INDIAN NUCLEAR POWER PROGRAMME: A PROFILE

P.T.KRISHNA KUMAR.

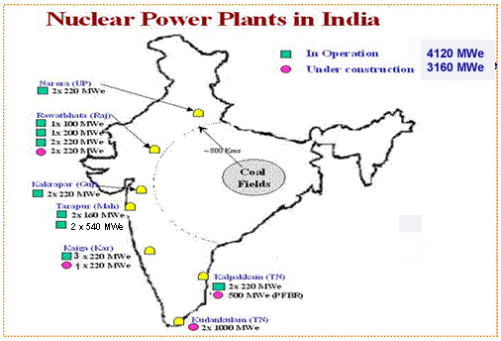
INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH

KALPAKKAM, INDIA

INDIAN REACTORS

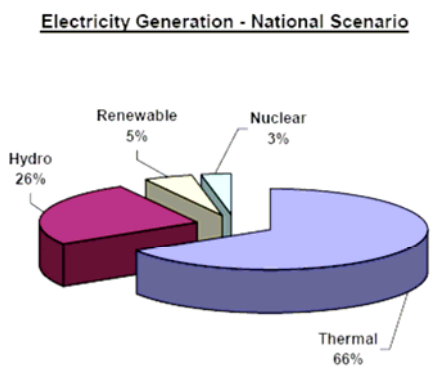
- PAST BWR USA
- CANDU
- PRESENT 4500 MWe.
- FUTURE 900 GWe.
- THORIUM.

INDIAN MAP



INDIA

- 2% WORLD LAND MASS.
- 2% GLOBAL ELECTRICITY.
- 5% GLOBAL COAL RESERVE.
- EASTERN INDIA.



ELECTRICITY SCENARIO

- TOTAL INSTALLED CAPACITY 1,20,000 MWe.
- 66% FROM COAL.
- 26% FROM HYDRO.
- 3% NUCLEAR.
- 5% WIND,TIDAL ETC.

INDIA

- **POOR RESERVE OF OIL AND NATURAL GAS.**
- **70% OF OIL CONSUMED IS IMPORTED.**
- **ENERGY SECURITY, A MIX OF COAL, OIL, NUCLEAR, OTHER NON CONVENTIONAL SOURCES.**

NUCLEAR POWER IN THE WORLD

- **360,000 MWe TOTAL CAPACITY**
- **16% of WORLD ELECTRICITY.**
- **440 REACTORS IN 31 COUNTRIES.**

•FISSION PROCESS

FISSILE AND FERTILE ELEMENTS

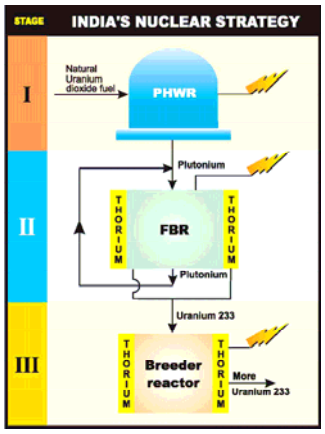
- **FISSILE 235U, 233U, 239PU**
- **FERTILE 238U, 232Th**
- **AVAILABLE IN NATURE**
- **URANIUM 235U[Fissile]+ 238U[Fertile]**
- **THORIUM 232Th[Fertile]**
- **ARTIFICIALLY PRODUCED**
- **239PU[Fissile] FROM 238U**
- **233U [Fissile] FROM 232Th.**

TYPES OF NUCLEAR REACTORS

- **THERMAL [FUEL+MODERATOR+COOLANT]**
- **(SLOW)**
- **EX: PHWR,PWR,BWR,**
- **FAST [FUEL + COOLANT]**
- **EX: LMFBR, HTGCR**
- **PRODUCES ITS FUEL.**

INDIAN RESERVE

- **NAT.URANIUM 78,000 T**
- **0.8% OF WORLD RESERVE**
- **THORIUM 360,000 T**
- **32% OF WORLD RESERVE**
- **PRODUCTION OF HEAVY WATER**



NEED FOR PHWR

- NO ENRICHMENT OF URANIUM.
- LESS REQUIREMENT OF NAT.URANIUM.
- HIGHER PU PODUCTION.
- AVAILABILITY OF HEAVY WATER.
- CONVENTIONAL SIDE-INDIAN INDUSTRY.

