*The L N M Institute of Information Technology, Jaipur*

*(Deemed University)*

# Modernization and Automation of the Bar Mill

***ArcelorMittal Steel Plant, Temirtau, Kazakhstan***

***(May-June 2012)***

**Submitted by:**

*Sumit Gautam ( Y09UC285)*

*Fourth Year Undergraduate*

*B.Tech. (Hons.)*

# CONTENTS

# ABSTRACT

The ArcelorMittal Steel plant based in Temirtau, Kazakhstan is one of the most ancient steel plant. ArcelorMittal's core philosophy is to produce Safe, Sustainable, Steel. It has various shops or mills producing various qualities of steel grades that are supplied throughout the world. However, the plant is under rigorous automation now. A small overview to the internship is provided below.

Firstly, a lecture regarding the steel plant was delivered by the authorities describing various steel grades, production, quality and achievements over the past few years. After all the description, we all were provided with the safety rules that is the most important concern for ArcelorMittal Steel employees/trainees.

Secondly, a visit to the plant was scheduled where description to each shop was provided with every minute detail. For this, we were provided with special costume including helmet, gloves, glasses and shoes. The costume was for the safety issues.

Thirdly, we were given information about the process of automation. The training center of the ArcelorMittal was the place where we learned about the automation. In automation techniques, we dealt with the Siemens microprocessors and a program named Siemens Step 7 to control the processors. Under proper guidance, we steadily gained confidence and headed towards working for our projects.

Lastly, with the help of the automation techniques taught to us and our respective engineers, we started working on our projects. The project allotted to my group was: 'Modernization and Automation of the Bar Mill'. Bar Mill is a shop in the plant where steel bars are produced. It has a sub-unit called 'cooling station'. Our task was to perform the automation of the cooling station. The task was performed with the help of a Siemens microcontroller and Step 7 language. The project is in a very good working state and we performed our task as expected. The description to the project is taken up in the report later.

Overall, it was a very good learning experience for everyone who was present as an intern. We all got an opportunity to witness one of the world's largest steel plant and also got to work in it. I hope that the work we did there proves to be fruitful for the engineers in the plant and also to us in future.

# GENERAL INTRODUCTION

**ArcelorMittal is the world's leading steel company with operations in more than 60 countries**. It is a leader in all major global steel markets, including automotive, construction, household appliances and packaging, with leading R&D and technology, as well as sizeable captive supplies of raw materials and outstanding distribution networks.

With an industrial presence in over 20 countries spanning four continents, the company covers all of the key steel markets, from emerging to mature. Through its core values of Sustainability, Quality and Leadership, ArcelorMittal commits to operating in a responsible way with respect to the health, safety and well-being of its employees, contractors and the communities in which it operates. It is also committed to the sustainable management of the environment and of finite resources. The company is listed on the stock exchanges of New York (MT), Amsterdam (MT), Paris (MT), Brussels (MT), Luxembourg (MT) and on the Spanish stock exchanges of Barcelona, Bilbao, Madrid and Valencia (MTS).

**ArcelorMittal's core philosophy is to produce Safe, Sustainable, Steel.**

Safety is the Company's top priority. Their safety performance has improved consistently over the last three years, most recently by 25% in 2009, and they will continue to target our ultimate goal of zero accidents.

The Company's leadership position in the steel industry is the result of a consistent management strategy that focuses on product diversity, geographic reach and vertical integration - both into raw material production, designed to minimize risk caused by economic cycles, and downstream distribution, providing value-added and customized steel solutions through further processing to meet specific customer requirements. The customers are the heart of any business, which is why ArcelorMittal collaborate closely with them to ensure that they evolve and develop their products inline with their continually changing needs.

**ArcelorMittal is committed to its promise of 'transforming tomorrow' and the three values that underpin it - Sustainability, Quality and Leadership.** These values shape their behavior. ArcelorMittal recognizes that the Company has a duty to its stakeholders to operate in a responsible and transparent manner and to safeguard the wellbeing of all its stakeholders, including employees, contractors and the communities in which it operates.

That's why they have a strong focus on Corporate Responsibility. This is evidenced in numerous areas, for example the Company's efforts to develop breakthrough steelmaking technologies,their leadership of the steel industry's Ultra Low Carbon Steel (ULCOS) programme and the global activities of the ArcelorMittal Foundation.

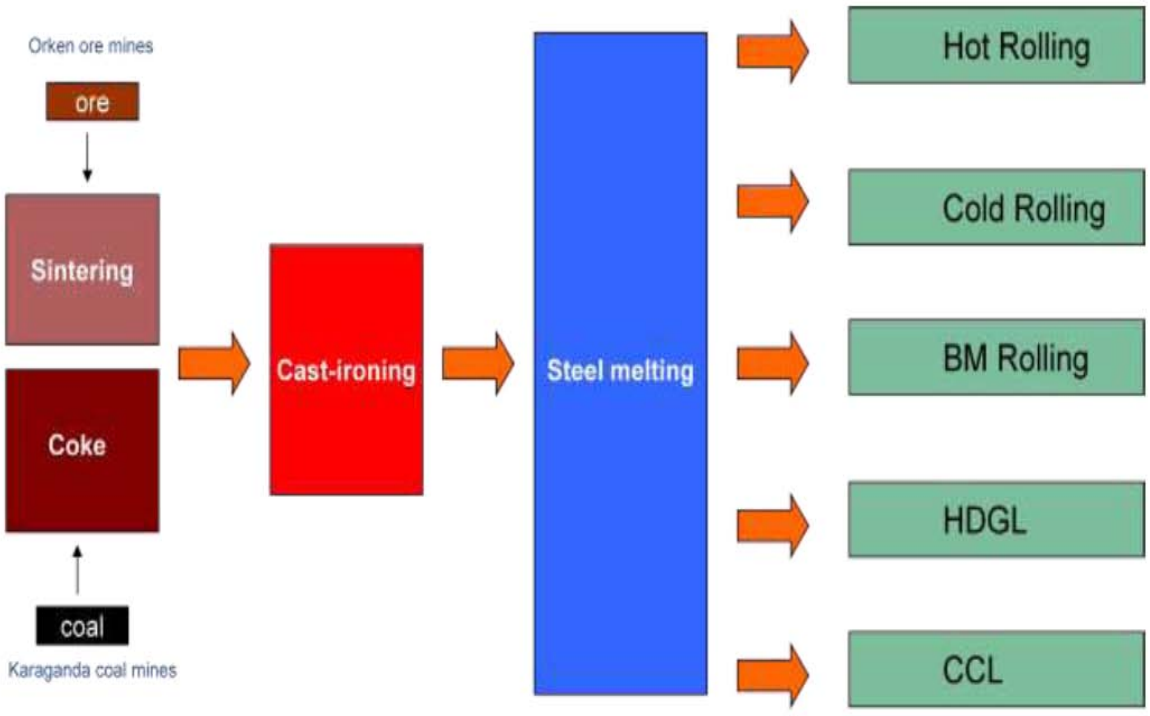
No discussion of the Group's philosophy would be complete without reference to their employees. The Company is only as good as its people, and the company's journey through the crisis was helped by their efforts, flexibility and understanding.

