An Internship Report on

Semester Long Internship at Forbes Marshall Pvt. Ltd., Kasarwadi, Pune

Submitted to

Vishwakarma Institute of Technology, Pune

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

in partial fulfilment of the reqquirements for

B.Tech.

in

Instrumentation and Control Engineering

by

Aditya Kolte

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Under the guidance of

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and

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Academic Year: 2018-19

Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Technology, Pune-37

(An Autonomous Institute Affiliated to University of Pune)

Certificate

This is to certify that the Internship report on, **Semester Long Internship at Forbes Marshall Pvt. Ltd., Kasarwadi, Pune**, submitted by **Aditya Kolte**is a record of bonafide work carried out by them under my guidance in partial fulfilment of the requirement for Bachelor of Technology in Instrumentation and Control Engineering at Vishwakarma Institute of Technology, Pune.

Prof. Archana Chaudhari
Internal Internship Guide
Dept. of Instrumentation Engineering
VIT, Pune

Dr.Shilpa Y. Sondkar
Head of Department
Dept. of Instrumentation Engineering
VIT, Pune

Dr. S.K.Karthick Kumar
Company Internship Guide
Reseach and Development,
Kasarwadi, Pune
Forebes Marshall Pvt.Ltd.

Date: 11 May 2019
Place: Pune

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Prof. Archana Chaudhari
Examiner

Dr.S.K.Karthick Kumar
Examiner

Date: 11 May 2019
Place: Pune

Acknowledgement

I consider myself truly fortunate to be able to pursue internship under the Semester long internship program of the Department of Instrumentation and Control Engineering. I am eternally grateful to the entire department for introducing such a thoughtful program for students and making it a big success. Internship in an industry gives an exact idea of how the theory learnt in the classes is useful in the real life. I would like to thank Prof. (Dr.) Shilpa Y. Sondkar, Head of department Instrumentation Dept; Prof. Archana Chaudhari, Student mentor, Instrumentation Dept and Prof. Rajendra Patel; Internship Guide, Instrumentation Dept for their substantial support and guidance throughout my Internship tenure and for looking after the academic side of the semester throughout my internship.

The internship tenure at Forbes Marshall Pvt. Ltd. was an eclectic experience in terms of knowledge application in practical life. Therefore, I feel really fortunate to have been able to be a part of this program. During the internship I got to acquire a wide spectrum of knowledge by some phenomenal professionals in the industry. I also came across some latest technologies in the market which enhanced my knowledge.

I express my deepest thanks to Dr. S.K.Karthick Kumar and Mr. Mayank Upadhyay for helping me at every step and giving essential guidance throughout my internship. I would also like to thank Dr. Anish Bekal, Mr. Sharad Phand,Mr. Sagar Ghute and the Entire Optics Lab team, for helping me understand various concepts in the electronics and automotive sector.

I consider this internship as an eclectic experience in my academic career. I will preserve the experience and knowledge acquired during this tenure and definitely utilise it in the coming future. I assure to improve the skills I learned during my internship constantly and apply them in my professional life. I sincerely hope to continue the cooperation with all of you in the future.

1)Aditya Kolte

Place: Vishwakarma Institute of Technology, Pune

Date: 22nd December 2018

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Abstract

In my eight semester of engineering, I got an opportunity to intern at Research and Development, Forbes Marshall Pvt. Ltd., Kasarwadi Pune. This internship was a completely knowledge pouring experience in my academic life as it provided me with a wide spectrum of technical as well as professional exposure accompanied with a vast amount of practical knowledge.

During my internship at Forebes Marshall, I was working as a part of the Optics Lab. The initial stage involved getting familiar with the project I was supposed to join and understanding its objectives. This stage also included the revision of basic optics and spectroscopy techniques. I understood how in actuall a new product is developed. I studied the journey of the Product from PoC to Prototyping and testing.

My main role was to handle the embedded programming required for the NIR Moisture Sensor. So next step included getting familiar with electronics hardware used and adapting to the Microcontroller and the programming tools used. This gave me an opportunity to work on TI's ARM based microcontrollers and strengthened my understanding of basic peripherals of a Microcontroller.

When the building of the Prototype was complete I was involved in the calibration process of the NIR moisture sensor. The calibration included two steps - sensor calibration and electronics calibration.

