PANDIT DEENDAYAL PETROLEUM UNIVERSITY

INDUSTRIAL ORIENTATION REPORT-2014

Submitted To:

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12BEE052

Acknowledgement

I am extremely thankful & indebted to the numerous engineers of different companies, who imparted me vital information about the functioning of their respective departments, thus helping me to attain an overall consideration about the functioning of their organization during Industrial Visits. I am highly thankful to them for their support, guidance and amicable behaviour.

A special thank to the H.O.D. of Electrical Department **Dr. Vivek Pandya** and Head Coordinator of Industrial Orientation Program Dr. **Jitendra Jamnani** for contriving Industrial Orientation Program (expert lectures and industrial visits) to enhance my practical knowledge.

I would like to convey my thanks to our Faculty Coordinator **Mr. Vatsal Shah** and other faculties of electrical department for hosting expert lectures, industrial visits and his support, guidance and amicable behaviour.

Last but not the least; I would like to thank my parents & my entire fellow Trainees who have been a constant source of encouragement & inspiration during IO Program.

Neel Soni

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EXECUTIVE SUMMARY

The introductory sessions of the orientation included motivational speeches like curing the cancer of mind etc. We were also given lectures by employees working in reputed companies, hence arousing our interest in working of industries by sharing their practical experiences with us.

Industrial orientation gave us a thorough insight of power generations process, the different components used and also the distribution of power. The experience was a reality check, throwing light on practical application of the theories and concepts learnt in the first two years of our B.Tech. Electrical course. We visited 4 major renowned privates & public sector companies, namely:

- Sardar Sarovar Hydro Power plant
- Electronics Quality Development Centre
- Gandhinagar Thermal Power plant
- Transformers and Rectifiers (India) Pvt. Ltd

The report tries to elucidate all the concepts learnt & observed during the industrial visits in each of the mentioned company.

Introduction

Today's almost every Engineering & Professional graduate programs in India entail industrial training for students as an indispensable part of their curriculum with an objective to enhance the knowledge of the students on different cutting edge technologies which have become important part of respective industries.

Importance and Objective of Industrial Orientation Program

Industrial Training is the important strategy to expose students to real work life situations and to equip them with the necessary skills that intensify their **job acumen**. Industrial training program or training related program can be continuously improved through formal **review and evaluation** of its outcome.

A key element in an engineering curriculum is an exposure to the **Professional** engineering practice sought through industrial training. Industrial training has traditionally been weighed as a potent grooming of the professional career of a fresh engineering graduate and it is the common method of the **harvesting skilled** engineers. A well-structured industrial training program as a part of curricula has been recommended for the completion of an Under-graduate course.

Motive of Industrial Orientation Program

We should note that industrial training is an essential component in the development of the practical and professional skills required for an engineer and aid to prospective employee for the future employment. We should make considerable effort and give sufficient thought into obtaining the most relevant and effective industrial training. Whilst difficult, it is desirable to obtain experience in a range of activities, examples, design office (studio), management courses, laboratory, and site situations etc. it should also be noted that developing an awareness of general workplace behaviour and interpersonal skills are important objectives of industrial training experience.

Goals of the Industrial Orientation Program

1. To get a feel of the work environment.
2. To use the experience gained from the industrial training in discussions held in the lecture rooms.
3. To apply the students' knowledge taught in the lecture rooms in real industrial situation.
4. To gain experience in writing reports in respect of what you got during the industrial training.

Introductory Sessions

The introduction of industrial orientation was given by Mr. Vinit Bagaria regarding schedule of the industrial orientation program.

On day one, first guest lecture was by Ms. Sulatha Shetty from IDP. They make us aware about Career Opportunities in USA, Canada and UK after graduation. There are many Exams for further studies and Scholarships for students aspiring to study in foreign countries.

Second guest lecture was given by one of the speaker of Voice, Mr. Vikas Pansari. His topic was Power of Habits. He briefly discussed about both good and the bad habits that human beings inculcate among them with the passage of age. He also discussed the dis-advantages of smoking, alcohol, drugs, etc. He motivated the students to leave these addictive stuffs and to inculcate good habits.

Third guest lecture was by Mr. Parasharan Chari from Endeavor. He discussed the various career opportunities to the students based on their area of interest. He also discussed about the various entrance exams that a student should appear to get into the best universities based upon his interest.

Technical Lectures

On day two, two expert lectures were arranged for us. The first lecture was by Mr. Jayendra Vyas from Electrotherm India Ltd. He revised our basic concepts of electrical engineering. He also discussed about power ratings of various house-hold appliances.

On the same day, the next expert lecture was by Mr. V. G. Patel from Transformers and Rectifiers (India) Pvt. Ltd. He discussed about the manufacturing of the power transformers, their windings, core and the assembly of the whole transformers. He also discussed various cooling methods for power transformers and the tests performed on them before they are used for operation.

On the third day, we had technical lectures mainly based on electronics. The first lecture was by Dr. Nishit pandya from NTICE Technologies. His topic was Power Supply Design. He discussed about the load and line regulation, voltage regulators and various convertors as well.

The second lecture on the same day was on Variable Frequency Drive application on motors by Mr. S. B. Mahajani from Amtech electronics Pvt. Ltd. He discussed about IGBT's, crystal oscillators and capability curve of motors under various weather conditions.

Visit 1: SARDAR SAROVAR HYDRO POWER PLANT

Date: 24th June, 2014

Sardar Sarovar Hydro Power Plant Profile :

The Sardar Sarovar Dam is a gravity dam on the Narmada River near Navagam, Gujarat in India. A gravity dam is a massive sized dam fabricated from concrete or stone masonry. They are designed to hold back large volumes of water.

It is the largest dam and part of the Narmada Valley Project, a large hydraulic engineering project involving the construction of a series of large irrigation and hydroelectric multi-purpose dams on the Narmada River. A gravity dam is a massive sized dam fabricated from concrete or stone masonry. They are designed to hold back large volumes of water. By using these materials, the weight of the dam alone is able to resist the horizontal pressure of water pushing against it.

The project took form in 1979 as part of a development scheme to increase irrigation and produce hydroelectricity. At present, the length of the main concrete gravity dam is 1210.00m and maximum height above deepest foundation level is 163.00m. Catchments area of river above dam site is 88,000 Sq.km.

