SAVONIA

Manufacturing and Erection of Telecommunication Towers

Mechanical Engineering and Production Technology

Engineering and International Business Varkaus

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Bachelor's Thesis

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SAVONIA UNIVERSITY OF APPLIED SCIENCES **THESIS Abstract**

Field of Study Engineering			
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Abstract

Telecommunication towers are a combination of steel structures that used for communication purposes among people. All the wireless communication, mobile networking, radio broadcasting and television antennas are connected via these towers.

A full telecommunication tower is a whole set of mechanical structures and electronic signal processing unit which is used to connect the people via telecommunications. All the telephone lines and mobile phone services are connected through these towers. These towers are also used for radar system and other armed forces purposes.

Different heights of towers are used in different places and purposes. They can vary from 15 to 60 meters and some time more if required. For example in the land areas towers are higher in hill area so 15 to 30 meters high towers can be used but in land areas they are 30 to 60 meters in height.

The Goal for the final project was to learn the sequence from manufacturing to erection and the step by step manufacturing processes of telecommunication towers. Material used for it, different machine processes, corrosion protecting techniques, logistics and supply, final erection of towers on sites were learnt in detail and different techniques were used.

Keywords
Flow Chart, Manufacturing Processes, NDT, Hot Dip Galvanizing, Quality control, Erection

Confidentiality
Public

Contents

Tables and figures

Terms and abbreviations

ATL	**Associated Technologies Limited**
HDG	**Hot Dip Galvanizing**
MAG	**Metal Inert Gas**
GMAW	**Gas Metal Arc Welding**
QC	**Quality Control**
QA	**Quality Assurance**
AC	**Alternating Current**
DC	**Direct Current**
NDT	**Not Destructive Testing**

1 Introduction

Telecommunication towers are used for communication purposes among people. All the wireless communication, mobile networking, radio broadcasting and television antennas are connected via these towers.

A full telecommunication tower is a whole set of mechanical structures and electronic signal processing unit which is used to connect people via telecommunications. All the telephone lines and mobile phone services are connected through these towers. These towers are also used for radar system and other armed forces purposes.

Different heights of towers are used in different places and purposes. They can vary from 15 to 60 meters and some time more if required. For example in the land areas towers are higher in hill area so 15 to 30 meters high towers can be used but in land areas they are 30 to 60 meters in height.

There are different types of the telecommunication towers which are used i.e. monopole, self supporting and guyed etc. The most used are the self supporting towers in the field of telecommunication, which is the specialization of final project and thesis as well.

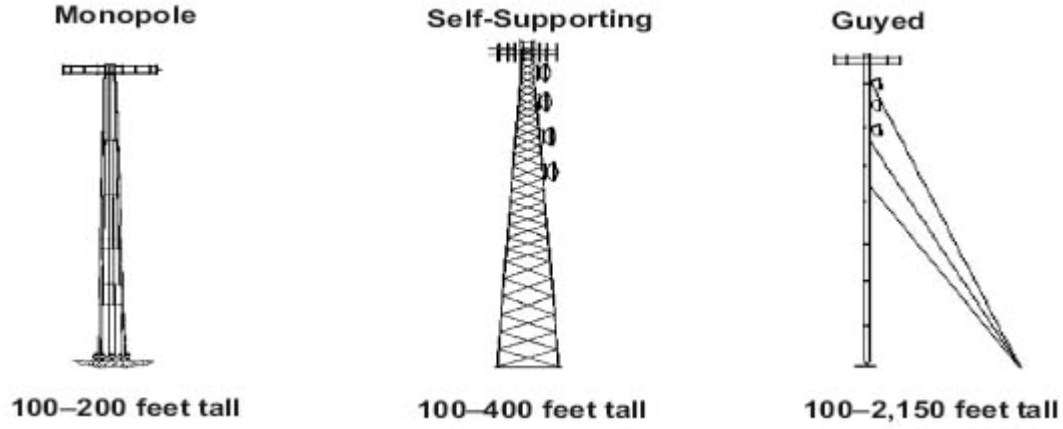

Fig 1.Types of telecommunication towers. (Elcosh organization. 2011)

Telecommunication towers are manufactured in the factory and later erected on the site area. A tower takes up to two weeks to be completed and some time even more; depending the site and the height of the telecommunication towers.

2. Company Details and Field of Project Work

2.1 The Company

The company where work placement and project work was done is located in Lahore, Pakistan and the name of the company is Associated Technologies Ltd. It's a well reputed and ISO 9001 certified company in the country with matchless quality. It was established in 1987 with small business and now it's one of the well established and well reputed company in the country.

Fig 2. Location of company (auto bar pvt ltd. 2012)

2.2 Products

ATL deals with all kind of infrastructures i.e. steel structures, hydro power projects, thermal power projects, construction works, housing and buildings, telecommunication towers, civil works and other energy division works etc.

Hydro Power

Steel Structure

Electrical power plants

Infrastructure and Construction

Fig 3. Products of ATL Company (ATL. 2011)

Steel structure

Associated Technologies Ltd has a big enough manufacturing unit in the industrial estate. The company manufactures all the steel structures according to client's requirements. All the telecommunication towers with different sizes from 15 to 60 meters are manufactured in the factory unit and then further transported to the sites for the erection purpose.

In this manufacturing unit the company has a team of management, engineers, accounting and finance division managers, supervisors and workers. They work in teams work and do different projects given by the clients.

Hydro power

ATL has its own team to work on both private and government sector. It works in hydro power division on the contract basis as well. Different clients all over the country are dealt for different projects by ATL.

As the Pakistan is an agricultural based country so it needs water for that purpose and there are about 25 dams, reservoirs and lakes in Pakistan. At the same time hydro power energy is used to generate electricity for the country needs for both public and industrial areas. ATL is also providing its services in the hydro power sector around the country.

Power plants

ATL also deals with the power plant industry. The company has its staff, machinery and equipments and works on the power plant projects around the country. It provides power plant installation facilities and maintenance/services facilities too. The company's head office deals with all of its clients and takes new contracts.

Infrastructure and construction

Infrastructure and construction facilities are also provided by ATL. The company works for both private and government contracts. ATL has been involved in construction of high buildings and bridges around the country and took its part in infrastructure.

ATL has well experienced management with skilled labor that works for different projects around the country.

