Palestine Polytechnic University

College of Engineering

Mechanical Design of Rotational Galvanization

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Dedication (Arabic)

إلى السنبلة الذهبيّة في بِلادي و بيّارات البرتقال ...إلى كرومِ العِنَب و غصن الزيتون ...و دَم الشهداء و دَمعة الأطفال .....إلى رغيف الطابون و ريح الزَعتر ......إلى (فِلسطين). تِلكَ التي صَنعتني كَي أكونَ هُنا .

إلى الشموع التي احترقت لتصنع لنا غدا أفضل .... (شهداء الحرية).

إلى القابعين خلف القضبان لننعم بطعم الحرية.....(أسرانا البواسل) .

الى ملاكي في الحياة...الى معنى الحب و الى معنى الحنان و التفاني....الى بسمة الحياة و سر الوجود...الى من كان دعائها سر نجاحي و حنانها بلسم جراحي الى اغلى الحبايب...(امي الحبيبه)

الى من كلله الله بالهيبه و الوقار....الى من علمني العطاء بدون انتظار....الى من احمل اسمه بكل افتخار..ارجو من الله ان يمد في عمرك لترى ثمارا قد حان قطافها بعد طول انتظار و ستبقى كلماتك نجوم اهتدي بها اليوم و في الغد و الى الابد...(والدي العزيز)

إلى من تحلو بالإخاء وتميزوا بالوفاء والعطاء إلى ينابيع الصدق الصافي......(أصدقائي).

إلى الذين أجدهم معي في السراء والضراء ..... (أقاربي الأعزاء) .

إلى من سرنا سوياً ونحن نشق الطريق معاَ نحو النجاح والإبداع إلى...(زميلاتي وزملائي)

إلى أولئك الذين يحملون على كاهلهم بناء جيل المستقبل....(أساتذتنا الكرام).

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Symbols	**Meaning**
kg	Kilo graham
N	Newton
hp	Horse power
mm	Mile meter
cm	Centimeter
m	meter
m^2	Square meter
m^3	Cubic meter
C̊	Celsius
F̊	Fahrenheit
rev/min	Revaluation per minutes

Abstract

The main idea of this project to build and implementation tank, where the Hot-dip galvanizing process occurs inside it, A coating consisting of iron-zinc alloy phases, which are formed during metallurgical reaction between the two metal, so the requirement for successful galvanizing is clean surface of steel part, this achieved by degreasing and pickling, The advantages of zinc coatings are enhanced through duplex systems (organic coating on zinc coating), which achieve long-term and effective corrosion protection by using the two effects of both coatings.

Hot-dip galvanizing consist of three basic steps to get a good steel corrosion protection, these steps are: surface preparation, galvanizing, inspection.

This process has many advantages such as: First, all steps of galvanizing process done inside the one tank unlike traditional method whereas process done through several tanks. Second, safe time, high quality, and have acceptable cost, but this process it has difficult design.

يهدف هذا المشروع الى تصميم خزان تتم فيه عملية الجلفنة للمواد الصلبة وحمايتها من الصدأ والتآكل, حيث تتم عملية الجلفنة من خلال طلاء المواد الصلبة بمادة الزنك المنصهرة التي بدورها تتفاعل معها مشكلة طبقة عازلة تقوم على حمايتها من الصدأ, ويعتمد نجاح هذه العملية على نظافة سطح المادة الصلبة فكلما كان السطح أنظف كلما كان مقاومة المادة الصلبة للصدأ اقوى وتمتد لفترة زمنية أكثر.

تتم عملية الجلفنة من خلال عدة خطوات اهمها : تحضير السطح وتنظيفه, الجلفنة, والتدقيق ومراجعة القطعة قبل انتاجها بشكل نهائي.

وما يميز هذه الطريقة عن غيرها هو ان جميع الخطوات المتبعة في عملية الجلفنة تتم داخل الخزان نفسه على عكس الطريقة التقليدية التي يتم فيها تمرير المادة المراد جلفنتها من خلال عدة خزانات, ومن ميزاتها ايضا السرعة في العمل, الكفاء والجودة المطلوب توفرها في المنتج, ولكن بالمقابل هذه الطريقة هي أصعب في التصميم على عكس الطرق التقليدية الاخرى

Chapter 1
Introduction

1.1: What is Hot-dip galvanizing?

Hot-dip galvanizing is one of the oldest methods of zinc coating, the most efficient and economic ways of protecting steel from corrosion, process is achieved by passing the product through a molten bath of zinc at an extreme temperature.

Hot-dip galvanizing (HDG). The process is inherently simple which provides a distinct advantage over other corrosion protection methods. While the steel is in the boiler, the iron in the steel metallurgic ally reacts with the molten zinc to form a tightly-bonded alloy coating that provides superior corrosion protection to steel. [1]

Hot-dipping uses “drain” method accompanied by standard practices which include design adjustments and size limitation to galvanize the steels. However, during the past decade or so, many reports have revealed cracking in hot galvanized construction or structural steels. [2]

Hot-dip galvanized steel parts or assemblies are often required to be painted. The reason for painting can be to identify the particular structure, for architectural reasons, to provide a particular type of protection, or to extend the service life of an existing structure. [3]

In this phenomenon the ductility of a solid metal becomes drastically reduced after surface contact with liquid metals that often have lower melting point/solidification temperatures than the solid metal.

A glimpse at the numerous conclusions of a few researchers leads to the following summary:

**)embrittlement(التقصف) due to zinc, like lead, bismuth, antimony and tin have been reported to occur most frequently after dip galvanizing oxy-fuel cut, welded or sharply cold formed parts.

**) in each situation the fractures are the result of, or at the location of some thermal or cold forming process, and almost always start from a stress riser such as sharp corners or pre-existing micro-cracks.

**)upon examining the fracture surface it contains zinc or zinc reaction products.

**)while it is understood that materials that form inter-metallic compounds normally do not experience liquid metal embrittlement, some researchers believe that the impurities (like tin and lead) in the coating material may be responsible for the contamination.

In his work on this phenomenon, Kinstler reported fewer but similar findings that are associated with LMAC. He concluded that:

a) The fractures are often intergranular.

b) The fractures occur at or result from some thermal or cold working process.

c) The fracture surface was coated with zinc or zinc reaction products.

The information throughout this section on durability, longevity, cost, and sustainability applies only to the hot-dip galvanizing (commonly referred to as batch, general, or after-fabrication galvanizing).

The combination of a paint system with a hot-dip galvanized coating is often referred to as a “duplex system” .When paint and galvanized steel are used together, the corrosion protection is superior to either protection system used alone

The implementation of a paint system onto a hot dip galvanized surface requires careful surface preparation and a good understanding of both corrosion protection systems.

The margin for error is very small when dealing with newly galvanized steel surface preparation. However, there have been many examples of paint adhesion problems on older or more moderately aged galvanized steel surfaces, and the most common cause is improper or incomplete surface cleaning and preparation.