In 2009, ArcelorMittal had **revenues of $65.1 billion and crude steel production of 73.2 million tonnes**, representing approximately 8 per cent of world steel output. The same year, the company had sales of approximately $65.1 billion, steel shipments of approximately 71 million tonnes and crude steel production of approximately 73 million tonnes.

As the ArcelorMittal management puts it, "Steel is a versatile material whose properties allow it to be used in a wide range of applications requiring varying weights, strengths and levels of corrosion resistance. Steel is also highly economical. Its complete recyclability makes it an environmentally friendly material. Our customers around the world transform steel into demanding applications, including roofing and building equipment, food containers, pipes and appliances."

**ArcelorMittal Steel Plant in Temirtau-Kazakhstan,** produces steel of various types used all over the world. The plant has various factories which produce steel, coal from ores and provides power supply, water supply etc to Temirtau city. Pollution control has been the major concern and is an important point to be taken care of.

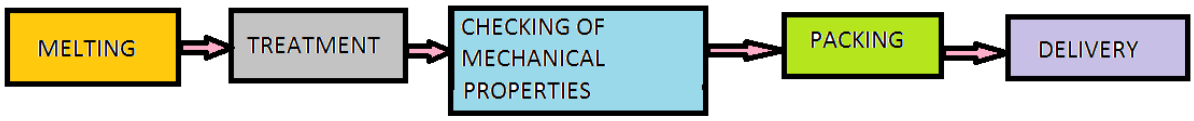
An overall brief description to the plant can be shown via a flow chart:



# STEEL PRODUCTION

Metal steel is very important and will exist in times to come. One can make it in any shape. Steel is used in various fields including construction. There are over 5 million workers overall in the world that work in steel manufacturing companies. 315 thousand of them work in ArcelorMittal Company. Over 102 Million tons of steel is produced overall and the company holds first place in the production of steel.

The production of steel can be depicted by a flow chart as follows:




The various physical properties that are taken into account during the steel production are:

1> Hardness
2> Welding
3> Electrical Transmission
4> Temperature Resistance
5> Ability to Deform
6> Keeping initial form

Special kinds of steel types are produced in hot rolling mill, cold rolling mill, white/black tin plate, galvanization, plastic carbon rolls and bar mills. 79 kinds of standards are there for metaprobes. Up to 780 grades of metal products are produced – 445 grades of hot rolls, 128 grades of cold rolls, 6 grades of tin rolls and 171 grades of bar rolls. Sheets, foils and strands are produced out of these. 10 to 23 tons of hard rolls are produced. Different grades are produced for the customers (eg. Steel for car parts, motors, barrels etc is made by the cold rolls). Steel carbon is a special kind of cold roll produced. The coils of weight nearly 8 tons are delivered at once.

Tin plate grades are of two types: black tin (with actually no tin covering) and white tin (with tin coating). These can be delivered in coils or steel packets. The white tin is nearly same as black tin but has some more covering of tin.

Galvanized rolls are produced up to 800,000 tons. They are in the form of coils, sheets or profile sheets. They are also used for construction purposes, pipes, air

ventilators, roof coverings etc. They are also used for making containers and packages.

Bar mill produces small kinds of bars. Also average or medium products are also produced. Amateur bar mill produces bars with thickness 8-30mm round in shape having diameter 14 to 15mm. Steel can be molded into different shapes like angles, stripes, round and several others. The bars produced are about 6-12m long and weight of each package is 3-5 tons.

Hot rolling mill produces hot rolls. The capacity of hot rolling mill is 4.6 million tons. The hot rolling plant uses oil and coke gas as fuels. Cold rolling shop 1 has 12 stands and they are the main equipments of the shop. In this shop, rolling of hot stripes is performed - thickness 1.5 to 12mm. Very thick and hot rolls can be produced (20-186mm). Before rolling process, the metal is heated. Cold rolling shop 2 is mostly used to create products for car industries. Metal straps are pickled with acids. The production in this shop is about 1.3 million tons per year.

After rolling, the products are divided into two parts for: 1. Galvanizing shop and 2. Thermical treatment (metal treated without air for no oxidation). It is difficult to make metal hard once it is softened. In cold rolling shop 3, paper like sheets of metal are formed. This shop has 6 stands used for rolling the tin plates. After rolling, thermal treatment is performed.

In case of white/black tin plates, black plates have no tin plating in general while white plates have tin plating. This process is very different from Galvanization. In Galvanization, some other metal (mostly zinc) is coated over steel surface to provide corrosion. In plastic carbon rolls, various colors are painted over carbon and hence corrosion is resisted. Similarly, in bar mills, the steel billets are converted into bars and the carbon content in the steel is taken care of.