2.3 Field Of Project Work

The Field of final project and thesis was in the field of fabrication and erection of telecommunication towers. Starting from raw material to fabrication and erection of towers, all the operations are done in factory unit. The company has its own manufacturing unit in industrial area with about more than 60 workers and staff who work in different units of the factory. General Manager of the company was supervisor for final thesis and project work.

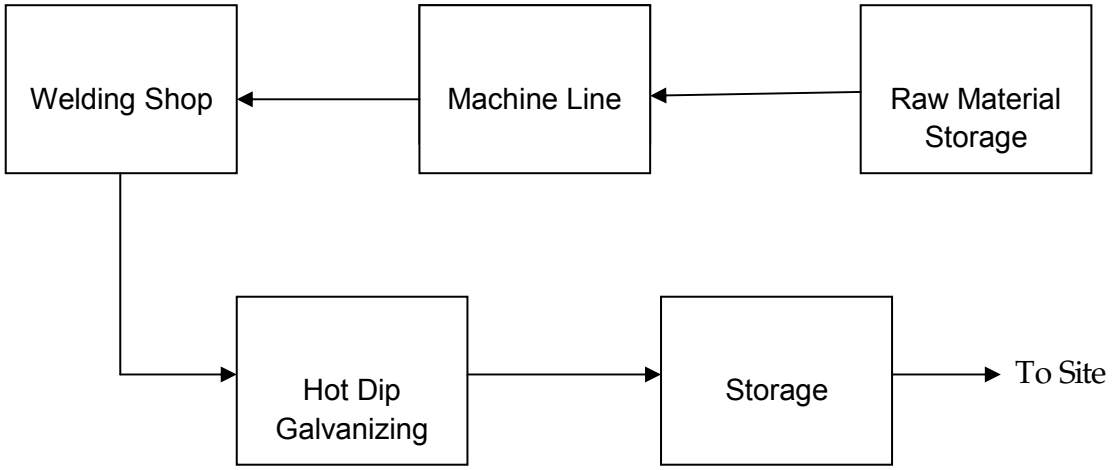

Fig 4. Sequence of operations in factory unit

Manufacturing units of the Factory

Raw material storage

ATL factory's raw material storage is spread over the vast area about 400 meters square. All the raw material is unloaded by trucks here in this storage, the storage have its own toll to weight the steel angle bars and other products while either coming in the factory or while outgoing. All the necessary paper work is done and the documents are safely placed in order. There is a supervisor and some helping staff that works in the storage and takes care about all the necessary jobs in the storage.

Machine line

Machine line of the company has several different machines i.e. power presses, drilling machines, grinding machines in different sizes, milling machine and lath machine. Some mechanical conveyors are used for the handling of steel profiles because they are heavy in weight. The Machine shop of the company has all the important tools and its layout is according to safety rules.

It was important to go through with the working principles of different machines, how they work, how to manufacture the work pieces according to the drawings, and what kind of tools, different lubricants and coolants are used for them. Meetings were held with the machine line supervisors and guidelines were taken from the company supervisor and different manufacturing processes were done for the manufacturing of telecommunication towers.

Welding shop

Welding shop of the company has big enough area to do 3 different kinds of welding at same time and about 15 workers and a foremen works in this department. Work was done to learn about the different techniques for manufacturing welding joints and the use of different non destructive testing for the welded parts.

Hot dip galvanizing

The HDG plant is big enough and has 8 baths for degreasing, and molten zinc. The work was done to learn about the different techniques and quality checks (discussed in details in coming pages). When the HDG process is done, after quality check the final product is sent to the storage and then further to sites according to client's orders.

2.4 Working Tasks and Procedure

The work was done in all units of the factory. The work placement and thesis timings were scheduled according to instructions given by supervisors. For that, the work was done in all the factory units, mostly in production line and technical documentations area.

During the work placement, the main job was to understand the working principles of different processes and project work. During one year work placement, couple of hours was served

every day for project work as well. Guidelines were taken from both of supervisors at the university and work place.

According to above Fig 4, the work was done in all areas of Associated Technologies Limited.

2.5 Planning

Planning of this project was started when an email about basic task of the project was received from Mr. Zahid Shah (General Manager) from Associated Technologies Limited (ATL). For setting up about the main idea of this project, several meetings were arranged among the team members. The project scope was defined by discussing the problem and their solutions. It was decided to divide the project into phases to make it easy and explanatory.

Information sources concerning the research topic were analyzed and it was decided to start research immediately.

2.6 Research

Every research project starts with an idea but with limited information. This project was also started with an idea of extension but there was only limited amount of written and oral information. So a thorough information search was necessary to collect information about the technical documentations of manufacturing and erection of telecommunication towers, its existing system, dimension, standards and material list etc.

Machining and HDG was most important research area because it helped to take initiative in the whole project. Methods used in this area included information search through internet and meetings with the department supervisors and QC department to study operating systems.

Meetings with Mr. Zahid Shah were arranged to discuss and learn about the whole system and some upgrading. I.e. to provide information to machine operators, improvement in HDG plants and MAG welding etc. phone calls were also made to him to find out about the practical questions which arose time to time as theoretical knowledge about the process increased.

Understanding of existing system was a big task in such a big factory unit. The basic idea of existing unit was understood with the help of pictures provided by the company and through the practical visits during work placement, as it was necessary to see the whole system on the factory, so guidelines from the manager were taken.

Also visiting sites for the erection was a challenge in research, especially to travel around on site nationwide. Travelling to some sites was the part of thesis as well, which helped to understand the erection of tower thoroughly.

So mainly, the research of the project was from manufacturing to the final erection of the telecommunication towers. It include the manufacturing processes, HDG, transportation and working on sites to know about the whole system of telecommunication towers.

3 Manufacturing Process of telecommunication tower:

Manufacturing processes of telecommunication towers and the flow of material and products can easily be understood by the following flow chart in fig 5.

