بسم الله الرحمن الرحيم

Palestine Polytechnic University

PPU College of Engineering and Technology

The Home of Competent Engineers and Researchers

College of Engineering &Technology

Mechanical Engineering Department

Graduations Project

Designing and Building of an Experimental System for Monitoring and Controlling "Adsorption Unit"

Bachelor Thesis

Project Team

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Hebron-Palestine

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Palestine Polytechnic University

(PPU)

DEPARTMENT HEAD AND SUPERVISOR SIGNATURE

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According to the project supervisor and according to the agreement of the Testing committee members, this project is submitted to the department of mechanical engineering at college of engineering and technology in partial fulfillment of the requirement of (B.Eng) the bachelor's degree.

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Hebron-Palestine

2012

Abstract

This project responds to local environmental problem resulting from a local galvanization industry. It aims at designing and building an adsorption process utilizing a suitable local adsorbent.

The project will include a design of monitoring and controlling column adsorption process.

After construction of system, experiment performed to test the operation of the process and investigate the effect of a selected operating parameter (e.g. flow rate). Response curves (dimensionless exit concentration versus time) measured for a step change in inlet concentration.

A control system designed for an industrial process including two column (one operation and one stand –by)

Dedication

To our parent who

Spent night and day doing their best

To give us best….

To all student and who

Wish to look for

The future

To who love the knowledge and

Looking for the new

In this world

To who carry candle of science

Tonight his avenue

Of life

To our beloved country Palestine

To all of our friends

Acknowledgment

To our great supervisor, who offered his best for this project to see light through his instruction and device DR. Maher Aljabary, with all his kindness and wisdom we thank him we would also like to thank our college for support and help .

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Introduction

Project Background and Plan

1.1 Introduction

Pollution is one of the major problems facing the environment in Palestine. Pollutions are caused by factories and car exhausts, human waste, and others. These include factory waste water. The industrial wastewater is often discharged without treatment, causing pollution to soil and groundwater, as well as sea water. Industrial wastewater contains various pollutants of heavy metal e.g. chromium, copper, zinc. These wastewater are released from various industries such as tanning leather and galvanization. Such pollutants affect the public health.

One of the pollution problem are caused by industrial galvanization wastewater; a process of metal electro plating, such as iron, steel, by layer of zinc or zinc alloy. This layer protects the metal from corrosion (chemical damage). Zinc helps in the prevention of corrosion because it interacts with many of the chemicals more easily than its interaction with iron. For example, when iron reacts with oxygen from air, an iron oxide (rust), is composed. In galvanized iron, zinc protects the iron interaction with oxygen, forming zinc oxide preventing rusting. Steel is one of the most metals that are galvanized releasing wastewater containing heavy metal such as chromium and zinc which are pollutants.

There are many techniques for the disposal of the wastewater, one of them is adsorption, this project deals with implementation of this technique on real wastewater from galvanization.

The treatment of wastewater, using adsorption process with activated carbon as adsorbent removes various substances from wastewater. This occur by collection of pollutants onto the surface of adsorbent solids. It is a removal process where certain molecules are bound to an adsorbent particle surface by either chemical or physical attraction.

Adsorption occurs whenever a solid surface is exposed to a gas or liquid, it is defined as the enrichment of material or increase in the density of the fluid in the vicinity of an interface, Under certain conditions, there is an appreciable enhancement in the concentration of a particular component and the overall effect is then dependent on the extent of the interfacial area.

1.2 Project Description

This project responds to an environmental need by designing and constructing of a process to control water pollution in a local industry (galvanization iron). It studies the effect of concentration operating variables applied to treat contaminated water through the installation of sensors on the pipeline for supply and discharge of the process, Digital signals reflecting the change in concentration of pollutants between liquid fluid entering and leaving of the process will be computerized.

The project also include design of control circuitry for an of application in the presence of two devices in parallel (one works and the other in the development of back wash), so that it establishes a transition from one to another, after satisfying the first order to prepare it for later worked non-stop operation.