# PLANT VISIT

The following sites or shops are the places where we visited in the ArcelorMittal steel plant sequentially:

## ➢ Four Warehouses

- There are four positions where ores are deposited. There are layers of certain pattern that the ores follow as they form a heap shape or gather over each other. Then this ore is used for production. Heap-1and heap-2 are for the iron ore and heap-3 and heap-4 are for complimentary materials. The ores which came from different places of Kazakhstan are of different colors and are arranged accordingly in the heap.
- Size of particle of iron ore – 8cm
- We crush it and convert in the size of 10mm.
- Then the process of enrichment is performed.

## ➢ Crushers

- The raw crude ore pieces are brought to the crusher machine and they are crushed into smaller particles.
- Very fine particles are taken into sintering machine.
- The finely crushed ore pieces are sprinkled and leveled evenly on the sinter machine and they are heated in presence of coke and oxygen.

## ➢ Sinter Shop

- Iron ore is mixed with coke.
- We use coke because it is porous and enhance the heating of iron ore.
- The mixture of ore and coke is put on the cart which has pores in it.
- There are three machines each has 143 carts.
- Carts carry ore from warehouse to sinter shop.
- Coke gas is used to heat the mixture which maintains the temperature around 1100 C to 1200 C.
- And then the mixture is cooled.
- If size of the particle is less than 7mm it is melted again else sent to next stage.

## ➢ Coke and Chemical Plant

- There are seven batteries which are like furnaces.
- In each battery we heat the concentrated coal in absence of air to get coke which is used as a fuel in blast furnace.

- This coke is carried to a tower in which it is cooled with the help of water for 4 minutes.
- The water used in the tower contains small particles of coke.
- Therefore, this water is filtered and the water is used again.
- Unloading of cooled coke is done by dropping them on the conveyor belt and then coke sorting is done.
- Sorting is done according to the size of particles.
- If size of a particle is less than 40mm it is sent to blast furnace else sent to sinter shop.
- Coke gas obtained is also purified and while it is done we get tar as an output.
- This coke gas is used in sinter shop to heat the ore.

## ➢ Blast Furnace

- 70% of the total material used here is from the last process which is coke (fuel).
- Coke from coke tank is taken to another tank which is mixed with other materials.
- Then this mixture goes to the furnace, it is blown with hot air.
- Ignition of coal is done and then mixture starts melting.
- Output of the reaction is liquid iron and slag.
- To get liquid iron from the blast furnace we require 8 hours.
- Side product of this process is furnace gas which is inflammable and used in various shops.

## ➢ Basic Oxygen Furnace (BOF) (Converter Shop)

- The convertor shop has the following three in processes:

➔ Mixer
➔ Casting line
➔ Converter

- First we put reflecting materials and then we put iron from the blast furnace and then oxygen is blown through pipes called glands.
- This oxygen oxidizes the carbon present and is converted to carbon dioxide.
- Molten pig iron goes to steel ladle.
- From steel ladle, it goes to intermediate ladle and there alloying chemicals are added to improve the properties.
- Then this chemically treated iron goes to the two rolling lines which form the shape of the final product.
- The final product is the slabs formed by the casting lines having dimensions 750mm to 2m width, 180/200/220mm thickness,4.5 to 10 m length.
- In this process only, the billets are formed from the slabs that are further used in the bar mills.

## ➢ Bar Mill

- Basic work: to convert the "billets" into different shapes (bars, different angles etc.)
- Process:

1> Billets come on rolling machine; they move it inside the heating machine (furnace)

2> The shape formation is done in a main stand that has 16 different stands – here compressing of billets takes place which are very long and hence are cut later.

3> Cooling bed- after pieces are formed and cut they are cooled down here.

4> Finally they are cut again (according to the requirement) and are packed for use.

## ➢ Hot Rolling Mill

- Basic work: steel sheets and coils are formed
- Process:

1> Slabs from BOF- preheated .

2> Four separate furnaces heat them , each having capacity of 30 slabs.

3> Now rolling and compressing is done by 2 separate stands – black (preface- compresses less) , white (final-) stands. Each of them consist of – back up roll(provides pressure) and working roll (creates movement and form metal).

4> Finally after this step we get a 2 mm thin sheet.

## ➢ Cold Rolling Mill

- Basic work: Washing and further thinning process performed.
- Process (in reverse order):
  1> The steel sheets that comes to this shop are washed with acid(to remove impurities). The process is also known as pickling.
  2> To make the sheets more thinner, they are put into thinning stands and then heated in a furnace with coal gas and coke.
  3> Then the product is taken to the tampering mill where it becomes strong and with a thickness of 0.4mm.
  4> The sheets are then covered with pulp oils (0.18mm) so that the product does not stick to the $6^{th}$ stand mill.
  5> The deformity in the sheets that comes from hot rolling mills are called scales.
  6> After covering, we do cleaning again (kind of brushing).

## ➢ Galvanizing Shop

- Basic work: Production of coils, sheets and profile sheets.
- Process:
  1. The sheets come into the shop and are put into an electrolytic solution of zinc.
  2. Then the galvanizing process is performed and the sheets are galvanized.
  3. The galvanized sheets are then rolled again and good quality product is exported via rail.

# INTRODUCTION TO AUTOMATION

- Scheme of automation of plant and consider this scheme in Siemens.
- Siemens presents various automation levels.
- There are 7 levels of automation.
- Level I is fuel level and some executive stuffs are presented in this level.
- Level II is programming the controllers.
    - 200-300 serial controllers
    - 400 serial controllers
    - Programming devices presented on this level.
    - Station PCS7 are located in this level.
    - System of treating, storing and developing are presented in this level.
- Details of 2nd level of automation:
    - 200 serial controllers (only power station and CPU).
    - Input/ Output devices can be analog or digital.
    - Lowest capacity controller
    - This controller does not suffice the needs and hence it is not used in the plant.
- **S7-300 details**:
    - System based on controller of 300-serial.
    - 4 stands used in this controller
    - Devices-practical task letter
    - Base of the device is rail.
    - Rail is passive element (doesn't contain any electronic-piece of metal).
    - Different blocks and systems are fixed on the rail.
    - Block is connected to one another through a connector and then put on the rail.
- Elements that are basis of 300 controller:

1. **Power Station (PS)**:
    - It is an optional element.
    - Nowadays we have to use it.
    - But in all systems, it has a part of CPU.
    - Now, this element is separately used.
2. **Central Processing Unit (CPU)**:

- It is the processing unit of the processor.
- Generally placed after PS in sequence.