When the surface is cleaned and prepared correctly the combined paint and galvanized steel corrosion protection system gives extremely long lifetimes.

The adhesion of paint onto galvanized steel becomes a very small problem when the galvanized coating has weathered for at least a one-year period. The zinc corrosion products form a very dense, indissoluble protective layer that accepts a paint coat readily.

For many years, galvanized articles made by hot-dip coating techniques were identified by a characteristic spangle appearance. This is still true today to some degree. However, because of changes in the zinc cleaning process, in the galvanizing process, in the demands of the marketplace, and health concerns, relatively little hot-dip galvanized steel sheet made today has a visible spangle.

Its main application fields proposed is the surface protection against atmospheric load in all corrosively grades as well as to protect the metal structures of indoor ventilated spaces.

Continually increasing proportion of steel constructions manufactured in Europe-yearly more than 6 million ton-are covered by coatings hot-dip galvanized. Nowadays the products get also mechanical loads beside corrosion effects at industrial filters; industrial, agricultural, public square pavement grids hot-dip galvanized meaning new and at the same time expanding application fields.

At surfaces hot-dip galvanized exposed to abrasive wear, sand and Breakstone spreading there is an application demand for today wear- and friction resistant coatings.

1.2 History of hot dip galvanizing

Galvanizing is found in almost every major application and industry where iron or mild steel is used. The utilities, chemical process, pulp and paper, automotive, and transportation industries, to name just a few, historically have made extensive use of Galvanizing for corrosion control. They continue to do so today.

Zinc

- Zinc has a self-healing mechanism in it. The zinc coating sacrifices itself slowly by galvanic action to protect the base steel. This sacrificial action continues as long as any zinc remains in the immediate area.

- Zinc melts at 420 C, and boils at 907 C.

- Zinc comprises an estimated 0.004% of the Earth's crust.

- Zinc ranks 25th in order of material abundance in the Earth.

- Zinc is essential for the growth and development of almost all life: between 1.4 and 2.3 grams of zinc are to be found in the average, healthy adult.

Zinc and Steel

Zinc's most remarkable quality is its natural capacity to protect. By protecting steel against corrosion, zinc protects buildings, automobiles, ships and steel structure of every kind from corrosion by atmosphere, water and soil.

The history of galvanizing starts over 300 years ago, when an alchemist-come-chemist dreamt up a reason to immerse clean iron into molten zinc and to his amazement, a shimmering silver coating developed onto the iron.

The story of zinc is closely interlinked with that of the history of galvanizing; ornaments made from alloys that contain 80% zinc have been found dating as far back as 2,500 years. Brass, an alloy of copper and zinc, has been traced to at least the 10th century BC, with Judean brass found in this period containing 23% zinc.

The famous Indian medical text, Charka Samhita, written around 500 BC, mentions a metal which when oxidized produced, also known as ‘philosopher’s wool’, thought to be zinc oxide. The text details its use as an ointment for eyes and a treatment for open wounds. Zinc oxide is used to this day, for skin conditions, in calamine creams and antiseptic ointments.

In 1742, a chemist named Melouin presented a paper to the French Royal Academy in which he described how a zinc coating could be obtained on iron by dipping it in molten zinc. Interest in Melouin’s discovery spread quickly through scientific circles and the first application was to use molten zinc as a cheap protective coating for household utensils.

In 1780, an Italian, Luigi Galvani, discovered the electrical phenomenon of the twitching of a frog’s leg muscles when contacted by two dissimilar metals, namely copper and iron. Galvani incorrectly concluded that the source of the electricity was in the frog’s leg.

Experiments with dissimilar metals were further pursued by Alessandro Volta, who came to believe that the flow of electrical current was caused by the contact of the dissimilar metals themselves.

In 1824, Sir Humphrey Davy showed that when two dissimilar metals were connected electrically and immersed in water, the corrosion of one was accelerated while the other received a degree of protection. From this work he suggested that the copper bottoms of wooden naval ships (the earliest example of practical cathodic protection) could be protected by attaching iron or zinc plates to them.

In 1829 Henry Palmer of the London Dock Company was granted a patent for ‘indented or corrugated metallic sheets’, his discovery would have a dramatic impact on industrial design and galvanizing.

In 1836, Sorel in France took out the first of numerous patents for a process of coating steel by dipping it in molten zinc after first cleaning it. He provided the process with its name ‘galvanizing’. It is interesting to note that Sorel was aware of the electrochemical nature of corrosion and the sacrificial role of the zinc coating on the iron. Originally, the word galvanizing did not refer to the process of coating but to the fundamental property offered by this coating.

Although uncertain, the first use of galvanized corrugated iron is believed to be for the Navy at Pembroke Docks, Wales in 1844.

By 1850, the British galvanizing industry was using 10,000 tons of zinc a year for the protection of iron. This period also saw the invention of an engineered material that would help to embed ‘galvanizing’ into the language of people across the entire globe.

Today, more than 600,000 tons of zinc is consumed annually in North America to produce hot-dip galvanized steel – 200,000 tons for after fabrication (batch) process and 400,000 for the continuous galvanizing process. Galvanizing is found in almost every major application and industry where iron or steel is used. The utilities, chemical process, pulp and paper, automotive, and transportation industries, to name just a few, historically have made extensive use of galvanizing for corrosion control.

1.3 The Hot-Dip Galvanizing Process

The hot-dip galvanizing process consists of three basic steps: surface preparation, galvanizing, and inspection.

1.3.1 Surface Preparation

Surface preparation is the most important step in the application of any coating. In most cases, incorrect or unsuitable surface preparation is the cause of a coating failure before the end of its expected service lifetime. [4]

The surface preparation step in the galvanizing process has its own built-in means of quality control because zinc wills not metallurgical react with an unclean steel surface. Any failures or drop in surface preparation will immediately be apparent when the steel is withdrawn from the molten zinc, because the unclean areas will remain uncoated and immediate corrective action must be taken. [5]

Once a job has been delivered and accepted at the galvanizer's plant, there is one point of responsibility for guarantee that the material leaves the plant properly galvanized. That point of responsibility is the galvanizer.

On-site painting or other field-applied systems of corrosion protection may involve the use of different subcontractors and/or work groups to prepare the surface and to apply the coating. Paint can only be applied under certain weather conditions.

Surface preparation for galvanizing consists of four steps: degreasing, acid pickling, Rinsing, and fluxing.

