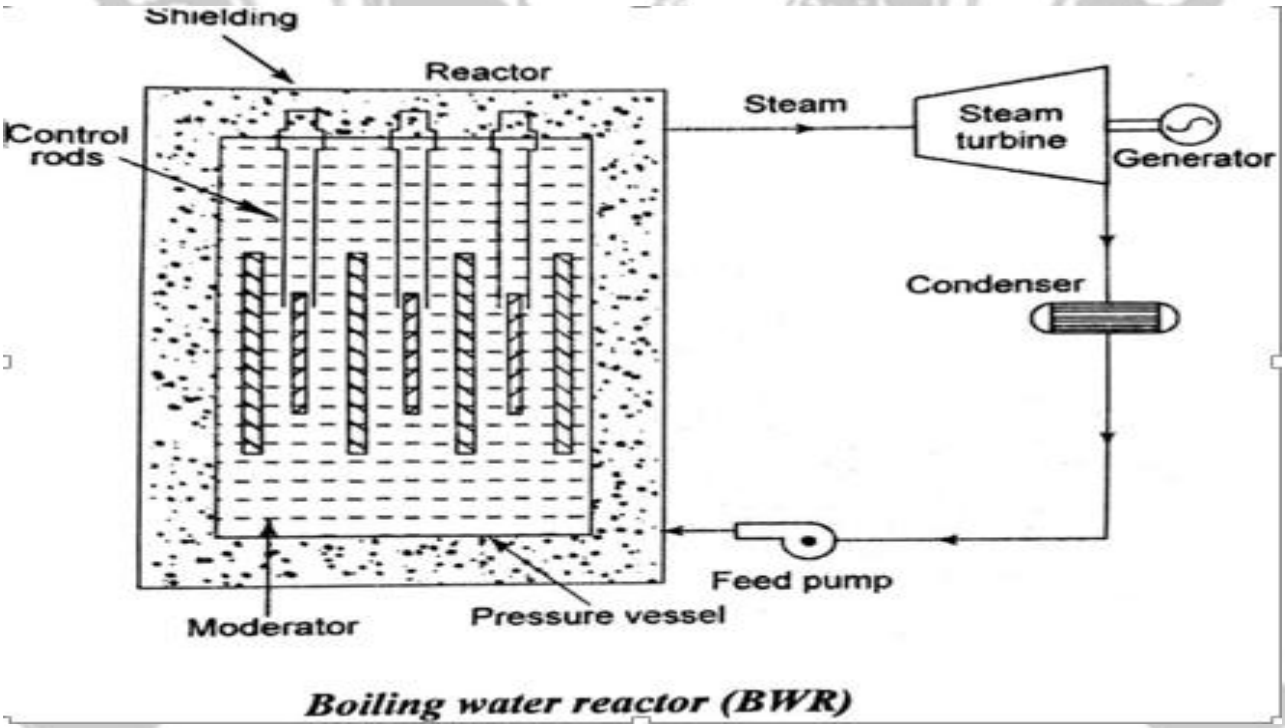
ME8792-POWER PLANT ENGINEERING
UNIT III-NUCLEAR POWER PLANTS
3.2-BOILING WATER REACTOR (BWR), PRESSURIZED WATER REACTOR (PWR)

BOILING WATER REACTOR (BWR)

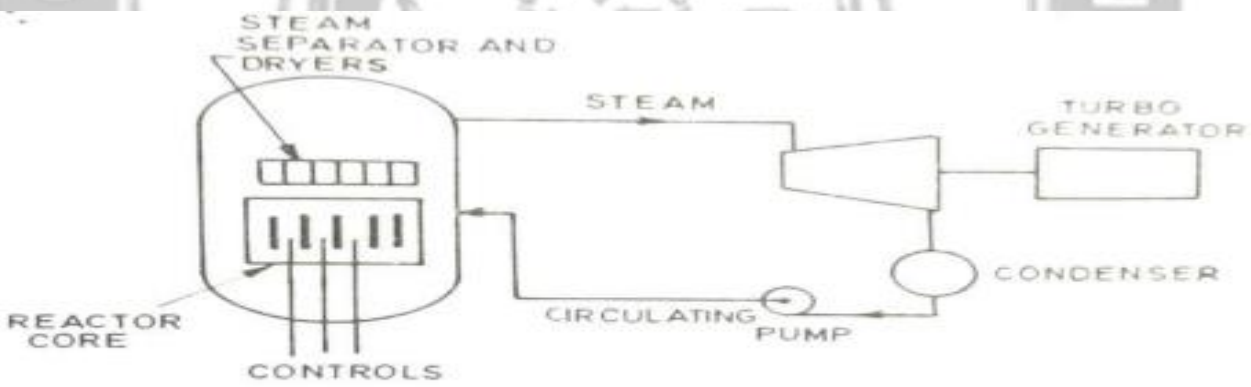
In a boiling water reactor enriched fuel is used. As compared to PWR, the BWR plant is simple. The plant can be safely operated using natural convection within the core or forced circulation as shown in the fig. below.
For the safe operation of the reactor the pressure in the circulation must be maintained constant irrespective of the load. In case of part load operation of the turbine some steam is bypassed.
In this plant cycle, also known as direct steam cycle, steam is produced in the reactor itself instead of in a heat exchanger. Since auxiliary power is reduced from 6% to 1% by elimination of the heat transfer circuit between reactor and steam generator, the overall plant efficiency increases with a BWR. Boiling water reactor use enriched uranium as a fuel (enriched uranium contains more fissionable isotope U235 than the naturally occurring percentage 0.7%). The fuel rods contain small cylindrical pellets of uranium dioxide with an average initial enrichment of about 2.6% in uranium235.