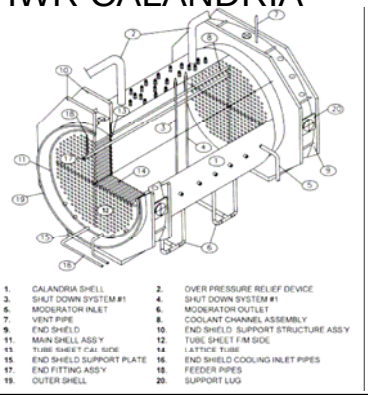
INDIAN PHWR

- **POWER** 220 MWe / 540MWe
- **FUEL** UO2
- **MODERATOR** HEAVY WATER
- **COOLANT** HEAVY WATER

PHWR COMPONENTS

- CALANDRIA-END SHIELD
- REACTOR VAULT
- COOLANT CHANNELS
- SHUT DOWN SYSTEMS
- CONTAINMENT

PHWR CALANDRIA



PHWR CALANDRIA

- MADE OF SS 304L.
- 306 OR 392 PRESSURE TUBES.
- MODIFICATION IN END SHIELDS.
- FUNCTION OF VAULT.

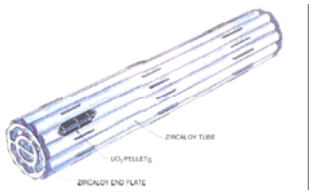
PHWR COOLANT CHANNELS

- PRESSURE TUBE.
- ZIRCONIUM-2.5% NIOBIUM ALLOY.
- GARTER SPRINGS.
- REPLACEMENT OF COOLANT CHANNELS.

PHWR REACTIVITY CONTROL

- NO MODERATOR DUMP.
- SHUT DOWN SYSTEMS
- PRIMARY CADMIUM.
- SECONDARY LIQUID POISON.

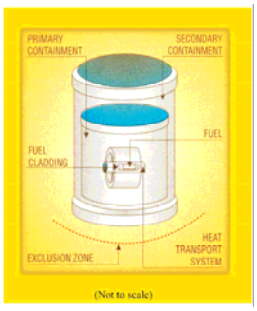
PHWR FUEL ELEMENTS



PHWR FUEL PERFORMANCE

- 220 MWe 540 MWe.
- 12 OR 13 BUNDLE.
- 19 OR 37 ELEMENTS.
- FAILURE RATE 0.096%.

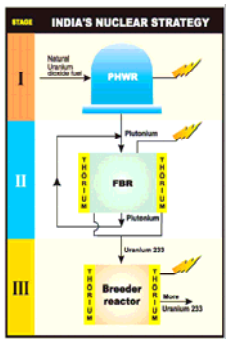
PHWR CONTAINMENT



PHWR CONTAINMENT

- DOUBLE CONTAINMENT.
- PRIMARY PRESTRESSED CONCRETE.
- SECONDARY REINFORCED CONCRETE

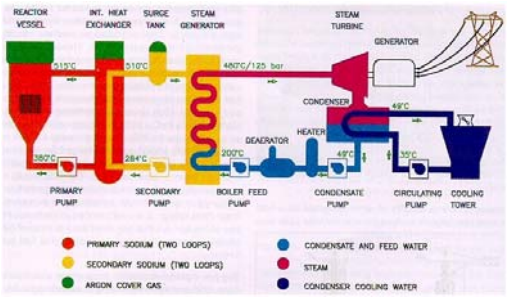
FAST REACTOR



FAST BREEDER TEST REACTOR

- RAPSODIE
- 70% PUC AND 30% UC.
- LOOP TYPE.
- SODIUM COOLANT.
- 40MWt.

