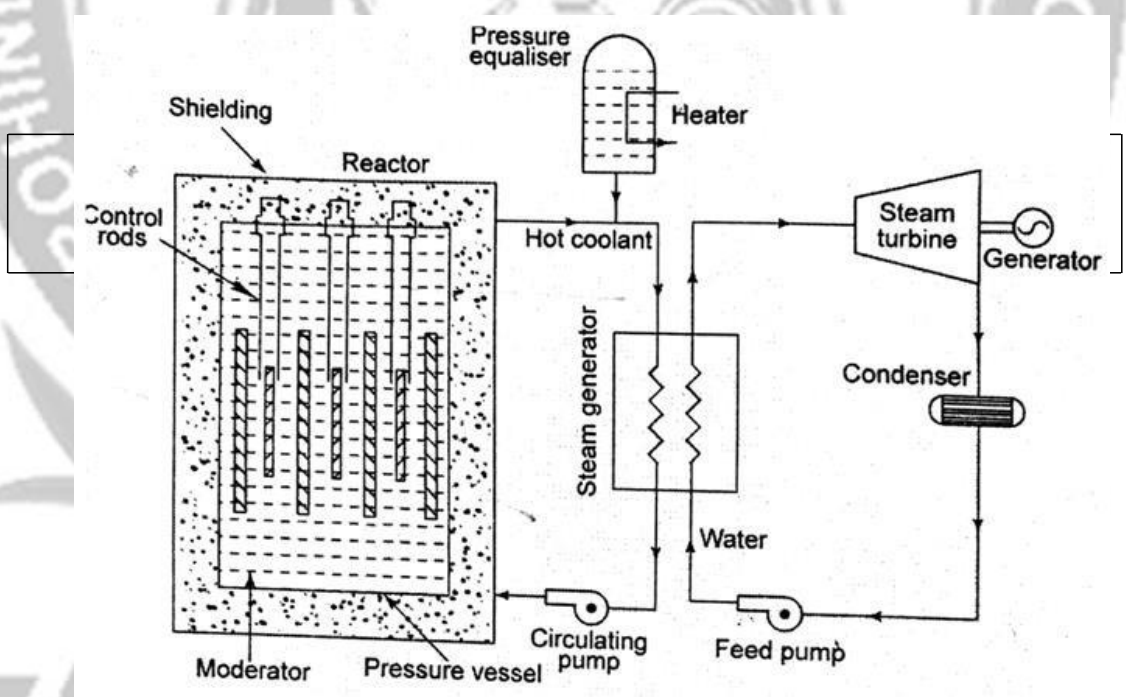
ME8792-POWER PLANT ENGINEERING

UNIT III-NUCLEAR POWER PLANTS

3.4-GAS COOLED AND LIQUID METAL COOLED REACTORS. SAFETY MEASURES FOR NUCLEAR POWER PLANTS.

GAS COOLED REACTOR

In such a type of reactor, the coolant used can be air, hydrogen, helium or carbon dioxide. Generally inert gases are used such as helium and carbon dioxide. The moderator used is graphite. The problem of corrosion is reduced much in such reactors.This type of reactor is more safe specially in case of accidents and the failure circulating pumps. The thickness of gas cooled reactor shield is much reduced. as compared to theother type of reactor. Arrangement of high temperature, gas cooled reactor is shown below:



There are two principal types of gas cooled reactors developed for centre station service and these are :

(1) The gas cooled, graphite moderator reactor (GCGM)

(2) The high temperature gas cooled reactor (HTGC).

Both types are graphite moderated. The former (GCGM) uses natural uranium fuel while the latter (HTGC) employs highly enriched uranium carbide mixed with thorium carbideand

clad with graphite.

The coolant pressure and temperature in GCGM are about 7bar 336^0C

respectively, for HTGC, these figures are 15 to 30 bar and 700^0C to 800^0C.