Experimental design and the project opens the way to study the variables specific to the scientific process as Inquiry.

1.3 Project Aim and Objectives

The general aim of the project is to design and build experimental system for monitoring and controlling “Industrial Adsorption “.To reduce the environmental impacts of wastewater; That results from manufacturing galvanization in local industry by adsorption unite.

The specific objectives of the project include

1) Proposing a process for water treatment facility (galvanized iron) through the application of adsorption technology, including the identification of material suitable for contaminant sorption studied.
2) Designing of the process to get rid of pollutants in wastewater in electroplating, the building of a column adsorption (at laboratory), with its accessories including distributor, tubing, pump, valve and tanks…etc.
3) Designing monitoring system and control the treatment process, including sensors or measuring instruments that connected to the computer to explain the condition of solution.
4) Constructing and installing all the necessary equipment for processing system controlling monitoring, and examination of its performance.
5) Testing the performance of the system on real samples from industry.
6) Investigating the effect of one of the process parameters (such as flow rate), on the response of the system (e.g exit concentration as a functional of time).

1.4 Importance of the Project

This project serves local industry and environmental sector in Palestine,

1) This project serves the local industry - sector of metal (galvanized iron).
2) The project serves the local environment by building a scientific model is applicable to reduce the pollution of the environment.
3) The project opens the way to connect the Mechatronics field of environmental technologies through the installation of sensors connected to computer programming and through the control circuitry of the state of industrial.
4) After applying the idea of water pollution in a specific industrial sector can be generalized to other industrial sectors and thus serve those sectors.
5) Can follow-up project in the future to conduct a research study on the impact of all the variables that control the process and control system, and then publish a scientific paper.

1.5 Project Tasks

Implementing the set objective in section 1.3.

1) Study the process of water treatment plant (galvanized iron) through the application of adsorption technology and identification of material suitable for contaminant sorption studied.
2) Design of the processing to get rid of pollutants in wastewater in electroplating, is the building of a column adsorption (at laboratory), with its accessories including distributor, tubing , pump and tanks.

3) Design monitoring system and control the treatment process, including. sensors or measuring instruments and connect them with the computer.
4) Constructing and installing all the necessary equipment for processing and system control and monitoring, and examination of its performance.
5) Testing laboratory for testing the performance of the system.
6) Study the effect of one of the variables (such as flow rate).

1.6 Implementation Plane

Table 1.1 Action Plane for the first semester

Week / **activity**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Select the project idea																
Review previous studies																
Design process project																
Review the design and modify the necessary																
Writing the first report																

Table 1.2 Action Plane second semester

Week / **activity**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Source and purchasing equipments and other necessary																
Model building																
programming control system																
Test the operation of the process																
Investigating the effect of operating parameter																
Writing the final report																
Documentation																

1.7 Budget

The estimated budget for implementing this project is 720 JD. Table 1.3 provides detailed budget information.

Table 1.3 The Estimated Budget of Implementing Project

The estimated budget	
Item	The estimated budget (JD)
1. Software	100
2. Materials, samples	100
3. Equipment	500
4. Stationery	20
5. Movement and transportation	20
6.Total	740

Chapter Two

Review of

Galvanization and Adsorption

2.1 Introduction

Advances in water and wastewater treatment technology need spur for the development of technologies that may be more effective and less costly the contamination of water by toxic heavy metals through the discharge of industrial wastewater is a worldwide environmental problem.

One of these industrial applications is galvanizing steel, galvanizing steels very important in an industry where the galvanized steel provide protection for the steel from corrosion and it gives us a clean surface and excellent surface appearance. But the galvanization a double edged sword as it produces through galvanization pollutants that have an impact on the environment and people.

Adsorption is the solution were used to remove pollutant from water that it used in galvanization. In this chapter we have talk about galvanization of steel, types of galvanization, step of galvanization emissions from galvanizing operations. Adsorption importance and the adsorbent used in adsorption system.