3.1 Flow Chart

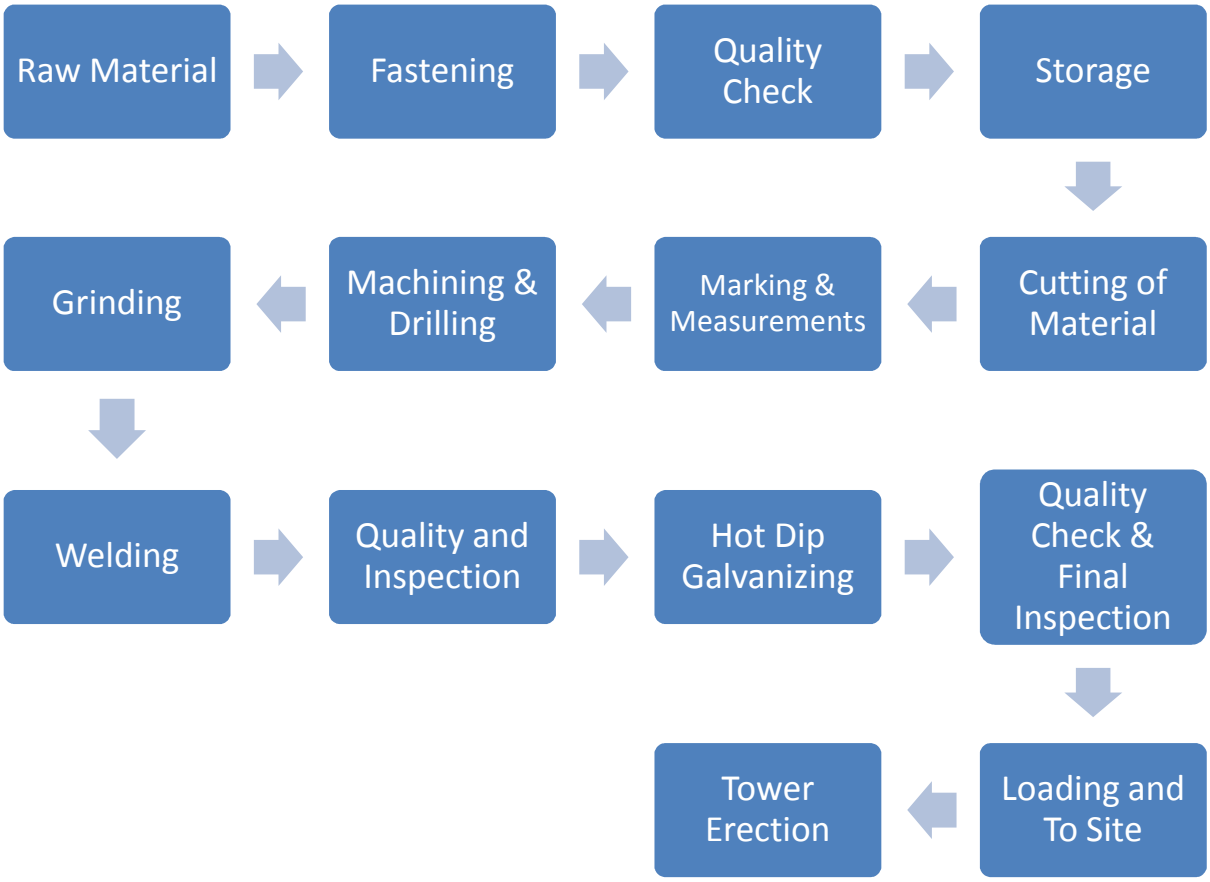

Fig 5. Detailed flow chart of company

3.2 Raw Material

The raw material used for manufacturing of self supported telecommunication towers are steel angle bars. It can be in different sizes and different profile types i.e. L, V, T-shape and flat angle bars (see Fig 6), iron net and other sheet metal etc. Steel in normal condition itself is corrosion resistant but for further improvements HDG and paints are applied.

Raw material is chosen according to the structural parts, for example most heavy steel angle bars are chosen for the purpose of tower leg parts and other different parts are used in different sizes for structural member of telecommunication tower.

Raw material is directly purchased from the suppliers and as the company has mass production so different suppliers supply raw material for manufacturing processes. Steel angle bar material is according to international standards and specifications. Its quality is checked both by suppliers and company itself because in such case of designing tower for the age of 25 years, the tower material must be chosen according to standards.

Steel angle bars are directly transported to company storage and they are further sent to machine shop for further processes after quality check.

Fig 6. Different steel profiles (Bocad company. 2012)

3.3 Fastenings

Fastenings are the necessary parts of tower which are used to fasten the different part of towers. They are used only during erection of towers and are supplied by the suppliers. The supplier itself is a company that makes different fastening in different types and sizes i.e. bolts, nuts, washers and anchor bolts which are used to fasten leg joints to the foundation.

Fastenings are also transported directly to company storage and its quality is checked both by the supplier and the company. When company's orders are confirmed by clients then a complete tower structure and fastenings are transported to sites for final erection of telecommunication tower.

Fig 7. Fastening (Excel fastener Inc. 2012)

3.4 Quality Check

When raw material and fastening products get to the factory, it is needed to check the quality of products. The factory's QA department has responsibilities to assure the quality of both of them.

There are two sessions that are responsible for their quality check, one is for raw material and another one is for fastening. Mostly the raw material is supplied by suppliers and its according to standards but if some wrong material and any material which does not meet the company requirements is found, is informed to supplier or sent back.

The QC department is mostly responsible for the quality check of fastening which is supplied by the suppliers. All of the fastenings are checked step by step. The company has different charts and tables according to standard and different gauges are used too for checking lengths, diameters, threads and some other dimensions according to drawing. Some measuring tools i.e. vernier caliper and micrometer are also used.

Drawing samples are also provided to suppliers so that they could supply the fastening according to ATL standards and requirements. So, for that, quality is checked twice, both by the supplier and the QC department of ATL.

Thread Gauges

Sheet metal measuring gauge

Fig 8. Basic quality tools used for QC (Alibaba trade company. 2012)

3.5 Storage

The factory has its own vast storage where they store raw material, fastening products and some different tools. There is a storekeeper who works in store and keeps the things in order.

The store has two main departments, one is for raw material and fastening and another is for tools. They both are supervised with the same management. Different kinds of documentation are used for storage use. Material issue, material required, material shortage, material purchasing, order sheet and some other documentation are used for the purpose of production line and quality control and quality assurance department.

