GIDC Degree Engineering College
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A Report of Industrial Visit to

"Nuclear Power Corporation of India Limited (NPCIL), Kakrapar"

Organized by

Mechanical Engineering Department (19)

For

7th Semester B.E. Mechanical Engineering

On

23rd and 24th September 2019

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Prof. **Daksh R Tandel**, Prof. **Bruhad S Naik**

न्यूक्लियर पॉवर कॉर्पोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

-:Acknowledgement:-

The industrial visit at **Nuclear Power Corporation of India Limited (NPCIL), Kakrapar** was impossible to us without the efforts and valuable inputs from collage and faculties. We are here extending to our great acknowledgement and appreciation to following persons with their memorial inputs that are not limited only those mentioned below.

The first and the most acknowledged is **Principal Dr.N.D. Sharma,** who was very helpful to us. As a principal, he has inspired us to arrange industrial visit to Final year students. He has injected us the familiarity and methodology of planning of visit. Not only that as giving the permission of industrial visit, his academic guidance, fairness and responsiveness to kind of queries remains him as a role model, there of we are extending our gratitude to **Principal Dr.N.D. Sharma**.

We owe a deep sense of gratitude to **Shri Dr. H.S.Patil Sir, Head of Mechanical Engineering Department**, always supports and provides all the facilities and guides at each and every stage and solves all the problems regarding the Industrial visit. His constants encouragement , timely suggetion helped to complete industrial visit and conclude it, ascertaining him a commemorative plaque at deep of our heart.

It is privilege to thank **Nuclear Power Corporation of India Limited, Kakrapar** to give us Permission for Industrial Visit.

We thank profusely to **all the students** for kind behavior and support at every stage during Industrial visit.

Again thanks for valuable collaborations

Prof. **Krunal A. Hathiwala**

Prof. **Dhaval S. Chaudhari**

Prof. **Daksh R Tandel**,

Prof. **Bruhad S Naik**

-:About NPCIL:-

Nuclear Power Corporation of India Limited (NPCIL) is a Public Sector Enterprise under the administrative control of the **Department of Atomic Energy (DAE),**Government of India. The Company was registered as a Public Limited Company under the Companies Act, 1956 in September 1987 with the objectives of operating atomic power plants and implementing atomic power projects for generation of electricity in pursuance of the schemes and programmes of the Government of India under the Atomic Energy Act, 1962. NPCIL also has equity participation in BHAVINI, another PSU of Department of Atomic Energy (DAE) which implements Fast Breeder Reactors programme in the country.

NPCIL is responsible for design, construction, commissioning and operation of nuclear power reactors. NPCIL is a MoU signing, profit making and dividend paying company with the highest level of credit rating (AAA rating by CRISIL and CARE). NPCIL is presently operating 22 commercial nuclear power reactors with an installed capacity of 6780 MW. The reactor fleet comprises two Boiling Water Reactors (BWRs) and 18 Pressurised Heavy Water Reactors (PHWRs) including one 100 MW PHWR at Rajasthan which is owned by DAE, Government of India and two 1000 MW VVER reactor KKNPS-1&2, in this, latest addition to the fleet is the unit-2 of Kudankulam Nuclear Power Station, a 1000 MW VVER (Pressurised Water Reactor type), which has started its commercial operation on March 31, 2017. Currently NPCIL has Eight reactors under various stages of construction totaling 6200 MW capacity.

Pre-project activities at new sites, which were accorded ‘in principle' approval by the Government, have been initiated so as to enable early launch of projects at these sites.

Being a responsible corporate citizen, NPCIL accomplishes CSR activities and implements projects related to Sustainable Development (SD). The company is compliance to Corporate Governance as per guidelines issued by Department of Public Enterprises (DPE).

Vision:-

“To be globally proficient in nuclear power technology, contributing towards long term energy security of the country.”

Mission:-

To develop nuclear power technology and to produce nuclear power as a safe, environmentally begin and an economically viable source of electrical energy to meet the increasing electricity needs of the country.