FBTR



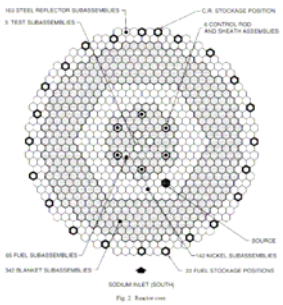
FBTR COMPONENTS

- CORE.
- REACTOR VESSEL.
- COOLANT SYSTEMS.
- CONTROL.

FBTR CORE

- MADE OF SS.
- 65 ASSEMBLIES OF FUEL.
- 342 THORIA BLANKETS.
- 143 NICKEL REFLECTORS.
- 163 STEEL REFLECTORS.

FBTR CORE



FBTR VESSEL

- MADE OF SS
- DOUBLE VESSEL.
- CORE.
- ROTATING PLUGS.
- PRIMARY PIPING.

FBTR COOLANT SYSTEMS

- PRIMARY SODIUM.
- SECONDARY SODIUM.
- HEAT EXCHANGERS.
- PURITY OF SODIUM.

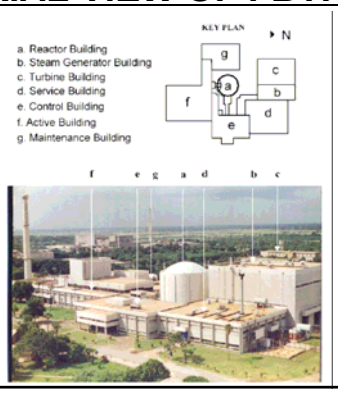
FBTR CONTROL AND SAFETY

- REACTOR SHUT DOWN BY TWO CONTROL RODS.
- DOUBLE VESSEL.
- SODIUM VOID NEGATIVE.
- NO VALVE IN THE PRIMARY SIDE.

FBTR MAIN CHARACTERISTICS

- Reactor power 40 MWt
- Fuel Mark I 70% PuC + 30% UC
- Fuel Mark II 55% PuC + 45% UC
- Fuel pin diameter 5.1 mm
- No. of pins in a SA 61
- Control rod material B4C

AERIAL VIEW OF FBTR



DESIGN OF PFBR

- PROVEN FUEL PUO2 + UO2.
- POOL TYPE.
- ADVANTAGES OVER LOOP.
- 500 MWe.

PFBR CHARACTERISTICS

- POWER 500MWe.
- CORE HEIGHT 1000 mm.
- CORE DIAMETER 1900 mm.
- FUEL PUO2 + UO2.
- FUEL PIN DIA 6.6 mm.
- FUEL PIN IN SA 217.
- CLAD D9.

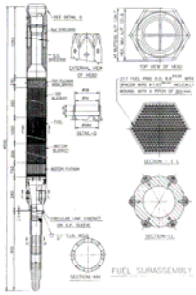
PFBR COMPONENTS

- CORE.
- REACTOR VESSEL.
- COOLANT SYSTEMS.
- CONTROL AND SAFETY.

PFBR CORE

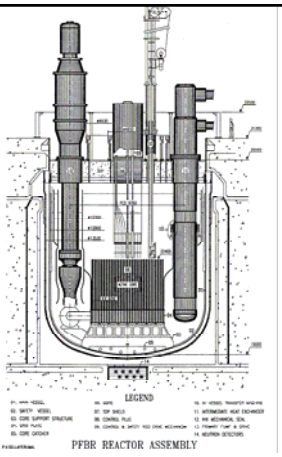
- 181 ASSEMBLIES.
- TWO ENRICHMENT 21% , 28% PUO2.
- 217 PINS IN A ASSEMBLY.
- ACTIVE FUEL 1000mm.
- AXIAL BLANKET 300mm.
- CLAD D9

PFBR FUEL PIN



PFBR VESSEL

- DOUBLE VESSEL.
- CORE.
- PRIMARY PUMP, HEAT EXCHANGER.
- ROOF SLAB.
- ROTATING PLUGS.