3. **Interface Model (IM)**:
    - It is put in third position (i.e. after PS and CPU).
    - If the system is on some set of rails, rails have to be connected.
    - Interface must have some model to connect there on one rail.
    - We don't need any model.
    - Resolve the phase of interface model.
4. **Signal Model (SM)**:
    - In the form of Digital input and digital outputs.
    - Also in the form of Analog inputs and analog outputs.
5. **Functional Model (FM):**
    - Functional models can be used for interactions.
    - They are executed quicker than programs.
    - Hardware is quicker in comparison.
    - Different standards: counting/position/closed loop control.
6. **Communicating Processor (CP)**:
    - Connected to different systems.
    - It has different standards including point-to-point/profibus/Industrial net.

- **S7-400 Controller**:
    - It has the highest performance compared to other controllers.
    - System of 400 serial is same as the structure of 300 controllers.
    - But there is one difference which is: IM can be placed anywhere in the sequence.
    - In our case IM is placed in the last.
    - Intellectual rail (not a piece of metal but electronic element) – we can put some models in these rails.
    - Models are connected almost parallel.
    - Connectors connect the devices one-by-one.
    - In case of parallel convertors, if one model is broken then also the other models will work.
    - These are the main differences of 400 controllers and 400 serial has highest performance of all.

# PROGRAMMING THE CONTROLLER

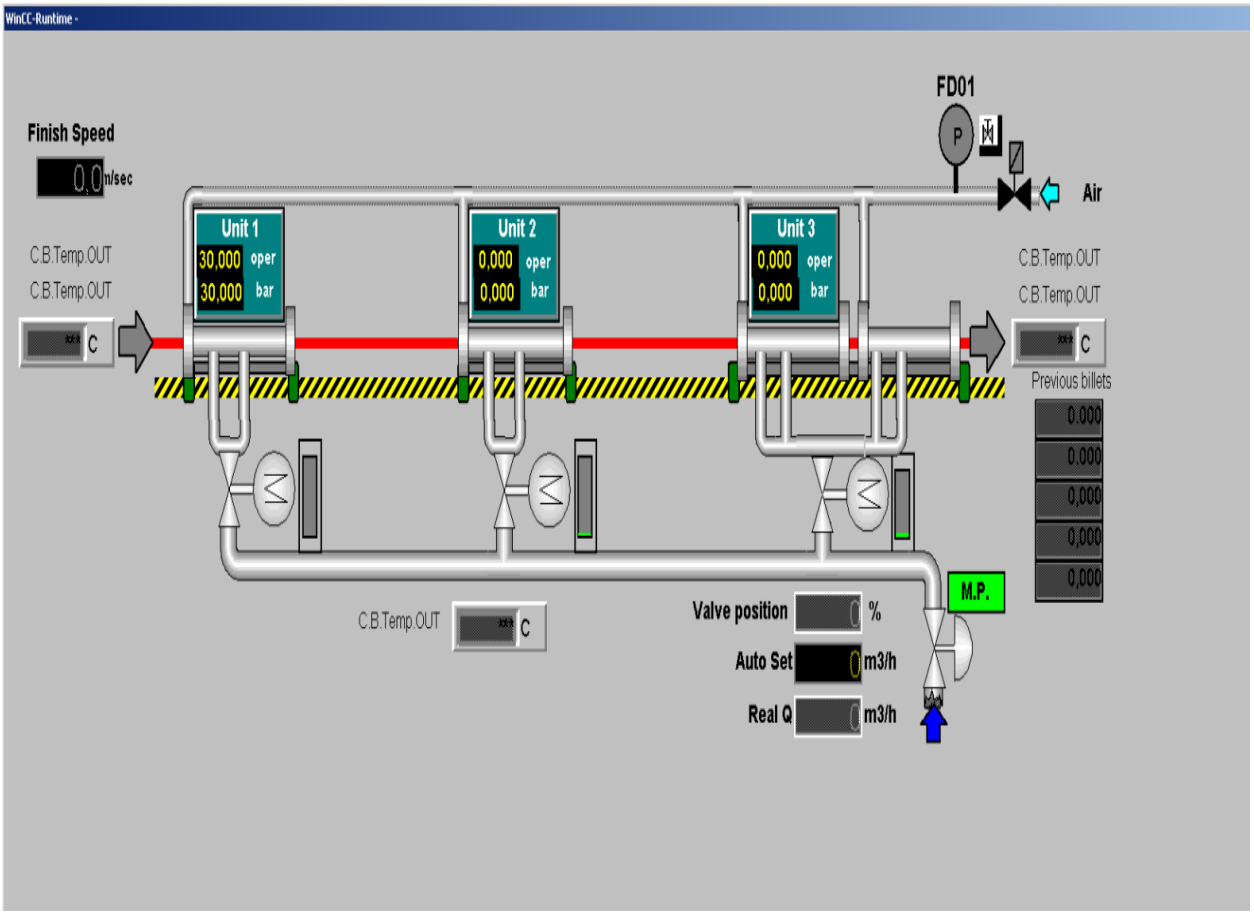
- The controller does not have any program initially.
- One can connect screens/keyboards to the controllers (that is why controller is connected to program devices).
- Program units are presented by Siemens.
- Any computer can be made into programming unit.
- **PCI Card**:
    - This card can be inserted into any desktop or laptop and can be connected to any controller.
    - With the help of this card, we can make program of our wish.
- **CPI Card**:
    - CP5613 also there.
    - All components are connected together so any one can be used to program the controller.
- **MPI net**:
    - It is the multipoint interface net.
    - Several programming devices in one net convenient to have such system.
- Common things:
    - There are some indicators in the processor.
    - **SF** – System fault indicator (if RED then mistake).
    - **BF** – Bus fault (CPU has output in **PROFIBUS**).
    - If on PROFIBUS, we have fault, then RED indicator will be turned ON.
    - **CPU s7-300 (314C)** – does not have PROFIBUS (so NO indicators).
    - For diagnosing – we use LEDs (Faults/OK).
    - **CPU 315-2DP** has **BATF** – Battery fault (in our case we didn't have it).
    - These have accumulator battery–if battery is discharged – Indicator BATF – RED.
    - Controllers have RAM and this RAM contains program and data.
    - Accumulators are used so that we don't lose data when we turn OFF the system.
    - **FLASH** memory is used in this controller.
    - Everything is saved in FLASH and RAM.
    - Standard **MMC card** is used (small size) of 64 KBs.
    - **DC 5V** – Potential is 5V.
    - **FRCE (FORCE**) :
        - This is a special mode for the controller.
        - This mode can be used in an emergency case.
        - Usage of this mode is not normal.
        - This is used when bad programmers work on the controller.
        - In this mode, we can manage all the outputs of the precision.
        - Generally, good programmers knows about faults of program
    - **RUN** – Green indicator implies that the program is working.
    - **STOP** – (ON/BLINK) : Program not working.

