INTRENSHIP REPORT
ON

FUNDAMENTALS OF TRANSFORMER MAKING AND SWITCHGEAR ASSEMBLING

BY

GOUTAM CHANDRA SUTRA DHAR
MD. MOSHAROF HOSSAIN
MD. RAIHAN FARUQUE

Submitted to the
Department of Electrical and Electronic Engineering
Faculty of Science and Engineering
East West University

partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and ctronic Engineering

B.Sc. in EEE

Fall, 2010

Approved By

Academic Advisors

Dr. Ishfaqur Raza

Department Chairperson

Dr. Anisul Haque

Training Certificate

ENERGYPAC

EE.UP/Admin/EWU/TR/2010-10(008)
Date: 2nd Oct 2010

TRAINING CERTIFICATE

This is to certify that **Md. Mosharof Hossain**, Bearing Roll No. **2006-3-80-007**, a Student of Electrical and Electronic Engineering Department of East West University of Bangladesh. He was attended an Industrial Practice, which was programmed from 21st Aug 2010 to 4th Sep'2010 at Energypac Engineering Ltd, Baruipara, Savar, Dhaka, Bangladesh. During his Industrial attachment he has taken some practical experience about Power Transformer, Impulse, Distribution Transformer, Instrument Transformer (Both CT & PT), Fabrication, CNC Machine Shop, Paint, Powder Coating, Isolator and Switchgear Items (LT, HT & PFI) etc.

Nothing has been recorded against his character and conduct during his attachment.

I wish him every success in life.

Fida Mahmood Hasan
Manager (Admin & Utility)

ENERGYPAC ENGINEERING LTD.

ENERGYPAC

EE.UP/Admin/EWU/TR/2010-10(004)
Date: 2nd Oct 2010

TRAINING CERTIFICATE

This is to certify that **Md. Raihan Faruque**, Bearing Roll No **2006-3-80-005** a Student of Electrical and Electronic Engineering Department of East West University of Bangladesh. He was attended an Industrial Practice, which was programmed from 21st Aug 2010 to 4th Sep 2010 at Energypac Engineering Ltd, Baruipara, Savar, Dhaka, Bangladesh. During his Industrial attachment he has taken some practical experience about Power Transformer, Impulse, Distribution Transformer, Instrument Transformer (Both CT & PT), Fabrication, CNC Machine Shop, Paint, Powder Coating, Isolator and Switchgear Items (LT, HT & PFI) etc.

Nothing has been recorded against his character and conduct during his attachment.

I wish him every success in life.

Fida Mahmood Hasan
Manager (Admin & Utility)

ENERGYPAC ENGINEERING LTD.

ENERGYPAC

EE.UP/Admin/EWU/TR/2010-10(003)
Date: 2nd Oct 2010

TRAINING CERTIFICATE

This is to certify that **Gautam Chandra Sutradhar**, Bearing Roll No. **2006-3-80-008**, a Student of Electrical and Electronic Engineering Department of East West University of Bangladesh. He was attended an Industrial Practice which was programmed from 21st Aug'2010 to 4th Sep'2010 at Energypac Engineering Ltd, Baruipara, Savar, Dhaka, Bangladesh. During his Industrial attachment he has taken some practical experience about Power Transformer, Impulse, Distribution Transformer, Instrument Transformer (Both CT & PT), Fabrication, CNC Machine Shop, Paint, Powder Coating, Isolator and Switchgear Items (LT, HT & PFI) etc.

Nothing has been recorded against his character and conduct during his attachment.

I wish him every success in life.

Fida Mahmood Hasan
Manager (Admin & Utility)

ENERGYPAC ENGINEERING LTD.

East West University
EAST WEST UNIVERSITY
LIBRARY
43, Mohakhali, C/A

Acknowledgment

At first we wish to convey my heartfelt thanks to almighty Allah for his help to complete the Internship successfully and all those who helped us and provided us with support in making this report. Without their assistance we could not have completed our Internship.

We want to thank Mr. Moniruzzaman, manager, ENERGYPPAC ENGINEERING LTD. He coordinated our internship program and helped us get introduced to other engineers. He managed our training schedule in a most caring manner. Without his support and guidance during our internship, we could not have accomplished our training.

We thank Engr. Asaduzzaman, Ad. GM, Engr. Syed Muztaba Ali, DGM, Engr. Mozaharul Islam, DGM, Engr. Belal Hossain, Manager, Engr. MD. Rashiduzzaman Bulbul, Asstt for their support, guidance, and mentorship. They helped us learn and be introduced to topics which made up our internship program.

We also would like to thank all the respected officers and employees of ENERGYPPAC ENGINEERING LTD. for their endless support. They also played an important role in copleting our internship program.

We are also very grateful to all of our teachers for their encouragement and cooperation through our internship program and academic life.

Our respectable teacher Dr. Md. Ishfaqur Raza, Associate Professor, Department of Electrical & Electronic Engineering, East West University (EWU) is very cordial to us. He is our supervisor and has great concern about our internship. He was visited our internship training center. He helped us with their guideline and advice to prepare the report. His positive attitude will always be a source of inspiration for us.

Dr. Anisul Haque is the Chairperson and Professor of the Department of Electrical & Electronic Engineering, East West University (EWU). He was instrumental for our industrial training because EEE Department under his dynamic leadership has been able to maintain good relation with a Company like ENERGYPAC. It was easy for us because of him to get opportunity at the ENERGYPAC for industrial training.

Executive Summary

We have completed our internship in ENERGYPAC ENGINEERING LTD. The factory is located at Savar, Baruipara. We did our internship related tasks in this factory. Energypac primarily manufactures substation equipments, primarily transformers and switchgears. In this report we have focused on various types of machines which are being used to make the transformer and switchgear assembling. To make a transformer, one hundred and fourteen different tasks were involved and most of which were introduced to us. Most of the raw materials for manufacturing transformers and switchgears assembling come from abroad. We were shown the making of transformer coil, which depends on the transformer power rating. We were also shown the assembling and internal connection setup of the transformer, including cooling system, tank making and painting.

Different types of switchgear panels are assembled in Energypac like LT panel, HT panel, PFI panel, ATS, EURO box etc. Quality of the components used in assembling switchgear panel is very vital. The switchgear panels are assembled in the factory, where proper wire connections and design is important. Most of the switchgear elements, such as breaker, relay are from abroad. However, Energypac makes outdoor and indoor switchgear panel.

When we work on the Energypac got opportunity to see the entire task to make a transformer and switchgear and we completed all of the work successfully. We saw the current transformer and potential transformer making process, while the complete working principle was shown to us. We also saw the isolator and circuit breaker making process. They generally use MCV, VCV, MCCV, ACV circuit breaker. Energypac makes the vacuum circuit breaker only, the other types of circuit breaker are imported. Isolators are fully manufactured in Energypac. They manufacture three types of isolator like, pantograph, center break, and double break. Fabrication process is also fully done in Energypac.

The testing part of Energypac is another most important feature. They test all their manufactured equipments. They do various type of test. One important test is "special type test". This type of test is done only at Energypac. For the purpose of this type of test they create arc on the transformer and observe its output. Some of these transformers are exported to India.

We tried our best to learn the different technical and engineering issues from the engineers of Energypac.

Chronology

The duration of our internship was 12 days. Daily activities for 12 days are given below.

DETAILS OF TRAINING SCHEDULE

Date	Section	Duration	Contact Person
21.08.10 -24.08.10	Transformer & Impulse	4 days	Engr. Asaduzzaman, Ad. GM Engr. Asim Kumar Bhakta
25.08.10 – 28.08.10	Switchgear	3 days	Engr. Syed Muztaba Ali, DGM
29.08.10 – 30.08.10	CT/PT	2 days	Engr. Mozaharul Islam, DGM
31.08.10 – 04.09.10	Isolator, Breaker & Fabrication	3 days	Engr. Moniruzzaman, Manager Engr. Belal Hossain, Manager

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

1. INTRODUCTION

In the Fall semester of 2010 we got an opportunity to do internship in Energypac Engineering Ltd. Energypac gave us the opportunity of practical exposure to the electrical machines which have only learnt in our classes and seen in books with focus on theory of operation. Energypac is one of the top engineering companies in Bangladesh. It is contributing greatly to the development of the power sector in our country. We believe Energypac is one of the most desirable places to obtain practical knowledge on substation equipments.

1.1. COMPANY PROFILE

1.1.1. FOUNDATION

Energypac is one of the leading power engineering companies in Bangladesh. Constant research and development, state of the art production facility, quality products, competent services, and countrywide operations have made it into a leading engineering company, widely acclaimed by its customers. Energypac was incorporated in 1982 as a private limited business enterprise. It is powered by 1200 skilled manpower of which 150 are graduate engineers. The relentless efforts and dedication of these people are providing the opportunity to research and develop technology to innovate and develop new products. It maintains on time delivery, pre and post sales services, establishing a long term business relationship with the customers. To meet countrywide demand of its products and services, Energypac has extensive distribution network throughout Bangladesh with full-fledged offices in the major cities like Chittagong, Khulna, Rajshahi, Sylhet, and Bogura. In an effort to introduce its products globally, Energypac has established its offices in India, and China. Energypac has already exported its products and services to India, Yemen, Ghana, Sudan, Uganda, Nigeria, Saudi Arabia, and United Kingdom.

The company's businesses initiatives are organized through their Strategic Business Units, which are: Energypac Engineering Ltd., Energypac Power Generation Ltd., Tech Advantage Ltd., Energypac Electronics Ltd., Energypac Agro Ltd., and Energypac Fashions Ltd. Energypac has several business partners, which are ABB, AREVA T&D, and Mitsubishi Electric.

Energypac is an ISO 9001:2008 and 14000:2004 certified company. While creating better and environmentally compatible technologies, Energypac focuses on the customer's demand with appropriate products and solutions as well as services.

1.1.2. *MANAGEMENT*

Enamul Haque Chowdhury
Managing Director

Engr. Rabiul Alam
Director & CEO

Humayun Rashid
Executive Director

1.1.3. *PHILOSOPY*

The management philosophy of the ENERGYPAC ENGYNEERING LTD. is "to produce high-quality Engineering that create a positive impression and satisfy customer by applying the local technologies we have developed throughout our history with the aim of contribution to a more affluent way of life".

1.1.4. *QUALITY POLICY*

As a result of its consistent guarantee of the highest quality, Energypac has achieved ISO 9001:2008 and 14000:2004 certificates for all its range of transformers and also its other products. This certification is done by United Registrar of Systems Ltd., UK and marked UKAS Quality Management. Regular internal & external quality audits also ensure full and continuous conformity with these International standards. Energypac aims to reduce the health, safety and environmental impacts of its products and processes and prevents pollution by utilizing a structured risk management approach, taking into account the needs of its customers and society at large. All new activities are also assessed for environmental impact and appropriate health and safety provision.

1.2. OBJECTIVE OF INTERNSHIP

Out internship program was guided by certain objectives which we have written down here. These objectives are listed below.

- ✓ It will provide us the opportunity to test our interest in transformer, switchgear before permanent commitments are made.
- ✓ To review the process of making a transformer and establishment of a switchgear [1].
- ✓ Observe the application of theory to practical design, manufacture, and implementation.

Develop skills and techniques relevant to our careers.

Develop attitudes conducive to effective interpersonal and team relationships.

SCOPE AND METHODOLOGY

eport is based on the internship program where we reviewed the basic making process of a rmer and establishment of switchgear, current transformer, and potential transformer [2]. contains the electrical and non-electrical equipment description which is needed to make a rmer and switchgear assembling. We also reviewed the testing process of these nents. The report contains relevant information about a substation as was observed during ernship program. This report is written on the basic of two ways information collection, talking and discussing with technicians and employee and personal observation and r resource is company web site and manuals.