Objectives:-

- To maximise the power generation and profitability from nuclear power stations with the motto ‘safety first and production next’.
- To increase nuclear power generation capacity in the country, consistent with available resources in a safe, economical and rapid manner, in keeping with the growth of energy demand in the country.
- To continue and strengthen QA activities relating to nuclear power programme within the organisation and those associated with it.
- To develop personnel at all levels through an appropriate Human Resources Development (HRD) programme in the organisation with a view to further improve their skills and performance consistent with the high technology.
- To continue and strengthen the environmental protection measures relating to nuclear power generation.
- To continue and strengthen the neighborhood welfare programme/CSR activities for achieving inclusive growth of surrounding population.
- To share appropriate technological skill sand expertise at national and international levels.
- To bring about modernisation and technological innovation in activities.
- To coordinate and endeavor to keep the sustained association with the other units of DAE

Operating Units and Units Under Construction:-

The Operating Nuclear Power Units are:

Tarapur Atomic Power Station	Units-1&2 (2x160 MW BWRs),
Tarapur Atomic Power Station	Units-3&4 (2x540 MW PHWRs),
Rajasthan Atomic Power Station	Units 1to 6 (100 MW, 200 MW and 4x220 MW PHWRs),
Madras Atomic Power Station	Units-1&2 (2x220 MW PHWRs),
Narora Atomic Power Station	Units-1&2 (2x220 MW PHWRs),
Kakrapar Atomic Station	Units-1&2 (2x220 MW PHWRs),

Kaiga Generating Station	Unit-1 to 4 (4x220 MW PHWRs) and
Kudankulam Nuclear Power Station	Unit-1&2 (2x1000 MW VVER)

In addition, NPCIL also has a 10 MW Wind Power Plant at Kudankulam site.

The units under construction are:

Kakrapar Atomic Power Project	Unit-3&4 (2x700 MW PHWRs)
Rajasthan Atomic Power Project	Units-7&8 (2x700 MW PHWRs)
Gorakhpur Haryana Anu Vidhyut Pariyojna	Units-1&2 (2x700 MW PHWRs)
Kudankulam Nuclear Power Project	Unit-3&4 (2x1000 MW VVER)

Operating Performance:-

The nuclear power gross generation of 40001 MUs was achieved in the year 2016-17. NPCIL has set several records in the safe operation of nuclear power plants. So far NPCIL has consistently maintained overall availability factor of reactors above 80% for several years.

Safety Performance:-

NPCIL has about 48 years of experience in safe operation of nuclear power plants, with motto of ‘Safety first and Production next'. The Environmental Management System (EMS) and Occupational Health and Safety Management System (OHSMS) as per ISO-14001: 2004 and IS-18001: 2007 respectively are maintained at all the stations. By following the principle of ALARA (As Low As Reasonably Achievable) and maintaining the highest standards of safety within the Nuclear Power Plants (NPPs), the occupational exposures of employees of the company at various NPPs are maintained well below the values specified by the regulator, Atomic Energy Regulatory Board (AERB). The environmental releases of radioactive effluents from NPPs are maintained significantly low (average less than 1% of the limits specified by AERB). NPCIL contributed in enhancing safety & reliability of nuclear power plants globally through its active participants in World Association of Nuclear Operators (WANO), Candu Owners Group (COG), IAEA and other international organizations. NPCIL units have received several safety awards from various national agencies like AERB, NSCI, Gujarat Safety Council, National Safety Council-Mumbai and DGFASLI.

Public Outreach Programme:-

Recognising the need of reaching out to people around its sites and sharing the information on nuclear power to generate correct perspective about nuclear power, NPCIL scaled up its Public Awareness programmes in a structured manner using a multipronged approach. Through several modes of communication, dissemination of accurate information on nuclear power to different target groups is being done regularly.