# PROJECT DESCRIPTION

- Project Allotted : **Modernization and Automation of the Bar Mill**
- The following is the sequential processes in the Bar Mill
  - **HEATING FURNACE**
    - 4 separate furnaces heat the billets coming from BOF
  - **16 PRESSING STANDS**
    - Heated billets can be shaped into different forms.
  - **COOLING STAND**
    - Bars are cooled down and their quality can be improved
  - **CUTTING**
    - Long formed products are cut down according to requirement
  - **PACKING**
    - Final products are packed into bunches and loaded in trains
- **Cooling station (Our main task was the Automation of this part)**
  - 4 underground pumps - amongst which maximum 3 can work. M1 and M2 work always. And M3 and M4 are used when any one of them does not work.
  - In each pump there is one gate valve which is automatic and another valve which is manual generally used for repairing purposes.
  - This underground station is a connecting network to the cooling station above the ground and they are connected via a position valve.
  - This position valve plays the main role in regulating the water flow rate hence controlling the pressure.
- **3 sections of cooling stand**
  - After finishing stand the temperature that is before cooling is about 250.304 degrees.
  - After 3$^{rd}$ stand the temperature of bars is 554.427 degrees.
  - Length of bars after first two stands is the same. But the length can be altered in the 3$^{rd}$ stand according to the required diameter.
  - Last stand is particularly used to roll smaller diametric bars since here the water and air pressures are lower as compared to the rest two.
- **Problem statement**
  - To automatically set the two main parameters i.e.
    1. Water flow rate
    2. Water pressure

    in cooling station for better quality and enhancement of bars.