2. TRANSFORMER

2.1. INTRODUCTION

Twenty first August was the first day of our internship, and we were supervised by Senior Engineer Md. Munirul Huda. In the beginning, he sent us to the transformer department and told us to get an appointment with Engr. Asaduzzaman. After some official work we got an appointment and waited in the conference room for Engr. Asaduzzaman. Within few minutes Engr. Asaduzzaman joined us and we had an orientation. Then he asked about us and we all gave a brief introduction about ourselves. At the time of our introduction part he gave us some information about Energypac and wanted to know what we knew about Energypac, and why we were interested in the internship at Energypac. We told him that we considered ourselves very fortunate to have the opportunity to do our internship in Energypac because it is one of the leading power engineering companies in Bangladesh and is in fact emerging as a first choice global supplier of electrical equipments. He then gave us a brief explanation about transformer.

2.2. TRANSFORMER

Engineer Asaduzzaman reviewed with us the workings of a transformer, as a static device which transforms alternating current (AC) electrical power from one voltage to another voltage keeping the frequency same by electromagnetic induction.

He also told us about the working tactics of transformer. The summary of the discussion is as follows: In the alternating current (AC), electrical power supply system is being used for supply to the users, which is transferred through the transformer. In the normal propagation of power to users, the power is generated at about 11-15 kV. It is then passed through its first transformer stage to increase the voltage to the transmission level somewhere between 220-500 kV. When it reaches the end of the transmission route it is then transformed again this time down to the 132 – 33kV sub-transmission level. It is then sent to the distribution utility zone substations where it is again transformed down to 11-22 kV and is then sent on its final path to local street or pole distribution transformers where it is brought down to the final voltage of 415/240 volts.

2.2.1. TYPES OF TRANSFORMER

When we finished our introductory part Engr. Asaduzzaman send us to his assistant engineer Engr. Asif Hossain. Mr. Asif told us about different types of transformer in a power system, where distribution transformer and power transformer are most significant.

2.2.2. ENERGYPACS TRANSFORMER

Energypac produce three types of transformer, which are distribution transformers, power transformers, and instrument transformers.

2.3. DISTRIBUTION TRANSFORMER

ngr. Asif Hossain gave us an explanation of distribution transformers. This transformer is used r the purpose of distribution of power. This type of transformer is primarily used to supply latively small amounts of power to residences. It is used at the end of the electrical utility's elivery system. 11KV/415V is the standard voltage rating and Energypacs Distribution ansformer also holds the standard rating. A distribution transformer is given in figure-1.

Figure 1: Distribution Transformer (www. victoryelectricals.com)

2.4. POWER TRANSFORMER

st as he did for distribution transformers, Mr. Asif Hossain then gave us an explanation of wer transformers. According to his discussion we understood that a power transformer is a nsformer which transfers electrical energy in any part of the circuit between the generator and e distribution primary circuits. One of the main applications for Power Transformers is to nvert the power being transmitted to a very high voltage as it is much more efficient to nsmit power at exceedingly higher voltages. In this way less power is lost due to resistance. 2KV/33V is the standard voltage rating and Energypacs Power transformer also holds the ndard rating. A power transformer is shown in figure-2.

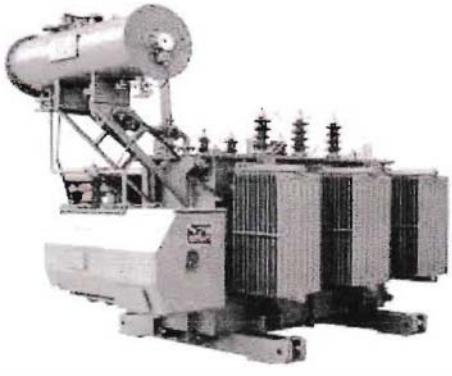


Figure 2: Power Transformer (www. victoryelectricals.com)

2.5. CONSTRUCTION OF TRANSFORMER

On the 21st of August Engr. Asif Hossain took us to the construction department of transformer. Here we spent about half an hour and we observed the department and saw the construction procedure. The making of the transformer is divided in the following section: Coil Section, Core Section, Assembly Section, Tank Section, Valves, Paint Section, and Ending.

2.5.1. COIL SECTION

Engr. Asif Hossain told us that electrolytic copper is being used in transformer which plays an important role in transformers. Electrolytic copper is insulated by pure cellulose paper of concentric moored type so that it may withstand the stresses of possible short circuit. The coil stay in a huge role and the workers cut down the coil from the role as designed for transformer. The coil binding process is different for both the High Voltage side and the Low Voltage side.

High Voltage coils: When moved in to the coil section we observe that round and insulated wire are used in transformer as a raw material. A High Voltage coils is a solid cylindrical former (Figure-3) predetermined diameter. The coil is made in number of layers which depends on the design of the transformer. The starting and finishing leads of each coil are terminated on either side of the coil. These leads are properly locked at number of points.

Figure 3: High Voltage Coil (www. jetcham.com.tw)

Low Voltage coils: Raw material is also the same for the Low Voltage coils (figure-4), i.e. copper used for better performance. Copper strip is prepared to be carbon and dust free using sandpaper. A wooden cylindrical forma is used. All other procedure is almost same. The coil is made in several layers, which depends on transformer power.

Figure 4: Low Voltage Coil (www. jetcham.com.tw)

A huge vacuum section is available in the coil section. We saw that after the construction of both sides of coils, they were transferred into a vacuum section to ensure their dryness. This is because moisture in the coil can reduce the performance of a transformer.

2.5.2. *CORE SECTION*

After watching the coil section we moved around the core section which is situated near the coil section. We saw the core wrapped in a giant role. Engr. Asif Hossain told us that the basic raw material for the core is Cold Rolled Grain Oriented (CRGO) silicon steel, as shown in figure-5. It varies with different grade and thickness. It is in the form of thin sheets and cut to size as per design requirement of the transformer. A Micro Tool Machine (MTM) is used to cut the core in size. The MTM follows instruction from a computer program to cut the core (silicon steel sheet) to perfect size. If necessary, it is possible to make hole in core, as per the design. At the time of core cutting it is important to be careful about the dimension of the core otherwise a small error can result in significant problems.

In the core section the workers helped us learn about the core shape. They told us the core should be cut in two shapes, one shape is called corner shape which contain 45° angle corner view (figure-5, right) and another shape is called benoze shape which helps support the corner shaped core. When we did our Electrical Machine courses we learned that an assembled core shape with 45° angle reduce losses and increase the core concentration about the magnetic flux that surrounds a current-carrying conductor into a very small area, and the thickness of the core moving away from the area of the conductor very rapidly has less effect. An assembled core with both shapes is shown in figure-6.

As with the coils, the core must also be keep in vacuum section to ensure the cores are dry.

Figure 5: Steel Core, with corner shaped (right) (www. abctransformer.tradeindia.com)

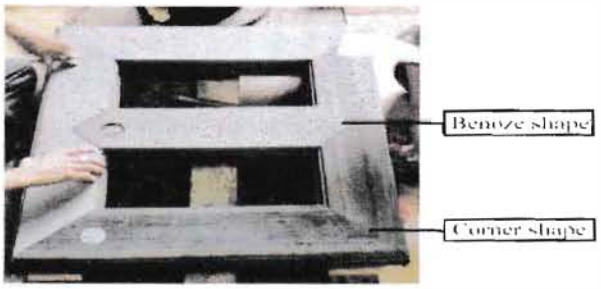


Figure 6: Core assembling (www.abctransformer.tradeindia.com)

2.5.3. *ASSEMBLY SECTION*

We moved into the assembly section on the 22nd of August. Here we saw the coil winding part and core assembly parts are taken to the assemble section to fit them together according to the transformer design. We saw this whole process as it was explained to us. The core assembly is vertically placed with the foot plate touching the ground. The top part of the core is removed to place the coil winding. Each limbs of the core are tightly wrapped with cotton tape and then varnished. Cylinder made out of insulating press board paper is wrapped on all the three limbs. Low Voltage Coil is placed on the insulated core limbs. Insulating block of specified thickness and number are placed both at the top and bottom of the low voltage coil. Cylinder made out of corrugated paper or plain cylinder with oil ducts are provided over low voltage coil. High voltage coils are placed over the cylinder as shown in Figure-7. Coil assembly is shown in Figure 8.

Figure 7: Assemble of core and coil (www.manishelectricals.tradeindia.com)

Top core frame including core bolts and tie rods are fixed in position. Primary and secondary windings are connected as per the requirements. The requirements can be delta connection or y connection. Phase barrier between high voltages phases are placed as per requirement. Finally, the component is placed in the heating chamber.

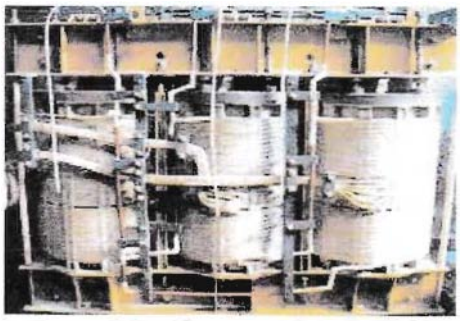


Figure 8: Assembly of core and coil of (left) distribution transformer & (right) power transformer (www.abctransformer.tradeindia.com)

2.5.4. *TANK SECTION*

On the last day of our internship Engr. Moniruzzaman explained us about the tank section and painting section of transformer. He guides us to the tank section and paint section. He mentioned that the transformer contains two main parts and his modified explanation is given below:

First: The tank is a body of a transformer as shown in as given in figure-9 gives protection to the internal equipment of transformer. We did not see the construction procedure of the tank of a transformer, but Engr. Moniruzzaman explained the whole procedure to us. According to him the tank is manufactured by forming and welding steel plate. This part is going to be used as a container for holding the core and coil assembly together with insulating oil. The base and the body are connected through bolt. These parts are manufactured in steel plates assembled together with weld beads. The windings and core are fixed together in such a way that no parts can move during vibration. In addition, the tank is designed to support total vacuum during the treatment process. Sealing between the base and body is provided by weld beads.

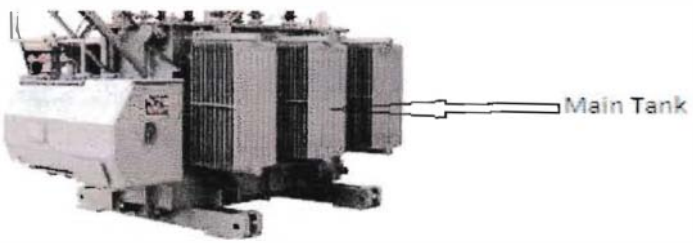


Figure 9: Main Tank (www. victoryelectricals.com)

Second: In the tank section Engr. Moniruzzaman told us about the second part of the transformer tank named conservator (shown in figure-10), which is also called expansion reservoir. He told us that for transformer protection transformer oil is stored in the conservator, in total vacuum.

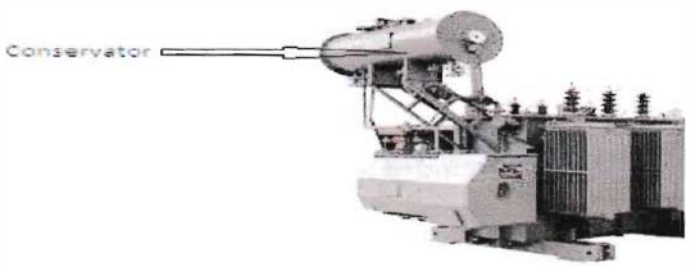


Figure 10: Conservator tank (www. victoryelectricals.com)

2.5.5. *PAINTING*

Engr. Moniruzzaman then explained to us painting section of a transformer. Painting is very important for transformers as it protects it from erosion. He said that a perfect quality painting

gives a defensive protection from difficult weather condition and also a good looking outlook of a transformer. According to his speech the entire procedure of painting is done under two stages:

Tank cleaning: Into the painting section Engr. Moniruzzaman told us transformer tanks can be cleaned using sand. Sand hits the transformer tank with a huge force. In this way the tank gets ability to stay protected from the erosion. But after this step the tank should be paint within few hours, otherwise it will lose its erosion protection ability. The alternate way of cleaning of tank is chipping or grinding. The outside surface of the tank is short blasted to achieve a very fine and smooth finish.