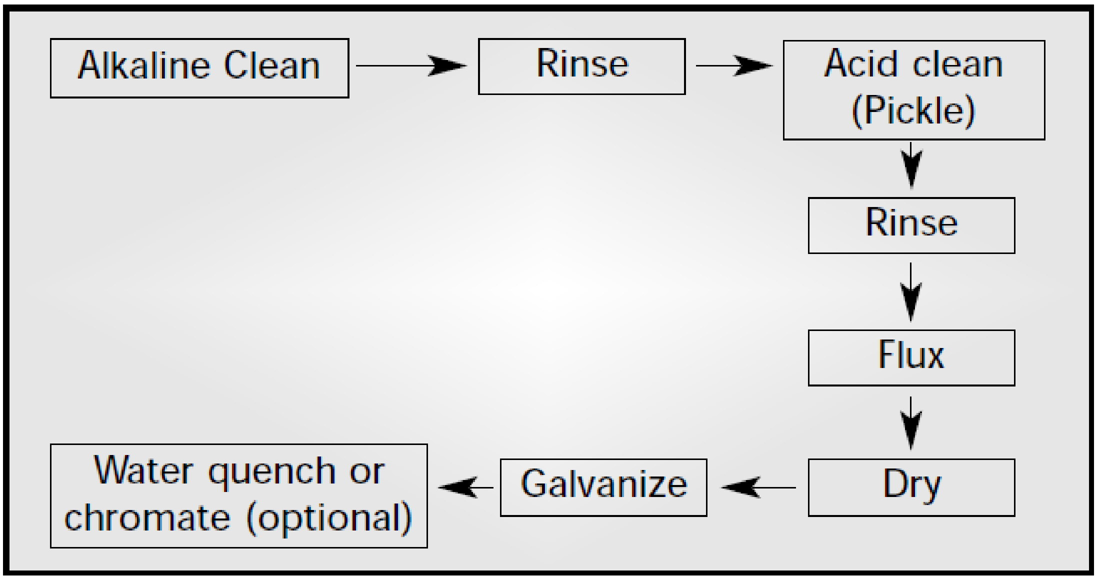

Figure 1.1: dry galvanizing processes

1.3.1.1 Degreasing - Caustic Cleaning –

A hot alkali solution, mild acidic bath, or biological cleaning bath removes organic contaminants such as dirt, paint markings, grease, and oil from the steel surface. Degreasing baths cannot remove epoxies, asphalt, or welding slag; thus, these materials must be removed by grit-blasting, sand-blasting.

1.3.1.2 Pickling–

Scale and rust normally are removed from the steel surface by pickling in a dilute solution of hot sulfuric acid or ambient temperature hydrochloric acid removes mill scale and iron oxides (rust) from the steel surface.

1.3.1.3 Rinsing–

After chemical cleaning by pickling the work is again washed in a water bath to minimize the transfer of any acid residues to subsequent stages of the process. [6]

1.3.1.4 Fluxing–

The final surface preparation step in the galvanizing process serves two purposes. It removes any remaining oxides and deposits a protective layer onto the steel to prevent any further oxides from forming on the surface prior to galvanizing.

Flux is applied in two different methods; wet or dry. In the dry galvanizing process (see figure 1.1), the steel or iron is dipped or pre-fluxed in an aqueous solution of zinc ammonium chloride. The material is then dried prior to immersion in molten zinc.

1.3.2 GALVANIZING

In the true galvanizing step of the process, the material is completely immersed in a bath of molten zinc. The bath contains at least 98% pure zinc and is heated to approximately 840˚F (449˚C).

Fabricated items are immersed in the bath until they reach bath temperature. The zinc metal then reacts with the iron on the steel surface to form a zinc/iron intermetallic alloy. The articles are withdrawn slowly from, the galvanizing bath and the excess zinc is removed by draining, vibrating and/or centrifuging.

The metallurgical reaction that result in the formation and structure of the zinc/iron alloy layers will continue after the articles are withdrawn from the bath, as long as the article remains near bath temperature.

Because the galvanizing process involves total material immersion, it is a complete process; all surfaces are coated. Galvanizing provides both outside and inside protection for hollow structures. Hollow structures that are painted have no interior corrosion protection.

Galvanizing is performed at the factory under any weather or humidity conditions. Most brush- and spray applied coatings depend upon proper weather and humidity conditions for correct application. This dependence on atmospheric conditions often translates into Costly construction delays.

Hot-dip galvanizing is a factory-controlled process performed under any climate conditions. Most brush and spray-applied coatings depend upon proper climate conditions for correct application. Dependence on atmospheric conditions often translates into costly construction delays. The galvanizer’s ability to work in any climate conditions provides a higher degree of assurance of on-time delivery; Working under these circumstances, galvanizing can be completed quickly and with short lead times.

1.3.3 Inspection

The inspection of hot-dip galvanized steel is simple and fast. The two properties of the coating closely scrutinized are coating appearance and coating thickness. A variety of simple physical and laboratory tests may be performed to determine thickness, uniformity, adherence, and appearance.

Products are galvanized according to long-established, well-accepted, and approved standards of ASTM, the Canadian Standards Association (CSA), the International Organization for Standardization (ISO), and the American Association of State Highway and Transportation Officials (AASHTO). These standards cover everything from minimum required coating thicknesses for various categories of galvanized items to the composition of the zinc metal used in the process.

The inspection process for galvanized items also requires minimal labor. This is important because the inspection process required to assure the quality of many brush- and spray-applied coatings is highly labor-intensive and requires expensive skilled labor.

Once a job has been delivered and accepted at the galvanizer’s plant, there is one point of responsibility for ensuring the material leaves the plant properly galvanized.

1.4 Physical Properties of Galvanized Coatings

1.4.1 The Metallurgical Bond

Galvanizing forms a metallurgical bond between the zinc and the underlying steel or iron, creating a barrier that is part of the metal itself. During galvanizing, the molten zinc reacts with the iron in the steel to form a series of zinc/iron alloy layers. (Figure 1.2) is a photomicrograph of a galvanized steel coating's cross-section and shows a typical coating microstructure consisting of three alloy layers and a layer of pure metallic zinc.

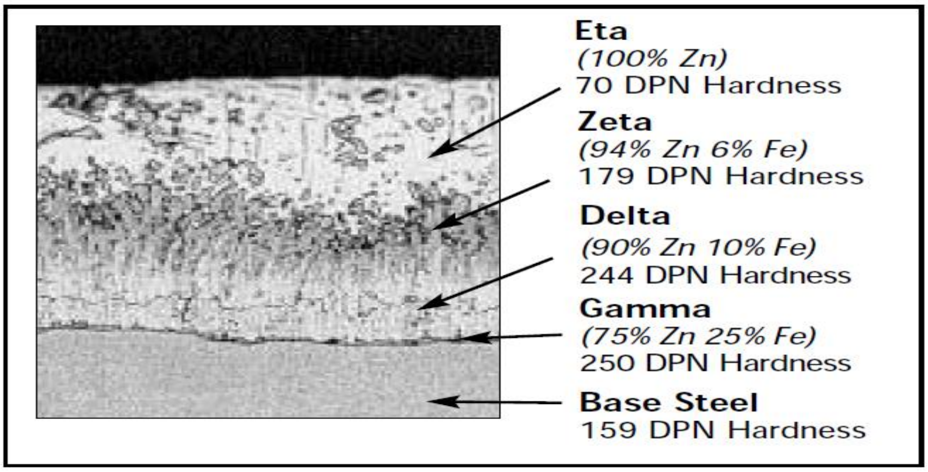

Figure 1.2: photomicrograph of galvanized steel

The galvanized coating is adherent to the underlying steel on the order of several thousand pounds per square inch (psi). Other coatings typically offer adhesion rated at several hundred psi, at best.