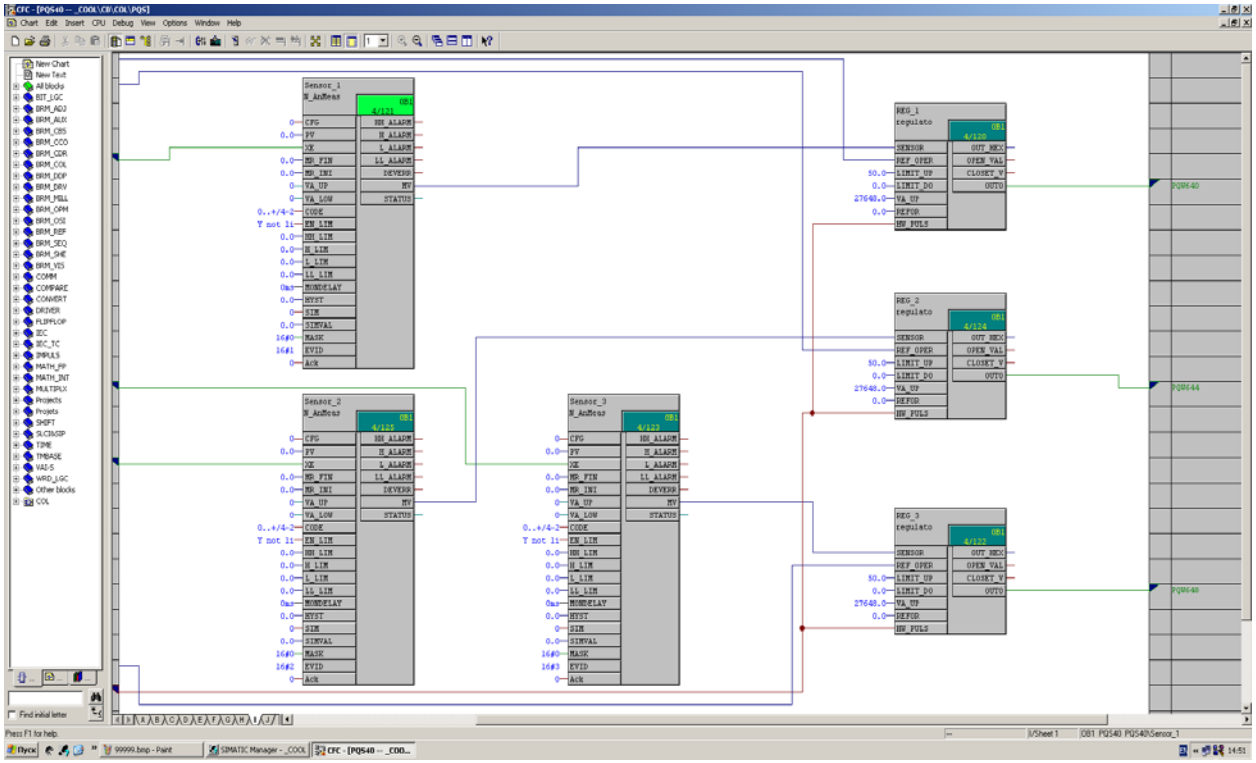
- **WinCC Layout**



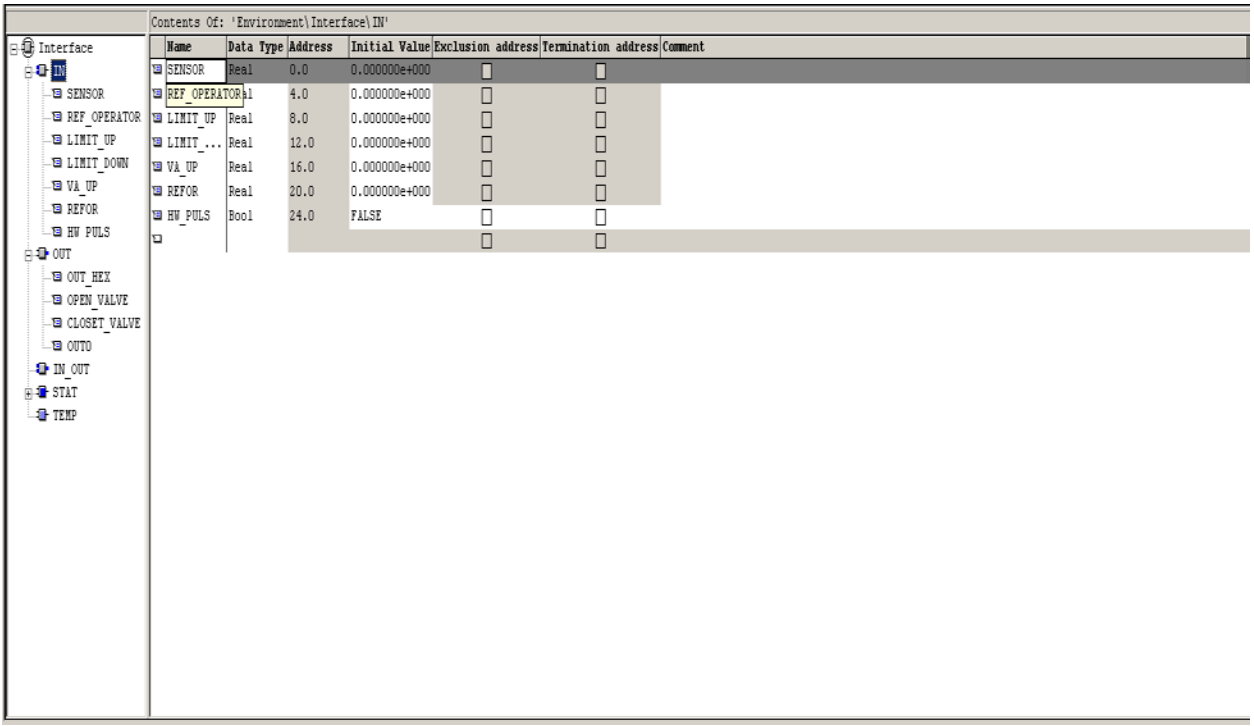

- **Our Aim**
  - We have a pressure sensor in the above mentioned cooling station to sense the incoming water pressure.
  - Further this pressure is compared with the pressure given by the operator. If it is not equal to the given pressure the 3 regulators adjust the valve outlets accordingly to make them equal.