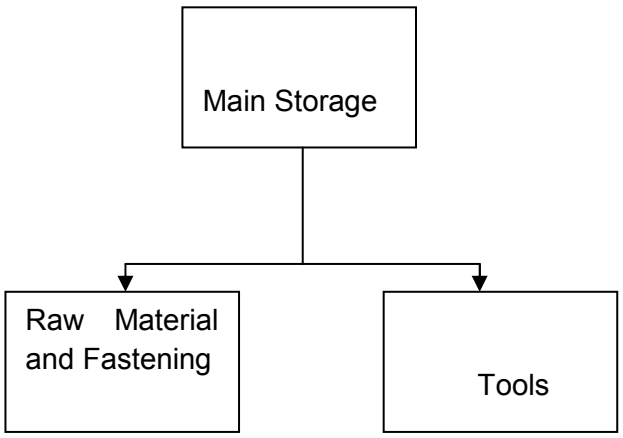

Fig 9. Company Storage

3.6 Cutting of Material

After the raw material is issued from the storage the next and first operation of manufacturing is cutting of angle bars that are done with the presses. Before cutting the angle bars it needed to measure and have to do some marking according to required sizes. There are three presses in the factory which are used to cut different angle bars in different shapes and sizes and then material is sent to machine shop.

Presses liken the one presented in Figure 10 that is used for cutting angle bars are either operated hydraulically or then mechanically. They are from 1 to 3 tons in capacity.

Fig 10. Power Press (tootoo trade Co. 2012)

3.7 Marking and Measurements

When the angle bars are cut in the size then the next process is about markings according to measurements on it. Different drawings are used for each part and marking is done according to the available drawings. At this stage, as it's the first and main stage of the manufacturing of telecommunication towers, the workers who do the marking job are well experienced and they do the quality check themselves at same time during marking process.

Different tools like scribers, as shown in Figure 11 and different colors of chalks or temporary paints are used for the purpose of marking.

Fig 11. Types of Scribers (abm tools company. 2012)

3.8 Machining and Drilling

When marking is finished, the material is ready for machining processes. For that, the factory has about six drilling machines and different grinding machines. Actually, when the marks are ready and points are located the holes in angle parts need to be done by drilling process that is quite precise. Workers have to be well trained so that they can use exact tools and drill the right sizes of holes because when the tower will go for site for erection then there should not be any play between tower members. That can cause all tower breakage when its windy or bad weather like storm etc.

Technical documentation work need to be done by using Auto Cad in which, the use of part numbers in drawings and different scaling work need to be mention.

Work need to be done according to the drawings and some inspection need to perform to check either if the parts are manufactured according to drawings or if there are some mistakes. The work needs to be done by workers under the guidance of foremen and some faulty parts have to be fixed under the guidance of concerning supervisor and foremen.

A typical drawing of the tower steel part and the drilling machine used for the drilling purpose is shown in the Fig 12 and Fig 13 on the next page.

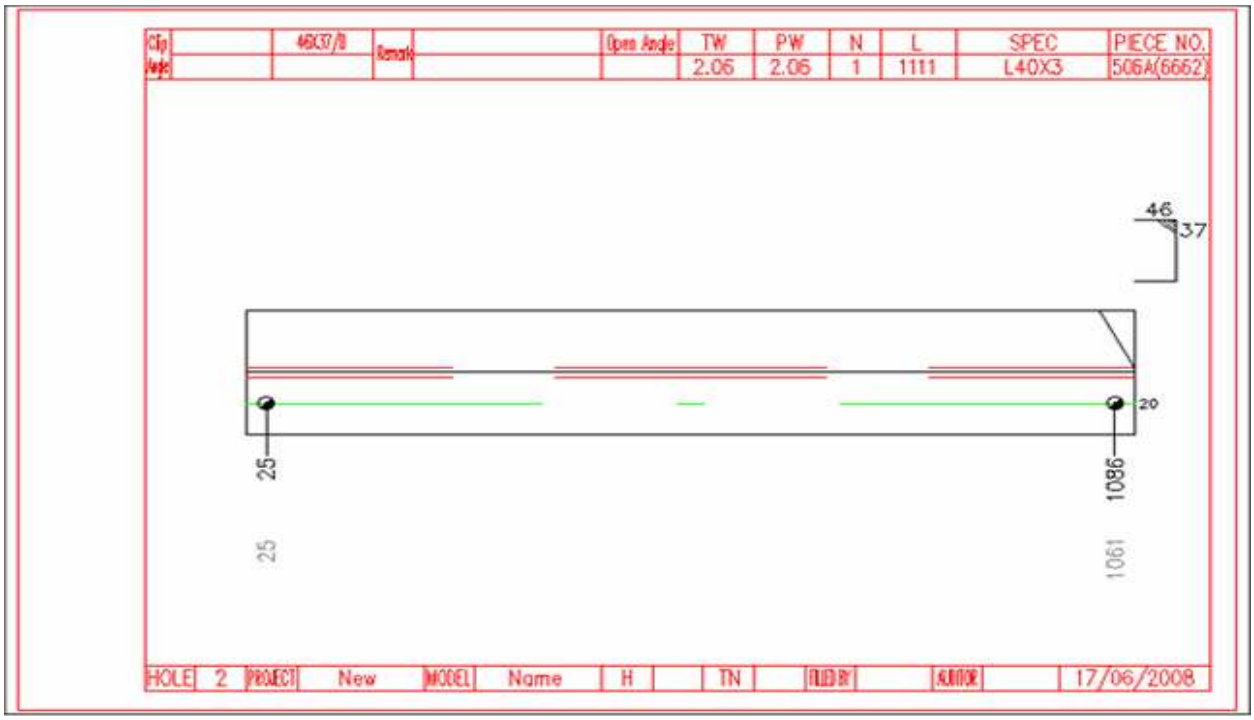

Fig 12. Drawing sample of a tower part (Daopower company, 2012)

Fig 13. Drilling Machine (Mach sources Co, 2012)

3.8.1 Lubricants used for Machining Process

Coolants are used for the devices to prevent its overheating, transferring the heat produced by the device to other devices that use or dissipate it. For an ideal coolant it should have high thermal capacity, low viscosity, is low-cost, neither causing nor promoting corrosion of the cooling system either in a machine part or cutting tools.

Coolant is commonly used in automotive, some temperature-control applications. In industrial processing, heat transfer fluid is used both in high temperature as well as low temperature manufacturing applications. Mostly the coolants used in ATL are cutting fluids.

In other hand **Cutting fluid** is a type of coolant and lubricant designed specifically for metal working and machining processes. Different kinds of cutting fluids are used for different purposes i.e. oils, oil-water emulsions, pastes, gels, aerosols (mists), and air or other gases. Cutting fluids may be made from petroleum, animal fats, water and air, or plant oils etc. A good cutting fluid must have the following properties:

- A cutting fluid must keep the work piece at a stable temperature.
- It must ensure safety for the people handling it and for the environment upon disposal.
- It prevents rust and corrosion on cutting tools and machine parts.
- It must maximize the life of the cutting tip by lubricating the working edge or tip.