Painting of tanks: In the painting section Engr. Moniruzzaman explained that a covering of hot oil resistance paint is applied on the internal surface of the tank, when the tank has been cleaned. Red Oxide primer is used to paint the outside of the tank. Then finally a shiny gray color is used to color the whole tank and inserted in the heat chamber and heating with 220° temperature.

2.5.6. *ENDING*

We did not see any ending section but Engr. Moniruzzaman explained it to us. In this section fitting and accessories are checked as specified in the drawing. Air pressure test is used to detect any leakage or seepage in transformer. Transformer oil is filled to its maximum level. Explosion Vent, Winding Temperature Indicator, Buchholz relay, Oil temperature indicator, Magnetic oil-level indicator, Pressure relief device, Dehydrating breather, and all other equipment is checked. After all of this a transformer is ready for use.

2.6. TEST

On the 22nd of August Engr. Asif Hossain introduced us to the test department of transformer. This department is maintained by Engr. Bulbul Ahmed and Engr. Hemale Hossain. Engr. Bulbul Ahmed told us the test of transformer is classified into In-Process Test, Routine Test, Type Test and Special Test

2.7. IN PROCESS TEST

In-process testing is the testing of parts at each stage of the assembly process to ensure conformance to specification, prior to the product moving on to the next assembly stage. This enables manufacturers to identify product defects or process abnormalities at the earliest possible stage, resulting in potentially enormous savings. This test is classified into Magnetic Balance Test, Excitation Current Test, and Vector Group Test

2.7.1. *MAGNETIC BALANCE TEST*

We observed the magnetic balance test on the 23rd of August, and the test was done by Engr. Hemale Hossain. He explained the magnetic balance test to us and how the test is performed.

According to his explanation the Magnetic Balance test is conducted on Transformers to identify internal turn faults and magnetic imbalance. The magnetic balance test is usually done on the star(Y) side of a transformer. A two phase supply 440V is applied across two phases. The last phase is kept open. The sum of these two voltages should give the applied voltage.

The voltages obtained in the secondary will also be proportional to the applied voltage. This indicates that the transformer is magnetically balanced. If there is any inter-turn short circuit that may result in the sum of the two voltages not being equal to the applied voltage. The Magnetic balance test is only an indicative test for the transformer. Its results are not absolute. It needs to be used in conjunction with other tests.

2.7.2. *EXCITATION CURRENT TEST*

The excitation current is the minimum amount of current needed to maintain the core in a state of magnetic excitation. It is measured at the rated voltage, and usually given as a percentage of the rated current. This test was shown by Engr. Hemale Hossain.

As we saw the excitation test is done by connecting a single-phase supply to any available winding with an ammeter in the circuit to monitor the exciting current. Three such single-phase tests are necessary for a three-phase transformer. The relationship between the single phase readings is important; it should be as follows:

- ✓ The readings taken on phase A and C should be within 5% of each other.
- ✓ Reading on phase B should be between 65% and 90% of the readings on phase A and C.

2.7.3. *VECTOR GROUP TEST*

Engr. Asif Hossain explained the vector group test to us. He said that the Vector group is punched on the name plate by the manufacture based on user requirement. Aim of vector group test at site is to check if there is any damage in the windings during transportation and erection.

2.8. *ROUTINE TEST*

A group of tests are routinely performed in most steps to detect relatively common disorders. It also establishes a base for further evaluation of a device. Engr. Bulbul Ahmed explained to us most of the transformer routine tests that are done in Energypac. Its classification is given below.

- ✓ Measurement of winding resistance
- ✓ Measurement of Insulation Resistance
- ✓ Measurement of voltage ratio and check of vector relationship
- ✓ Measurement of Turn ratio

- ✓ Measurement of impedance voltage and load loss
- ✓ Measurement of no load loss
- ✓ Dielectric tests
- ✓ Separate source voltage withstand test
- ✓ Induced over–voltage withstand test
- ✓ Tests on on-load tap changer

During our internship we learned the following routine tests.

2.8.1. *MEASUREMENT OF WINDING RESISTANCE*

We did not see this test but Engr. Bulbul Ahmed told us about the method of winding resistance test. Winding of a transformer coil has resistance which introduces losses. This loss should be contained as it has tendency to cross the loss limitation. Therefore we need to measure the winding resistance and this measurement is done using the current voltage method. This method was explained to us by Engr. Bulbul Ahmed.

The current voltage method: According to Engr. Bulbul Ahmed we apply winding current through the reference resistance and winding resistance in the system, the voltage drops occurs in both resistances. The voltage drop values of reference and winding resistances are compared to determine the value of unknown resistance (winding resistance) which is read directly from the bridge instrument. A block diagram of testing circuit is shown in figure-11 which was provided by Engr. Bulbul Ahmed.

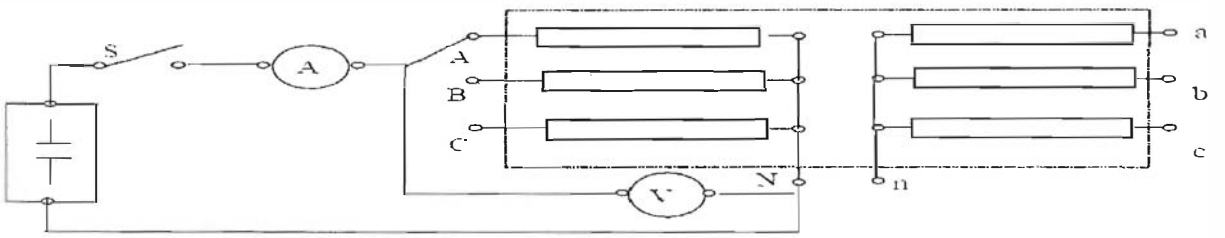


Figure 11: Winding resistance measurement, Current-Voltage method (www.energypac.com)

2.8.2. *MEASUREMENT OF INSULATION RESISTANCE*

The winding insulation resistance test was explained to us by Engr. Bulbul Ahmed but we did not see any insulation resistance test. This test is a measure of quality of insulation used in the transformer. It is also known as the Meggar test. He said that insulation resistance can vary due to moisture content, cleanliness and the temperature of the insulation parts. All measurements are

corrected to 20° C for comparison purposes. It is recommended that tank and core are always grounded when this test is performed. All windings are short-circuited at the bushing terminals. Resistances are then measured between each winding and all other windings and ground. Resistances are measured using the Megger; that is why this test is known as Megger Test.

2.8.3. *MEASUREMENT OF VOLTAGE RATIO AND CHECK OF VECTOR RELATIONSHIP*

The voltage ratio or the turn ratio of the transformer is determined at no-load condition. This measurement contains the verification of no-load voltage ratios specified by the specification and detection of any problem within the coils or tapping connections. Measurements are carried out on all taps and on all phases. This test was explained to us by Engr. Bulbul Ahmed.

Voltage ratio measurement is generally done with volt-meters. Circuit connection for measurement is shown in figure-12. For three-phase transformers three-phase AC supply and for single-phase transformers single-phase AC supply is applied to the HV side of the transformer. For measuring input & output voltage the voltmeter is connected to both the HV & LV side. Using the voltage at HV side and inducted voltage on LV side, voltage ratio is calculated:

$$\text{Voltage Ratio} = \left(\frac{V_{HT}}{V_{LT}}\right)$$

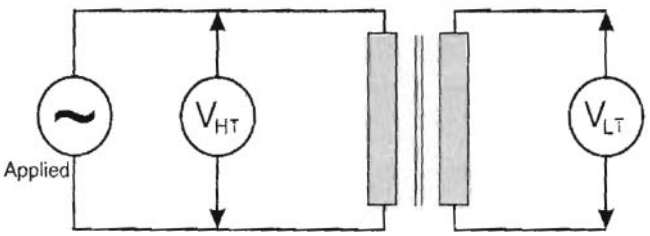


Figure 12: Measuring circuit connection diagram (www.energypac.com)

2.8.4. *MEASUREMENT OF TURN RATIO*

In the morning of 22nd August Engr. Hemale Hossain did this test. We were lucky as we were just on time to see the test. The Transformer Turns Ratio test (TTR) is used to make sure that the Turns Ratio between the windings of the transformer is correct, as this ratio determines what the output voltage of the transformer with respect to the input voltage. Engr. Hemale Hossain mentioned that the ratio is calculated under no-load conditions. The ratios are calculated at the tap positions for each winding and for the transformer. The voltage is applied to one winding and the voltmeters connected to both low voltage and high voltage windings are read simultaneously. The turns ratio is the ratio of the HV voltmeter and the LV voltmeter readings. When ratio tests are made on three-phase transformers, the ratio is calculated one phase at a time. The measured

ratio is compared with the ratio calculated using nameplate voltages. The variation should be within 0.5%.

2.9. *TYPE TEST AND SPECIAL TEST*

Type Tests and Special Tests are carried out only on one transformer of a lot. These types of tests are performed at Independent International Labs. Engr. Bulbul Ahmed explained to us the two type and special transformer tests that are done in Energypac, which are the Lightning impulse test and the measurement of sound level.

2.9.1. *LIGHTING IMPULSE TEST*

Lightning is one of the unique tests of transformer in Energypac. No other company in Bangladesh has the facilities to do this job. We were very excited to see the test. Engr. Bulbul Ahmed told us that the cost of this test is very high and it is also dangerous. Here an impulse generator (Figure-13) is used to produce the specified voltage impulse wave for 2.4 micro seconds. The voltage applied here is seven times the rated voltage, for example, for 11KV rated transformer 75KV voltage is applied. For a three phase transformer, impulse test is carried out on all three phases in succession.

Engr. Bulbul Ahmed gave instruction to his assistant engineer to connect wire and we were told to stay in the safe room as it was very dangerous and he did not want to take risks. After ensuring safety the voltage is applied on each of the line terminal in succession, keeping the other terminals earthed. The current and voltage wave shapes are recorded on the oscilloscope and any distortion in the wave shape is observed, as this is the criteria for failure. The distortion is determined by comparing recorded data with the standard data.

This test uses very high voltages. A randomly selected transformer is used for this test. A huge vibration occurs during the test and therefore the life time of the tested transformer is reduced.

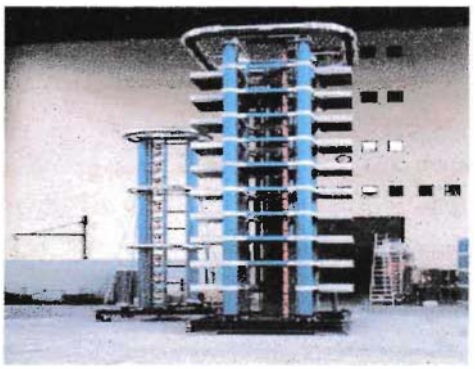


Figure 13: Impulse Voltage Test System (www. altronprofile.co.za)

2.9.2. MEASUREMENT OF SOUND LEVEL

Measurement of sound level test is not important for a country like Bangladesh, but for other country it is critical. Engr. Bulbul Ahmed told us that Energypac does not perform the sound level test. But he told us about the sound level test to get an idea. At first, the background noise level is measured. Then, the transformer is powered at rated voltage and frequency under no-load conditions in order to carry out transformer noise level measurements. This is done at several points around the transformer, at a distance of 0.3 m from the machine unless, due to safety reasons. Following agreement between supplier and purchaser, the distance can be increased to 1m. Measuring positions shall be spaced at a distance of no more than 1 meter between each other. However, a minimum of 6 positions is required. The measurements shall be carried out at half the equipment height, when it does not exceed 2.5m; otherwise, they shall be performed at 1/3 and 2/3 of the component height. After performing transformer sound level measurement, the machine is de-energized and background noise level is measured again. At the end, the final transformer sound level is calculated by applying a correction taking into account background noise level. In case there is a high difference between the transformer and background noise level (>8 dB) no correction is applied. A random connection scheme for measurement of sound level is shown in figure-14.