-:About Plant:-

Kakrapar Atomic Power Station is a nuclear power station in India, which lies in the proximity of the city of Vyara in the state of Gujarat. It consists of two 220 MW pressurized water reactors with heavy water as moderator (PHWR). The construction costs originally were estimated to be 3.8252 billion rupees, the plant was finally finished at a price of 13.35 billion rupees. Construction of units 3&4 started in November 2010. In January 2003, KAPS Unit-1 went critical on 3 September 1992 because of a leakage in the cooling loop and began commercial electricity production a few months later on 6 May 1993. KAPS Unit-2 went critical on 8 January 1995 and began commercial production in September 1, 1995. CANDU Owners Group (COG) declared K.A.P.S. as the best performing pressurized heavy water reactor.

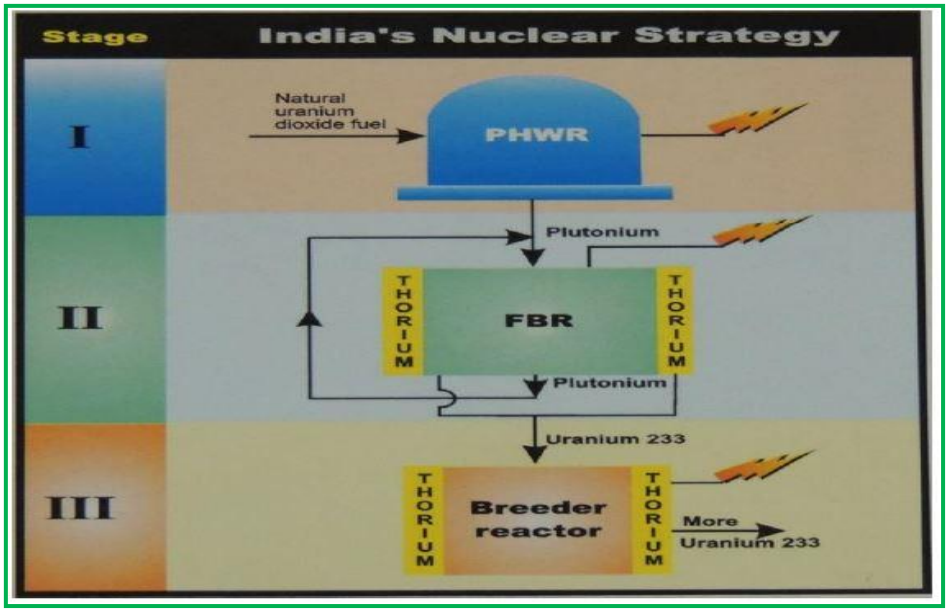
Nuclear power corporation of India limited(NPCIL) is Public Sector Enterprise under the administrative control of the **Department of Atomic Energy (DAE),**Government of India. It was established on 17th September, 1987.There are 20 units running under the NPCIL all over the India. Approximated installed capacity is 4780Mwe. All the Nuclear power plants are ISO-14001 and IS-18001 certified. The nuclear power plants under NPCIL are situated at Tarapur, Rawatbhata, Kalpakkum, Narora, Kakrapar and Kaiga. The type of reactors is BWR or PHWR.

About Nuclear Power Plant at Kakrapar:-

Kakrapar Atomic Power Station is a nuclear power station in India, which lies in the proximity of the city of Vyara in the state of Gujarat. Commercial operation of plant has started on May 6, 1993. In plant there are two pressurized reactors of 220MW with a heavy water as moderator (PWHR). The construction costs originally were estimated to be 3.8252 billion rupees; the plant was finally finished at a price of 13.35 billion rupees. Construction of units 3&4 started in November 2010. Kakrapar Nuclear Plant has won so many national and international awards for their safety and performance.

India's Nuclear strategy is classified in 3 stages: (1) PHWR (2) FBR (3) Breeder reactor

Kakrapar Nuclear power plant is working on stage 1. New two plants which are under construction is also working on stage 1 and it will produce 700MWe.