The project has uplifted the standard of the people living in Gujarat, Rajasthan, Madhya Pradesh and Maharashtra. The reservoir formed by the main dam has a gross storage capacity of 0.95 million hectare meters. The annual power generation at the project is estimated at 5469 GWH.

It has impacted in every sector whether it is irrigation or drinking water or power supply. It provides irrigation facilities to 18.45 lakhs hectare of land, covering 3112 villages of 73 talukas in 15 districts of Gujarat. It will also irrigate 2, 46,000 ha. of land in the strategic desert districts of Barmer and Jallore in Rajasthan and 37,500 ha. in the tribal hilly tract of Maharashtra through lift. A special allocation of 0.86 MAF of water has been made to provide drinking water to 131 urban centres and 9633 villages (53% of total 18144 villages of Gujarat) within and out-side command in Gujarat for present population of 28 million and prospective population of over 40 million by the year 2021.

INFORMATION OF TRAINING:

We were taken to the Sardar Sarovar Dam on the very first day of our industrial visits. There we saw blocks of dam which are used to store massive amount of water. Storage of water is utilized for following objectives:

• Hydropower

• Irrigation

• Water for domestic consumption

• Drought and flood control

• For navigational facilities

• Other additional utilization is to develop fisheries

There are two power houses viz. River Bed Power House (RBPH) and Canal Head Power House (CHPH).

1. **RBPH:**
   The RBPH is an underground power house stationed on the right bank of the river located about 165 meters downstream of the dam. It has installed capacity 1200MW. The dam's main power plant houses six 200 MW reversible Francis Pump turbines to generate electricity with a rated head of 100 metres varying between 80.6 metres to 112.8 metres and afford a pumped storage capability. The turbine – generator set is been provided by M/S Sumitomo Corporation, Japan. These sets can work at a minimum water level of 110.65 metres.

2. **CHPH:**
   CHPH is a surface power station in the saddle dam on the right bank of the river. It has installed capacity 250MW. It contains five 50 MW Kaplan turbines generators provided by BHEL (Bharat Heavy Electricals Limited). These units can work with a minimum water level of 110.118 metres.

The energy generated from both the power houses is to be evacuated through 400 KV level through interconnecting transformers at GIS, situated in RBPH switch yard. There are 6 penstocks of diameter 7.72 metres and 110 metres long with flow rate of 40,000cusec/second. The 400 KV Switchyard is indoor type having Gas Insulated Switch Gear and Bus bars. The energy is transmitted to party states i.e. Gujarat, Maharashtra and Madhya Pradesh in the proportion of 16:27:57 respectively through 400 KV double circuit transmission lines, namely SSP-Kasor, SSP-Asoj, SSP-Dhule and SSP-Nagda respectively.

Also we were shown a presentation regarding the overall view of the project , its benefits , irrigation area covered , future constructions yet to be done etc. Overall it was a nice experience to know about such a big project working so efficiently.

Fig 1. Francis pump turbines

Fig 2: Sardar Sarovar Dam

Fig 3: Catchment Area

Visit 2: ELECTRONICS AND QUALITY DEVELOPMENT CENTRE (EQDC)

Date: 26th June, 2014

EQDC Profile:

Popularly known as **EQDC**, Electronics & Quality Development Centre was established, by Govt. of Gujarat. & since then, it has been functioning under the umbrella of STQC (Standardization, Testing, Quality, and Certification), Dept. of Electronics and Information Technology, Ministry of Communication & Information Technology, Govt. of India.

Electronics and Quality Development Centre is a 9001:2008 ISO certified company situated at GIDC Electronics Estate, Sector - 25, Gandhinagar with primary objective to provide world class services in Calibration, Testing and Training in Quality awareness.

With primary objective at the time of EQDC's inception – "Helping electronics industries in the Electronics Estate, GIDC, Gandhinagar, Gujarat", it has widened its vision "To provide world class services in Calibration, Testing and Training in Quality awareness". The main activities of the EQDC are as follows –

1. Calibration of instruments

2. Testing of components, assembly, sub-assembly

3. Third party inspection

4. Consultancy for Quality system

5. Training program for engineers

This has resulted in to its image of Laboratory of National repute, and Nation-wide customer base. The centre is a four storey building with different sections on each floor. We were escorted throughout the centre by various people of different department. The initial turn over for the year 1999-2000 was Rs 19 Lac, which now has touched Rs 4.2 Cr for the year 2009-2010.

INFORMATION OF TRAINING:

EQDC is a four storey building with different sections on each floor. On the first floor, we were introduced to Mr Anil sir, salesman of the company, in the Audio-Video room. He meticulously explained us the importance of the calibration in the industries. The process of periodic checking of test & measuring instruments (TMI) by comparison with another instrument of better accuracy is termed as Calibration. He also affirmatively explicated about

the quality of the product and how the sale of the product hugely depends on its quality. "Best is the quality, best would be the sale in the market" he said.

For the best quality to maintain, regular check-ups or inspection of the instruments are done by the third party. EQDC offers calibration services to industry and organizations in the following domains: Electro Technical Calibration, Non Electrical Calibration, Onsite Calibration, Medical Equipment Calibration. After the brief description of the company and getting acquainted with the company details, we headed towards the ground floor.

TESTING:

The testing of the Equipments were done at the ground floor . The testing of various products and systems to assure the quality, safety, and security is a measurement assurance practice, to verify the compliance to the international and national specifications. The effectiveness of quality control steps depends directly on the accuracy and confidence with which the test & measuring instruments (TMI) can yield test results. EQDC offers testing in following domains:

Electronics and Electrical Testing

1) Component Testing
2) Equipment System Testing
    i) Industrial Equipment
    ii) Medical Equipment
3) Environmental Testing
4) Safety Testing
5) EMI/EMC Testing
6) Opto Electronics Testing
7) Solar PV Testing

Software and System Testing

1) Software Testing and Assessment

2) Software Process Assessment

3) Information Security Testing and Assessment

Various testing machines we observed are discussed below:-

1) Vibration and shock Table –

When the product is delivered, it should not break or get damaged due to unavoidable vibrations while transporting from one place to the other. This test checks the mechanical strength of the product. The product is clipped on the shock table and the vibrations are produced. If the product withstands the vibrations then it is taken for further tests else the product is rejected. Specifications of vibration and shock table :

Rated force : 400kgf
Frequency : 3.5-5 kHz
Accuracy : 31.14 %

2) ***Universal Testing Machine –***

This machine tests the durability and ductility of the wire. The sample wire is clamped from both of its ends. The sample is then stretched from both the extremes. Different wires have different withstand capability; hence according to the rating of the wire it should withstand that much of force. Specifications –
Load capacity – up to 5000 kgf
Accuracy – 1% of the load

3) ***Environment Testing Chamber –***

After despatching, the product should work properly in any environmental conditions. Hence this test is very useful to check whether the sample would work normally in different environmental conditions. The sample is put inside the testing chamber and temperature is varied while the sample is in working condition. The equipment is also tested in the conditions where it has to be used. Also, humidity test is done to inspect any damage caused by humidity.