1.4.2 Impact and Abrasion Resistance

The coating microstructure displayed in (Figure 1.2) also indicates the hardness of each layer, expressed by a Diamond Pyramid Number (DPN). The DPN is a progressive measure of hardness. Which means the higher the number the greater the hardness. Typically, the Gamma, Delta, and Zeta layers are harder than the underlying steel. The hardness of these inner layers provides exceptional protection against coating damage through abrasion.

Hardness, ductility and bond strength/adherence combine to provide the galvanized coating with unmatched protection against damage caused by rough handling during transportation to and/or at the job site as well during its service life. The toughness of the galvanized coating is extremely important since barrier protection is dependent upon coating integrity. Furthermore, because galvanizing provides more than just barrier protection, even if the impermeable coating is physically damaged, it will continue to provide cathodic protection to the exposed steel (Figure1.3).

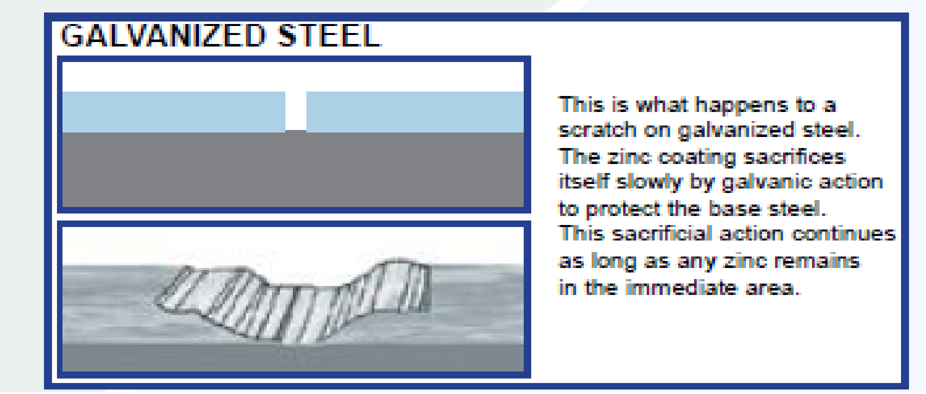

Figure 1.3: Zinc protects scratched base steel

The toughness of the galvanized coating is extremely important, since barrier protection is dependent upon coating integrity. Other coatings damage easily during shipment or through rough handling on the job site. Furthermore, all organic forms of barrier protection, such as paint, are permeable to some degree (pinholes), which means electrolytes in the environment will begin to damage even an intact coating. (Figure 1.4)

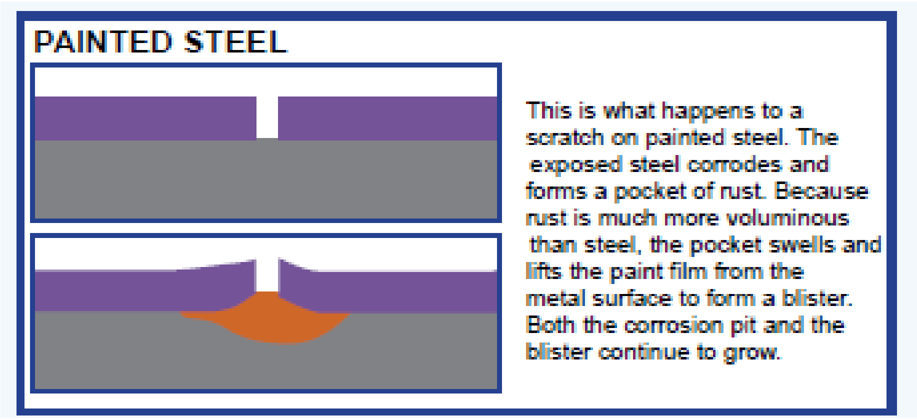

Figure1.4: Under film corrosion causes paint to peel and flake

1.4.3 Complete, Uniform Coverage

The metallurgical reaction that occurs between zinc and steel is a diffusion process, which means the coating grows perpendicular to all surfaces.

Therefore, the galvanized coating is at least as thick at the corners and edges as on the rest of the article Additionally, since hot-dip galvanizing is a total immersion process, both the outside and inside of hollow structures are coated.

Brush- or spray-applied barrier coating systems have a natural tendency to thin at corners and edges, and provide no coverage, and thus, no corrosion protection on the inside of hollow structures such as pipe and tubes.

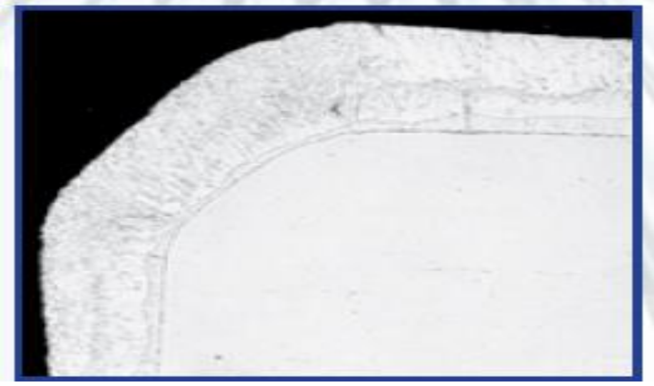

Figure 1.5: Full Corner Protection

Chapter 2:

Advantages and Disadvantages of Hot-dip galvanizing process

2.1 Advantages of Hot-dip galvanizing process.

2.2 Disadvantages of Hot-dip galvanizing process.

2.3 This Project

Hot-dip galvanizing

Steel corrosion protection has long history, so the discovery of this principle has several important discovers in the past, the most important is hot-dip galvanizing, process provides a distinct advantages over other corrosion method and the advantage of this project Furthermore the other method: process can done in the one tank not through several tank as in (Figure 2.1). Although the presence of these advantage there are some disadvantages.