After the prototype was completed it was installed in a Paper Mill located in Talegaon for on feild testing, This on feild testing was a great learning experience for me, i could understand a number of practical problems and ways to overcome those. The feild test was a success as the sensor achieved great accuracy and precision.

Apart from the above project I contributed in many other ways in the Optics lab while conducting small experiments. The Internship helped me gain immense amount od practical and technical knowledge.

Chapter 1

Basic Introduction of Forbes Marshall Pvt. Ltd.

Forbes Marshall is a leader in process efficiency and energy conservation for Process Industry, with over seven decades of experience building steam engineering and control instrumentation solutions. Their unique complementary strength allows the company to design and offer industry specific solutions that focus on energy conservation and process efficiency for diverse sectors. Their knowledge, innovative solutions, reliable products and global presence make FMPL a trusted partner.

The Company's Energy Conservation Audits, systems and customised solutions have been able to save energy and fuel costs for our customers. We design and manufacture a wide range of advanced technology instrumentation for continuous stack emission monitoring, road tunnel atmosphere sensing, and plant safety equipment that is capable of meeting today's tough environmental and legislative demands. For 70 years, FMPL has partnered process industry in providing solutions in process efficiency, energy conservation and environmental monitoring. Highly skilled and dedicated engineers spend considerable time visiting process plants to identify solutions.

With focused investments in manufacturing, RnD and services, we create value for our stakeholders. We consistently bring new and innovative products to the market. Several of our products have received awards for innovation. The Minimax Modular Boiler, the Effimax (a unique boiler efficiency monitoring system), the Wireless Trap Monitoring System for remote monitoring of multi-location traps Thermodynamic Trap, Two Orifice Float Trap, Distributed Control system, Thermocompressor, and the Electronic Compound Regulation Burner Operation and Control System, Stack Analysers, Vortex Flowmeter, the MAC (Master Air Controller) and Biosens, a revolutionary new analyser for instant BOD analysis, are examples of our cutting edge research and development.

The Company's core values of Family Spirit, Integrity, Innovation and Entrepreneurship and Delivering Value not only to our customers, but also to their members and society make Forbes Marshall a place that puts people first: members, customers, suppliers, associates and the community.

FMPL is concerned with the community beyond the factory's gate. Since the inception of the company, sustainable social initiatives have been the key drivers of its philosophy to contribute and give back to the community. FMPL's diverse and sustained programs support health, education and life skills development in communities. It also help the community, particularly women, to engage in entrepreneurial ventures to support their families and thereby gain the skills and confidence in dealing with issues that impact their lives.

Forbes Marshall Pvt.Ltd. has been listed several times among the Top 5 "Best Workplaces in India", and first in the manufacturing industry by surveys conducted by the Great Place to Work Institute in association with Economic Times.

Chapter 2

Near Infrared Moisture Sensor

2.1 Introduction

Moisture content in materials like textile, food, and paper plays an important role in determining the quality of the end product. Moisture sensor estimates the percentage of moisture content in a provided sample.
Near Infrared Moisture sensor works on the principle of Electromagnetic waves absoption by water molecules. Moisture is measured by observing the ratio of diffused reflectance at two different wavelengths.
Existing methods of measuring moisture include -
1) Resitive method - Here, Short circuit can cause damage.
2) Volumetric Analytical method - Here, Sample size is a constraint.
The NIR Moisture sensor works with the Spectroscopy method which has no such constraints.

2.1.1 EM absorption of water

1) Rotational transitions in water molecules result in microwaves absorption. 2) Rotational transitions result in Far Infrared(FIR) absorption. 3) Vibrational transitions causes Middle Infrared(MIR) and Near Infrared(NIR) absorption. Absorption peaks of water are due to the presence of OH bond. These peaks are pronounced at 1940nm and 1450nm.