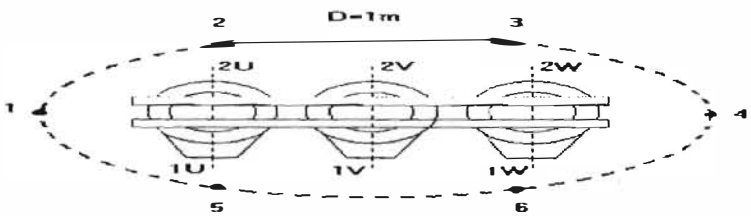


Figure 14: Connection scheme for measurement of sound level (www.energypac.com)

2.10. MAINTENANCE OF TRANSFORMER

Transformer is the heart of any power system. Hence preventive maintenance is always cost effective and time saving. Any failure of the transformer can affect the whole establishment. The engineers explained to us the maintenance of a transformer, as given as below:

- ✓ Oil: The oil in the transformer should be kept as clean as possible. Dirt and moisture will start chemical reactions in the oil that lower both its electrical strength and its cooling capability. Contamination is of concern when a transformer is opened. Most transformer oil is contaminated to some degree before it leaves the refinery. It is important to determine how contaminated the oil is and how fast it is degenerating. Determining the degree of contamination is accomplished by sampling and analyzing the oil on a regular basis. Also oil level should be checked regularly. Oil BDV & acidity checking must be done at regular intervals. If acidity is between 0.5 of 1mg KOH, oil should be kept under observation. Following are several other maintenance activities.

- ✓ Insulation resistance of the transformer should be checked once in 6 months. Megger values along with oil values indicate the condition of transformer.
- ✓ Periodic Dissolved Gas Analysis can be carried out.
- ✓ Bushings should be cleaned and inspected for any cracks.
- ✓ Dust & dirt deposition, Salt or chemical deposition, cement or acid fumes depositions should be carefully noted and rectified.
- ✓ Periodic checking of any loose connections of the terminations of HV & LV side.
- ✓ Breather examination. Dehydration of Silica gel if necessary.
- ✓ Explosion vents diaphragm examination.
- ✓ Conservator to be cleaned from inside after every three years.
- ✓ Regular inspection of OIL & WINDING TEMPERATURE METER readings.
- ✓ Cleanliness in the Substation yard with all nets, vines, shrubs removed.

Although maintenance and work practices are designed to extend the transformer's life, it is inevitable that the transformer will eventually deteriorate to the point that it fails or must be replaced. Transformer testing allows this aging process to be quantified and tracked, to help predict replacement intervals and avoid failures. Historical test data is valuable for determining damage to the transformer after a fault or failure has occurred elsewhere in the circuit. By comparing test data taken after the fault to previous test data, damage to the transformer can be determined.

2.11. ACCESSORIES AND PROTECTIVE DEVICE FOR TRANSFORMER

The last day of the transformer section was the 24th of August. On this day we were introduced to transformer accessories and its protective devices [3][1]. Engr. Bulbul Ahmed and Engr. Asif Hossain told us about the transformer accessories and its protective devices.

Some type of accessories and protective device of a transformer is given below:

2.11.1. *BUCHHOLZ RELAY*

Buchholz Relay was explained by Engr. Bulbul Ahmed. He said that due to the electric supply through the coil, the core became hot. The transformer oil in the tank is used to control the temperature of transformer; if it fails then pressure can be raised. For sudden pressure rise it responds by tripping. An oil alarm is also used for backup. The Double-float Buchholz relay

(Figure-15) is actuated either by pressure waves or by gas accumulation. Separate contacts are installed for alarm and tripping.

Figure 15: Double-float Buchholz relay (www. hyoda.co.jp)

2.11.2. *OIL TEMPERATOR INDICATOR*

Oil temperature measurement was also explained by Engr. Bulbul Ahmed. Transformer oil must stay at a reasonable temperature for good performance. A thermometer (shown in Figure-16) is essential to indicate the transformer oil temperature. A dial type contact thermometer is used to indicate actual top-oil temperature via capillary tube. Sensors are mounted in the well below the tank cover. Up to four separately adjustable alarm contacts and one maximum pointer are available. The contact thermometer must be install such that the temperature of the transformer oil is readable from the ground.

Figure 16: Dial-type contact thermometer (www. reinhausen.com)

2.11.3. *PRESSURE RELIEF DEVICE*

Pressure relief device was explained by Engr. Bulbul Ahmed. He said that it is possible to get high pressure due to the internal temperature of the transformer. Therefore the transformer should have the ability to relief the high pressure. The pressure relief device (Figure-17) relieves abnormally high internal pressure through shock waves.

Figure 17: Pressure relief device with alarm contact and automatic resetting (www. directindustry.com)

2.11.4. *WINDING TEMPERATURE INDICATOR*

Winding temperature was explained by Engr. Bulbul Ahmed. He told us that the Windi temperature increases when load increases. Therefore to protect the transformer winding t temperature must be managed. The winding temperature indicator (Figure-18) is used for that.

Figure 18: Winding temperature indicator (www. shaktisales.net)

2.11.5. *DEHYDRATINR BREATHER*

Engr. Bulbul Ahmed also explained to us the Dehydrating Breather. Transformer need to protected from moisture. However, due to some unfortunate coincidences, moisture may get in the transformer. A dehydrating breather (Figure-19) is a system which removes most of t moisture which is drawn into the conservator.

Figure 19: Dehydrating breather (www. alibaba.com)

2.11.6. *EXPLOSION VENT*

Explosion vent (Figure-20) is for discharging excess pressure when it develops in transform during loading. This information was given by Engr. Bulbul Ahmed.

Figure 20: Explosion vents (www. alibaba.com)

2.12. COOLING SYSTEM

High temperatures can damage a transformer winding insulation. Temperature management is of transformer is very important for good performance. Cooling system of tranformer keeps the temperature within acceptable limits. Types of cooling system of transformer were discussed by Engr. Bulbul Ahmed. Some of them are used in Energypac and some of them are not. All the cooling systems that we learned in Energypac during our internship program are given below:

2.12.1. *ONAN COOLING TYPE*

ONAN type is also known as Oil Immersed Natural cooled Type (Figure-21). In this system the core and winding assembly is immersed in oil. Cooling is obtained by natural circulation of oil under natural thermal head only. In large Transformers the surface area of the tank alone is not adequate for dissipation of the heat produced by the losses. Additional surface is obtained with the provision of radiators. This type of cooling system is being used in Energypac.

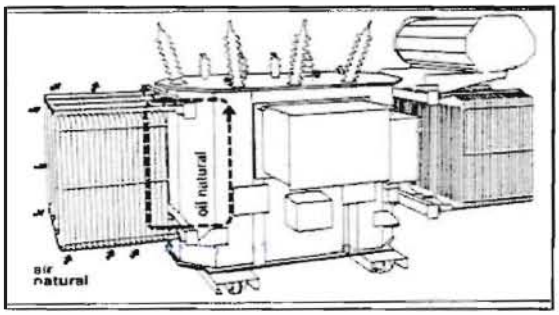


Figure 21: Oil Immersed Natural cooled ONAN (www. wabashpower.com)

2.12.2. *ONAF COOLING TYPE*

ONAF type is also known as Oil Immersed Air Blast cooling (Figure-22). In this system fans are used. The fans create air circulation which helps keep the temperature under control. With the ONAF type cooling system it is possible to reduce the Transformer size for the same rating. This saves cost. This type of cooling system is being used in Energypac.

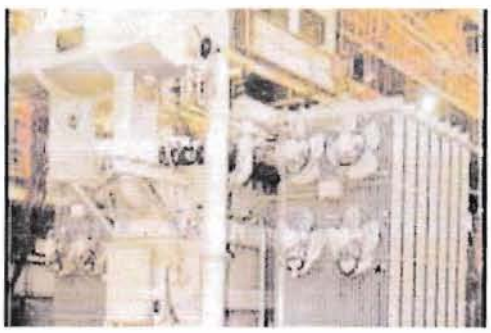


Figure 22: Oil Immersed Air Blast - Type ONAF (www.electrical-engineering-portal.com)

2.12.3. OFAN COOLING TYPE

Both oil and air are used in this cooling system. However, oil circulation is forced and air circulation is natural. A pump is used in oil circulation system which forces the oil to circulate through a panel. However, air circulation occurs naturally in this cooling system. This is known as Forced Oil Natural Air cooling system (Figure-23), which is not used at Energypac.

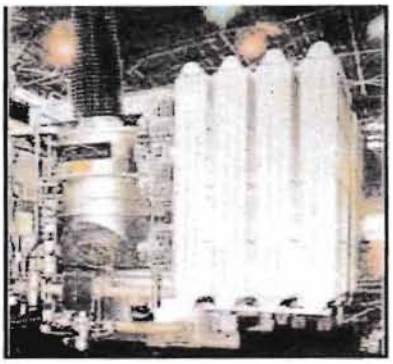


Figure 23: Forced Oil Natural Air Cooled (OFAN) (www.electrical-engineering-portal.com)

2.13. TAP CHANGER

On the 21st of August Engr. Asif Hossain took us to the winding section and showed us a tap changer of a transformer. He then explained what it does and how it is connected. A tap changer (Figure-24) has connection points along the transformer winding that allows the number of turns to be selected. This device is then connected to power transformers for regulation of the output voltage to required levels. This voltage regulation is normally obtained by changing the ratios of the transformers on the system by altering the number of turns in one winding. Tap changers offer variable control to keep the supply voltage within various limits.

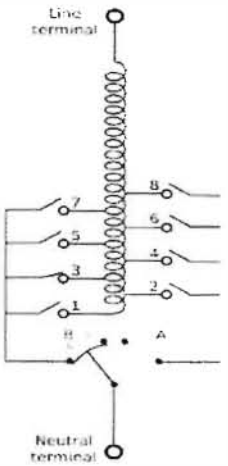


Figure 24: Block Diagram of tap changer and physical view of Tap changer (www.thefullwiki.org)

Tap changing can be done when transformers are a) at no-load and b) at load condition. These are called off load and on load tap changing. The off loads tap changing costs less. The tap positions are changed after the transformer is taken out of the circuit. The on-load tap changer on the other hand tries to change the taps without the interrupting the load current.

2.14. RADIATORS

We learnt about radiators in an outfield. On 24th of August we were walking around the assembly section and we saw Engr. Bulbul Ahmed. Then we went to him and he asked if we knew about radiators. Then he explained that radiators are heat exchangers and are used to transfer thermal energy from one medium to another for the purpose of cooling. A radiator plant is equipped with press machines, seam, and welding facilities. Pressed steel radiators are tested for dimensions and leakages. Pressure tests are performed to check for leakages. After welding, all the tanks are chemically processed to remove any traces of grease, rust, welding slag and other impurities. Complete tanks are tested for dimension and leakage tests. In transformer radiators are filled with fluid which has the ability to reduce the internal thermal energy of the transformer. Fluid propagates through radiator to radiator and absorbs the thermal energy to keep the transformer internal temperature in limit. A radiators figure is given below (Figure-25).

Figure 25: Radiators (www. indiamart.com)

2.15. MARSHALLING BOX

The marshalling box was described by Engr. Bulbul Ahmed. The box is used display readings. The windows of the marshalling box should always be kept clean so that the readings of the oil temperature indicator and winding temperature indicator can be easily read from outside. Some dehydrating agent may be kept inside the marshalling box so that the box is always dry. The marshalling box must be locked. An example of marshaling box is given below (Figure-26).

Figure 26: Marshalling box (www. tmc.com.au)

2.16. OIL OF TRANSFORMER

Engr. Bulbul Ahmed explained to us that the transformer oil is usually a highly-refined mine oil that stays stable at high temperatures and has excellent electrical insulating properties. It used in oil-filled transformers. Its functions are to insulate, suppress corona and arcing, and functional as a coolant. These are mineral oils and are used to dissipate the heat generated electric transformers. They also act as electrical insulators.