4) ***Dry Heating Chamber –***

This is also the temperature test for the product. The product is put inside the chamber where the temperature is varied from -60 to 300 deg. Celsius. The product is taken out and is checked if the same is working properly.

5) ***Dust Chamber –***

As the name suggest this machine tests the working capability of the product in the windy and stormy conditions. To provide the actual environment, EQDC uses talcum powder as the dust ingredient. This process is also performed to fill up the cracks in the product.

CALIBRATION:

Another important activity performed by the EQDC is the calibration of the equipments . The process of periodic checking of TMI by comparison with another instrument of better accuracy is termed as Calibration. Accurate measurements play a vital role at each stage in development and production of quality product. The effectiveness of quality control steps depends directly on the accuracy and confidence with which the test & measuring instruments (TMI) can yield test results.

EQDC offers calibration services to industry and organizations in the following domains :

- Electro Technical Calibration
- Non Electrical Calibration
- Onsite Calibration
- Medical Equipment Calibration

1. Electro-technical Calibration-

The Electro Technical Calibration standards held by the EQDC laboratories are traceable to the national standards through the high Precision Calibration Laboratories. The calibration services provided covers almost all general purpose| electrical, electronic Test Measuring Instruments (TMI) like **panel meters, DMMS, Oscilloscope, breakdown testers, CT, PT, power and energy meters (single & three phase), LCR meters and LCR standards, milli ohm and Micro ohm meters, function generators, oscillators, signal generators etc.**

Services Offered:

- Voltage AC/DC Parameter
- Current AC/DC Parameter
- High Voltage AC/DC Parameter
- Modulation Parameter
- Oscilloscope Parameter
- Power Energy Parameter
- RF Parameter
- RLC Parameter
- Time and Frequency Parameter

2. Non-Electrical Calibration –

Laboratories of EQDC are providing non electrical calibration services for Temperature, Humidity, , Dimensions, Mass, Pressure . The calibrations facilities are regularly upgraded with sate of art technology equipments / standards. The calibration reports issued has wide acceptability and includes measurement uncertainty. The turnaround time for calibration of instruments is minimum and the calibration charges are rationalized across the EQDC laboratories. **Services Offered:**

- Dimension
- Humidity
- Mass
- Pressure
- Temperature

3. ***Onsite Calibration -***

EQDC also cater to the mobile/onsite calibration requirement of customers. These services are provided to customers as on site calibration services for almost all electronic test and measuring instruments, on request.

4. ***Medical Instrument Calibration -***

Thermometers, Blood Pressure apparatus, Pipettes, weighing scale, Auto clave, Blood storage/Refrigerators, Analyzers, RF based equipments, Monitors, etc. are being calibrated/Tested in Medical Laboratory.

Fig 4: Electronics and Quality Development Centre

VISIT 3: GANDHINAGAR THERMAL POWER STATION

Date:27th June 2013

Company Profile

Gandhinagar Thermal Power Station is a coal-fired power station the capital at Gandhinagar, the capital of Gujarat, India. It is located on the bank of Sabarmati River near Gandhinagar. There are two units of 120 MW each (Unit no. 1 & 2), three units of 210 MW each (Unit no. 3, 4 & 5) with a total installed capacity of 870 MW. All the above units are of BHEL (Bharat Heavy Electricals Limited) make. GTPS is constructed to meet with power needs of North Gujarat and to improve the voltage condition of the Western Grid. Gandhinagar thermal power station unit 1 & 2 are over 36 years old.

Information About The Visit:-

The whole electrical batch was divided into two groups of 30 students each. Every student was provided with a helmet as a safety measure. We were guided directly to the generator floor. Prior to that, we were given some important safety instructions. We were prohibited to touch anything in the plant. The expert guide on the floor gave us the specifications of the generators and the turbines. The whole process in the plant was explained to us as follows:

Layout Of G.T.P.S.:

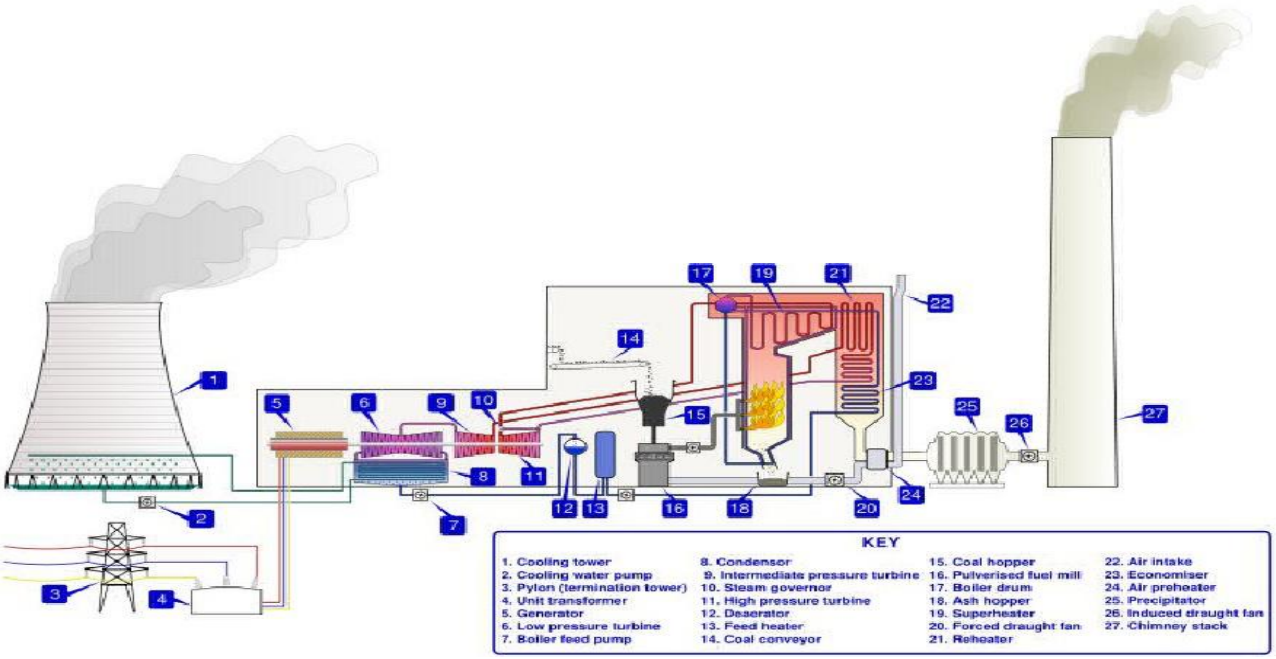


Fig. 5:- Layout of G.T.P.S.

Coal specifications :

Bituminous coal coming from Nagpur, calorific value: 3800kcal/kg, ash content: 35%, sulphur: 1%

The coal is supplied to crusher house with the help of conveyers and in the crusher house the coal is crushed and sized. The crushed coal coming out of the crusher is then supplied to coal bunker with the help of a conveyor belt. Crushed coal is fed to pulveriser through feeder into very small particles. Hot air is passed through the feeder to dry the coal before being fed to pulveriser. The coal is then sent to the boiler by bowl mill which carries the coal particles to boiler.

First of all, the steam from the boiler drum enters into the low temperature super heater. Then the steam passes to plane super heater through super heater and finally it reaches to final super heater where its temperature is taken up to 535`C and the pressure of 149 kg/cm^2, it is given to the high pressure turbine. Re-heater obtains the used steam from the high-pressure turbine at a pressure lower than the boiler pressure and which is nearly 34.1 kg/cm^3. The low pressure steam passing through re-heater is heated to 540◦ and then it is introduced in the I.P turbine. All this is done since turbine is provided with a superheated steam. The steam entering the I.P turbine has pressure of 32.1kg/cm^2. The specifications of the turbine are as follows:

Table 1: Specification of Turbines

	Unit 3	Unit 4	Unit 5
HP turbine	25	25	25
IP turbine	20+20	20+20	20+20
LP turbine	8+8	8+8	8+8
Exhaust temp.	54	52	40.2
Efficiency	37.22%	47.71%	41.37%

After IP turbine the steam is directly taken to the LP turbine. It rotates the turbine and due to heat it expands; hence the diameter of the LP turbine is bigger compared to HP or IP turbines.

The generators are connected with the turbines with a common shaft. As the turbines rotate with 3000rpm, generator rotor also rotates with the same speed.

Generator specifications:

4 Pole, cylindrical, field rotating.

Stator: 15750V, 9030 A

Rotor: 310V, 2600A

Rotor rotates in the stator and cut the flux lines around the coil and thus the electricity is generated. Hydrogen gas is used as a coolant for the stator because of its high thermal conductivity.

Different Cycles:

Next we were taken to the control room from where the whole plant's functioning is been checked. The whole control room was divided into 5 panels for controlling 5 different cycles namely:

- Coal cycle
- Feed cycle
- Boiler cycle
- Turbine cycle
- Generator cycle

1. Coal cycle:

To control the power generation, the amount of coal is varied and rpm of the generators is undisturbed. The coal is conveyed with the help of coal conveyer from an external stack and ground to a very fine powder by a pulveriser. A pulveriser is a device for grinding coal for combustion in a furnace in power plant. There it is mixed with the pre-heated air driven by the Forced Draught Fan. The hot air-fuel mixture is forced at high pressure into the boiler where it rapidly ignites. According to the requirement the coal input per hour is varied . at that time coal was fed at the rate of 140.5 tonnes/ hr.

2. Feed cycle:

For generating the power to about 870 MW we need lot of water and the same is arranged from river Sabarmati. Water of high purity is pumped into the boiler where it turns into steam. The steam is piped into the HP turbine. The steam is returned to the boiler re-heater and then passed through IP and LP turbines respectively. The steam is condensed and fed to the cooling tower.

3. Boiler cycle:

Coal fired units produce electricity by the burning coal in a boiler to heat water to produce steam. The steam, at tremendous pressure, flow into a turbine, which rotates armature of generator to produce the electricity. The steam is condensate and converted back into water, and the returned to the boiler to complete the closed cycle.

4. Turbine cycle:

This panel displayed the temperature and pressure of steam inside the turbine and speed of turbine.

- Turbine inlet steam flow: 593.37 tonnes/hr.

- Superheated steam pressure:149.36 kg/cm2
- Superheated steam temp.: 532.93 degrees
- R.p.m.: 3000

5. Generator cycle:

The total energy produced by the total plant was been displayed in this panel and engineers took regular check of the readings of this panel . The reading at that time were:

- Active power : 160 MW
- Supply frequency : 49.82 Hz

At any point of time all the generators connected to the grid must run at the same speed or in a "synchronized" mode. As such Coal fired thermal power plants are slow to respond to load changes because of thermal inertia. Hence utmost care is taken for variation in frequency.

Salient Features Of 120 MW G.T.P.S. Unit:-

- **PLANT CAPACITY**: 2*120 MW
- **BOILER CAPACITY**: 383 tones/hour of steam at Pressure of 136 kg/(cm)squ and 540`C
- **COAL HANDLING PLANT CAPACITY**: 250tones/hour
- **CHIMNEY HEIGHT**: 94.5 m
- **COOLING TOWER HEIGHT**: 118 m
- **COOLING WATER PUMP**: 8500 3m/hour
- **CAPACITY OF CONDENSOR**: 261 kg/hour
- **CAPACITY OF SERVICE WATER OVER HEAD TANK**: 500 m^3
- **CAPACITY OF STEP UP TRANASFORMER**: 140 MVA
- **STEP UP RATIO**: 13.8 kv / 220 kv
- **CAPACITY OF UNIT AUXILARY**: 15 MVA
- **STEP DOWN RATIO**: 13.8 kv / 6.6 kv