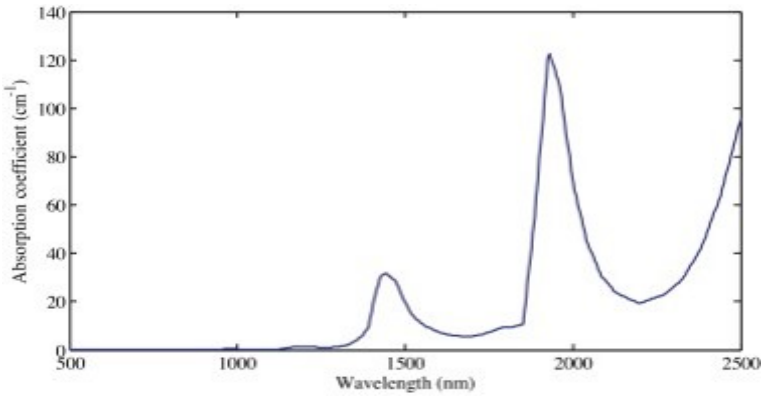

Figure 2.1: EM absorption of water molecules

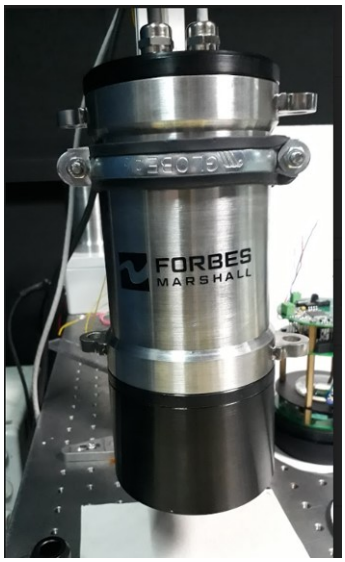

Figure 2.2: NIR Moisture Sensor

2.1.2 Instrument Design

The aim of the NIR moisture sensor is to measure the concentration of moisture present on the surface of samples like paper, textiles etc. This NIR moisture sensor measres diffused reflectance at three specific wavelengths in range of 945nm to 15550nm. The illumination light is produced by narrowband LEDs at specific wavelengths.
The reflectance of the spectra is measures for known concentrations of the samples. This gives the constants for the calibration polynomial. This polynomial is used to estimate the concentration of unknown materials.
The Microcontroller's EEPROM is used to store the configuration parameters and the calibration coefficients this minimizes the setup time of the sensor and helps eliminate data loss due to power failures.

2.1.3 Communication

The NIR Moisture sensor has two outputs - 4-20mA stadndard current output and RS485 MODBUS support. The register map for the MODBUS structure is well defined and ExOR HMI is used along with the sensor to provide the user an interactive interface.
The HMI is used for display as well as to alter the calibration/configuration parameters. The 4-20mA output can be used when the sensor is sensor is used in an quality control system. The range of moisture corresponding to the 4-20mA output can be set as per the user's requirement.

MODBUS RTU

This is used in serial communication and makes use of a compact, binary representation of the data for protocol communication. The RTU format follows the commands/data with a cyclic redundancy check checksum as an error check mechanism to ensure the reliability of data. Modbus RTU is the most common implementation available for Modbus. A Modbus RTU message must be transmitted continuously without inter-character hesitations. Modbus messages are framed (separated) by idle (silent) periods. The NIR Moisture sensor is programmed as a MODBUS slave device. It responds to the master device(HMI in our case) query and sends a valid output. The programming of the MODBUS slave and address maping of different parameters was done from scratch as a part of this internship.

2.1.4 Calibration Procedure

Primary Calibration

Primary calibration of the sensor is done in labaratory for each unique sample. The primary calibration involves the following -
1) **Integration Time Adjustment** - Integration time increases the avereging of the detector outputs which results in higher signal to noise ratio. (Intergration time should be set according to the on feild conditions)
2) **Reference Measurement** - Ceramic plate is used as a reference material for the calibration. The time corresponding drift can be nullified by checking for change in these reference readings. If a drift is found the sensor can be given the new set of readings as a new reference and the calculations are done accordingly to give proper moisture reading.
3) **Sampling** - Square samples of weight more than 1gm and size 150mmX150mm are