2.2 Galvanization

Galvanizing or electroplating is the process of painting some metals, such as iron, steel, by layer of zinc or zinc alloy. This layer protects the metal from corrosion (chemical damage). Zinc helps in the prevention of corrosion because it interacts with many of the chemicals more easily than its interaction with iron. For example, when iron reacts with the oxygen of the air, an iron oxide (rust). If you were galvanized iron, zinc protects the iron interaction with oxygen, forming zinc oxide before it is made up rust. Steel is one of the most metals that are galvanization.

2.2.1 Application of Galvanization

Galvanizing is an attractive and economical means of corrosion protection for a wide variety of commercial and industrial steel articles. Typical examples are galvanized roofing, siding roofing nails and other fasteners, sidings, beams, box sections, utility poles, fencing and general industrial and agricultural components.

Industrial galvanizing is the process of coating where the material or product is dipped in molten liquid. Galvanizing is the best and most reliable type of coating, galvanization is crucial to enduring reliability. The protective coating acts as a guard against rust. Utilizing industrial galvanization greatly contributes to the retaining of the original value and quality of metal products over time galvanization zinc metal is commonly used to galvanize different products for protection against corrosion. zinc metal is used in building, construction, infrastructure, household appliances, automobiles, steel furniture etc.

2.2.2 Types of Galvanization

1)Hot Deep Galvanization

It is the process of coating iron, steel, or aluminum with a thin zinc layer, by passing the metal through a molten bath of zinc at a temperature of around 860 °F (460 °C).

the pure zinc reacts with oxygen to form zinc oxide

$$Zn + O_2 \longrightarrow ZnO$$

Carbon dioxide retract to form zinc carbonate , zinc carbonate usually dull grey, fairly strong material that stops further corrosion in many circumstances

$$ZnO + CO_2 \longrightarrow ZnCO_3$$

2)Electro-Galvanization

This process includes the development of steels in a solution of zinc sulfate and water. When the passage of electric current in the solution, covers a thin layer of zinc on the surface of steel. Electro-galvanizing mainly used to galvanized one piece of steel.

The requirement for successful galvanizing is that the item to be dipped must be free from contaminants prior to dipping. Pretreatment to achieve the surface required for galvanizing may include cleaning, pickling and fluxing. Some items for example structural steel, may arrive on site in a clean state and not require any cleaning. The cleaning of iron and steel items may include any of the following physical and chemical treatments.