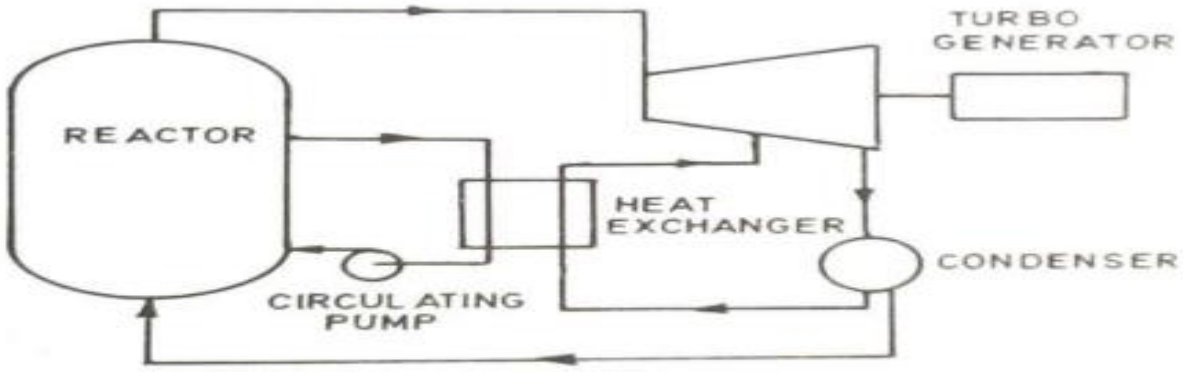
Boiling water reactor (BWR)

Advantages of BWR:
Heat exchanger circuit is eliminated and consequently there is gain thermal efficiency.
There is use of a lower pressure vessel for the reactor which further reduces cost and simplifies containment problems.
The metal temperature remains low for given output conditions.
The cycle for BWR is more efficient than PWR for given containment pressure, the outlet temperature of steam is appreciably higher in BWR.
The pressure inside the pressure vessel is not high so a thicker vessel is not 'required.

Disadvantages of PWR: -
Possibility of radioactive contamination in the turbine mechanism, should there beany failure of fuel elements.
More elaborate safety precautions needed which are costly.
Wastage of steam resulting in lowering of thermal efficiency on part load operation.
Boiling limits power density ; only 3 to 5% by mass can be converted to steam per pass through the boiler.
The possibility of burn out of fuel is more in this reactor than PWR as boiling of wateron the surface of the fuel is allowed.