taken.
Step 1: This sample is soaked in steam to absorb moisture.
Step 2: Sample is placed under the sensor and detector readings(A,B,C are noted) also weight of the sample is noted. Step 3: Sample is allowed to dry at room equilibrium and above step is repeated until no change in weight is observed.
Step 4: Once the equilibrium is reached the sample is dried in oven repeatedly and step II and III are repeated until no further change is observed in weight by 0.01gm.
Step 5: Sample is dried in oven at 105 degree celsius for 45 minutes to get its bone dry weight.
4) **Calibration fit** -
Step 1: Moisture percentage by weight is calculated.
Step 2: Coefficients of the calibration equation are then calculated using Multiple regression. The reading obtains in the sampling process are used as inputs for curve fitting in the multiple regression model. Step 3: The obtained coefficients are then entered into the sensor via the HMI.
5) **Current Clibration** - Ensuring that the sensor produces proper 4-20mA current output corresponding to the moisture content. The sensor is fed with a linear equation which establishes a relation between pwm and output current. A two point calibration is performed to get the coefficients of this linear equation. The calculations are done inside the microcontroller unit itself, the user only needs to enter the measured current via the HMI. (Current to be measured using a calibrated DMM)

Secondary Calibration

LEDs intensity goes on reducing because of aging. To compensate for this deterioration secondary calibration is needed periodically. The same ceramic plate which was used at the time of calibration is inserted into LED cover. If A,B,C values have been changed from the previous values then these will be saved as new reference by using HMI.

2.1.5 Results

Calibration Results

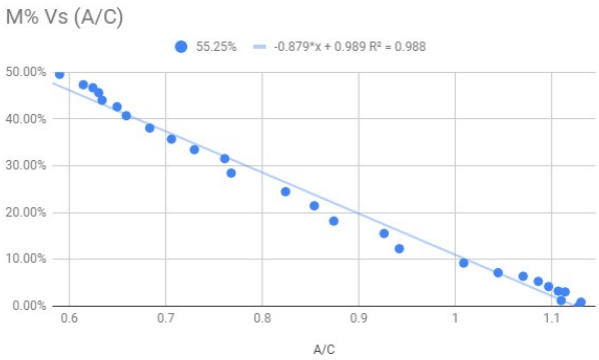

Figure 2.3: Moisture vs C/A

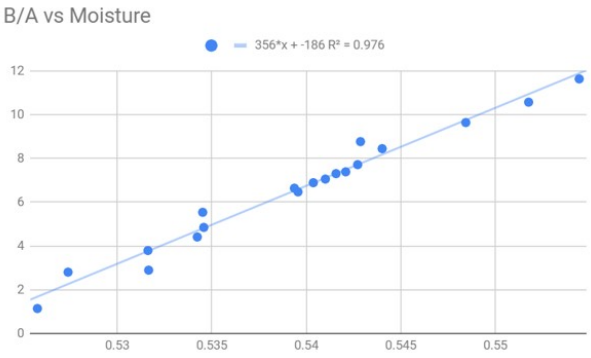

Figure 2.4: Moisture vs B/A

21903.5566	11516.3564	20213.6309	1.053	1.041	1.13960114
21899.9297	11549.9619	20260.0098	1.071	1.041	2.801120448
21827.7363	11604.9756	20227.4883	1.072	1.041	2.891791045
21705.0625	11538.9502	20127.8027	1.082	1.041	3.789279113
21613.3262	11546.5869	20121.0098	1.089	1.041	4.407713499
21583.7363	11538.1729	20102.5996	1.094	1.041	4.844606947
21638.1113	11565.9873	20271.8867	1.102	1.041	5.5353902
21457.8926	11577.8711	20209.6914	1.113	1.041	6.469002695
21437.6348	11562.8258	20192.834	1.115	1.041	6.6367713
21396.5039	11562.0605	20173.6152	1.118	1.041	6.887298748
21366.9121	11559.6943	20171.9688	1.12	1.041	7.053571429
21334.7461	11554.3418	20159.5762	1.123	1.041	7.301869991
21309.5898	11551.6201	20159.8828	1.124	1.041	7.384341637
21260.2109	11538.2891	20145.7871	1.128	1.041	7.712765957
21204.5684	11535.6035	20136.6172	1.137	1.041	8.443271768
21196.0586	11506.6338	20170.3242	1.141	1.041	8.764241893
20956.5	11493.3359	20071.3555	1.152	1.041	9.635416667
20837.3633	11497.2793	20052.5566	1.164	1.041	10.56701031
20664.1953	11457.042	20008.7383	1.178	1.041	11.62988115