## ➢ CFC Chart

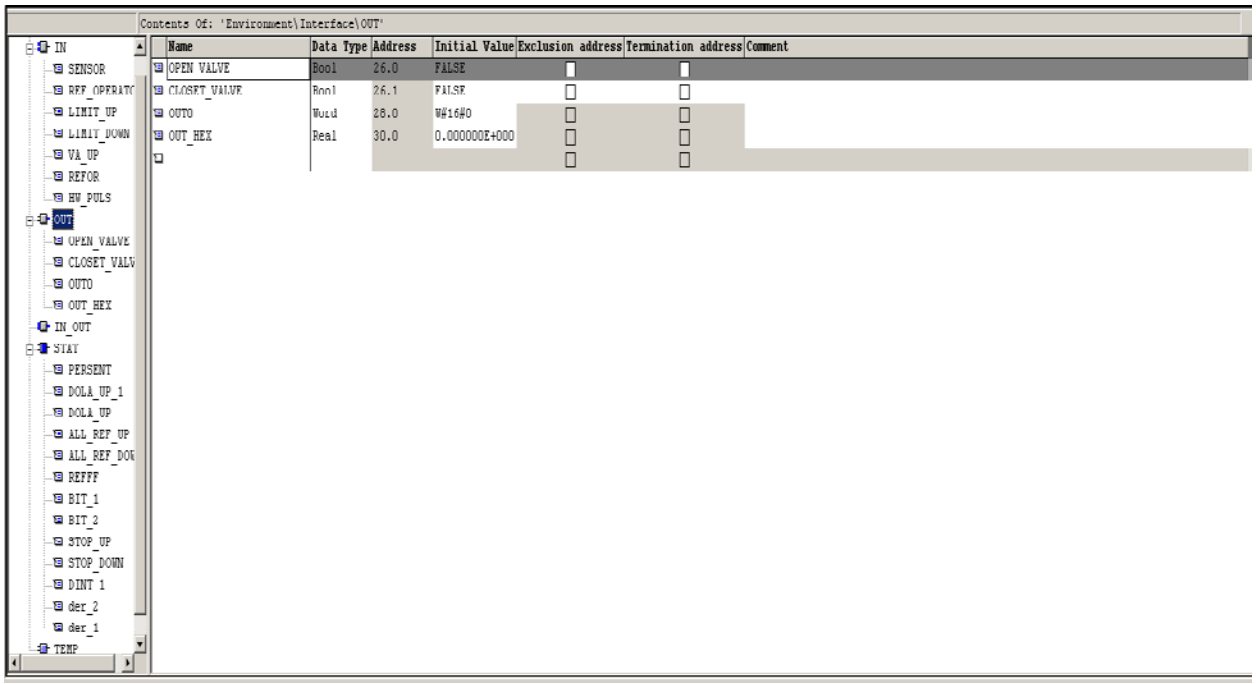
### o FUNCTIONAL Block



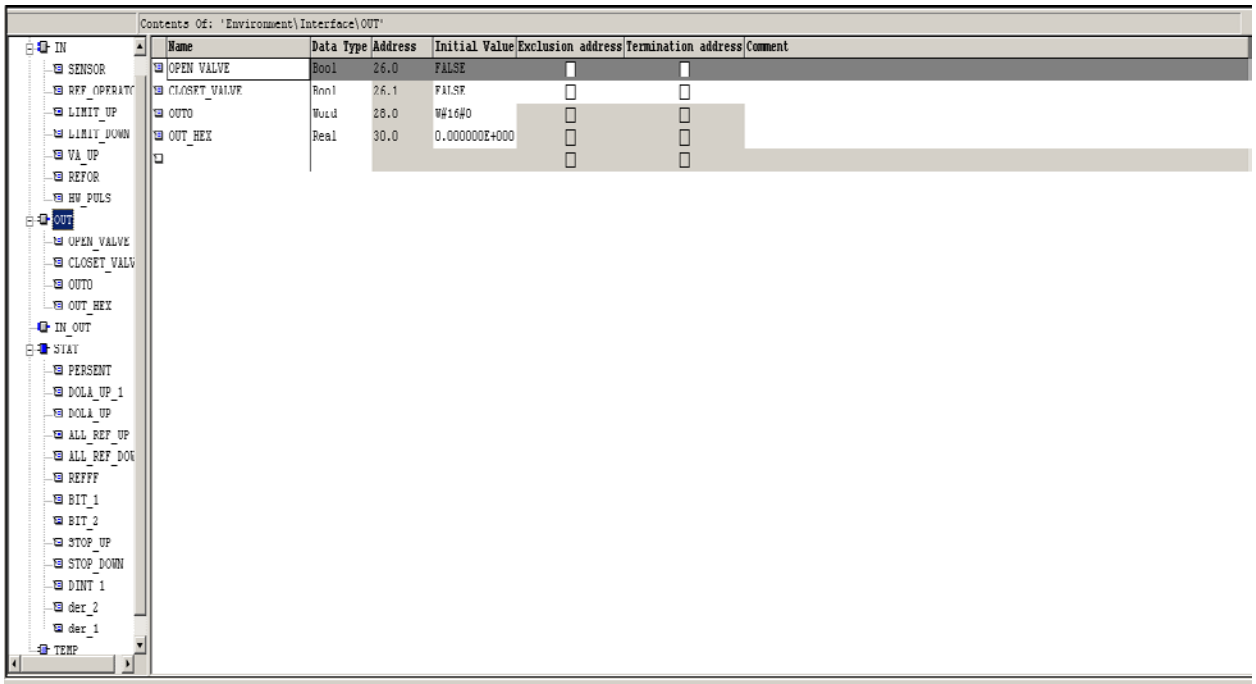
### o INPUT Block



- **OUTPUT Block**



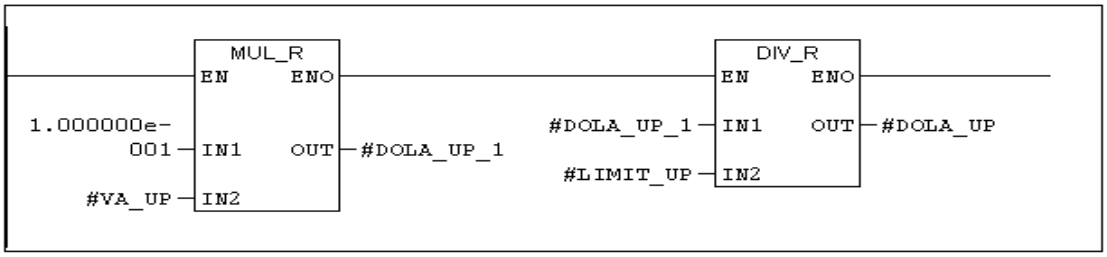

- **STAT Block**



## ➢ Networks ( PROJECT):

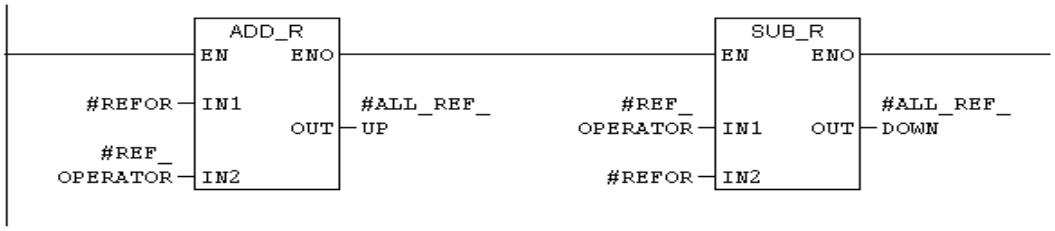
**Network 1**: Title:

Comment:



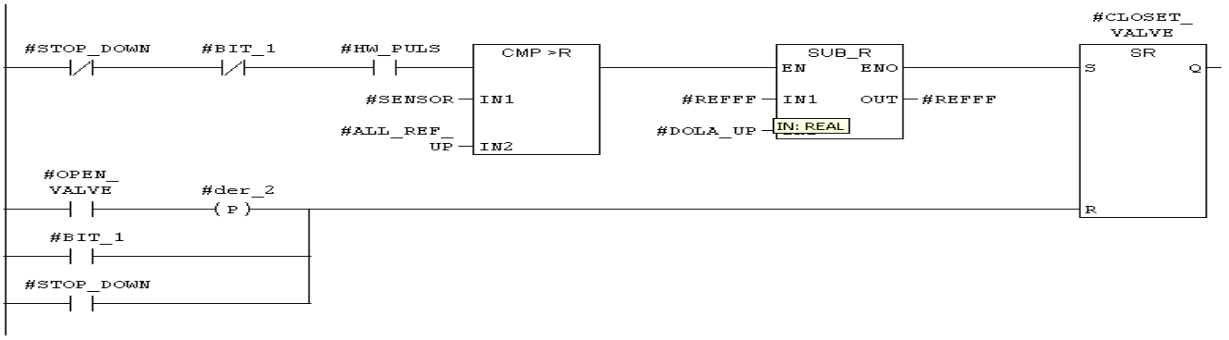

**Network 2** : Title:

Comment:



