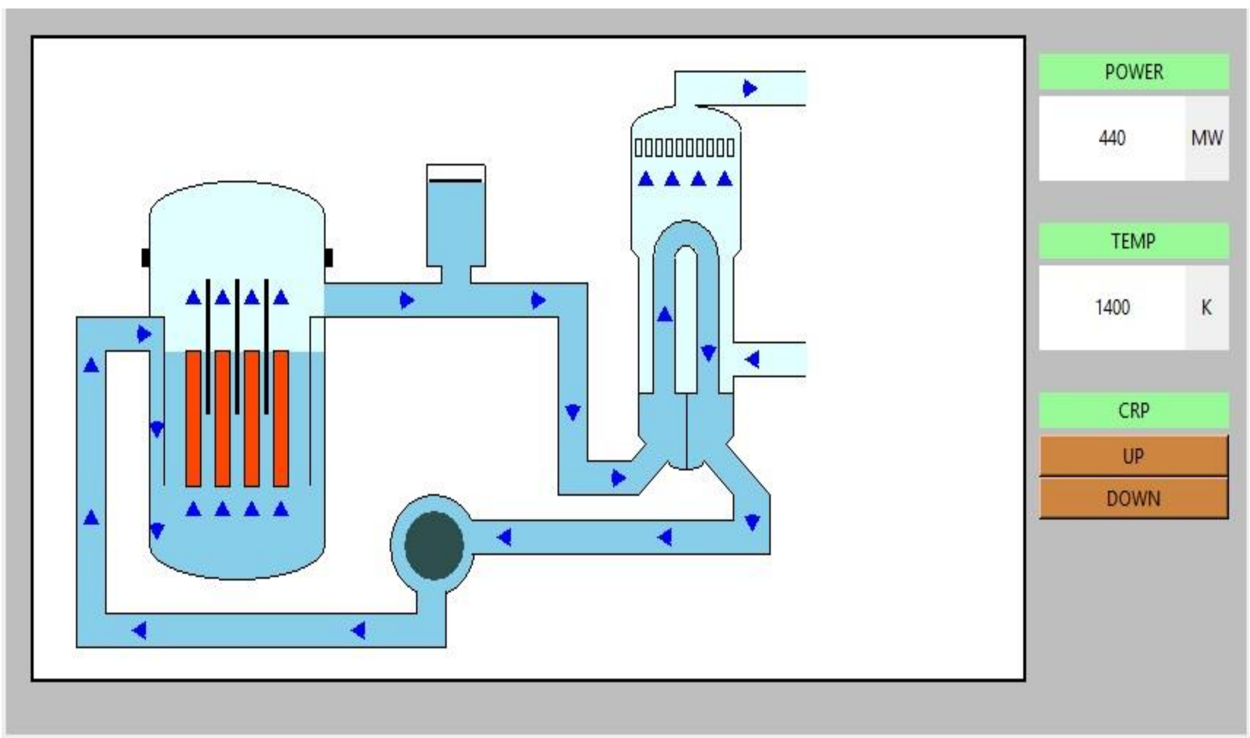

Fig 4.1(b) PWR's control rods movement upwards

In this figure we can see that when the temperature is around 1400 kelvin the output power is around 440 Megawatts. Now in the following figure we can distinguish that when the temperature is reduced the output power also reduces.

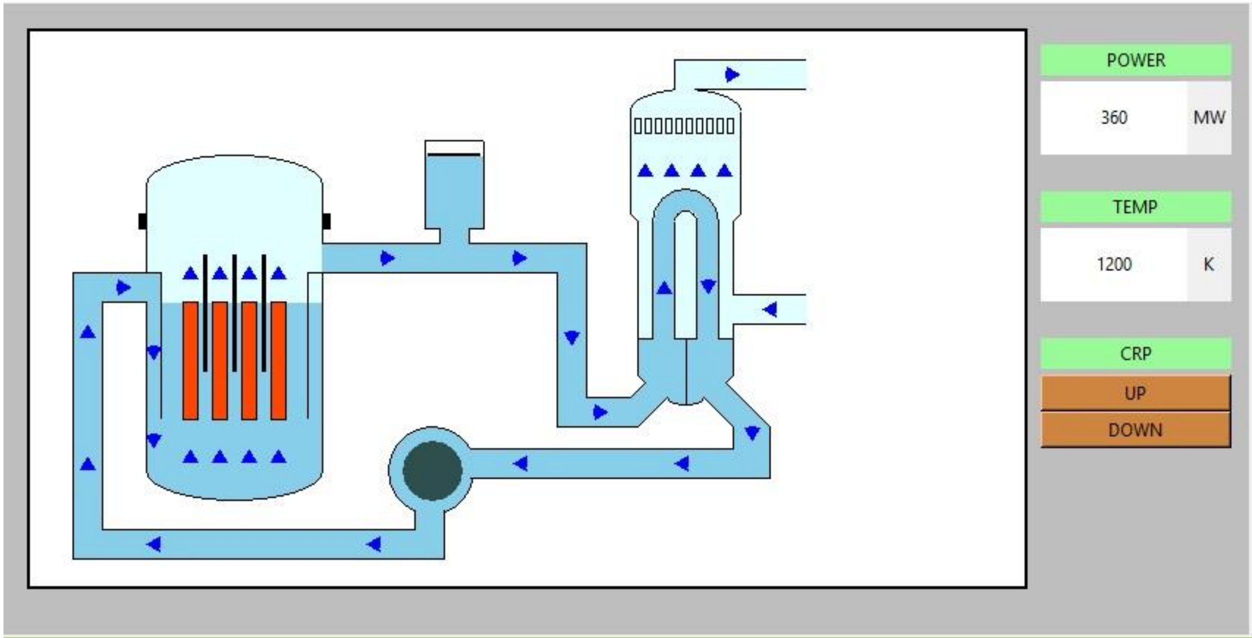

Fig 4.1(c) PWR’s control movement downwards

4.2 CONCLUSION

In conclusion we can say that understanding the motion of water, control rod and variation in temperature is affecting the output power and this can be clearly understood in this thesis. In future this work can be extended by introducing some other complex parameter such as stress or combination of complex parameters such as temperature and stress etc. introducing these things can make understanding of internal operation of PWR simulator more easier.

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