Figure 2.5: Sampling data of Raw A,B,C values

3.823529412	1.026294547	0.2381219589
4.757281553	1.030939958	0.2384691566
6.303724928	1.033249932	0.2401514322
6.571428571	1.03328008	0.2402012831
6.74904943	1.033931287	0.2404939616
7.190160833	1.035435552	0.2408241934
7.54005655	1.037166238	0.2412338926
8.146067416	1.042356497	0.2426787671
M	B/A	C/A

Figure 2.6: Sampling data of C/A, B/A and Moisture

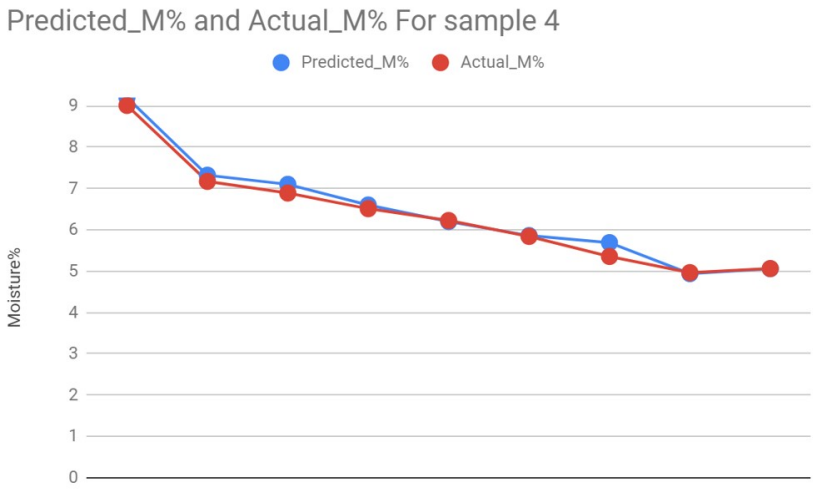

Figure 2.7: Predicted Moisture(Sensor o/p) vs Actual Moisture

Field Results

Sr. No.	Predicted_M%	Actual_M%	Error
1	9.2	9.00	-0.19
2	7.32	7.17	-0.14
3	7.1	6.88	-0.21
4	6.6	6.51	-0.08
5	6.2	6.22	0.02
6	5.86	5.84	-0.01
7	5.69	5.35	-0.33
8	4.94	4.96	0.02
9	5.06	5.06	0.00

Figure 2.8: Comparison table of Sensor O/P and Actual moisture values at site

Figure 2.9: Physical installation at site

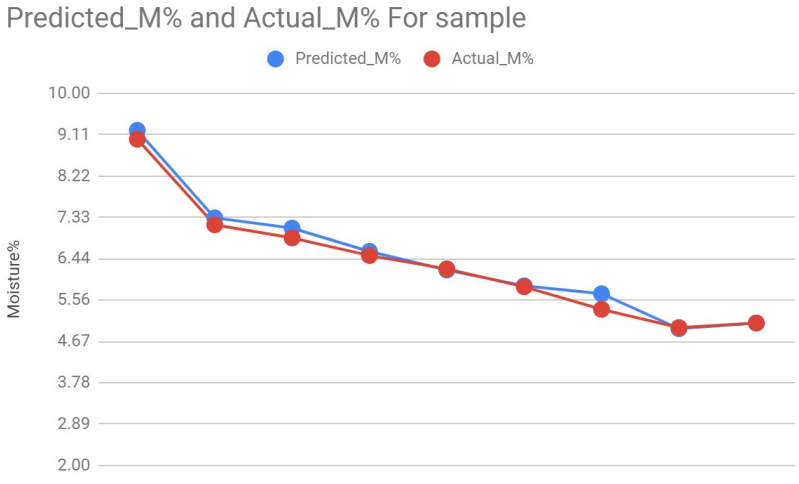

Figure 2.10: Comparison of Sensor O/P and Actual moisture values at site

2.1.6 Advantages of NIR Moisture sensor

1) Fast and accurate measurement results.
2) The long life span of light sources and detector.
3) No moving parts.
4) Maintenance free.
5) Non Contact type measurement.
6) Very low power consumption.
7) Compact size.
8) One time calibration.