Advantages of Gas cooled reactor :-

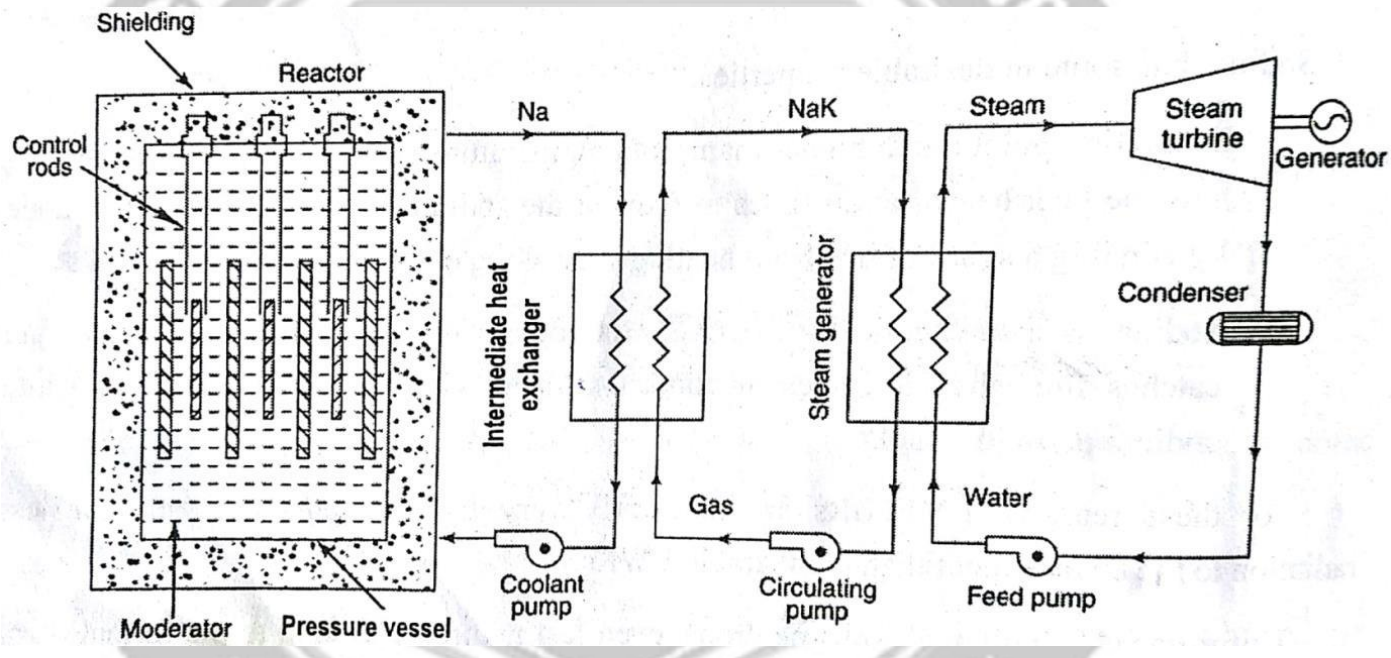
1. The processing of the fuel is simpler.
2. No corrosion problem
3. As a result of low parasitic absorption it gives better neutron economy.
4. Graphite remains stable under irradiation at high temperature
5. The use of carbon dioxide as coolant completely eliminates the possibility of explosion in the reactor which is always present in water-cooled plants.

6 The uranium carbide and graphite are able to resist high temperatures, and, therefore the problem of limiting fuel element temperature is not as serious as in other reactors.

Disadvantages of Gas cooled reactor :-

1. Fuel loading is more elaborate and costly.
2. Power density is very low (due to low heat transfer coefficient), therefore lard vessel is required.
3. Since the critical mass is high therefore large amount of fuel loading is initially required.
4. If helium is used instead of carbon dioxide, the leakage of gas is a major problem.
5. More power is required for coolant circulation (as compared with water-cooled reactors).
6. The fontal is more complicated due to low negative coefficient as helium does not absorb neutrons.

LIQUID METAL COOLED REACTORS



Sodium-graphite reactor (SGR) is one of the typical liquid metal reactors. In this reactor sodium works as a coolant and graphite works as a moderator. Sodium boils at 880 ^{0}C under atmospheric pressure and freezes at 95 ^{o}C. Hence sodium is first melted by electric heating system and be pressurized to about 7 bar. The liquid sodium isthen circulated by the circulation plump. The reactor will have two coolant circuits orloops.

(1) The primary circuit has liquid sodium which circulates through the fuel core and gets heated by the fissioning of the fuel. This liquid sodium gets cooled in the intermediate heat exchanger and goes back to the reactor vessel.

(2) The secondary circuit has an alloy of sodium and potassium in liquid form. This coolant takes heat from the intermediate heat exchanger and gets heat from liquid sodiumof primary circuit.

The liquid sodium-potassium then passes through a boiler which is once through type having tubes only. The steam generated from this boiler will be superheated. Feed water from the condenser enters the boiler, the heated sodium-potassium passing through the tubes gives it heat to the water thus converting it into steam. The sodium- potassium liquid in the second circuit is then pumped back to the intermediate heat exchanger thus making it a closed circuit.

The reactor vessel, primary loop and the intermediate heat exchanger is to be shielded for radio-activity. The liquid metal be handled under the cover of an inert gas, such as helium, to prevent contact with air while charging or draining the primary or secondary circuit / loop.

Advantages of SGR

1. The sodium as a coolant need not be pressurized.
2. High thermal efficiency at low cost.
3. The low cost graphite moderator can be used as it can retain its mechanical strength ant purity at high temperatures.
4. Excellent heat removal.
5. High conversion ratio.
6. Superheating of steam is possible.

7. The size of the reactor is comparatively small.

8. The neutron absorption cross-section of sodium is low and, therefore, it is best suited to thermal reactor with slightly enriched fuel.

Disadvantages of SGR

1. Sodium reacts violently with water wed actively with air.
2. Thermal stresses are a problem.
3. Intermediate system is necessary to separate active sodium from water.
4. Heat exchanger must be leak proof.
5. It is necessary to shield the primary and secondary cooling systems with concrete blocks as sodium becomes highly radioactive.

SAFEY MASURES FOR NUCLEAR POWER PLANTS

In case of nuclear power plants, the three main sources of radio-active contamination of the air are: -

1. Fission of nuclei of nuclear fuels
2. The effect of neutron fluxes on the heat carries in the primary cooling system and on the ambient air
3. Damage of fuel element shells the above explained air- contamination can cause health hazard to worker and community and negative effect on the surrounding forests.

Hence requires the following safety measures: -

1. The nuclear power plant should be constructed away from human habitation. An exclusion zone around the plant should be provided where no public habitation is permitted.
2. The materials to be used for the construction of a nuclear power plant should be of required high quality standards.
3. Waste water from the nuclear power plant should be treated and purified
4. The nuclear power plant must be provided with a safety system which should safely

shut-down the plant as and when necessity arises.

5. There must be periodic checks to ensure that the radio-activity does not exceed the permissible value n the environment.

6. While disposing of the waste from the nuclear plant , it should be ensured that there is no pollution of water of river or sea where these wastes are disposed.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