3.9 Grinding

When all the machining processes are done step by step then the next process is grinding. There are about eight grinding machines which are used for grinding the sharp edges of angle bars and small pieces.

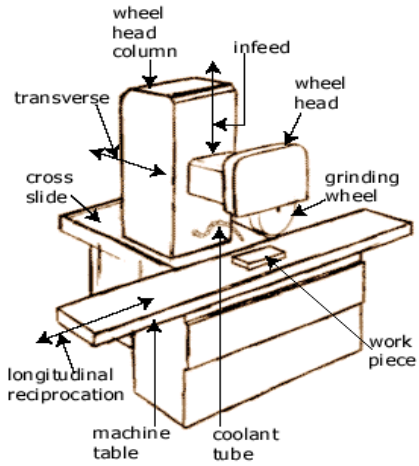

Fig 14. Grinding Machine (efunda.com), Grinding Wheels (Direct industry, 2012)

Grinding process is done after the cutting and drilling process because when angle bars come to the grinding machines they have sharp edges and some of the cutting chips are left on the holes. They can cause some injuries for further manufacturing operations and handling during the erection on site.

Types of grinding wheels

Three different types of materials are used for the grinding process.

- Aluminum Oxide

- Silicon carbide

- Cubic boron Nitride

3.10 Welding

Some parts of telecommunication tower are sent further for welding that need to be welded i.e. tower foundation joints etc. Three different kind of welding systems are used in a welding unit.

1- Electric Arc Welding

2- Oxy Acetylene Welding

3- MAG Welding

a. Electric Arc Welding

Arc welding uses a welding power supply to create an electric arc between electrode. As a result the base material melts the metals at the welding point. Both alternating current (AC) and direct current (DC) can be used as a power supply for the welding unit. In the welding area the molten metal is usually protected by some type of shielding gas or slag.

Electric arc welding is mostly used for tower wire net which is during erection for the standing purpose, during erection and later when maintenance is needed. Also it is used for the ladder manufacturing process, which is used to climb on the tower when some telecom accessories are installed, and later, for climbing up on the tower.

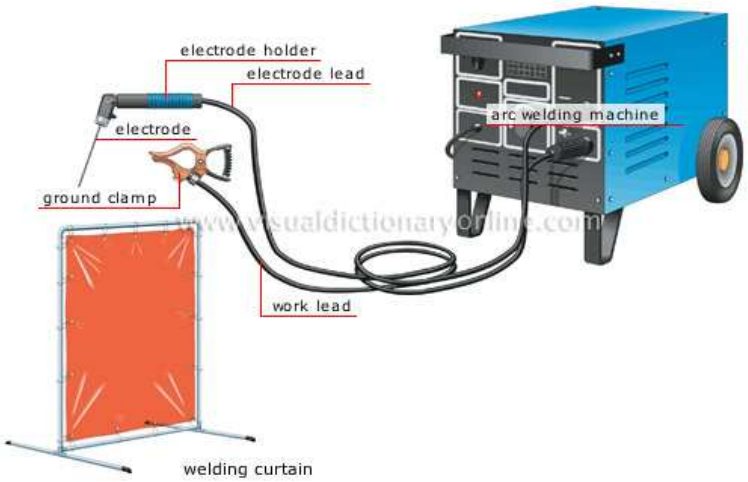

Fig 15. Principle of electric arc welding (visual.merriam-webster dictionary, 2012)

b. Oxy Acetylene Welding

Oxy acetylene welding is a process in which fuel gases are used to weld and cut different metals**.** In this type of welding mostly the pure oxygen and acetylene gases are used. It is possible to get a flame at the temperature of 3500 °C and which is used for welding and cutting angle bars.

Oxy acetylene welding is used both for welding the tower member joints and cutting purposes.

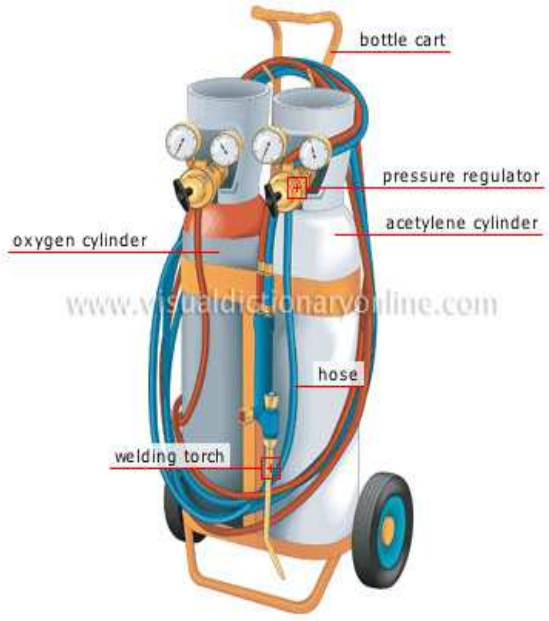

Fig 16. Principle of oxy acetylene welding (visual.merriam-webster dictionary, 2012)

c. MAG Welding

Metal Active Gas (MAG) welding can be either automatic or semi automatic arc welding process in which a continuous wire electrode and a shielding gas are fed through a welding gun.

MAG Welding is mainly used for the tower base joint that is also called foot joint. As the whole tower has to rely on it that has tonnage of weight, so the welding joint must have enough strength to bear that much weight for 25 or more years. The MAG welding process is adapted for the base joint welding because it needs to be welded in big enough thick layer. One of the best qualities of MAG is it does not leave crakes and other welding faults but if it's done properly. So the welders in ATL are well skilled and qualified. They weld tower base joint in welding shop of the factory unit.

After the welding process, some inspections and NDT are done to make sure that no faulty parts of the tower goes to the site.