2.17. IDENTIFICATION OF A TRANSFORMER THROUGH SYMBOL

Dyn11: From engineer Bulbul Ahmed we learned the tactics to read transformer symbols. Dyn is vector group notation of transformer where Dyn11 means High Voltage winding side connected in Delta (D), Low Voltage winding side is connected in Star (y) and n indicates t neutral. 11 stand for the phase displacements between the primary side & secondary side. In clock the 11 o-clocks creates angle of 30 deg between the small needle & big needle, so t phase displacement is 30 degrees. This is only defined for three-phase transformers. connection group denotation, the High Voltage winding is shown first (as a reference) than t other winding are written in lower case letters. Another interesting thing in this symbol is capi letter indicates High Voltage side and lower case indicates Low Voltage side.

3. SWITCHGEAR

During our internship, we spend 3 days in Switchgear section. Engr. Syed Muztaba Ali, DGM of Energypac Engineering Ltd are showed us this section. At first he tried to give us a fundamental idea about Switchgear and the summary of his discussion is that switchgear is one of the major portions in the electric power or grid system. It is actually the combination of electrical disconn cts, fuses and circuit breakers which is used to isolate electrical equipment. Switchgear is used for normal routing switching, control, monitoring and automatic switching during abnormal and faulty operating conditions such as short circuits, under voltage and overloads.

3.1. SWITCHGEAR PRODUCT

After learning the basic concepts of switchgears, we were told how Energypac Engineering Ltd runs the switchgear section. An engineer explained to us that the switchgear section of the company is complete, with experience and skills as well as machineries, machining facilities and test equipments. The switchgear section of Energypac makes the following:

- ✓ LT metering panel
- ✓ Power factor improvement plant (PFI)
- ✓ Control metering and Relay panel
- ✓ HT metering panel
- ✓ Load Break Switch.
- ✓ Distribution Panel → AC Distribution Box (ACDB)

  → DC Distribution Box (DCDB)

We observed all these products and tried our best to learn from our exposure at Energypac. Engr. Syed Muztaba Ali and other associated engineers were very helpful. On the following section we discus each of the product that were introduced to us.

3.2. LOW TENSION (LT) METERING PANEL

At First we observed the Low Tension (LT) Metering Panel (fig 27). Engr. Syed Muztaba Ali told us that these panels are very reliable in performance, easy to install and low on maintenance. They were made for controlling and distributing power at AC 50Hz and rated voltage up to 440V. The panel is equipped with ammeter, voltmeter and a miniature circuit breaker.

Figure 27: LT metering panel (www.energypac.com)

3.2.1. *USING APPLICATION OF LT*

LT metering panel is used in power stations, industrial installation and residential buildings for power distribution, control and protection of the circuit.

3.2.2. *TECHNICAL INFORMATION OF LT*

After discussing basic applications of the LT panel, we were explained the technical details of the low tension panel manufactured by the Energypac Engineering Limited. This helped us understand the manufacturing process of the LT panel. Another engineer then took us to the manufacturing section for observing the manufacturing of the LT panel. After observation we understood the construction process of LT panel, which is summarized below.

- ✓ Dimension of LT panel is 400mm*1000mm*2200mm (W*H*D) which can be customized to customer requirements.
- ✓ Panel frame consists of zincified "C" shaped steel, which meets the IEC439 standard, which is the International Electro technical Commissions Publications standard for low voltage switchgear.
- ✓ In the inner part of the frame, the cabinet and separation cubicles dimension is modular.
- ✓ Switchgear equipment is divided into main bus bar compartment, branch bus bar compartment, functional unit compartment and cable compartment.
- ✓ Standard insulation is provided in each unit for preventing damage due to arc.
- ✓ Pressure-releasing ventilation is provided in each functional compartment for releasing gas created during fault.
- ✓ Bus bar material consists of high conductance electrolytic copper as per IEC431 standard.
- ✓ Fixing bolts of the bus bar are of high intensity to make the installation good.
- ✓ Wire cross-section in current return circuit is $2.5mm^2$ & voltage return circuit is $1.5mm^2$.

3.3. POWER FACTOR IMPROVEMENT PLANT (PFI)

After discussion of LT panel Engr. Syed Muztaba Ali told us about Power Factor Improvement Plant. From his discussion we learn that this plant is designed for improving the degraded Power Factor and angle between actual power and power being utilized with digital power factor display of the system. This plant is equipped with microprocessor based PFC relay. In figure 28 a PFI plant manufactured by Energypac is shown. Details are discussed in later sections.

Figure 28: PFI plant (www.energypac.com)

3.3.1. *REQUIRMENT OF POWER FACTOR CORRECTION*

To understand the PFI plant we must understand why power factor correction is required. Engr. Syed Muztaba Ali did a complete discussion on this topic .We know that the power factor is the ratio of real power and apparent power. Real power is the ability of a circuit, its working power while apparent power is the product of absolute voltage and current of the circuit. Due to non linear load, i.e. inductive load, apparent power will be greater than real power and the power factor will be low, wasting power. Power factor improvement plant will help reduce power loss.

3.3.2. *TECHNICAL INFORMATION OF PFI*

After observing the manufacturing of the LT panel we move to the PFI manufacturing section to observe the PFI plant. We got some of the technical information of this panel from associated engineer and also our own observations. These are given below

- ✓ Modular Design of panel
- ✓ Compact Arrangement of necessary equipment and wire.
- ✓ Dimension of Panel size is 600x600x1700 mm (single unit)
- ✓ Microprocessor based PFC (Power Factor Correction) relay up to 16 stages.
- ✓ Capacitor ratings (2.5, 5, 10, 20, 25, and 50 KVAR.... etc).
- ✓ For suitable stepping of capacitor bank magnetic contactor is used

On the 2nd day in switchgear section Engr. Syed Muztaba Ali discussed with us about the Control, Metering and Relay panels, which are designed to protect and control transformers, bus stations and transmission lines [4]. The panel is equipped with electromechanical/numerical relay, KW/ KVAR meter, auto/hand trip for counter circuit breaker, frequency meter, interposing transformer and fuse. An Energypac PFI plant is shown in fig 29 .

Figure 29: Control Relay Panel (www.energypac.com)

3.4.1. *USING APPLICATION OF CONTROL, METERING AND RELAY PANELS*

Goal of this panel is to increase energy efficiency and control the equipments associated with power station industrial plant and switching station. This panel is also used for over current and earth fault protection

3.4.2. *TECHNICAL INFORMATION OF CONTROL RELAY PANEL*

At first when we observed the Control and Relay panel it looked very complicated as the panel was equipped with a lot of equipments. But associated engineer help us understand its construction and connections. Some of the technical information is given below.

- ✓ Simplex & duplex pattern of the panel
- ✓ Standard dimension panel of height 2350mm, Width 400mm to 900mm and depth 500mm to 1200mm.
- ✓ Enclosure equipped with interior lamp
- ✓ Anti condensation facilities
- ✓ Separate bus bar and cable chambers.
- ✓ Sufficient space for incoming and outgoing cables.
- ✓ Fabricated with 2/2.5/3mm CRCA sheet steel.

3.5. HIGH TENSION METERING PANEL

After observing the PFI plant we learnt about the High Tension Metering Panel (see fig 30). Thi panel is designed for high voltage application. The panel is equipped with vacuum circu breaker, current transformer, potential transformer, ammeter and voltmeter.

Figure 30: HT Panel (www.energypac.com)

3.5.1. TECHNICAL INFPRMATION OF HT

The High Tension panel is manufactured by Energypac. The construction and functionality of th High Tension panel helped us analyze the panel condition. The information is given below.

- ✓ Sheet steel clad.
- ✓ Dust and vermin proof.
- ✓ Free standing and floor mounting.
- ✓ CT and PT with metering and protection panel as to IEC.
- ✓ For easier checking Control and indicating devices are utilize on the front of the lov voltage compartment.
- ✓ Rated voltage and current are correspond to 12 / 33kV and 630/800/1250A
- ✓ Basic Impulse level 75kV
- ✓ Rated frequency 50Hz

3.6. LOAD BREAK SWITCH (LBS)

On the 3rd day in the switchgear section we studied a Load Break Switch (see fig 31) which i made for 11kv/33 kV 3 pole. This load break switch is rated for 11kv 630 A and 26.3ka/1 secon short time current. The panel is equipped with HRC fuse, CT, PT and earthing switch.

Figure 31: Load Break Switch (www.energypac.com)

3.6.1. *USING APPLICATION OF LBS*

The Load break switch can be used for arc quenching by puffer action. The panel is designed in such way so that if fault occurs in any phase it will isolate the whole three phases from the system instantly. It is also used for over current protection using HRC fuse.

3.6.2. *TECHNICAL INFORMATION OF LBS*

From Engr. Syed Muztaba Ali's discussion and our observation we got the technical information of Load Break Switch manufactured by Energypac. It involves the construction and functionality information. It helped us understand how Load Break Switch is formed and also analyze the condition of the panel. The information is given below

- ✓ Manual and fuse blown tripping facility.
- ✓ High speed make and break mechanism
- ✓ Scattering of arc is prevented by retaining insulation level.
- ✓ Protect meter from over current protection. HRC fuse is used with an earthing switch interlocking with main mechanism.
- ✓ LBS can't operate when earth switch is on and vice versa
- ✓ Standard panel size is 900x900x1800 mm & weight is around 450 kg.

3.7. *AC/DC DISTRIBUTION PANEL*

Finally Engr. Syed Muztaba Ali discussed with us the AC/DC Distribution panel (see fig 32). The AC distribution panel is designed to operate at 415 V, 3 phases, 50Hz. It is a well grounded system. The DC distribution panel is designed to operate at 110V. This is not earthed. The panel is equipped with ammeter, voltmeter and control fuse.

Figure 32: Distribution Panel (www.energypac.com)

3.7.1. *USING APPLICATION OF AC/DC DISTRIBUTION PANEL*

The primary function of the distribution panel is to distribute ac/dc current from a supply to various subsidiary circuits. It also provides fuse/breaker for each circuit. The panel has some advantage as it can economize the electricity distribution process and provide safety against electrical hazards like short circuit. The panel accepts 3 phase input volt and distribute various combination of single and 3 phase outputs.

3.7.2. *TECHNICAL INFORMATION OF DISTRIBUTION PANEL*

Technical information of Distribution Panels manufactured by Energypac is given below. It discusses the construction and functionality of the equipment. This information is helpful to understand how Distribution panel is formed and how it works.

- ✓ Panels are made by self standing sheet steel cubical and single front construction.
- ✓ High conductivity aluminum alloy is used for main bus and connection.
- ✓ Bus limited maximum temperature is 85°
- ✓ Bus bars are laminated by heat shrunk insulating sleeves with suitable phase identification marking.
- ✓ The switches and fuses will have the capability of quick break and make mechanism.
- ✓ CT is cast resin type of class 10P10 for protection and class 1ISF less than 5 for metering.
- ✓ The wiring is 650 grades PVC insulated with standard copper conductor of 2.5 mm for control and current circuit and 1.5 mm for voltage circuit.
- ✓ Using removable type gland plate at least 4mm thick.

3.8. CONNECTION SYSTEM

During the introduction of the switchgear panel, one question that came to puzzle us is how the equipment of the panel is connected. We brought up the question with Engr. Syed Muztaba Ali. The summary of his discussion is given below.

From transformer the connection will establish in incoming panel of circuit breaker. Incoming panel of the circuit breaker will then connect with Bus bar of switchgear panel. The current transformer (CT) will connect to the bus bar. The purpose of using CT is to reduce the rate of current due to protection and measuring. The rating of CT is 5A. For controlling high current a fuse is used. When high current passed fuse will cutoff to protect the ammeter, which cannot measure above 5A. For this reason a connection is made between CT and control fuse and then control fuse to ammeter. For observing the phase voltage a connection from bus bar is established in connecting panel. From the connecting panel it is connected to the ER voltmeter. Finally from the switchgear panel bus bar, a connection is made to the outgoing panel of the circuit breaker. From that a connection is made to the other side of the transformer. The block diagram is provided below.