2.2.3 Galvanization Process

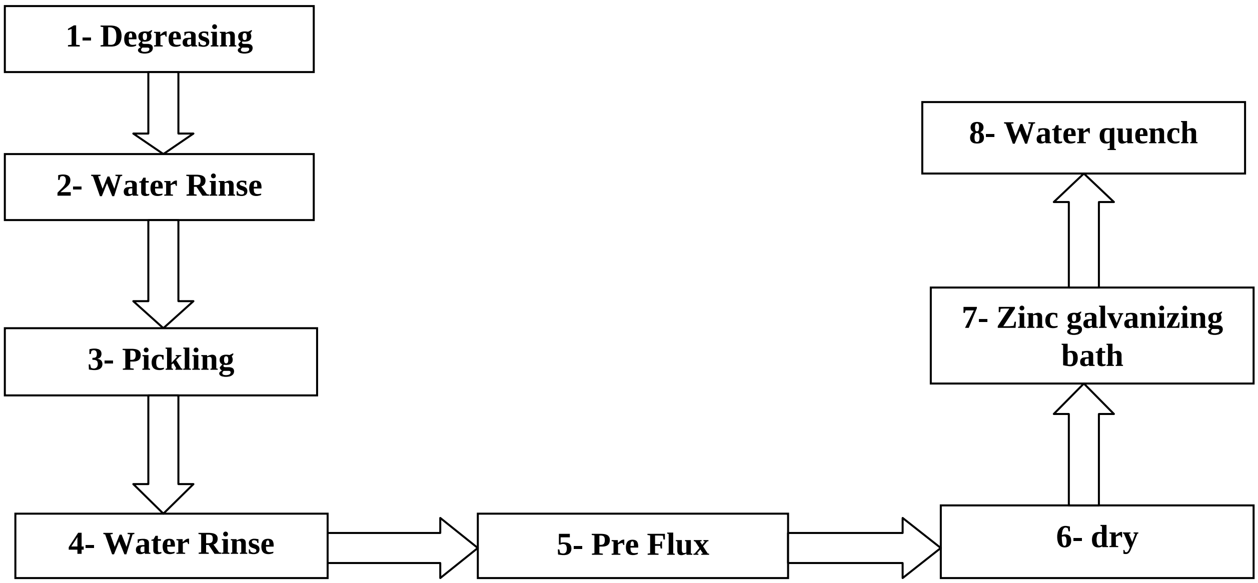


Figure 2.1 Hot Deep Galvanization Process

1. **Degreasing**

First the steel is immersed in an acid degreasing bath or caustic solution in order to remove the dirt, oil, and grease from the surface ,organic contaminants and paint from the steel surface of the steel. after degreasing the steel is rinsed with water.

2. **Water Rinse**

The degreased articles are water raised in rinse bath with air agitation to ensure intended degreasing and prevent carryover of iron particles and residual solution to acid bath.

3. **Pickling**

Hydrochloric acid is used in pickling operations for carbon, alloy and stainless steels. Steel pickling is the process by which iron oxides and scale are removed from the surface of steel by converting the oxides to soluble compounds. Pickling is required for steel products that undergo further processing such as wire production, coating of sheet.

4. **Water Rinse**

After chemical treatment by pickling the part is again washed in water to minimize the transfer of any acid residue to subsequent stage of the process

5. **Pre Flux**

The applied flux stage immediately follow the pickling and rising stages to remove any remaining traces of impurities and provide a final intensive cleaning of steel surface, the flux usually consists of any aqueous solution of chloride principally a mixture of zinc chloride and ammonium chloride .

6. **Dry**

After immersion in the flux tank steel articles for galvanizing are dried and became coated with thin film of flux.

7. **Zinc Galvanizing Bath**

The galvanizing operation take place in molten zinc, the temperature is controlled in most work in the range 440c-460c ,zinc has melting point of approximately 419c . The galvanizing process causes the formation of coating consisting of layers of zinc on the surface of steel.

8. **Water Quench**

The galvanizing steel nearly hot , so the water quench used to decrease the temperature of steel or cooling it by air with a time.

2.2.4 Wastewater From Galvanizing Operations

wastewater occur from spent rinse water following pre-cleaning, and sometimes from quenching activities after coating. Other sources of wastewater occur through rinsing and batch dumping of process baths. The process baths usually contain metal salts, acids, bases, and dissolved base materials.

Table 2.1 Material Inputs and Wastewater From Galvanizing Processes

Process	Material input	wastewater	Solid waste
Degreasing	Substrate to be galvanized, alkaline degreasing solution	Dissolved solution in water	Process sludge
Pickling	Acid pickling solution, Hydrochloric Acid Sulfuric Acid	Spent acids in water	Process sludge
Water Rinses	Rinse Water and substrate to be galvanized	Metal salts, acids, bases, dissolved base materials	Zinc and other metal sludge
Pre-flux	Zinc ammonium chloride ammonia solution		Zinc and other metal sludge
Galvanizing bath	Zinc, metal salts, acids	Metal and acid wastes, zinc, chromium (VI)	Oxide dross, zinc and other metal sludge
Water Quench	Sodium dichromate	metal and acid wastes, zinc, chromium (VI)	zinc and other metal sludge

2.2.5 Wastewater Effect From Galvanizing Operations

There are various types of wastewater from galvanization associated with various steps.