-:Operating Performance of the Plant:-

Location : Kakrapar, Surat, Gujarat

Unit	Reactor Type	Capacity(MWe)	Date of Commercial Operation
1	Pressurised Heavy Water Reactor(PHWR)	220	May 6, 1993
2	Pressurised Heavy Water Reactor(PHWR)	220	September 1, 1995

Cumulative Generation upto September – 2017 (Since Commercial Operation)

Unit	Cumulative Generation(MUs)
1	28891
2	29169

Generation Statistics during the Current Financial Year (2017-2018)

Unit	Gross Generation(MUs)	Capacity Factor (%)	Period
1	0	0	Apr 2017 - Sep 2017
1	0	0	Sep 2017 - Sep 2017
2	0	0	Apr 2017 - Sep 2017
2	0	0	Sep 2017 - Sep 2017

Previous Years Generation Statistics

Unit	Year	Gross Generation(MUs)	Capacity Factor (%)	Availability Factor (%)
1	2016-2017	0	0	0
1	2015-2016	1608	83	82
1	2014-2015	1943	101	99
1	2013-2014	1862	97	94
2	2016-2017	0	0	0
2	2015-2016	421	22	24
2	2014-2015	1586	82	88
2	2013-2014	1891	98	100

-:Constructional Data of Units:-

Main plant area: - 1000 * 700 m2

Excavation earth and rock: - 387000 m3

Concrete / Cement: - 235000 MT / 131000MT

Structural steel/RE steel: - 15000 MT/ 25000MT

Piping/ SS tubing: -55 km

Power and control cable: - 190km and 250km

Tallest Structure: - Unit 1 NDG (126.5m)

Technical Data:-

Type of reactor: - PHWR

Gross electricity generation: - 2* 200MWe

Type of Fuel: - Natural Uranium

Primary coolant: - Heavy water

Number of bundles: - 3672

Number of coolant channel: - 306

Length of bundle: - 49.5cm

Diameter of bundle: -8.15cm

Weight of bundle: - 16.5kg

Weight of uranium oxide cell: -15kg

Details of Constructional Element:-

Calandria : Made of stainless steel, 6.05m of diameter, 4.65m of length

EndShield : Diameter of end shield is 5.2m

Channel :5.33 m of zircoallytube (coolant tube)

Units Under Construction:-

In Kakrapar nuclear power plant there are two PHWR reactors named as KAPS-1 and KAPS-2. Both can generate electricity of 200MWe to 220MWe.KAPS-3 and KAPS-4 plants are under construction and their capacity to produce electricity of 700MWe. Expected date of commercial operation of KAPS – 3 AND KAPS – 4 are 2018 and 2019 respectively

Two units of 700 MW are under construction at NPCIL,Kakrapar.

Unit	Reactor Type	Capacity(MWe)	Construction Start	Expected Date of Commercial Operation
3	Pressurised Heavy Water Reactor(PHWR)	700	22 November 2010	2018
4	Pressurised Heavy Water Reactor(PHWR)	700	22 November 2010	2019

Details of Incidents on Plant:-

- 1998 KAPS-1 was switched off because of a leakage in the cooling loop for 66 days.
- 10 March 2004 the at the time of supply for the control rods were irreparably damaged during maintenance work. In response, poisons were added to the system and the reactor was shut off.
- On 22 August 2006 it was reported by village inhabitants the area around the power station had been penetrated. A search by the police did not result in any findings
- On 11 March 2016, KAPS-1 automatically shut down due to a leak of heavy coolant water, leaving both reactors non-operational. The leak was plugged ten days later.
- As of February 2017 both reactors are still shut down, with KAPS-1 awaiting replacement of its coolant channel.

-:Activities on the day of Visit:-

The bus had reached around 8:30 am at the Kakrapar site. We took entry for our visit at 10:00 am. In the visit, NPCIL authorities welcomed us on the Gate-Pass section. All the students had submitted their ID card photocopies there and registered first. We all moved to the main site of the plant by their bus. Then after reaching there, we were taken for the breakfast. After that, we moved to presentation hall. Then NPCIL Employee came there along with two other engineers. They explained the working of Nuclear power plant with the help of demo structure of the plant. The questioning was also being taken by us and the satisfactory answers were given by them. Then they explained all the nuclear power plants which are established and are under construction in India. They also distributed two booklets. Later they discussed about the various activities about plant in nearby areas.