Line→ CB →Bus Bar →CT → Control fuses → Ammeter

↓ ↓ → Relay → CB

↓ → Connecting Panel → Voltmeter

3.9. IMPORTANT EQUIPMENT USED IN SWITCHGEAR

Engr. Syed Muztaba Ali also discussed with us some important equipments which are essential for switchgear section. In the following section we discus some of these equipments.

3.10. IDMT RELAY

During observation period of switchgear panel we saw IDMT relay being used almost in all panels. So the question was why was IDMT relay is so necessary. We asked our guided engineer and from his discussion we know that IDMT is actually an inverse characteristic of current vs. time, up to certain increased value of current after which the time is definite. This relay is obtained by using saturated upper magnet. To protect the system due to increasing of fault current, the tripping management of this relay is designed in such way so that time taking will be in reverse manner. As a result when current reaches a certain value flux will not increase.

3.11. OVER CURRENT AND EARTH FAULT RELAY

Another relay that we observed in switchgear section was over current and earth fault relay. From our discussion with Energypac engineer we came to know that the component performed additional special functionality. For example, it also works as a IDMT relay & thermal relay. The relay is connected to the current transformer which measures the phase current and neutral

current of the power system. When the relay detects fault it will trip the circuit breaker. As phase current exceeds the set current and elapses the set operate time of the IDMT, the current unit of the relay will start operation. When the earth fault current overcomes the current and IDMT set current, the earth fault unit of the relay will operate. This relay is impo as it is not made in Bangladesh.

Figure 33: Over current And Earth Fault Protection Relay (www.energypac.com)

3.12. HRC FUSE

Other important equipment that we observed in switchgear section was High Rupturing Capa Cartridge Fuse (shown in fig 34) which is used for overload and short circuit protection. HRC fuse has a pre-arcing time less than 0.5 milliseconds and arcing time less tha milliseconds. While pre-arcing time is the time between commencement of the current loop the cut-off, the arcing time is the time between cut-off and final current zero. The fuse eleme connected in the middle of a tin bridge. When high current passes, the temperature increases exceeds the tin bridge melting temperature. This breaks the bridge thereby an arc is created. arc spreads and melts the quartz powder, creating a chemical reaction. As a result the caps sp is filled with a material of high dielectric strength which interrupts the current.

Figure 34: HRC fuse (www.energypac.com)

3.13. MAGNETIC CONTRACTOR

The equipment that we saw last was the Magnetic Contactor. Energypac engineer described magnetic contactor (see fig 35) to us. It is a device that is used for controlling current to ener or de-energize a load. It can handle large currents. It is applicable for AC 50/60 Hz, rated volt up to 660V. This contactor can be used as a time delay contactor and electromagnetic starter.

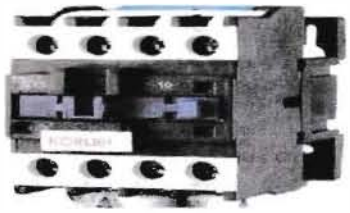


Figure 35: Magnetic Contactor (www.energypac.com)

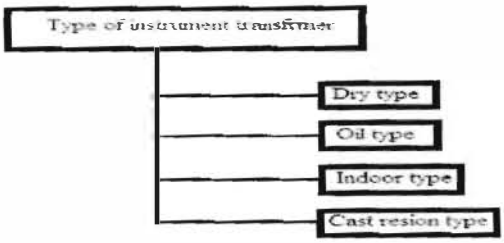
3.14. TESTING

n our internship period the switchgear section of Energypac was very busy working on the elivery of several customer switchgears. Though Engr. Syed Muztaba Ali and other engineers ied their best to shown us some tests, but they could not. So our learning range of testing witchgear was limited to discussion. From these discussions we also learnt that Energypac does wo types of testing. One of the testing is done before assembly and the other after assembly. his helps observe the perfection of the manufacturing switchgear product. Some tests are done or observing the associated equipment performance. One such test are discussed below

NALYZER/TIMING TEST:

his test is done for observing the relay performance used in switchgear panel. When fault ccurs it is required for relay to trip within 30 ms. If relay can't trip within 30 ms then it can't rovide the trip signal to circuit breaker. As a result circuit breaker can't handle the faulty ondition properly. So for observing relay performance a fault is created in this test and observed ow fast the relay responds.

Engr. Mozaharul Islam is very helpful person and he took great care of us. He is a DGM of instrument transformer section of ENERGYPAC ENGINEERING LTD. We stayed two days with him. He gives us some important information about CT and PT. We are very grateful to him for the time he spent with us. He said those transformers are used for metering and protection purpose of electrical equipments. Transformer like protective relays and control circuits are called instrument transformer. He said there are four types of instrument transformer, such as dry type, oil type, indoor type, and cast resin type.



But in Energypac generally they make only the following kind of instrument transformers,

1. Current transformer (Ref. sec- 1.3.2)
2. Potential transformer (Ref. sec- 1.4.2)

4.1. ESSENTIAL ELEMENTS

Mr. Mozaharul Islam said there were some essential elements necessary for the making of instrument transformers. These are core, coil, insulating oil, insulating paper, class of accuracy etc.

Core: The core of the transformer is grain oriented. The core is made of High permeability CRGO (core role grain oriented) silicon steel. The silicon steel is imported from abroad.

Coil: Mr. Mozaharul Islam said that most usable coil is of the super enamel type. The coil making process is manual.

Insulating oil: He said there were different types of insulating oil such as transformer oil, mineral oil, pironol, gravity 0.85 etc. The insulating oil is kept in the porcelain bushing. The insulation saves transformers from short circuit, fire and transformer explosions.

Insulating paper: They use two types of insulating paper such as craft paper and crepe paper for making insulation. Both insulating papers make good insulation for the core.

Class of accuracy: Accuracy is very important for manufacturing. Energypac has two reasons for increasing the accuracy of transformer. One is for metering and the other is for protection. For metering, the accuracy points are 0.1, 0.2, and 0.5. On the other hand for protection they follow 5p10, 5p15, and 5p20. (5p10 means class 5, p is protection and 10 is accuracy limit.

4.2. CURRENT TRANSFORMER

We were shown current transformer (CT) on the first day. He asked us some question. For example, "What is a current transformer?" – Which we answered correctly. He said that the current ratio is very much constant for a given range of primary current, as long as the phase angle error is within specified limits. He also told us about oil cooled/cast resin CT with ranges from 11 kV to 230 kV. Energypac also made outdoor/indoor type current transformer.

4.2.1. CONSTRUCTION OF CURRENT TRANSFORMER

Mr. Mozaharul Islam said that the current transformers (CT) can be designed as Single or Multi ratio. The ratio selection can be achieved by providing two or four sections in primary using series/parallel connections. Here the current ratio is 1:2:4. He said the core is made of High permeability CRGO silicon steel. We were also told of different shapes of core, such as rectangular, ring shape, oval, L - shape stampings and I – shape stamping, etc. In figure 36 are shown different types and shapes of core.

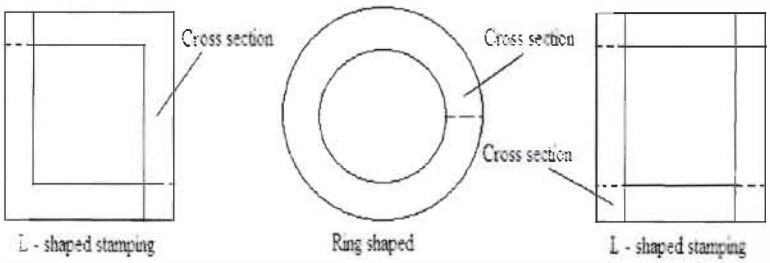


Figure 36: Core of the transformer

He said that for giving insulation on the core they used tap (Ref. insulation is shown in figure 37). Secondary winding was done automatically and distributed equally on the periphery of the core to minimize leakage reactance. Primary winding was done by putting insulation on copper conductors with double cotton covering.

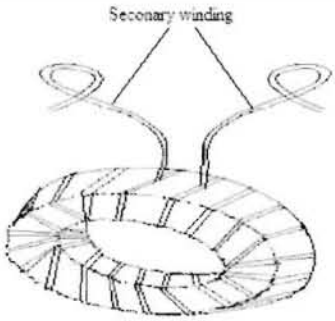


Figure 37: Secondary winding conductor wound on the tape

Mr. Mozaharul Islam said that they give an additional insulation on copper conductor, known as varnished fiber glass sleeve. They also use high quality crepe paper to build main insulation of the CT. They use brown/white glazed porcelain bushing with different shade profiles to suit different conditions. The bushings are hollow and cylindrical. Top tank (Oil expansion chamber)

of the CT is made of MS sheet. Stainless sheet tank is used for CTs for primary current of 1200A and above. Constructing of the current transformer is shown in figure 38.

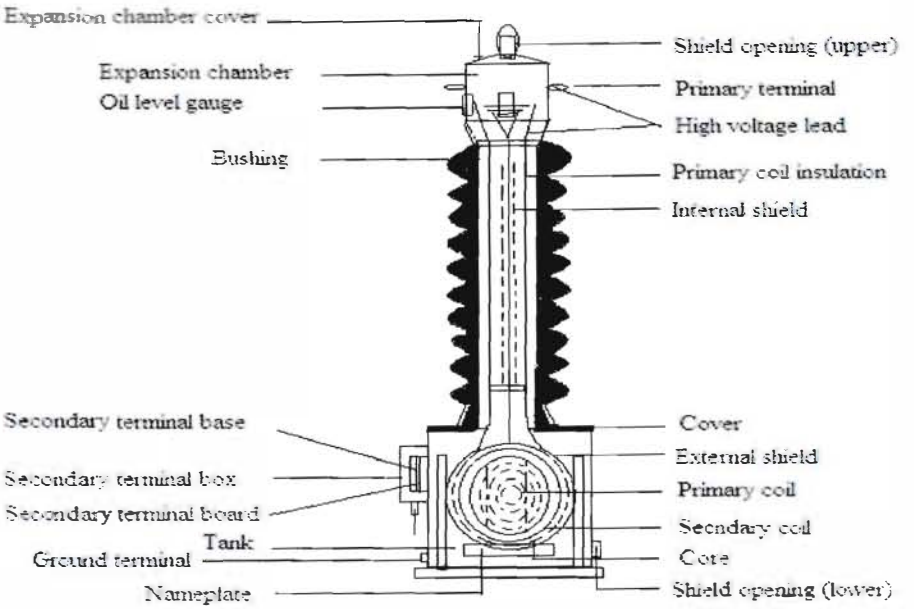


Figure 38: Construction of HV outdoor Current transformer

Figure 39: (left) HV outdoor CT (right) Dry type CT (www.energypac.com)

Figure 39 shows the HV outdoor current transformer (left) and dry type current transformer (right). Energypac makes another CT which is known as epoxy resin cast. Mr. Mozaharul Islam said for the standards of epoxy resin cast for CT they follow IEC, ANSI, VDE, BS, or customer's specification. There are two types of winding like LT (low tension) and HT (high tension). The windings are made over high quality cold rolled grain oriented steel. LT winding is designed as multi-layer winding. LT winding is wound on the core with additional insulation between adjacent layers. HT winding is designed to handle mechanical stresses due to thermal dilation. Because of the isolation, short circuit currents are not transmitted to the main insulation of the transformer. But here we observed something different. We have seen conductors being used for windings which are made of electrical grade electrolytic copper and it is used for secondary windings insulated with high quality, synthetic resin based insulation varnish.