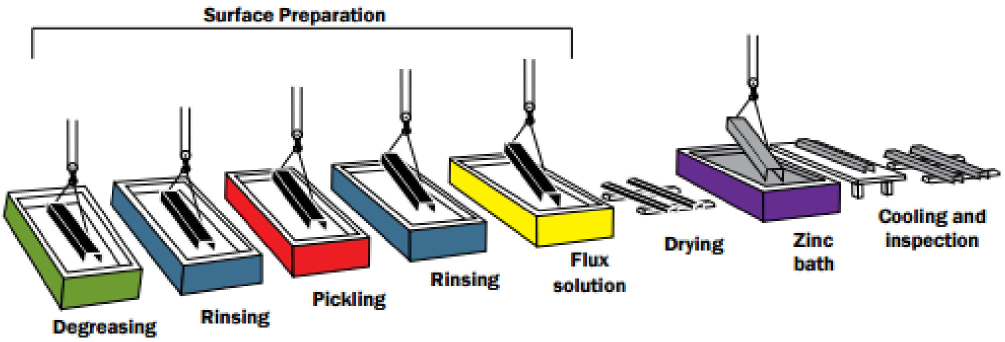

Figure 2.1: Traditional method of Hot-dip galvanizing process.

2.1 Advantages of Hot-dip galvanizing process:

* **Lower first cost.** Hot dip galvanizing generally has the lowest first cost when compared to other commonly specified comparable protective coatings for steel.

* **Lower maintenance / lower long term cost.** Even in cases where the initial cost of hot dip galvanizing is higher than alternative coatings, galvanizing is invariably more cost effective, due to lower maintenance costs during a longer service life. Maintenance is even more costly when structures are located in remote areas.

* **Long life.** The life expectancy of hot dip galvanized coatings on structural members is in excess of 50 years in most rural environments, and between 10 to 30 years in most corrosive urban and coastal environments

*** Surface preparation.** Immersion in acid ensures uniform cleaning of the steel surfaces; in contrast organic coatings must be applied on abrasive blast cleaned surfaces and verified by third party inspection.

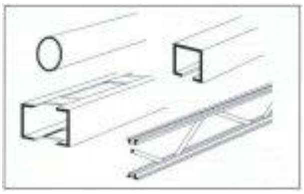

Figure 2.2: profiles and structures that are difficult to access mechanical cleaning

Figure 2.3: Micrograph showing the slightly thicker hat dips galvanized coating at corners.

*** Adhesion.** The hot dip galvanized coating is metallurgical bonded to the steel surface.

*** Environmentally friendly.** The coating is not toxic, arid it does not contain volatile substances.

*** Speed of coating application.** A full protective coating can be applied in minutes, a comparable multicoated paint system, may require up to a week. The effective application of a hot dip galvanized coating is not influenced by weather conditions.

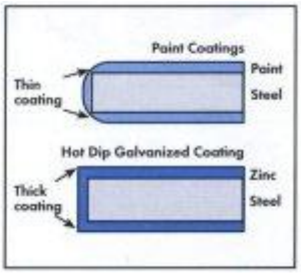

Figure 2.4: Point coatings are usually thinner averred corners and sharp edges.

*** Uniform protection.** All surfaces of a hot dip galvanized article are protected both internally and externally, including recesses, sharp corners and areas which are inaccessible for the application of other coating methods (figure 1). The coating is at least as thick over sharp corners and edges as on flat surfaces (figures 1.2 and 1.3). Thickness, coating adhesion and uniformity are features of the process.

*** Toughness.** A hot dip galvanized coating has a unique metallurgical structure, which gives outstanding resistance to mechanical damage during transport, erection and service.

*** Reliability.** The coating thicknesses specified are related to steel thickness. Coating life is reliable and predictable.

***Over coating with paint, (duplex protection).** If correctly applied a duplex system will provide durable color, chemical resistance and a synergistically extended service life.

2.2 Disadvantages of Hot-dip galvanizing process:

* Hot dip galvanizing can only be done in a galvanizing plant. Site enforcement is not possible.

* The color of the zinc coating can be changed only by painting.

* The dimensions of the component or structure are limited by the size of the zinc bath. Refer to the current copy of Hot Dip Galvanizing Today (Association journal) for available bath sizes or contact the Association.

* There is some risk that large flat unsupported sheet surfaces and long, slender beams will warp, due to the relatively high molten zinc temperature.

* The welding of zinc-coated steel can demand a somewhat different procedure compared to uncoated steel. The welding of hot dip galvanized steel results in a degree of coating loss through the 1st and 2nd Heat Affected Zones although a portion of the original coating remains intact right up to the edge of the weld.

This Project

The main idea of project to design, build, implementation and test tank of Hot-dip galvanizing process and this project taken because it is more effective than the traditional method for corrosion resistance

2.3 Project objectives

- Promote the use of hot dip galvanizing for cost effective corrosion protection in applications where its use is appropriate
- Identify and investigate potential new applications for hot dip galvanizing
- Participate in development projects on behalf of industry

- Provide assistance with quality control during hot dip galvanizing.
- Provide cost effective advice on corrosion case histories from the field.

2.4 Project Schedule and Time Plane

This section talks about the time of preparation for project at first semester, also talks about the financial cost of project as it is shown next tables

- **Task 1: Select the idea**
  Determine the project's idea, motivation, and what to be done in the project.

- **Task 2: Select the idea**
  Looking for open source design files, understanding the concept of the design, collecting information.

- **Task 3: select mechanical and electrical part**
  In this step the required components (hardware and software) and there costs will be determined, and starting to provide them.

- **Task 4: dynamic modeling**
  Mathematical model that describe the system motion should be done in this stage after dynamic modeling complete
- **Task 5 : Documentation**
  Documenting all work steps form the first to last.

Time Table

Table 2.1: relation between number of weeks & tasks.

Week Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T1																
T2																
T3																
T4																
T5																

Final approximate cost

Table 2.2: Final approximate cost

Name	Number	Price	Total Price
Cylindrical tank	1	4500	4500
pulley	4	500	2000
Electromotor	2	300	600
Gearbox	2	400	800
Beal (6in)	1	150	150
Pillar and Beal	10	50	500
base	1	2500	2500
Heat source	1	800	800
Lashes heat	1	100	100
pipe	1	100	100
Turning and welding	1	1000	1000
Other equipment	1	500	500

Total coast=13550(NIS)

Chapter 3

Mechanical Design and Functional Specifications of Hot-dip galvanizing process

3.1 Introduction.

3.2 Functional Specification.

3.3 Parts of the project, sketches and calculations.

3.1 Introduction.

This chapter explains the mechanical design of the project, where explain the functional specifications of the project, the principle of work, and parts of the project. With an explanation of the function of each part, addition to the sketches of each part and Clarify the calculations of the project design.