SALIENT FEATURES OF 210 MW UNIT OF GTPS:-

- **PLANT CAPACITY** : 3*210MW
- **BOILER CAPACITY** : 690 tones/hour of steam at pressure of 136 kg/(cm)squ at 540`C
- **COAL HANDLING PLANT CAPACITY**: 1000 tones/hour
- **CHIMNEY HEIGHT** : 120 m for 3 & 4 and 220 m for unit 5
- **COOLING TOWER HEIGHT** : 121 m for 3 & 4 and 131 m for unit 5

- **COOLING TOWER CAPACITY** : 33000 m^3 / hr
- **COOLING WATER PUMP CAPACITY :** 16,500 m^3/hour
- **CAPACITY OF CONDENSOR** : 700 t/hour
- **CAPACITY OF SERVICE WATER OVER HEAD TANK** : 150 m^3
- **CAPACITY OF STEP UP TRANSFORMER** : 140 MVA
- **STEP UP RATIO** : 15.7 kv / 220 kv
- **CAPACITY OF UNIT AUXILARY** : 15 MVA
- **STEP DOWN RATIO** : 13.8 kv / 6.6 kv
- **CAPACITY OF ASH HANDLING**: 160 T / hr

Fig 6: Gandhinagar Thermal Power Plant (G.T.P.S.)

Fig 7:- G.T.P.S. Switchyard

Fig 8:- Generator at G.T.P.S.

Visit 4 – Transformers and Rectifiers (India) Pvt. Ltd

Date: **28th June,2014**

Transformers and Rectifiers (India) Pvt. Ltd Profile:-

Incorporated in 1994, Transformers & Rectifiers (I) Limited has consolidated its position in the Indian Transformer Industry as a manufacturer of a wide range of transformers, which conform to the quality expectations of both the domestic and the international market. An ISO 9001 & 14001 & BS OHSAS 18001 company today, T&R as it is more popularly known, is proud to have executed a number of prestigious orders from developed countries such as Canada and the United Kingdom. The capability to develop world class power, distribution, and furnace and speciality transformers is credited to the creation of a world class infrastructure at three plants around the city of Ahmedabad, one of the leading industrialized cities of India. This facility is equipped with world class state of the art equipment and managed by a high skilled and experienced team of production personnel who consistently ensure that each and every production activity factors in an adherence to the high quality benchmarks established by the organization.

A VALUE BASED ORGANISATION:

As one of India's leading transformer manufacturing companies, and one that is held in high esteem even by their competitors, a great deal of relevance is attached to living up to their image as a value based organization. They are an ethically responsible company, operate with transparency, validate commitment and sincerity, both vertically and horizontally across the organization and inculcate a spirit of integrity. They also try and extend these values to our business associates, be it vendors or their valued customers.

Transformer is a static electrical device that is used to convert voltage from high value to low value or vice-versa without altering frequency. There are two main circuits in a transformer:-

1. Electrical Circuit – Transformer windings
2. Magnetic Circuit – Transformer Core

Transformer Windings:-

Windings in a transformer form the electrical circuit. Windings consist of the current-carrying conductors wound around the core of the transformer which must be properly insulated, supported and cooled. Copper and aluminium are two most widely used materials for the construction of power transformer windings.
There are two main types of Windings:-

1. Concentric Windings

1.1. Cross Over Windings:-

These are made of circular conductors not exceeding 5 to 6 sq. mm in cross section. Each coil consists of several layers and each layer consists of several turns. These are used for HV windings of relatively small transformers. These windings are not suitable for current exceeding about 20A. The conductors are generally round and are paper or cotton insulated.

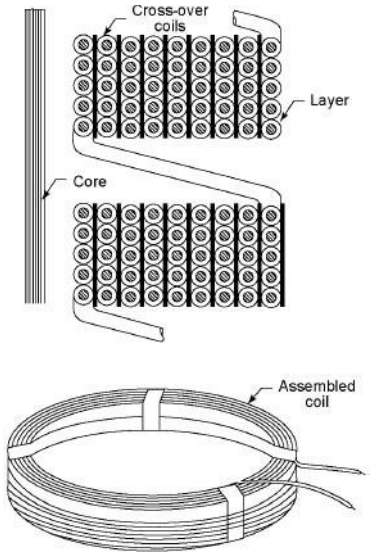


Fig. 8: Cross Over Winding

1.2. Spiral Windings:-

This type of windings is generally used up to 33kV and low current ratings. Strip conductors are wound closely in axial direction without any radial ducts between the turns. Spiral windings may be of single layer, double layer, or multi-layer type. Normally it is not necessary to provide any transposition between the parallel conductors of the spiral windings as the lengths and the identical ux are almost identical.

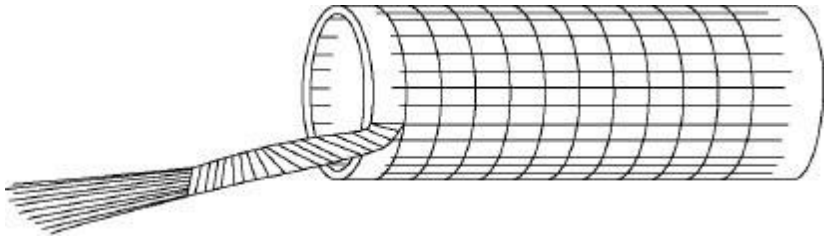


Fig. 9: Spiral Winding

1.3. Helical Windings:-

This is made up of large cross section rectangular conductor wound on its at side. The coil progresses as a helix. A number of conductors are used in parallel to form one turn. These are wound around the cylinder in the form of helix leaving a duct gap of 4.5-6 mm wide between two adjacent turns around the height. Helical windings may be single layer, double layer or

multi-layer, if the number of turns is more. This is commonly used for LV windings, i.e., low voltage and high current. The insulation requirement also is not too high.