4.2.2. MULTI RATIO CURRENT TRANSFORMER

The next day we saw a different type of CT. In its expansion chamber we saw four secondary inputs and four primary inputs. Upon our request Mr. Mozaharul Islam explained the CT to us. He said this is multi-ratio, tapping type CT. Maximum supply current is 1000 A. There are different lines for different current, such as 200 A, 500A, 1000 A. For opening new connection the CT has many taps.

4.3. POLARITY OF CURRENT TRANSFORMER

Mr. Mozaharul Islam said it is very important to know the polarity of transformer. If we do not identify polarity of the transformer we cannot identify direction of current and voltage. It gives the relative instantaneous direction of currents in the primary and secondary leads. The polarity of the current transformer is shown in figure 40. In figure 50 P and S are assigned polarity of primary and secondary winding. They marked the following polarity for current transformer

P1 and P2: primary terminal

S1 and S2: secondary terminal

If instantaneous current flows from P1 to P2 as marked by arrow in figure 56, the instantaneous current will flow from S1 to S2. Here R.E defines reference earth.

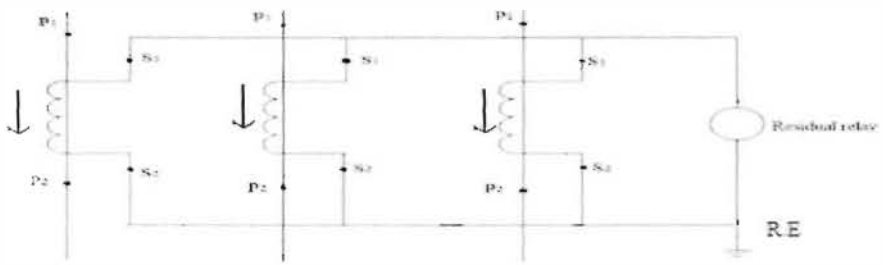


Figure 40: Polarity diagram of CT

4.3.1. POTENTIAL TRANSFORMER

After the CT he told us about Potential transformers. These are used for measurement and protection. PT may be either single phase or three phase units. These are necessary for voltage or directional distance protection. Volt-ampere rating of potential transformers is small compared to that of current transformers. It is not possible to use direct voltage for system protection due to its high value, and possible insulation problem of protective relays.

4.3.2. CONSTRUCTION OF POTENTIAL TRANSFORMER

He said the mechanisms of potential transformers are similar to current transformer. After talking with him we understood that there are two kinds of single phase electromagnetic PT, i.e. single pole (between lines and earth) and double pole (line-to-line). Type three phase PTs are star-star or star-delta connection. He said that the Potential Transformer consists of primary and secondary windings, electromagnetic core, bottom tank, oil expansion chamber, and porcelain

bushing, etc which are similar to current transformers. The example of HV outdoor potential transformer (left) and dry type potential transformer (right) is given in figure 41. Here they used copper enamel wire instead of super enamel for winding. Primary is wound with multilayer and graded insulation. Secondary is separately wound and inserted in the primary winding as per the requirement. Similarly they give tapping on the winding of the PT an it is done in dust-free atmosphere. Here core is Shell type which minimized leakage reactance. Bottom tank and oil expansion chamber are made of MS sheet. Brown/white glazed porcelain bushing with different shed profiles to suit different pollution condition is used. These bushings are hollow cylindrical type conforming to IEC 815/IS 5621. High quality electrical grade Kraft paper and crepe paper is used for insulating primary and secondary of PT.

Figure 41: HV outdoor (left) and Dry type (right) PT (www.energypac.com).

4.4. TEST OF INSTRUMENT TRANSFORMER:

Following test are done in Energypac for testing instrument transformers. These are

1. High voltage test
2. Insulation test
3. Analyzer test/timing test
4. Meager test
5. Routine test
6. Common test
7. Type test

We did not observe the instrument transformer testing.

5. CIRCUIT BREAKER

We worked with Mr. Moniruzzaman for two days. On day one, we finished circuit breaker and on day two we studied fabrication. He is the manager of this section. He said that a circuit breaker is an automatic switch which can interrupt fault current. They use different pole circuit breaker for arc-extinction. Generally used are single pole, double pole, and triple pole circuit breaker for arc-extinction. He said the Energypac made only vacuumed circuit breaker (VCB) and other transformer they buy from abroad. Generally they buy Miniature Circuit Breaker (MCB), Molded Case Circuit Breaker (MCCB), and Air Circuit Breaker (ACB).

5.1. VACUUM CIRCUIT BREAKER (VCB)

Energypac manufactures Vacuum Circuit Breaker which meets international standards. In Bangladesh Energypac is the only company where VCB is manufactured. The company manufactures two types of vacuum circuit breakers, one is indoor type and other is outdoor type. These circuit breakers are designed for switching short circuit current, provide ripple control system and handle transformers and generators under load and no load conditions.

5.1.1. *INDOOR TYPE VCB*

The Energypac Engineering Ltd. designs indoor type horizontal isolated and horizontal draw out type vacuum circuit breaker. Figure 42 shows the indoor type horizontal isolated VCB.

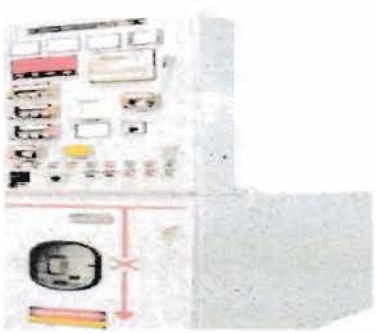


Figure 42: Indoor Type VCB (www.energypac.com)

5.1.2. *DESIGN FEATURES*

At first he talked about indoor type VCB. He also said the indoor type VCB is used inside of a power plant and substation. It is a high voltage product. So the trip function of the VCB is automatic. When voltage and current exceeds the rated values then the trip coil gives a signal and automatically opens the circuit breaker. The design of the VCB has the following features.

- ✓ High degree of safety & high operational reliability
- ✓ Simple in construction & Rugged design
- ✓ Modular and compact

- ✓ Made of metal clad type using CRCA steel of adequate thickness
- ✓ The interrupters are procured from CUTLER-HAMMER (EATON), USA.
- ✓ For arc extinction provide HHV 12 employs rated vacuum interrupters
- ✓ HHV-12 is manufactured strictly under technology standards set by the company with components and subsystems selected through strict quality control procedures as per IS 9001 certifications guidelines
- ✓ Cubicle compartmentalized design in various segregations
- ✓ Cable chamber accommodate with 6 nos. single core 1000 sq. mm
- ✓ The relays and meters are mounted on a hinged door and are located at a comfortal height for ease of viewing and maintenance.
- ✓ Earth switches provided as an integral part of the equipment
- ✓ Isolatable voltage transformer
- ✓ Ample current transformer accommodation
- ✓ Manual or motor charged main closing mechanism
- ✓ Extensive use in tropical environments
- ✓ Complete set of interlocks and padlocking facilities

5.1.3. *SPECIAL CHARACTERISTICS*

The vacuum or other circuit breaker is an essential equipment for switchgears. The vacu circuit breaker (VCB) has some special characteristics for protecting electrical instruments l transformer, transmission line etc. We get the following special characteristics in circ breakers, according to Mr. Moniruzzaman,

- ✓ Very low arcing time
- ✓ Quick recovery of dielectric strength
- ✓ Small contact gap
- ✓ Trouble free service
- ✓ Low energy mechanism

5.1.4. *OPERATING PRINCIPLE*

We learnt the operating principle of vacuum circuit breaker from Mr. Moniruzzaman. He sa for operating the circuit breaker in a very short time, Mechanism M-37 is provided w conventional design. First of all the machine is charged by motor. When charged, the closi spring is held by a latch which can be released either by manual means or by a solenoid to clo the circuit breaker. To open the spring, the required energy is provided by a spring in the dr assembly which is compressed during the closing stroke. The closing mechanism includ Breaker on/off and spring charged or discharged indications.

5.1.5. *INDOOR VCB TECHNICAL INFORMATION*

The table below shows the technical characteristics of the indoor VCB interrupter. Such technical particulars, type designation, applicable standard, rated voltage, normal voltage, norm rated current, frequency, short circuit breaking capacity, etc.

Table 1: Indoor VCB technical information

Technical Particulars	11KV	33kV
Applicable standard	IEC 60056	IEC60056
Type Designation	HHV-12	HHV-36
Normal Voltage	11kV	33kV
Rated Voltage	12kV	36 KV
Frequency	50 Hz	50 Hz
Normal rated current	630/1250/1600/2000 Amps	1250/1600/2000 Amps
Short circuit breaking capacity	20kA/25kA/31.5kA	25kA
Rated 1 Minute Power Frequency		
Withstand Voltage	28	75 kV Pms
Rated impulse withstand voltage	75	170 kV Peak
Duty Cycle full breaking capacity		
Normal	0-3 Min-Co-3 Min-Co	0-3 Min-Co-3 Min-Co
Auto reclose	0-0.3 Sec-Co-3 Min-Co	0-0.3 Sec-Co-3 Min-

5.1.6. *VCB APPLICATIONS*

Mr. Moniruzzaman told us where indoor type VCB is used. In Bangladesh, the VCBs are mainly used in Power stations, Transformers, Chemical industry etc. The purposes of the VCB are same for all application. He said generally the indoor type VCB is used in the following applications.

- ✓ Power stations
- ✓ Transformers
- ✓ Automotive industry
- ✓ Airport power supply
- ✓ Building power supply

5.2. *OUTDOOR TYPE VCB*

We were then told about outdoor porcelain clad vacuum circuit breaker which is suitable for industries and utilities. The outdoor type VCB is shown in figure 43.

Figure 43: Outdoor type VCB (www.energypac.com)

We were introduced to the design features of outdoor type VCB by Mr. Moniruzzaman. He said outdoor type VCB is used outside the power plant and substation and it is also a high voltage product. The trip function of the VCB is automatic. When voltage and current exceeds the rated range, the trip coil gives a signal which opens the circuit breaker. According to his information the design of this type of breaker consist following feature.

- ✓ Compact design & Low Maintenance
- ✓ Low operational load
- ✓ Low noise level
- ✓ Each phase contained in a porcelain bushing
- ✓ For arc extinction provide OFVp-36 employs
- ✓ OFVp suitable for auto reclosing and capacitor switching
- ✓ Mechanism is designed for short stroke & charged by motor
- ✓ Mechanism cabinet consist of sheet steel of IP 54 standards
- ✓ Cabinet equipped with Local/remote switch & Anti pumping relay
- ✓ Closing mechanism includes Spring charged or discharged

5.2.2. *OUTDOOR VCB TECHNICAL INFORMATION*

Table 2 shows the technical information of the outdoor VCB interrupter. The parameters include rated 1 minute Power frequency withstand voltage, type designation, applicable standard, rated voltage, normal voltage, normal rated current, frequency, short circuit breaking capacity, etc.

Table 2: Technical information of outdoor VCB

Applicable Standard	IEC60056
Type Designation	OFVp-36
Normal Voltage	33kV
Rated Voltage	36 kV
Frequency	50 Hz
Normal rated current	up to 1600 Amps
Short circuit breaking capacity	up to 25 kA
Rated 1 minute Power frequency withstand voltage	75 kV rms
Rated impulse withstand voltage	170 kV peak
Nominal creep age of bushings	Support – 910 mm Interrupter housing – 910 mm
Duty cycle 0 full breaking capacity	Normal – 0-3 MIN – CO- 3 MIN-CO Auto reclose - --0.3 sec-CO-3 MIN-CO

5.2.3. *VCB APPLICATIONS*

The VCBs that we have been introduced to are typically used in different applications. Following are several of such applications.

- Suitable for switching of arc furnace transformers up to 50 operations per day.

5.3. MINIATRE CIRCUIT BREAKER (MCB)

He said the miniature circuit breakers are used for Protecting and controlling the circuits against overloads and short-circuit; protection people and big-length cables in TN and IT systems. The operating voltage is 230/440 V and breaking capacity of is 3kA.