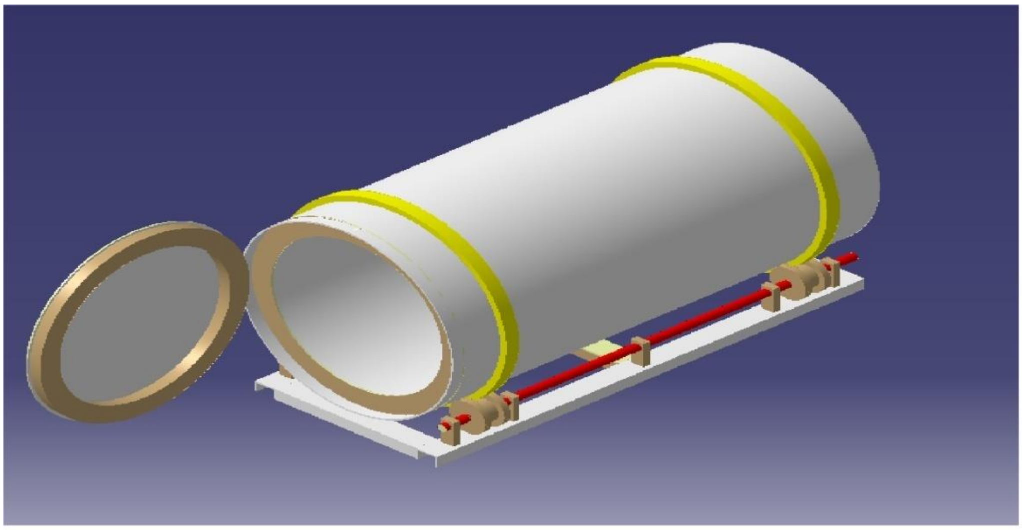

Figure 3.1: Conceptual design for the project

A cylindrical tank rotates by 4 pulleys connected by a special shaft on motor .Designed this cylindrical tank to do a new kind of galvanization different from the traditional ways of galvanization, a galvanizing using heat and pressure at the same time.

3.2 Functional Specification

Clarifying the functional specifications and principle of work of the project

1. Functional Specification

1- The temperature inside the tank approximation equal $300^{o}C$

2- The speed of the tank $4\,rev/min$

2. Principle of work.

Galvanizing the metal in a new way is different from the traditional method which is currently used, especially hot galvanizing.

Where the system was built completely and applied on the ground and consists of the principle of a three-steps

Step 1: - Suspension and insertion of metals and materials into the tank

Step 2: - Galvanization process that occurs inside the tank.

Step 3: - Take the metal out of the tank.

The following is a detailed description of each step.

Step 1: - Suspend and insert metal and material into the tank.

At the front of the tank there is a door that opens and closes to insert and remove the metal through it, inside the tank carriers were made that can be pulled out of the tank to hang the metal on it, the metal is suspended on the carriers and the carriers are then pushed into the tank, balls of solid zinc are placed inside the tank, then the door is closed with provisions.

Step 2: - Galvanization process that occurs inside the tank.

The process of glands in the system occurs on hot Therefore, the tank is supplied with a heat source located below the tank, after a period of time the temperature of the tank reaches 300 degrees Celsius, This high degree works to melt the solid zinc material and to raise the temperature of the metal prepare to receive interaction. After melting the zinc turns from solid state to liquid state that consists of a basin of molten zinc below the tank being along of the tank and the high amount of zinc that was smelting. At this time the, molten zinc will be below the tank and the metal suspended above the tank. The electric motor is then turned on which rotates the tank.

The rotation of the tank works to rotate the suspended metal which is at the top of the reservoir to the bottom of the tank the metal is ingested in the molten zinc basin due to the presence of high heat and pressure inside the tank the interaction of zinc and metal occurs glue the zinc on the metal surface and with the tank turnover at a slow speed of up to 4 rpm. The metal comes out of the molten zinc (bottom of the tank) to be rotated with the tank during this period the metal comes out of the molten zinc, in this period excess zinc falls off the surface of the metal with heat the material dries up on the surface of the metal to spin and is again immersed in zinc and forms another layer the process is repeated several times until the zinc alloy is formed on the surface of the metal. As a result of the reaction, they emit gases that have been disposed of by the tube located in the back of the tank

Step 3: - Take the metal out of the tank.

Before opening the door to remove the galvanized metal, the stream is opened down the tank to remove the molten zinc through it into a pipe extending to the basin, this basin has a temperature that keeps the zinc in the liquid state After removing the molten fuse from the tank ,The door is opened and the carriers are pulled out of the tank on which the galvanized metal is suspended, then the metal is then transferred to the cleaning and inspection stage.

3.3 Parts of the project, sketches and calculations.

In this chapter to clarify the parts of the project and explain the function of each part in addition to calculations of them

Parts of project

1. Cylindrical rotation tank.
2. Base
3. Pulleys
4. Bearing housing.
5. Shaft.
6. Track.
7. Gears
8. Spherical
9. Pipe
10. Electrical motor

The function, sketch, and calculation of each part.

3.3.1-Cylindrical rotation tank

The tank consists of three parts.

Part I: The body of the tank.

Part II: door.

Part III: Back Cover.

Part I: The body of the tank

It is a cylindrical tank with a length of 1 m and a diameter of 0.955 m and a thickness of 0.008 m, It is made of iron type (QR7036) because of the high temperature tolerance and prevents the adhesion of the galvanizing period on the internal flat, large iron thickness was chosen to prevent deformation of the tank due to heat and high weight.

The tank was made by folding the sheet using the hydraulic coil to obtain the cylindrical shape of the tank, The tank was welded by oxygen welding.

Figure 3.2: Body of tank

Part II: Door

Located at the front of the tank opens and closes to enter the material through, provisions shall be closed when closed to prevent leakage of gases, therefore, lids have been installed to withstand high temperatures to increase the provisions.

The door was made in circular shape with a diameter of 96cm ,Rock wool (صوف صخري)has been installed on the edges of the door to seal the provisions and prevent leaks of gases.

Part III: Back Cover

Is the back cover of the tank in a circular shape that closes the back of tank, the back cover is installed in the tank by oxygen welding, done a circular hole of 16 cm diameter in the center of the back cover to remove the gas pipe from it

Figure 3.3: Back cove of tank

Table 3.1: Dimensions of cylindrical tank

Parts	Dimensions(mm)
length of cylindrical tank	2000
Radius of cylindrical tank	500
Thickness of cylindrical tank	8
Diameter of pipe	150
inner diameter of door	450
inner thickness of door	50
outer diameter of door	508
outer thickness of door	8

$$v_{tank}=(\pi R^2 * l) \quad (3.1)$$

Where:

v_{tank} : - volume of the cylindrical tank.

R: - radius of the cylindrical tank.

l: - Length of the cylindrical tank.

Where (R and l $from$ $tabel$ (3.1))

$v_{tank}=(\pi * 0.4975^2 * 1)=0.77\ m^3$

To calculate the torque of the tank you need to calculate the mass of the tank, by the following equation

$$M_{tank}=A_{total}*H_{cylinder}*\rho_{Iron} \quad (3.2)$$

Where:-

A_{total}: - Total area of the cylindrical tank.

$H_{cylinder}$: - thickness of the cylindrical tank.

ρ_{Iron}: - The density of iron.

To calculate the total area of the cylinder, we calculate the area of cylinder and summation with side's area of the cylinder, we have two side area in this tank We calculate the area of the tank by considering that the tank shape is cylinder, by the following equation.

$$A_{cylinder}=(2\pi Rl) \quad (3.3)$$

$A_{cylinder}=(2 * 3.14 * 0.4775 * 1) = 3\ [m^2]$.