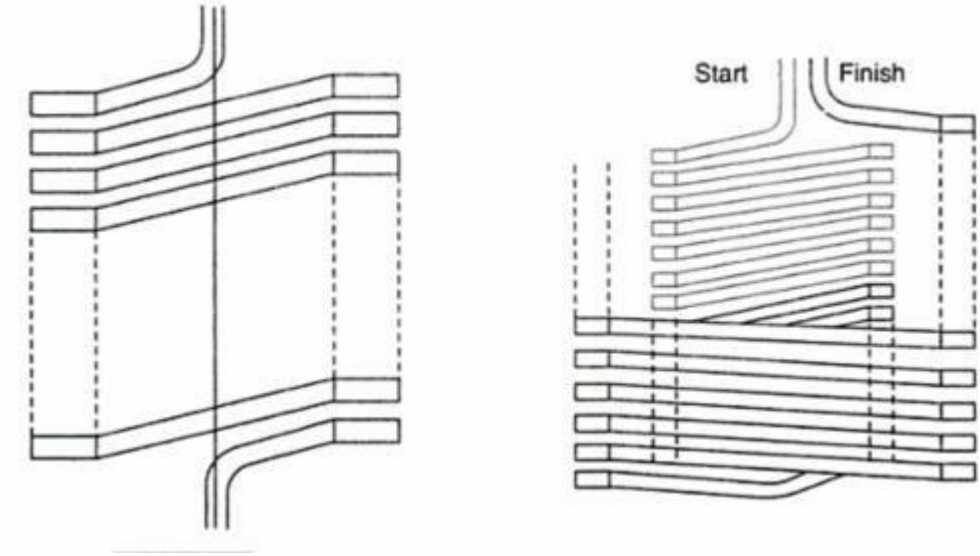


Fig. 10: Helical Winding

1.4. Continuous disc Windings:-

This type of windings is used for between 33 kV and 132 kV and medium current ratings. These coils consist of number of sections placed in axial direction with ducts between them. Each section is a at coil, having more than one turn, while each turn itself may comprise one or more conductors (usually not more than four or five), in parallel. The sections are connected in series, but without any joints between them.

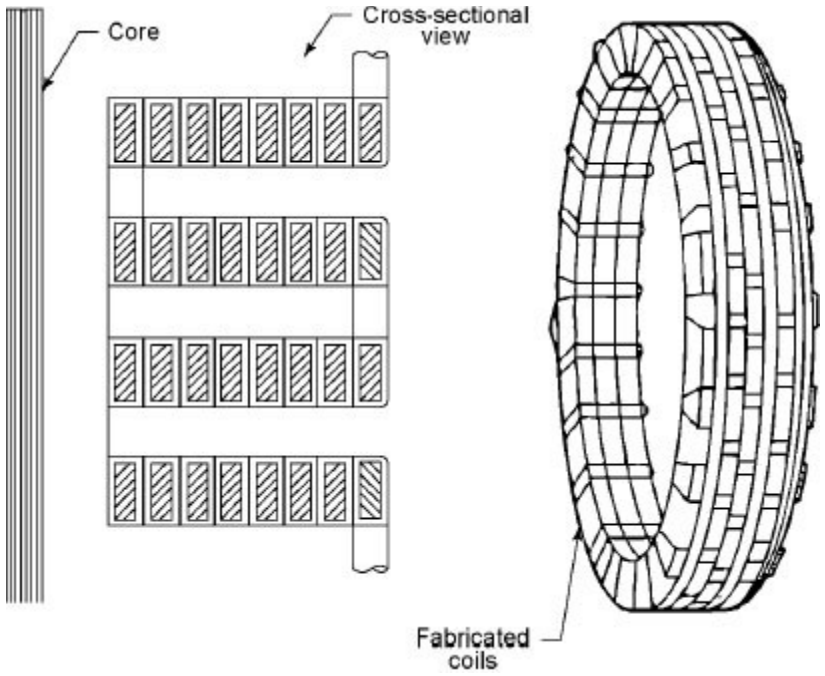


Fig. 11: Continuous disc Windings

2. Sandwich Windings:-

Sandwich windings are used in shell-type transformers. The high-voltage and low-voltage windings are split into a number of sections where each high-voltage section lies between two low-voltage sections. Such subdivision of windings into small portion reduces the leakage ux. In sandwich coils, easily leakage can be controlled. Desired value of leakage reactance can be obtained by proper division of windings. Higher the degree of subdivision, smaller is the reactance.

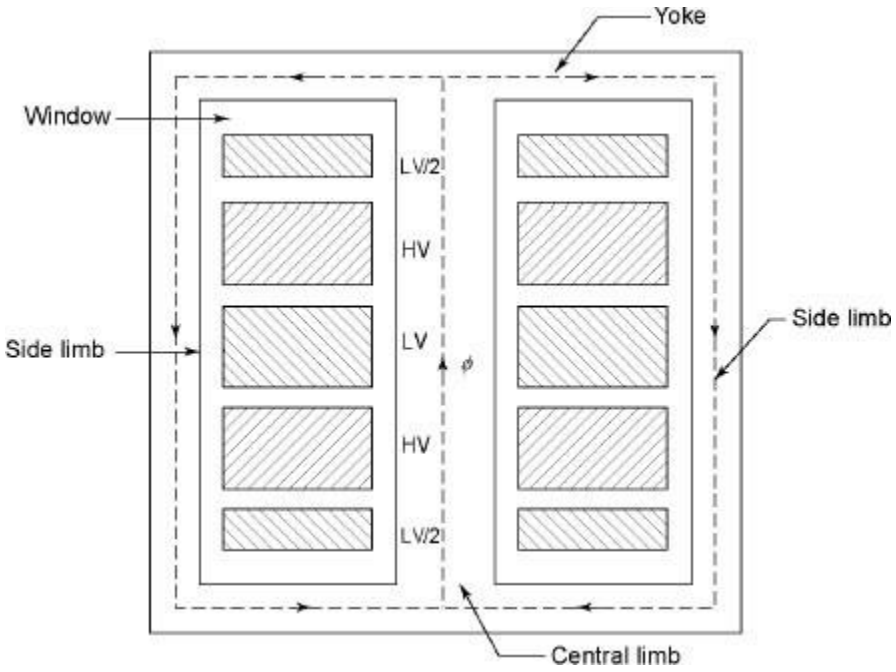


Fig. 12: ***Sandwich Windings***

Transformer Core:-

Purpose of Transformer Core:-

In an electrical power transformer, there are primary, secondary and may be tertiary windings. The performance of a transformer mainly depends upon the flux linkages between these windings. For efficient flux linking between these windings, one low reluctance magnetic path common to all windings should be provided in the transformer. This low reluctance magnetic path in transformer is known as core of transformer.