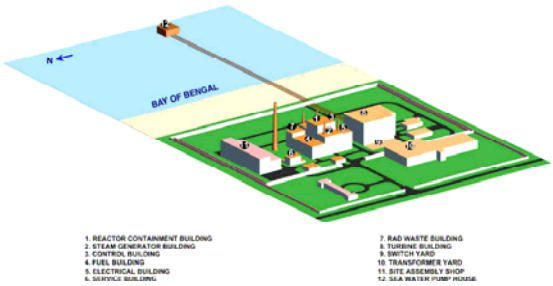


PFBR SAFETY

- NINE CONTROL RODS.
- DOUBLE VESSEL.
- DOUBLE ENVELOPE FOR PIPING.

- DEFENSE IN DEPTH.
- DELAYED NEUTRON DETECTION.
- TEN SCRAM PARAMETERS.

PFBR LAY OUT



1. REACTOR CONTAINMENT BUILDING
2. STEAM GENERATOR BUILDING
3. CONTROL BUILDING
4. FUEL BUILDING
5. ELECTRICAL BUILDING
6. SERVICE BUILDING
7. RAD WASTE BUILDING
8. TURBINE BUILDING
9. SWITCH YARD
10. TRANSFORMER YARD
11. SITE ASSEMBLY SHOP
12. SEA WATER PUMP HOUSE

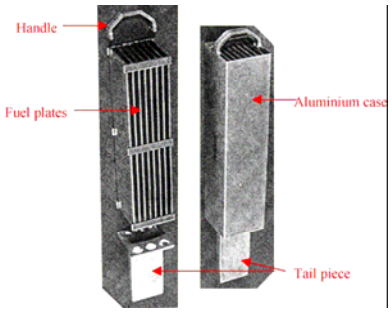
THIRD STAGE -THORIUM

- Th 232 [FERTILE] U233 [FISSILE]
- KAMINI REACTOR.
- 600 GRAMS OF U233.
- 30 KWt.
- MODERATOR AND COOLANT. WATER.

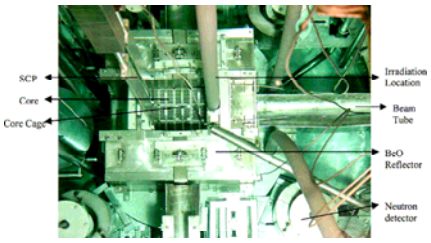
FEATURES OF KAMINI

- REFLECTOR BeO.
- CONTROL CADMIUM.
- VESSEL SS
- PIPING SS
- FUEL (U233 + Al)PLATES.

FUEL PLATES OF KAMINI



KAMINI REACTOR TANK



UTILITY OF KAMINI

- **ACTIVATION ANALYSIS.**
- **NEUTRON RADIOGRAPHY.**
- **GEOLOGICAL STUDY.**
- **CHEMICAL SAMPLES.**

ADVANCED HEAVY WATER REACTOR

- **[(Th-233U) MOX AND (Th-PU)MOX]**
- **MODERATOR HEAVY WATER.**
- **COOLANT WATER.**
- **300 MWe**
- **VERTICAL**
- **PRESSURE TUBE.**

CONCLUDING REMARKS

- In the year 1944, Dr. Homi Jehangir Bhabha (1909–1966) said, “when nuclear energy has been successfully applied for power production, in say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at home”.
- Six decades later, India has the largest number of nuclear power plants under construction in the world.

CONCLUDING REMARKS

- **SELF RELIANT CAPABILITY.**
- **PHWR.**
- **COMMERCIAL PFBR.**
- **EXPLOITATION OF THORIUM.**