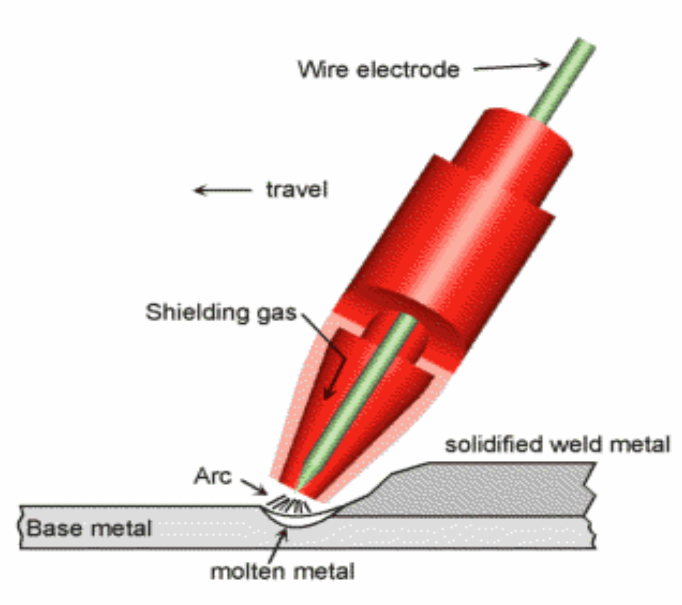

Fig 17. Principle of MAG welding (Designinsite online designer guide, 2012)

3.11 Quality and Inspection

When the products are ready after machining, grinding or welding then they are inspected again finally before they are sent for hot dip galvanizing. Mostly this is done by quality control supervisor in QC Department.

All the dimensions, especially the positions of holes and chamfer edges of all the tower parts are checked thoroughly with the use of gauges because they play an important role during erection. If some hole is misaligned or misplaced during the final erection, it needs extra time to drill a hole while all the team is erecting tower. So quality check is the most important step before hot dip galvanizing.

Quality check for the welding defects in tower base joint is the base for the entire tower because whole structure has to stand on it with the help of foundation. So there should not be any cracks or defects in the welding. That is why some NDT inspection is done for that purpose.

Mostly, the x-ray test for the welded parts is performed to check the internal cracks and faults of the welds.

3.11.1 X-Ray Test

This is a radiographic test method used to reveal the presence and nature of internal defects in a weld, such as cracks, slag blowholes and zones where proper fusion is lacking. In practice, an X-ray tube is placed on the side of the welded plate and an X-ray film, with a special sensitive emulsion, on the other side.

When developed, the defects in the metal show up as dark spots and bands, which can be interpreted by an operator experienced in this inspection method. Porosity and defective root penetration as disclosed by X-ray inspection are shown in Fig.18 (angelfire.com)

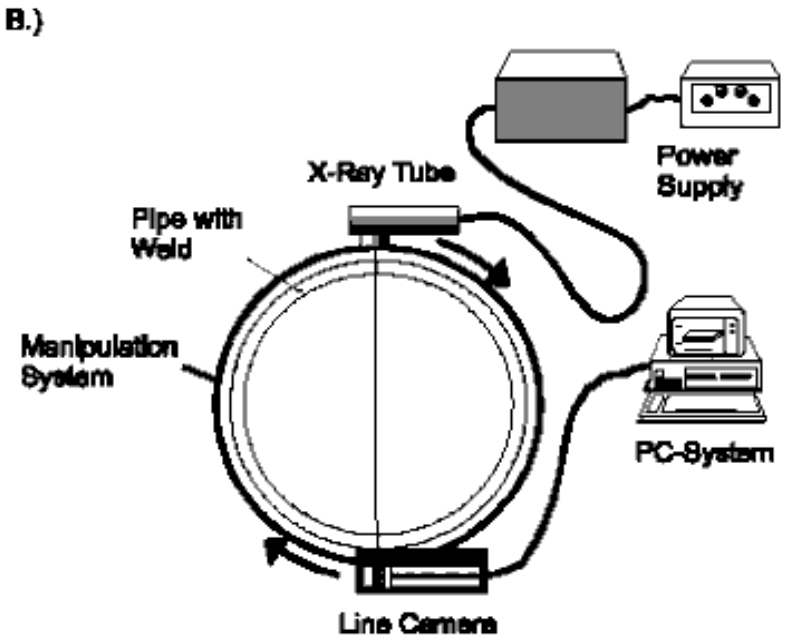

Fig 18. Principle of X-Ray test (ndt online database. 2012)

3.11.2 Magnetic Particle Test

This is a test or inspection method used on welds and parts made of magnetic alloy steels. In this process a strong magnetic field is set up in the piece being inspected by means of high amperage electric currents.

A leakage field will be set up by any discontinuity that intercepts this field in the part. That is how the weld defect is known and further actions are taken. (angelfire.com)

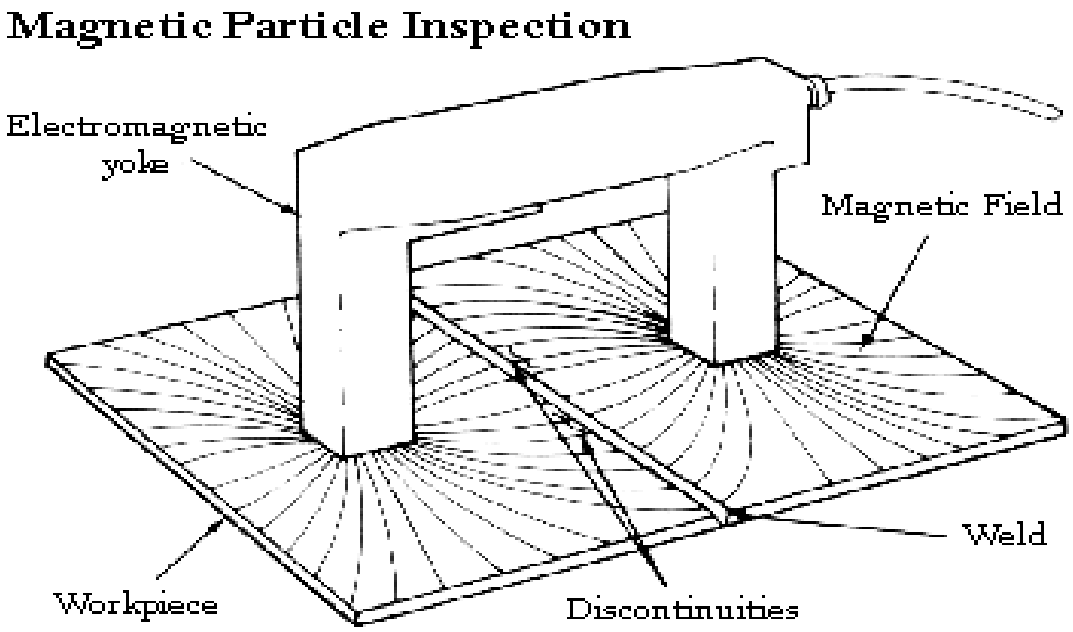

Fig 19. Magnetic particle test (Aerial inspection Co, 2012)

3.12 Hot Dip Galvanizing

The factory has its own big enough HDG plant, where all the parts of tower are galvanized by dipping in molten zinc. In this process all the machined parts are first dipped in caustic for cleaning dirt and degreasing etc. Furthermore they are dipped in sulfuric acid for surface preparation before it goes to molten zinc.