Where:-

$A_{cylinder}$: - area of the cylinder.

The area of the sides tank calculated by calculate the area of the door in front side and the area of rear side, considering that a closed area, so

$$A_{sides} = 2(\pi R^\wedge 2) \quad (3.4)$$

$A_{sides}=2(3.14 * 0.4775^\wedge 2) = 1.43[m^2]$.

Where:

A_{sides}: - area two sides of the cylinder.

So the total area of cylindrical tank equals

$A_{total} = (3 + 1.43 = 4.43\ [m^2].)$

Where:

A_{total}: - Total area of the cylindrical tank.

By the equation (3.2) and the density of the Iron used in the manufacture of tank is$(7700 kg/m^3)$.

M_{tank}=$(4.43 * 0.008 * 7700 = 273\ [kg].)$

Where:-

M_{tank}: $mass\ of\ the\ tank$

It must to calculate the torque output from the tank, to choose the horsepower required to motor, so it can Calculate the torque output from the tank, by the summation of moment.

$$\sum M = (J\ddot{\theta}) \tag{3.5}$$

Where:

M:-moment.

J: - second moment of inertia

$\ddot{\theta}$: - rotational acceleration of the tank

By analysis the system the summation of the moment as show in the following equation.

$$T_{tank} - (C_{eq} * \dot{\theta}) = (J\ddot{\theta})$$

Where:-

T_{tank}: - torque output from the tank.

C_{eq}: - equivalent friction between 4 wheels and the tank.

$\dot{\theta}$: - rotational velocity of the tank.

But the torque output from the tank so the equation became as following.

$$T_{tank} = (C_{eq} * \dot{\theta}) + (J\ddot{\theta}).$$

The system has 4 wheels do friction with surface of the tank as show in figure 3 (C1, C2, C3, and C4), the equivalent friction between iron and iron is 0.16 so the total equivalent friction is 0.64.

The speed of rotation tank$(4rev/min)$. Chose a slow speed until galvanizing up to all dimensions.

To calculate the second moment of inertia considering the tank is filled with liquid and therefore calculated second moment of inertia of the liquid. For the rotational acceleration of the tank, the tank rotation at a constant speed so acceleration will be in the system is acceleration due to run the motors until the system to put stability, this period will be one second.

Calculate the second moment of inertia for the tank and the liquid by the second moment of inertia equations

$$J_1 = M_{tank} * R^2 \qquad (3.6)$$

Where:

J_1: - second moment of inertia for the cylindrical tack.

Know the mass of the tank from equation $(3.2)$and radius from table (3.1)

$$J_1 = (273 * 0.4775^2) = 62.24\ [kg.m].$$

These is the value of second moment of inertia for the cylindrical tank, and to calculate the value of total second moment of inertia we will calculate the second moment of inertia in the tank by the following equation and summation with the second moment of inertia for the cylindrical tank . We consider that the liquid inside the tank is zinc, It is kind of materials used in the galvanization process and density is $(6570kg/m^3)$

$$J_2 = \left[(\pi \rho R^2) * \left(\frac{4}{\pi} - \frac{1}{4}\right)\right] \qquad (3.7)$$

Where:

J_2: - second moment of inertia for the liquid in the tack.

$$J_2 = \left[(3.14 * 6570 * 0.4775^2) * (\frac{4}{3.14} - \frac{1}{4})\right] = 4594\ kg.m$$

Through the summation of the equation (3.6) with (3.7)know the total second of inertia in the system

$$J = (J_1 + J_2)$$

Where:

$(J: total\ second\ of\ inertia\ in\ the\ system.)$

$$T_{tank} - \left(C_{eq} * \dot{\theta}\right) = \left(J\ddot{\theta}\right).$$

$$T_{tank} = \left(0.64 * 4\frac{2\pi}{60}\right) + \left(4656.23 * 4\frac{2\pi}{60*1}\right) = 1976.2\ [N.m].$$

The total torque output from the tank is $1976.2[N.m]$.

2-Base:

The part on which the tank is installed, the base was designed and worked with the following dimensions (160 x 81 cm).The base width is calculated so that the vertical force is on the surface of the tank at an angle of 45 degrees, It is the best angle to install the tank on the rollers safely to prevent its deviation in the case of rotation and prevent falling from the centers of fixation.

As for the length of the base is 160 cm long enough to match the length of the tank and the electrical motor and gas pipeline.

After calculating the length and width of the base, the base was made using U-shaped iron with a width of 12 cm ,the parts of the base were fixed by oxygen welding .

Figure 3.4: Base of tank

3-Pulleys

Four rollers were installed on the base of the tank is placed above it to facilitate the rotation process. The rollers are designed and worked on diameter 20 cm and width 5 cm, It is an appropriate diameter where there is sufficient distance between the shaft in the center of the pulley and the a track in which the pulley rotates, Where the width of the track is 5 cm and Diameter shaft 3 cm, these is a distance between the end of the track and the shaft surface is 3.5 cm, enough distance to avoid friction between them.

The turning of the rollers was done to clean the surface and obtain the required dimensions, In addition to a hole in the center of the roller with a diameter of 30 cm for the shaft.

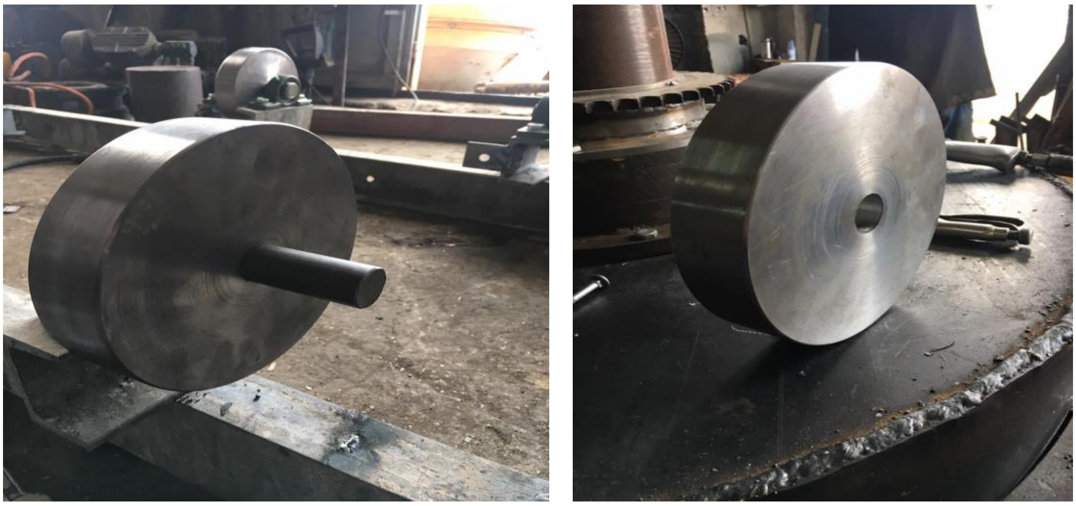

Figure 3.5: Pulleys of tank

4-bearing housing.