Material for Transformer Core:-

The main problem with transformer core is its hysteresis loss and eddy current loss in transformer. Hysteresis loss in transformer mainly depends upon its core materials. It is found that, a small quantity of silicon alloyed with low carbon content steel produces material for transformer core, which has low hysteresis loss and high permeability. Because of increasing demand of power, it is required to further reduce the core losses and for that, another technique is employed on steel, which is known as cold rolling. This technique arranges the

orientation of grain in ferromagnetic steel in the direction of rolling. The core steel which has under gone through both the silicon alloying and cold rolling treatments is commonly known as CRGOS or Cold
Rolled Grain Oriented Silicon Steel. This material is now universally used for manufacturing transformer core. Although this material has low specific iron loss but still; it has some disadvantages, like, it is susceptible to increase loss due to flux low in direction other than grain orientation and it also susceptible to impaired performance due to impact of bending and blanking the cutting CRGOS sheet. Both the surfaces of the sheet are provided with an insulating of oxide coating.

Transformer Assembly:-

While manufacturing a transformer for efficient manufacturing the work is divided and completed in several numbers of sections. Main sections are Winding Section and Core Assembly Section.

In Winding Section the conductors are wound on press-board cylinders as per the design and sent for Pressing.

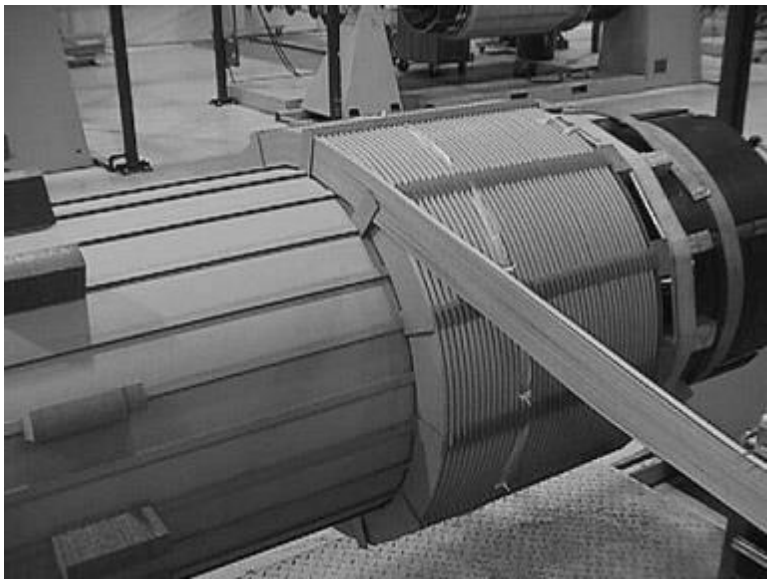


Fig. 13: Coil Winding Section

In Core Assembly Section the laminated CRGO steel sheets are arranged in such a manner that a `stepped laminated core' is obtained. Both these processes are done in parallel. After that, using supports the core sheets are held together and the windings are mounted on the core limbs as per the design requirement.

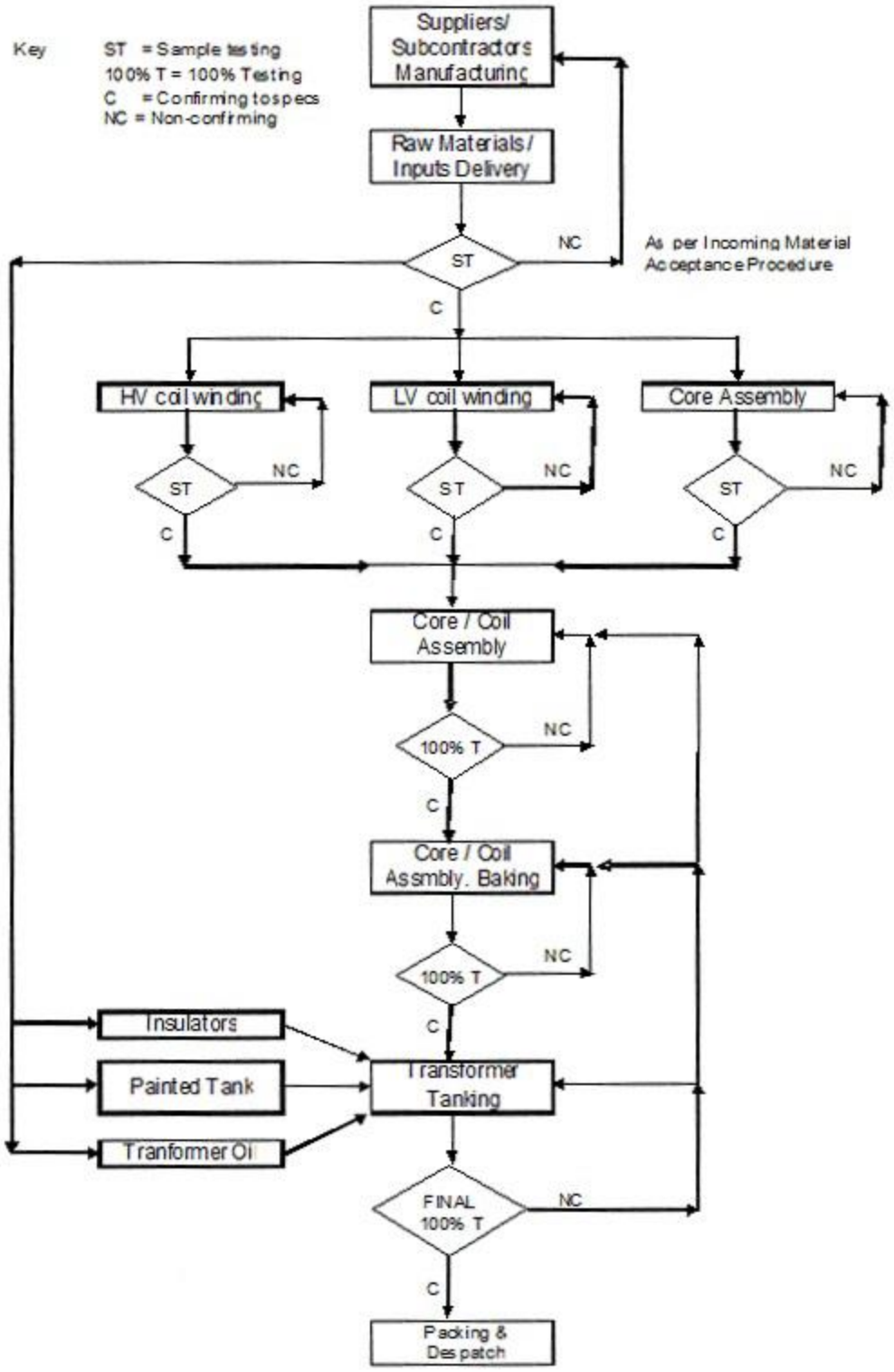
Fig. 14: Core Assembly Section

Other sections include the one where the core along with the windings fitted on it is put in the tank. Also there is a section for \Heating" (VPD) of the windings [This section comprises of an oven]. There is a section where the connections for HV and LV Bushings are done (Even Instrumentation transformers are fitted along with so as to facilitate the measurement of current and voltages). After all the fitting has been along with the connection terminal taken out, “Tanking" process is done.