At Main Gate of NPCIL,Kakrapar

Then we all were moved towards the working site of the plant where we had seen the natural draught cooling tower and the forced draught cooling tower. We all were moved towards the safety and control department. There we had observed different control rooms for different turbine sections. All the control of the whole generation system was controlled by that control room containing different control switches and digital panels. This whole controlling system was controlled by 2 to 3 control engineers. There were two different sections in the control room. One of them was for the whole controlling of the power generation of unit -1 and other was for the power generation for the unit-2. Then we were taken to the plant where we had seen the condensers, heat exchangers, water circulating pumps.

We had also seen re heaters. One of the engineers had given overview of the working of the heat exchangers and the other units. The steam which was generated was taken to the steam turbines and turbines were caused to generate the electricity which was generated by the generator. All the flows whether it was air flow or steam flow or water flow were flowing from the piping which was appearing to be a complex design of the plant. Though these much equipment were there the plant was very neat and tidy. We had also seen some release valves for releasing the unwanted flow of steam. This way, the complete information regarding each and every section of the plant was given by the allotted engineers and they also briefly explained regarding how this power generation was actually taking place.

They also explained that how this generated nuclear power was transmitted. They also discussed regarding how the backup power system was helpful in the case of power failure in the plant. After this we had seen the nuclear reactors from outside. One of the reactors was under the maintenance condition. One of those allotted engineers had told that the construction of two new plants each of capacity 700 MW were under construction and would get completed till year 2019-2020. Then a whole grid system containing generators, transformers, electricity transfer cables were observed. After this complete explanation we had went to the exit. After the complete explanation of the nuclear power plant we had been taken to the canteen for the lunch. After finishing the lunch we had travelled to the main gate by the company's transportation vehicle. Then after reaching at the main exit we had officially checked out and then after we had thanked the all authorities and left the plant. On the way back to college the photo of visit had been taken and all the students finally left for the college.

-:We Learn:-

On 23rd and 24th September 2019we reached at KAKRAPAR Atomic Power Station (KAPS). We reached inside power plant at 10:30 am.

We firstly got the overall technical information at Training centre by the expert technician of NPCIL

The plant consists of following components:-

1. Reactor Building (RB) – 1 & 2
2. Turbine Building (TB) – 1 & 2
3. Service Building
4. CW Pump House
5. Natural Draft Cooling Tower (NDCT) – 1 & 2
6. Induced Draft Cooling Tower (IDCT) – 1 & 2
7. Demineraliser Plant (DM Plant)
8. 220 KV Switch yard
9. Stack
10. Canteen Building
11. Administrative Building
12. Ware House

1. Reactor building (RB) – 1 & 2 :-

It consists of

a. Calandria

b. Primary Heat Transport Pump and Moderator System

c. Control and Shutdown

a. Calandria :-

This contains Uranium-236 R as a fuel integral with end shields.

Calandria

b. Primary Heat Transport Pump and Moderator System:-

Primary heat transport system circulates heavy water through the fuel in the coolant channels to extract the heat generated in the fuel by fission.

c. Control and Shutdown :-

Power generation is controlled and adjusted through reactivity regulating system. It consists two shutdown systems, primary shutdown system consists 14 nos. Of mechanical rods & secondary comprises of 12 nos. Of liquid poison tubes.

"Reactor building consists of two walls at 2.0 m distance apart, primary containment made up of pre-stressed concrete as a cylindrical shell and secondary made up of reinforced concrete. Primary Containment has 40m outer diameter while Secondary has 46m outer diameter."

2. Turbine Building (TB) – 1 & 2:-

The heat energy from reactor is transferred by PHT systems to light water in steam generators. Steam with 40 kg/sq.cm and temperature of 250 Celsius is supplied to the turbo generator through main steam headers.