Figure 44: Miniature Circuit Breaker (www.energypac.com)

Energypac imports different miniature circuit breaker models from Germany (See figure 44). These circuit breakers are not manufactured by Eneergypac.

5.4. MOLDED CASE CIRCUIT BREAKER (MCCB)

He also said they used another circuit breaker which is known as molded case circuit breaker (MCCB). The molded case circuit breakers are used for protecting and controlling the circuits against overloads and short-circuit. It also protects electrical machineries against overloads, and ground fault protection. Examples of molded case circuit breaker are shown in figure 45. Breaking capacity of this type of circuit breaker is 25 kA. They import different models of MCCV circuit breaker from Italy.

Figure 45: Molded Case Circuit Breaker (www.energypac.com)

5.5. AIR CIRCUIT BREAKER

He said the working principle is similar to other circuit breaker. These are also another imported circuit breaker. These circuit breakers are imported from Italy.

COMMON DATA

He said in this circuit breaker some data are common for all model of circuit breaker. Such as rated service voltage (Ue) is varying 690 V, rated insulation voltage (Ui) is 1000 V; rated impulse withstands voltage (Uimp) 12 kV, frequency (f) is varying [50 – 60] Hz and numbers of poles are 3 – 4.

6. ISOLATOR

this section we were helped by Engr. Mr. Belal Hossain. He was also very cordial with us. We yed with him only one day. Though this section is related to mechanical engineering it is a ry important section for Energypac and therefore it was included in our internship training nedule. Mr Belal Hossain told us about isolators which is also known as disconnecting switch. e main purpose of isolator is to disconnect the circuit at no load condition. First of all he roduced us to disconnector main assemblies, which are given below.

- ✓ The main current carrying parts.
- ✓ Support insulators mounted between the current carrying parts and base.
- ✓ The bottom base assembly.
- ✓ The operating mechanism box.
- ✓ Inter-stack, inter phase and down operating pipes.
- ✓ Earthling switch and its operating mechanism box.
- ✓ Supporting structure mounted between the base and the ground.

.1. *TYPE OF ISOLATOR*

r. Belal Hossain said generally they made three types of outdoor offload isolators,

1. Pantograph isolator (type EPG)
2. Double break isolator(type ECB)
3. Center break isolator(type EDB)

.2. *RATING OF ISOLATOR*

ere we see the voltage rating of the pantograph isolator is varying from 12 kV to 245 kV and e rated current is upto 3150 Amps. Short time current rating is upto 50 kA. These rating are ite similar for all type of isolator.

2.1. *ASSEMBLY OF PANTOGRAPH ISOLATOR*

e gives us some manufacturing information about pantograph isolator. He said that the ntograph isolator has the very low civil engineering profile. It has four point contacts in ntograph isolator. The trapeze contact is fixed to suit upper bus arrangement. This type of olator is very flexible for different bus bar layouts. A current transformer is connected through ulti finger hinge contacts. It has individual pole operation. This type of isolator is also known single break isolator.

2.2. *ASSEMBLY OF DOUBLE BREAK ISOLATOR*

case of double break isolator he said it has turned and twisted contacts. The terminal is vertical d horizontal and totally enclosed by actuator assembly. But here we see it has simultaneous eration of 3 poles by single operating mechanism at up to 245 kV.

6.2.3. ASSEMBLY OF CENTRE BREAK ISOLATOR

The mechanism of center break isolator is similar to double break isolator. The break is done in the center position of the isolator. Breaking is done automatically but closing is manually. Similarly the double break isolator it has turned and twisted contacts. The terminal is vertical and horizontal. Simultaneous operation of 3 poles by single operating mechanism is up to 245 kV. There is an example of center break isolator shown in figure 46.

Figure 46: Center Breaker Isolator (www.energypac.com)

6.2.4. TEST OF ISOLATOR

Mr. Belal Hossain noted the following tests for isolator.

1. High voltage test
2. Insulation test
3. Analyzer test/timing test
4. Meager test
5. Routine test
6. Common test
7. Type test

We did not learn the details about these tests. However, we discussed lightning. When lightning fell onto the transformer or transmission line there is a possibility to burst transformer or fire on the transformer or transmission line. This can create a high voltage for short time. For solving this type of problem we need to use isolator.

7. FABRICATION PROCESS ASSEMBLY

This is our last day at Energypac. It is the last part of our internship. Engr. Moniruzzaman helped us understand this section. We finished the whole section in one day.

He said that first of all they powder coded the steel path. After powder coding, the steel part was dipped in the acid tank. Then it is dropped in a rinse tank which was filled with normal water. Then the part is put into the drastic tank. Again the path is put into normal water, then it is dropped into a phosphate tank. At last it was sent to a dry-off oven. Powder spray is done in dry-off oven. The spray process is done electrically. Generally they spray the Berger powder. The temperature of the dry-off oven must be at 180 degree Celsius. He said for completing whole process they need 13 to 15 minutes.

7.1. SAND BLASTING PROCESS

This was second part in this section. Mr. Moniruzzaman said sand blasting is a very important for the transformer; because it is done to reduce corrosion of the transformer and other electrical equipments. He said there is a radiator tank where sandblasting is done. For completing sandblasting they mixed sand with air and this put at air blasting tank about 730kg. There is a nozzle in the tank. For completing the sandblasting they spray the sand by nozzle.

7.2. COLORING ASSEMBLY

There is another part called coloring assembly. This important section is needed to reduce corrosion. For completing the coloring of transformer they follow the below process

- ✓ Two types of color are used like AD zinc phosphate primer (light gray) and other is fenile (dark gray)
- ✓ Fenile is used after 12 hours later of zinc phosphate.
- ✓ T6 fenile is used for mixing
- ✓ Mixing ratio is 4:1 where 4 liters color is used for 1 gallon fenile
- ✓ They also used epoxy primer where color is light gray
- ✓ Next is a curing agent of epoxy primer. For this purpose they use T7 fenile where color ratio is 2:1:2 that mean 2% color, 1% curing and 1% fenile. They use epoxy enamel after 24 hours later. Color is verge gray and curing agent for epoxy enamel. Mixing ratio is 2:1:1 where 2% color, 1% curing and 1% fenile. Also use T7 fenile.

7.3. MACHINE SHOP

This is the last part of this section and we saw various types of machines which were used in Energypac machine shop. According to the engineers explanations these machines name and working operation are given below. Generally they used Lathe machine, Milling machine,

Shaper machine, Chaser machine, Drill machine, Surface grinding machine and last is Power Saw machine.

1. Lathe machine: A lathe is a one kind of machine which rotates the work piece on its own axis to perform various operations like cutting, sanding, etc. He said this machine is used for cutting the shaft or steel rod. By using this machine they can easily cut the shaft at appropriate size. (such a machine is shown in figure 47)

Figure 47 : Lathe machine (arcticboy.arcticboy.com)

At Energypac the lathe machine is used for the following purposes. Turning the shaft

- ✓ Facing the shaft at appropriate position
- ✓ Threat cutting on the shaft
- ✓ Hole enlarging on the shaft and steel path
- ✓ To making tapping on the shaft

2. Milling machine: Milling machines can perform a vast number of operations, for example slot and keyway cutting, planning, drilling etc. He said Milling machines are two basic forms, one is horizontal and other is vertical. (A milling is shown in figure 48)

Figure 48 : Milling machine (www.millingmachine-details.info)

According to the engineer the Milling machine is using for following purposes.

- ✓ To make gear on the shaft
- ✓ To make key way on the outside of the shaft

3. Shaper machine: A shaper is a type of machine that uses linear relative motion between the work piece and a single-point cutting tool. He said its cut is analogous to that of a lathe, except that it is linear instead of helical. (Shaper machine is shown in figure 49). He said The Shaper machine is using for following purpose.
   - ✓ To make key way on the inside of the shaft

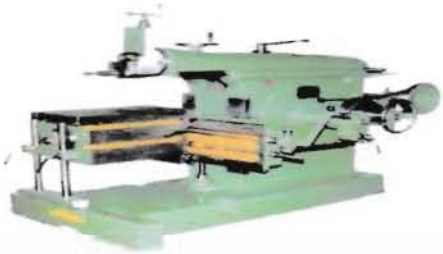


Figure 49 : Shaper machine (www. jiwan. in)

4. Chaser machine: A chaser is a type of machine that cuts a threat relative motion between the work piece and a single-point cutting tool. (Chaser machine shown in Figure 50).

Figure 50 : Chaser machine (www.indiamart.com)

e said Chaser machine are used for following purposes.

- ✓ Cutting a threat only outside
- ✓ Use for ring type elements

5. Drill machine: A drill is a machine fitted with a rotating cutting tool, usually a drill bit, used for drilling holes in various materials. The tip of the cutting tool does the work of cutting into the target material. (shown in figure 51)

Figure 51 : Drill machine (www. engineering.indiabizclub.com)

he drill machine is used for making a hole on the steel path

6. Surface grinding machine: A surface machine is a tool that smoothes the surface of various materials. (Shown in figure 52).

he chaser machine is used smoothing job surface

Figure 52 : Surface grinding machine (www. thesurfacegrinder.com)

.4. CNC MACHINE

r. Moniruzzaman helped us know about the CNC machine. He told us the full meaning of NC, which is computer numerical control. It is operated electrically. Also he gave us following sembly information about the CNC machine.

- ✓ Third generation scream manufacturing and fabrication
- ✓ It has hydraulic punch and capacity is 30 ton
- ✓ All are controled by CNC
- ✓ Sheet thickness can be punch 1.6 mm to 6mm
- ✓ Usable software is AP100 includes cat, cam, programming caesural dataset

.1. PROGRAM LOAD PROCEDURE

tried to give us basic idea about CNC machine and about its working principle. He said this pe of machine is used for making the hole on the steel plate. For this purpose machine has to member the size of the hole and measure distance between holes etc. As a result machine eds a program which is set by engineers on the computer before running the machine. Example this machine is shown in figure 53, which shows a cutting point view.

Figure 53 : CNC machine (Cutting point view)

important part of the machine is the computer where the software is installed. To operate the achine they need two rooms where one is for CNC machine and other is for computer. From side the room where computer is, an engineer operates the machine. For running this machine ey need to turn on memory by pressing memory button. Then they have to press program soft y for running the program. Then they press Dir key for understanding the direction of the steel th. After completing the procedure they have to type file number and they have to press

chine start working. According his given information program running process of CNC is en below:

Press memory on main control panel

↓

Press program soft key

↓

Press soft key

↓

Press Dir soft

↓

Type file number & press OSRH

↓

Press start button

8. CONCLUSION

his training we get the basic knowledge on transformer, switchgear, current transformer, ntial transformer, isolator, circuit breaker, and fabrication plant. In the transformer section saw the manufacturing process of different types of transformer. The Energypac generally e distribution transformer, power transformer, current transformer and the last is potential sformer. The operating principles of the transformers are different from each other. The ibution transformer is used for supplying the rated voltage and current. On the other hand er transformers are used for generating required power. Current and voltage transformer are l for protection purpose of electrical equipments. We saw the full construction of current and age transformer.

witchgear section we saw different types of switchgear panel. These are HT panel, LT panel, panel. We also visited the isolator and breaker section. In isolator section we saw three types solator; pantograph, center break, and double break. We saw the actual processing hanism of vacuum circuit breaker. In fabrication plant we saw powder coding, sand blasting, lasting, and color coding.

nachine shop we saw different types of machine and their working principle. Especially we the CNC current pump machine. This machine works fully electrically.

ast this internship introduced us with substation. Now we know about substation and its ntial equipments. This internship will play an important role as we begin our career.

9. REFERENCE

Sunil S. Rao, *Switchgear Protection and Power System*, Publisher: Khanna, 2008

William T. Taylor, *Transformer Practice*, Mcgraw-Hill Book Company, New York, 1913

Vladimir Gurevich, *Protection Devices and Systems for High-Voltage Applications*, Willis, Power Engineering Series

http://catalogs.indiamart.com/products/control-relays.html