2.1.7 Limitations

The device is sensitive to colour of the sample. This device does not work properly when there is huge difference in the colour shades of the material. Calibration will be required for different colours.

Chapter 3

Learning Outcomes

3.1 Softwares Used

My major role during the internship was to handle the embedded programing of the microcontroller used in the sensor. Following are the softwares that were used by me during this tenure. Working on these softwares helped me improvise on my programming skills and develope the required logic for efficient performance of the sensor.

3.1.1 Code Composer Studio v8.0

Code Composer Studio is an integrated development environment (IDE) that supports TI's Microcontroller and Embedded Processors portfolio. Code Composer Studio comprises a suite of tools used to develop and debug embedded applications. It includes an optimizing C/C++ compiler, source code editor, project build environment, debugger, profiler, and many other features. The intuitive IDE provides a single user interface taking you through each step of the application development flow. Familiar tools and interfaces allow users to get started faster than ever before. Code Composer Studio combines the advantages of the Eclipse software framework with advanced embedded debug capabilities from TI resulting in a compelling feature-rich development environment for embedded developers.
Microcontroller used for the project - Texas Instrumensts TiVA C series ARM based, tm4c1290ncpdt/tm4c1294ncpdt microcontroller.

3.1.2 JMobile Studio

JMobile is a modern and innovative software solution for the design of HMI applications in a simple and intuitive way. A powerful and versatile tool set allowing for the

rapid design of tailored applications crafted for a better, more modern user experience. Designed for simplicity, flexibility, and efficiency, JMobile and its advanced graphics engine is based on SVG technology with full object-oriented design properties. These Modern and flexible widgets allow for tailoring a truly better, more intuitive "User Experience" Better "Useability" for operators with modern widgets and navigation, better "Visibility" for management with remote tools and reporting, and better Serviceability both locally and from afar. JMobile client-server architecture is based on current web technologies providing users with advanced control and remote supervision a, from any browser, any device (smartphone, tablet, or computer). In addition, the ability to capture, store and share data in higher-level structures make it an effective tool for integration across the entire enterprise. A rich set of symbols, widgets and advanced functions (e-mail, RSS, PDF Reporting Scheduler, HTML5 Browser) allows JMobile deployment in a wide variety of applications and industries, from industrial to building and marine automation.
HMI used - ExOR ESmart07

3.2 Non technical learnings

The internship exposed me to the industrial Research and development. It helped me understand the complete process to make a new product. Also the set of acticities involved at every step.
Interaction with experienced personel working in the process industry helped me understand the difference between lab/classroom knowledge and field knowledge. The small yet important issues that can only be seen and understood on field were highlightened. Just as an example the Paper Mill has a lot of running static charge which would jump upto 1 feet. This amount of static is way above the standard norms, yet it had a very simple simple solution. Copper strands were left hanging at one end, just after the roller, these strands were given a separate ground. And as a result no static could further be felt. There were many such instances in the tenure of the internship which provided me with great insights and a good learning experience.

Chapter 4

Conclusion

During my internship at Forbes Marshall Pvt. Ltd. Kasarwadi, Pune, I gained tremendous knowledge in various aspects. I was involved in development of new sensors which led me to understand the ins and outs of the industrial RnD environment. The internship started with learning the basics about the sensor to be developed and then i was given an opportunity to handle the embedded progrmming required for the sensor. This enriched my technical knowledge to a great extend. The internship helped me to understand the journey of a sensor from Proof of concept to testing and then production.

After the lab testing of the sensor was successfully carried out, the next step was an on field trial. The on site testing help me understand the practical problems faced and how to deal with the non ideal conditions on field. Thinking of solutions to the comming issues and making changes accordingly was indeed a great learning experience.

In addition to this particular project i was also involved in testing of different equipments in the Lab. Also in carrying out small experiments for future products. This helped me strengthen my fundamentals. Interacting with different people from various different backgrounds helped me understand the different aspects of product development. Overall the whole semester long internship was an enriching experience and equally fun.

In this manner this semester long internship proved to be an eclectic experience for me in terms of technical and practical knowledge. I got an amazing exposure to the industry work environment and the work ethics in it.