For the main galvanizing process the tower parts are dipped in zinc bath at the temperature of 430 to 450 degree centigrade. It takes 5 to 10 minutes to dip and the hot zinc is vibrated from the material so that extra zinc could fell down back to bath and then zinc coated surface is ready.

After that galvanized angle bars are kept in air for about 5 to 10 minutes and then put in clean space where they could be remain safe and clean. As the towers are designed for about 25 years they must be galvanized because all the parts have to face different weather.

Galvanizing protects the steel from corrosion and keep the outer surface safe from the external corrosion caused by different weather.

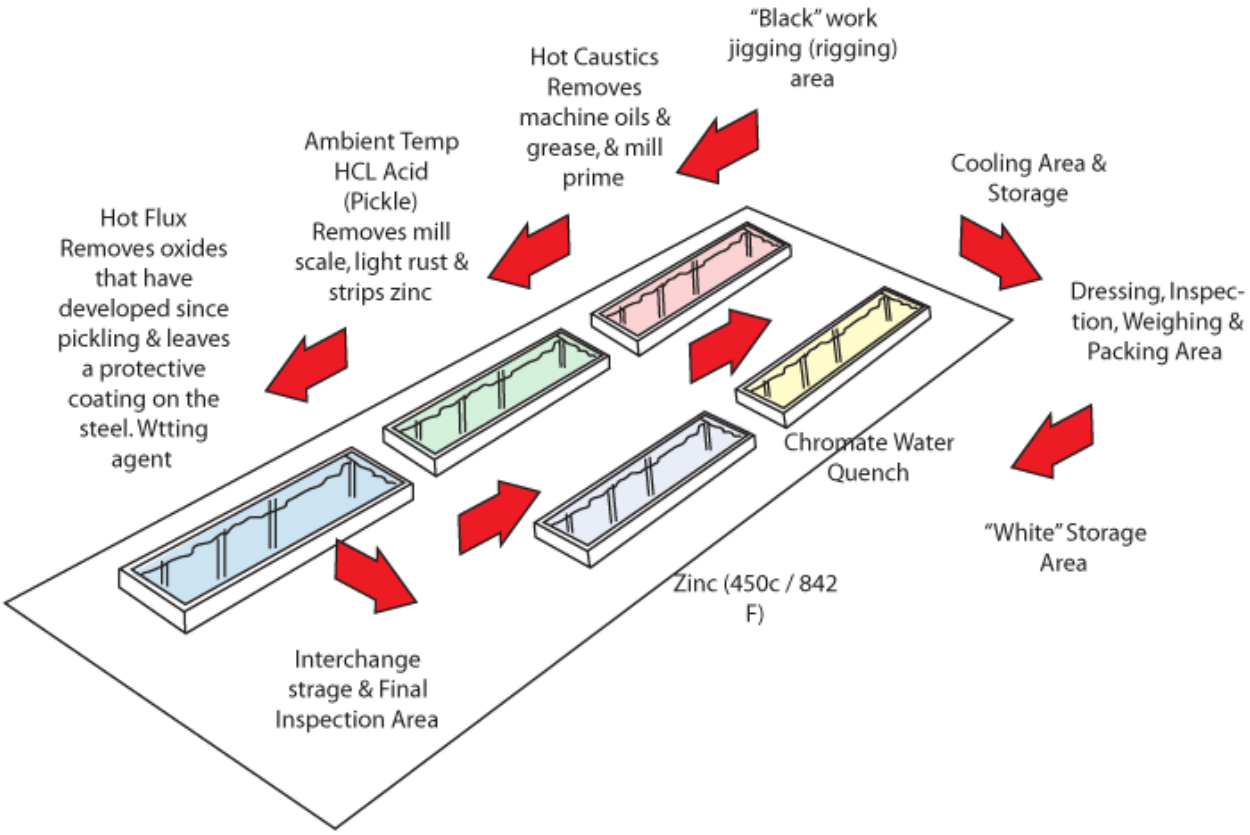

Fig 20. HDG Process (Industrials galvanizers Co. 2012)

3.13 Quality Check and Final Inspection

The last process after HDG and before sending it to storage, is quality check and final inspection where all the galvanized parts of tower are finally inspected by QC department.

In the final inspection zinc coated parts are inspected and it is made sure that there is not any faults i.e. blowholes, porosity, black spots and missed zinc coated places because it is necessary to galvanize parts in proper way. Otherwise there can be rusting and corrosion with the passage of time.

Zinc coating thickness is important to consider in point because of cost and safety factors. For checking zinc coating thickness, a special tool, positector is used. Thickness of zinc varies from 2 µmm to 1 mm, depending on the part and size of the tower member.

Fig 21. Use of Positector (Unidex trade Co, 2012)

Electronic magnetic gages (e.g. PosiTector 6000 F Series, PosiTest DFT Ferrous) come in many shapes and sizes. They commonly use a constant pressure probe to provide consistent readings that are not influenced by different operators. Readings are shown on a liquid crystal display (LCD).

They can have options to store measurement results, perform instant analysis of readings, and output results to a printer or computer for further examination. (defelsko.com)

4. Telecommunication tower erection

4.1 Tower Erection

The last operation handled by Associated Technologies Limited after manufacturing is erection of simply supported towers. When the towers are transported to site, the foundation of tower is ready before the tower structure is unloaded. The foundation of the part is constructed by company's civil engineers who make the foundation ready two weeks before the erection of tower. The foundation consists of concrete and works as base of tower.

Heavy cranes and different fork lifters are used for the handling the tower members. As they are heavy in weight, it is not possible to lift them easily. Different pulleys are used too during the erection of telecommunication towers and safety precautions are adapted for the safe work.