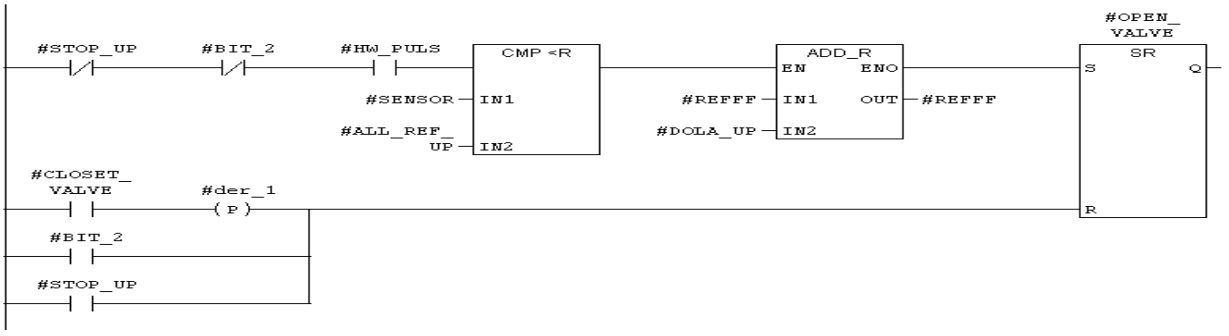

**Network 3** : Title:

Comment:



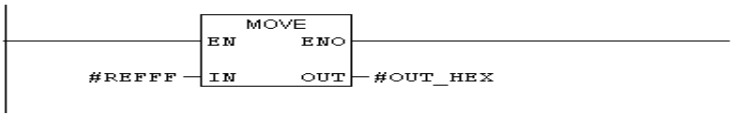

**Network 4** : Title:

Comment:



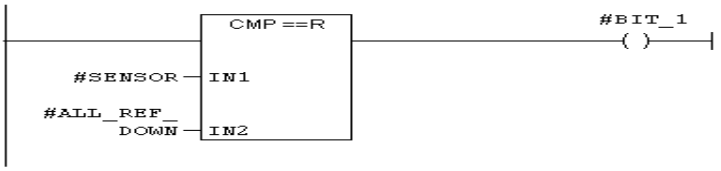
**Network 5 : Title:**

Comment:



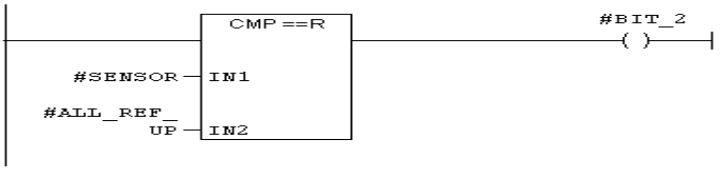

**Network 6 : Title:**

Comment:



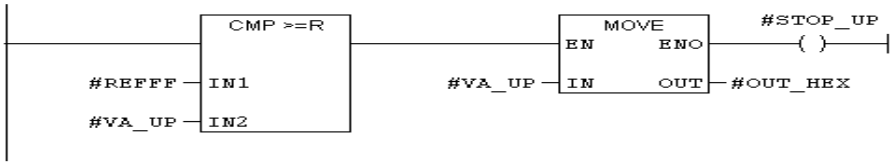

**Network 7 : Title:**

Comment:



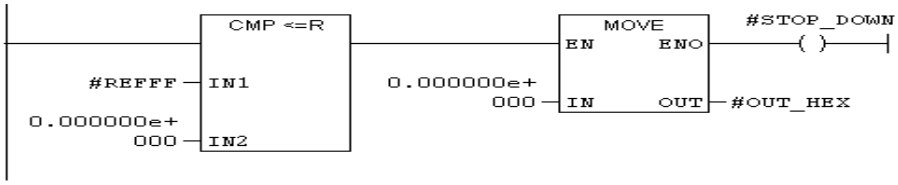

**Network 8 : Title:**

Comment:




**Network 9 : Title:**

Comment:




**Network 10 : Title:**

Comment:

# BIBLIOGRAPHY


1. Instructor in the Training Center, ArcelorMittal, Temirtau, Kazakhstan: **Mr. Oleg.**

**2.** Engineers in the plant: **Er. Evgenay, Er. Sergey and Er.Alexander.**

3. My group members: **Vikas, Shubhi and Natasha.**

4. Report by **Venkatesh Vishwanathan (Senior Colleague).**

5. Meetings held every day during the internship period by **Prof. Amit Neogi.**

# CERTIFICATES

## ➢ CERTIFICATION OF INTERNSHIP PROGRAM (MAY-JUNE 2012)

ArcelorMittal

Отдел Подготовки Кадров

CERTIFICATE

*This is to certify that* ***Mr Sumit Gautam*** *of The LNM Institute of Information Technology, Jaipur, India has successfully completed the project* ***"Modernization and Automation of the Bar Mill"*** *under summer training program during May-June 2012 at ArcelorMittal Temirtau, Kazakhstan.*

*His Performance has been* Excellent.

Chief Executive officer Vijay Mahadevan

25 June, 2012

- **CERTIFICATION FROM THE TRAINING CENTER, ARCELORMITTAL, TEMIRTAU, KAZAKHSTAN**

ArcelorMittal

Отдел Подготовки Кадров

# CERTIFICATE

*This is to certify that*

***Mr Sumit Gautam***

*of The LNM Institute of Information Technology Jaipur, India has undergone summer internship in the field of PLC from ArcelorMittal Temirtau, Kazakhstan.*

*His performance has been good.*

21 June, 2012.

(O. Koksharov)
The Leading Electronic Engineer
ArcelorMittal Temirtau