In Tanking process oil filling is done. After this process, the transformer is sent to the “Testing Section" is there where Routine and Special Tests are performed and accordingly dispatched to their respective customers.

Fig. 15: Assembled Power Transformer

Flowchart describing whole transformer manufacturing:-



Testing of Transformers:-

Tests performed on transformers are of two kinds the ones performed on the windings before they are put in the tank and the ones performed after the windings have been put inside the tank.

1. *Preliminary Tests* :-

Following tests are carried out in the works at different stages, before the core and coil assembly of the transformer is placed in its tank.

1.1. Core Insulation

After the core is assembled, a 2kV test is done to ensure that the insulation between clamp plates, core bolts and core is adequate.

1.2. Core Loss Test

This is conducted on the core assembly to ensure its soundness. Some turns are wound over the core and it's energized at normal flux density. Core loss and magnetizing current are noted and compared with design value.

1.3. Check of Ratio, polarity, Vector relationship and Winding Resistance of Transformers

Ratio test is conducted to ensure the correctness of voltage ratio between different windings on each tap winding. The tolerance allowed for ratio is 0.5% of the declared ratio or 10% of the percentage impedance voltage, whichever is smaller. The latter tolerance limit is not applicable for autotransformer and booster transformers, where impedance value is small. In order to get accurate ratio, a ratio-meter is employed. It also indicates the polarity of transformer windings. For a 3-phase transformer it's more usual to carry out a vector relationship test, in which one of the high-voltage and low-voltage line terminals are jointed together. The dc resistance of each winding is measured by Kelvin's double bridge method to check that there is no faulty joint.

2. Routine Test:-

2.1. Measurement of winding resistance

For calculation of I^2R losses in the winding, it is necessary to measure dc resistance of each winding. The resistance measurement should be done after the direct current circulating in the winding has reached a steady state. In some cases this may take several minutes depending upon the winding inductance. This test is usually carried out before load loss measurement. The average oil temperature is taken as the average of top and bottom oil temperatures and is taken as winding temperature.

2.2. Measurement of Voltage Ratio and check of voltage vector relationship

These tests are conducted to check that all connections to the bushings, tap changers, etc. have been correctly during final assembly.

2.3. Measurement of impedance voltage, short-circuit impedance and load loss

The test is carried out by short-circuiting, usually the LV winding and by supplying the impedance voltage to the HV winding. The measured power will also include small core loss which can be ignored. Note that 3-Watt meter Method is advised rather than 2-Watt meter so as to avoid large value of watt meter multiplier constant. Also the power factor can be less than 0.1 during load loss test and watt meters suit- able for such low power factors should be used.

2.4. Impulse Test

The tests normally include impulse testing on the terminals, where a steep-fronted impulse wave-shape simulates a lightning stroke close to a transformer in service. For very high voltage transformers an additional impulse test is applied, using a wave shape with longer duration and lower amplitude, but larger energy content. The impulse tests are monitored with oscilloscope graphs or equivalent transient recorders. This analysis is quite intricate but gives reliable information on any possible disturbances in the transformer.

Fig. 17: Impulse Test

2.5. Measurement of no load loss and current

2.6. Measurement of insulation resistance

2.7. Dielectric tests

2.8. Tests on-load tap changers

3. Special Tests:-

3.1. Measurements zero-sequence impedance of three phase transformers

The zero-sequence impedance is measured on star-connected windings, which have a earthed neutral, in order to determine the current which will low in the event of a line-to-earth fault. Reluctance path for zero-sequence flux is different in three-phase three-limb core and three-phase five-limb core and hence the value of zero sequence impedance lies between 80-90% of positive sequence impedance for transformer having three-limb core, whereas it is between 90-100% of positive sequence impedance for the case of five-limb core.

3.2. Measurement of acoustic noise level

This measurement measures the average sound level generated by the transformer, when energized at rated voltage and frequency at no-load with cooling fans and pumps in operation. The main sound comes from the core vibration, since there are no moving parts in the transformer.

3.3. Measurement of the harmonics of the no-load current

The harmonics of the no-load current in all the phases are measured by means of harmonic analyser at rate voltage and the magnitude of the harmonics is expressed as a percentage of the fundamental component.

3.4. Measurement of the power taken by the fans and oil pumps

3.5. Measurement of capacitances between windings to earth and between windings

3.6. Measurement of transferred surge voltage on LV windings

3.7. Measurement of insulation resistance to earth windings, or measurement of dissipation factor (tan delta) of the insulation system of capacitance

Training Outcomes

- Ability to acquire and apply fundamental principles of science and engineering.
- Capability to communicate effectively.
- Ability to identify, formulate and model problems and find engineering solution based on a systems approach.
- Ability to conduct research in the chosen fields of engineering.
- Understanding of the importance of sustainability and cost-effectiveness in design and developments of engineering solution.
- Ability to be a multi-skilled engineer with good technical knowledge, management, leadership and entrepreneurship skills.
- Awareness of the social, cultural, global and environmental responsibility as an engineer.
- Capability and enthusiasm for self-improvement through continuous professional development and life-long learning.

Conclusion

It is the conclusive fact that training is beneficial for students. It evinces that the program has significantly improved their 'personal attitude', 'Communication skills' and 'Work attitude'. The experience gained from training sharpens the business acumen of the students and open the doors of better employment prospects.

In essence, the new method of the student's placement needs to be reviewed and improved. However, this study needs an added insight. It is important for future research to incorporate a wider range of soft skills e.g. Leadership, teamwork spirit to ascertain the favourable outcomes.