Different tools are used step by step for the quality work and it takes about a week to completely erect a 60 meter high telecommunication tower.

Fig 22. Erection of tower (Pi-energy company. 2012)

The lower joints and legs of the tower are fitted with the foundation with anchor rods and bolts. And then whole tower is fitted upward by starting from foundation. Some heavy working cranes are used for that purpose and of course some fitters and workers under supervision. It takes about a week to erect one tower and the rest of the telecom devices are fitted later by client's own engineers.

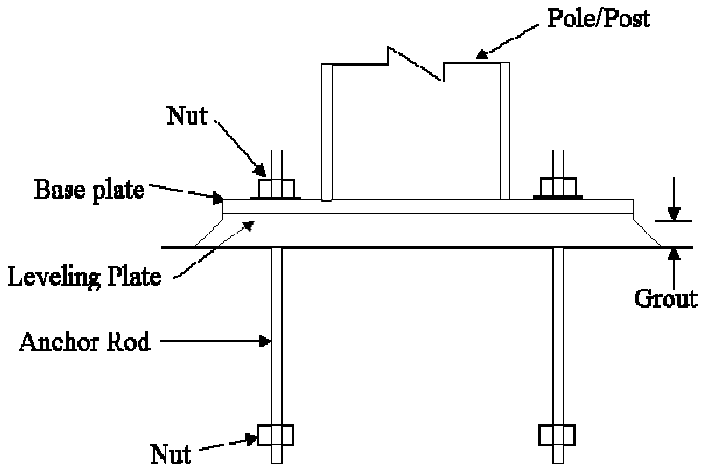

Fig 23. Schematic diagram of tower base joint with foundation (Vikas kumar gupta homepage, 2012)

When erection of mechanical structure of telecommunication tower is finished then different telecom companies install the telecom unit along with the tower. For that they use a control room (processing unit), antennas and some fiber cables for the purpose of communication. The whole tower from its erection to the final working takes about a month.

Fig 24. Installed telecommunication tower (Atl pvt ltd, 2011)

4.2 Equipment used in Erection

Some tools are used during the erection of towers for safe and best quality work. They include a surveyor, a bevel protractor, a bubble level, a feeler gauge and some other tools for the fastening purpose.

Surveyor

Bevel Protractor

Bubble Level

Feeler Gauge

Fig 25. Equipments used during erection (Tool fetch trade Co, 2012)

Surveyor

The surveyor is used for both before and during the erection of telecommunication towers.

Use before erection

The surveyor is used before the erection of the tower because the foundation has to be ready before tower parts arrive to the site. When the client decides the land to erect a tower and pays all the dues then the leveling and surveying is started. So the surveyor is used during that land surface surveying and during the construction of tower foundation. As the tower has to be erect for more than 25 years then the ground level and the foundation must be exactly on 180 degrees angle.

Use during Erection

The surveyor is also used during the erection process of the telecommunication towers. When the tower is big enough in height for example 60 meters, then after each and every 5 meters of the erection of tower the level according to the ground is used as reference and it is surveyed by using the surveyor.

The purpose of surveying is to erect tower according to the ground level for the safety reason because when in bad weather there can be a strong wind that can be the reason for accident.

Bevel Protractor

The bevel protractor is the tool used during the erection of tower to check the side angles of the tower because telecommunication tower are inclined in height. So for that the bevel protractor is used for checking the angles and all the fitters use it during erection.

Bubble Level

The bubble level is also one of the tools used during erection process for erecting the whole tower according to ground level and foundation. It is used to check the level of tower parts according to ground and a bubble inside of the tool is used for the inspection.

Feeler Gauge

Feeler Gauge is used especially for the base joint of the tower. As it is shown in above Fig 23, when the base plate is fastened or packed so the feeler gauge is used during that because there should not be any looseness or play in the tower base joint, that can be dangerous for the rest of tower erection and for later on. It is also used to check the gap between the tower members and packing plates in joints and fastening. Usually the feeler gauge number must be in between 1 to 3 mm because there should not be any play in any of the joint of the tower because for safety from bad weather.

4.3 Safety Precautions during Tower Erection

Some safety precautions must be considered during the erection of tower because safety is after all the most important factor of engineering. So for the safe work during erection of telecommunication tower, the following safety points must be followed during work.

- As all the tower members are heavy in weight so their loading, unloading and moving on site must be done carefully.
- All the team must use enough safety tools and equipments for the safe and secure work i.e. helmets, shoes, ropes, gloves and glasses etc.
- Handling of tower structure for such a big tower like 60 meter is quite big task, so all the teams must use cranes, fork lifter, pulleys and other tools for the safe work.
- It is guided to all the technicians to use their safety tools and they were told about the safety at work during all of the erection work.
- Some sharp edges of tower structure are a reason for injuries; everyone is advised to use long sleeve leather gloves etc
- First aid is provided for all the team when they get some injuries during the erection work and first aid box is provided by the company on the sites.
- Special safety shoes are used and provided to all the team during the erection work because they need to be used for the safe work, especially while climbing up on the telecommunication tower.
- All the erection team members are instructed and aware of the safety at work. Short courses and training regarding to safety at work, are organized by ATL Company.

5 Conclusions

In this thesis and final project report, manufacturing and erection of the telecommunication towers is discussed in details. This report is all about the manufacturing processes step by step; how towers are manufactured, what kind of materials are used, which machines and which processes are used and how is the final erection of telecommunication tower.

Starting from the raw material to the erection of tower takes about two weeks to be completed, so this thesis is all about the field of telecommunication which was done during one year of work placement. Almost everything was learnt about telecom towers during working hours in the company, named as Associated Technologies Ltd; situated in Lahore, Pakistan.

All the mechanical processes i.e. cutting processes, machining processes, drilling processes, grinding processes, different tools used for measurements and quality check and hot dip galvanizing (HDG) are discussed in this final project and thesis report.

Starting from the introduction to the use of different techniques during manufacturing and erection are discussed in detail to get the deep knowledge in the field of telecommunication towers.

This report tells about how the raw material for tower flows in the machine shop till the end of factory storage, logistics and transportation till the sites and its final erection. Erection techniques and tools used are also discussed in details.

Dedication:

Dedicated to all the Teachers in my life and especially to My Parents, who are my first teachers since I Born.

Ishtiaq Muhammad

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