There are two types of turbines are used in plant:

a. impulse turbines

b. reaction turbines

3. Service Building:-

It includes new fuel room, spent fuel storage bay, light water auxiliary cooling equipment, chemical laboratory, ventilation system and access to the reactor building.

4. Natural Draft Cooling Tower (NDCT) – 1 & 2:-

"It is naturally drawn cooling tower. It possess a typical structure with large base for strength & roof comparatively smaller for venturrie effect".

5. Induced Draft Cooling Tower (IDCT) – 1 & 2:-

It is mechanically drawn cooling tower with smaller height as compare to NDCT. In this cooling tower water is splited into droplets for decreasing it's temperature.

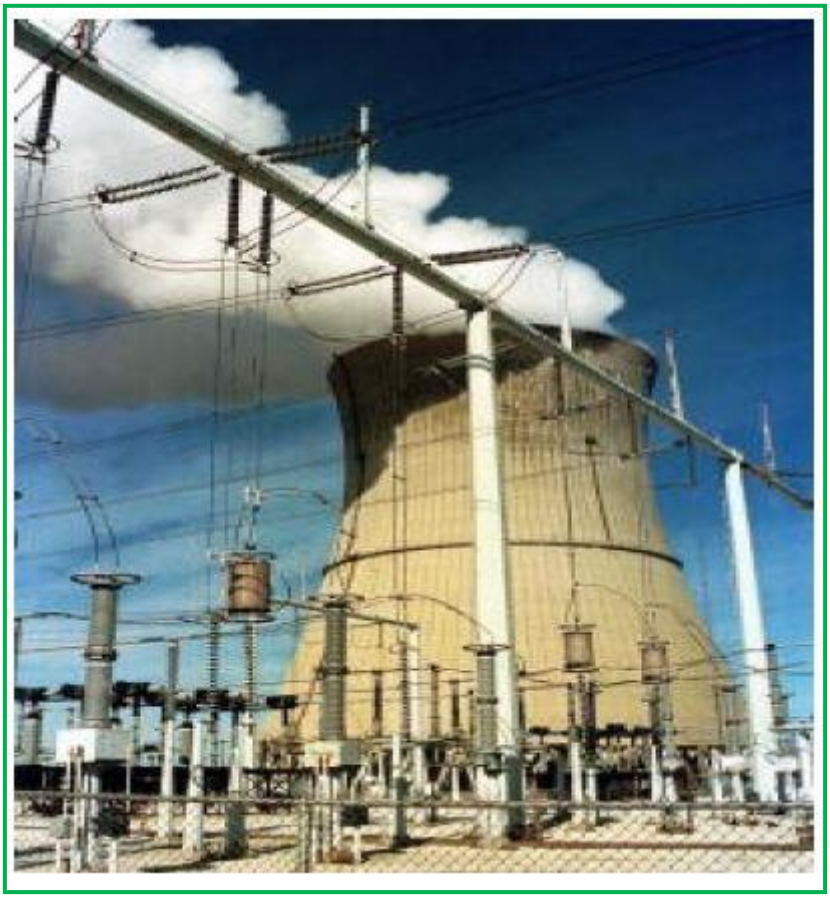
6. Demineraliser Plant (DM Plant):-

This plant demineralises water for controlling its conductivity and protecting the pipe from cavitation.Pipes are made from NIOBIUM for controlling ductile to brittle transition.

7. 220 Kv Switchyard:-

The switchyard has 13 bays. Each bay contains isolators , current transformers, lighting arrestors, wave traps and capacitor voltage transformer.

Station electric power is evacuated through seven nnumber of 220KV lines connecting to the Gujarat electricity board grid network, two lines to Haldarva (near Bharuch), two to Vapi, two to Vav (near Surat) and one to Ukai Thermal power station (interconnection).



8. STACK:-

Stack provide for the controlled release of gaseous effluents after filtration and dilution which is made of prestressed concrete of 100 m height.

-:Glimpse of Visit:-

At NPCIL,Kakrapar

At NPCIL,Kakrapar

At NPCIL,Kakrapar

Thank You

Department of Mechanical Engineering