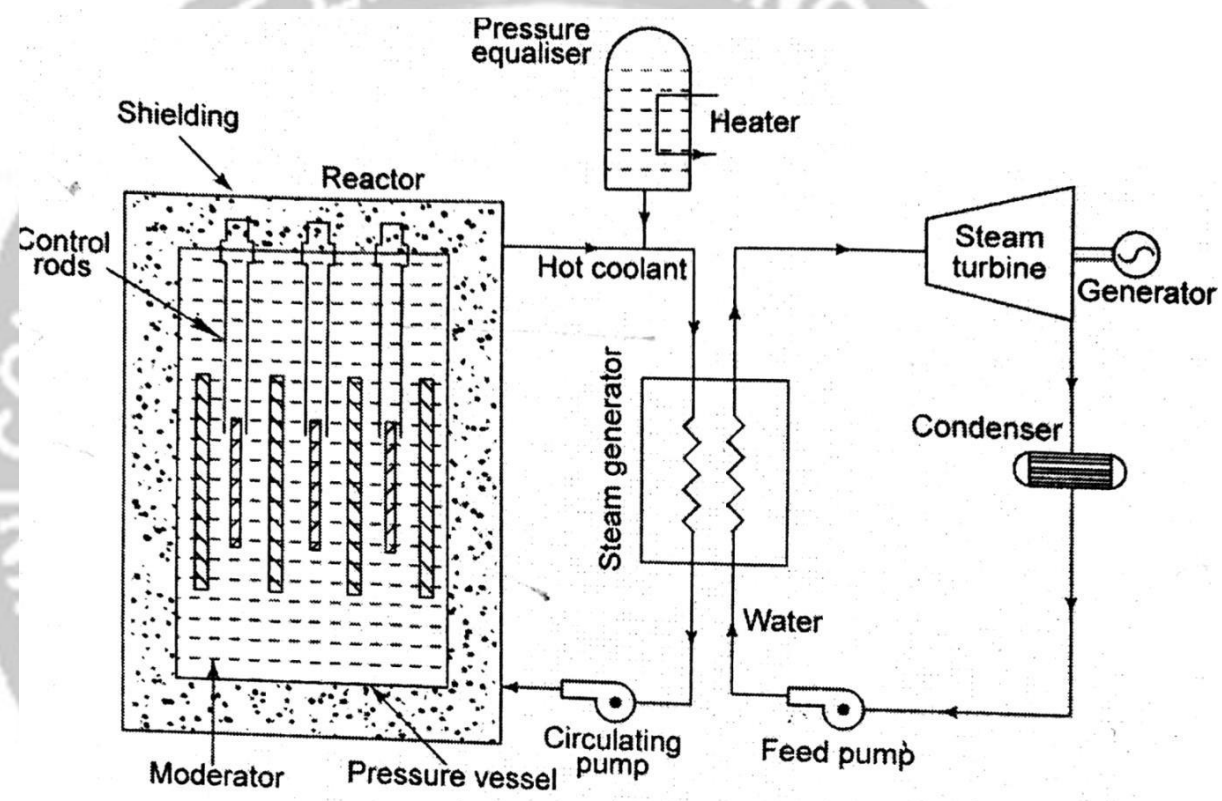
(a) Direct cycle boiling water reactor.



BWR cycles

PRESSURIZED WATER REACTOR (PWR)

A pressurized water reactor, in its simplest form, is a light water cooled and moderated reactor having an unusual core design, using both natural and highly enriched fuel. Refer Fig. below, in PWR, there are two circuits of water, one primary circuit which passes through the fuel core and is radioactive.



Pressurised water reactor

This primary circuit then produces steam in a secondary circuit which consists ofheat exchanger or the boiler and the turbine. As such the steam in the turbine is not radioactive and need not be shielded. The pressure in the primary circuit should be highso that the boiling of water takes place at high pressure. A pressurising tank keeps the
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water at about 100 kgf/cm so that will not boil.
Electric heating coils in the pressurized boil some of the water to form steam that collects in the dome. As more steam is forced into the dome by boiling, its pressure rises and pressurises the entire circuit. The pressure may be reduced by providing cooling coils or spraying water on the steam. Water acts both as coolant as well as moderator.

Either heavy water or the light water may be used for the above purpose.
A pressurized water reactor can produce only saturated steam. By providing a separate furnace, the steam formed from the reactor could be super-heated.

Advantages of PWR: -

Water used in reactor (as coolant, moderator and reflector) is cheap and easilyavailable.
The reactor is compact and power density is high.
Fission products remain contained in the reactor and are not circulated.
A small number of control rods is required.
There is a complete freedom to inspect and maintain the turbine, feed heaters and condenser during operation. .
This reactor allows to reduce the fuel cost extracting more energy per unit weight offuel as it is ideally suited to the utilization of fuel designed for higher burn-ups.

Disadvantages of PWR: -

Capital cost is high as high primary circuit requires strong pressure vessel.
In the secondary circuit the thermodynamic efficiency of this plant is quite low
Fuel suffers radiation damage and, therefore its reprocessing is difficult.
Severe corrosion problems.
It is imperative to shut down the reactor for fuel charging which requires a coupleof month's time.
Low volume ratio of moderator to fuel makes fuel element design and insertion of fuelrods difficult.
7 Fuel element fabrication is expensive.