Used 8 bearing housing type of (P201) shaft 30mm, to carry pulleys where 2 of the bearing housing was placed for each pulley ,the bearing housing is installed by the screws in the base.

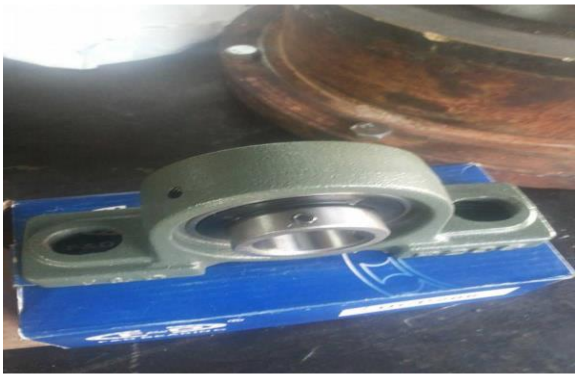

Figure 3.6: Bearing housing

5-Shaft

Is the link between the pulley and the bearing housing ,which is the most important part in carrying the weight of the tank.

Calculations have been made to select the appropriate shaft diameter according to the following equation, the diameter of the column was selected and equal to 30 mm, It is the right diameter to avoid deformation or cutting in the column due to high weight.

6-Track

These are two circular rings mounted on the surface of the tank as shown in the pictures. They were made of U-shaped iron with a width of 5 cm, folded in a round shape by a hydraulic file. Where it wraps around the tank as a track for pulleys, this track installs by welding with the tank so that the rollers are rotated in one direction, and prevent the movement of the tank forward and backward during rotation, the two tracks were distributed some 50 cm away from each other for the Balance of force.

7-Gears

They the parts responsible for transmission and torque from the motor to the tank, Where the previous design was replaced by the transfer of torque through the shaft and then the pulleys to the tank by friction, due to mismatch the diameter of the pulleys with the diameter of the tank to give the desired speed.

Therefore, a 28 cm diameter gear was installed on the back of the tank. The gear was fixed by the screw in the back center of the tank, and then opened a circular in the center of the gear to get out of the gas pipe.

The following image shows the shape of the gears



Figure 3.7: Gears of tank

8-Spherical

It is a large peals 16 cm inner diameter that has been installed in the center of the back of the tank, So that the pipe can be installed on it, to prevent the pipe from rotating with the tank.


Figure 3.8: Spherical

9-Pipe

A pipe was installed in the rear of the tank, this pipe works to remove toxic invasions that cause chemical reactions within the tank, the gasses are released through this pipe to the outside of the tank to be processed and disposed of in a safe manner.

A diameter of the pipe is 16 cm was chosen, which is a large diameter, so as to avoid obstruction of the pipe due to the gases and impurities that emerge from it.

Figure 3.9: Pipe of tank

10-electrical motor

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After finding torque output of the cylindrical tank, the torque of motor to be used for calculating even overcomes the torque of cylindrical tank.

It had used motor with speed equal 1400rev/min. And gear box ratio 1:100 used to decreasing the velocity and increasing the torque output from the motor, So the torque of motor must be equal or more

$$T_{motor} = \frac{T_{tank}}{ratio} = \frac{1976.2}{100} = 19.762[N.m]$$

To calculate horsepower motor produce output torque required using the following equation

$$(P = T * \omega) \qquad (3.8)$$

Where:

P: $the\ horse\ power\ of\ the\ motor.$

T: $the\ torque\ of\ the\ motor.$

ω: $the\ speed\ of\ the\ motor$

$$P = 19.762 * 1400 \frac{(2\pi)}{60} = 2895.8\ [watt].$$

Convert the horsepower of the motor form watt to horse power as in the following

$$P = \frac{2895.8}{746} = 3.88[hp]$$

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Chapter 4

4.1 Experimental result

4.2 Future work

4.3 Recommendation

4.1:-Experimental result

After the completion of the system and the installation of collection of parts, we performed practical experiments on the system, the following results were obtained

- The speed of rotation of the tank 4RPM.
- The rotation of reservoir was smooth without noise
- The require temperature inside the tank reaches 300 degrees Celsius in 3 hours.
- Metal galvanization takes 30 minutes per layer on the metal surface.
- The thickness of the zinc layer on the tank surface is 0.1 μm per cycle
- There is no leakage of gases.

4.4:-future work.

- Make a system larger enough to accommodate larger amounts of metal.
- The system works so that it works on galvanizing the metal over a layer.
- The work of a room is heat-insulated around the tank so that it works to maintain a regular temperature.
- Control of system by programmed way.

4.3:-Recommendations

- The difficulty of closing the door tightly without leakage therefore rock wool has been installed on the edges of the door to prevent leakage.
- Difficulty getting rotation speed so the 100: 1 gear ration was installed for speeding.
- Difficulty getting zinc material so you need a source that provides you with these materials.

Chapter 5

Conclusion

- The spangle on hot-dip galvanized steel sheet had been its primary identifying feature for many years.

- The demand for both lead-free coatings and very smooth products has resulted in spangle size being reduced by most producers until it is no longer visionalto the unhelpfuleye.

- This was, and to some range still is, of interestto certain pieces of the marketplace, but most users of galvanized sheet have become accustomed to a product that does not have a large, easily seen spangle.

-While, in the future, demand for a visible spangle may disappear, for aesthetic reasons some consumers still want to use spangled galvanize sheet for their products.

-There is a method of providing this without the risks of using lead-containing zinc. [7]

- The multilayer coatings of hot-dip galvanized corrosion density in the test-system does not depend on the fiction speed neither at heat treated nor at not heat treated specimens, but it depends on the medium pressure and on the resistance of medium deriving from that.

- The heat treatment improves the abrasive resistance. The higher hardness results higher abrasive resistance improvement.

- The linear corrosion dynamics of hot-dip galvanized layers tested does not depend on that, which layer comes to friction connection with abrasive medium.

-The inner gradient friction character did not affect the corrosiondensity measured, but the resultant of different gradient structure has different abrasive resistance. [8]

-The painting of galvanized steel has been a difficult task for many people. The secret of good painting on galvanized steel is the surface preparation of the galvanized surface.

-If the surface is recently galvanized, that is less than 48 hours out of the zinc kettle, the surface can be painted after a surface roughening procedure.

-If the surface of the galvanized part has been exposed to the environment for more than one year then the surface can be painted after the dirt, grease and oils have been removed.

-The most difficult time to paint galvanized steel is between one day and one year after it has been galvanized. Following the correct surface preparation procedures can give a satisfactory duplex system. [9]

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