These include:

1) **Degreasing**

To attach a thin layer of metal on a piece of work it is necessary to have a good carrying capacity. The surface has to be free of oil, dust, fat, water, metal splinters, and chemicals to guarantee the finish.

Degreasers are the most common method of soil removal for metal preparation prior to the application of coating. Wastewater from degreasing is contain mainly alkaline with pH relatively high and negative impacts on soil and plants, the sludge should be sent away for waste disposal in accordance with local waste regulations

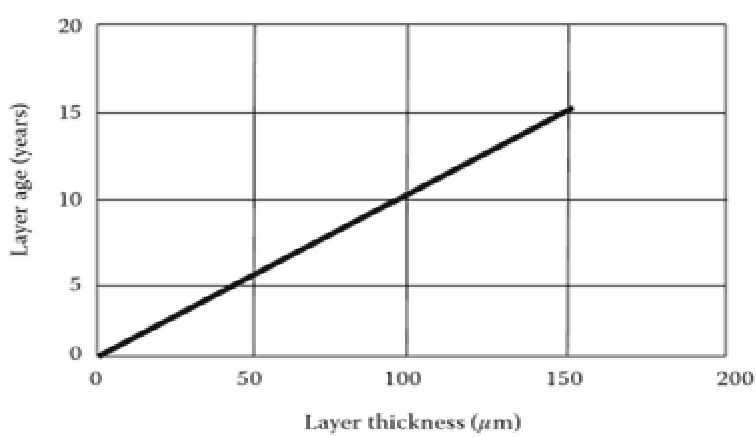


Figure 2.2 Relation between zinc layer thickness and expected life

2) Pickling

Pickling creates waste that requires treatment. This waste comes from the chemicals reaction and the waste contains heavy metals, mainly iron . This sludge should be sent away for waste disposal in accordance with local waste regulations.

3) Galvanizing Bath

Galvanization zinc metal is commonly used to galvanize different products for protection against corrosion. zinc metal is used in building, construction, infrastructure, household appliances, automobiles, steel furniture etc.

Chromium Cr(VI) is toxic, carcinogenic and mutagenic. It is highly mobile in soil and aquatic system and is a strong oxidant capable of being absorbed by the skin.

4) Water Quench

Sodium dichromate naturally occurs as bright orange crystalline powder. Sodium dichromate chemical is widely used as an oxidizing agent in several chemical reactions. It has wide application in galvanization process in various industries. Chromium (VI)

2.3 Adsorption

Adsorption is the process by which adsorbent such as (active carbon) removes substances from water. Defined adsorption is "the collection of a substance onto the surface of adsorbent solids." It is a removal process where certain particles are bound to an adsorbent particle surface by either chemical or physical attraction

Adsorption is the process through which a substance, originally present in one phase, is removed from that phase by accumulation at the interface between that phase and a separate(solid) phase.

In principle adsorption can occur at any solid fluid interface. Examples include:

- Gas-solid interface (as in the adsorption of a VOC on activated carbon).
- Liquid-solid interface (as in the adsorption of an organic pollutant on activated carbon).

Pollution control or for respiratory protection. In addition, adsorption phenomena play a vital role in many solid state reactions and biological mechanisms

2.3.1 Important of Adsorption

Advances in water and wastewater treatment technology need spur for the development of technologies that may be more effective and less costly. Nowadays, the contamination of water by toxic heavy metals through the discharge of industrial wastewater is a worldwide environmental problem.

The term "heavy metal" refers to the metallic elements having density greater than or equal to 6.0 g/cm^3.The most familiar metals are cadmium (8.65 g/cm^3), chromium (7.19 g/cm^3), cobalt (8.90 g/cm^3), copper (8.95g/cm^3),), lead (11. g/cm^3),), mercury (13.53 g/cm^3**),** nickel (8.91 g/cm^3) and zinc (7.14 g/cm^3).[3]

Adsorption is of great technological importance. Thus some adsorbents are used on a large scale as desiccants, catalysts or catalyst supports, and used for, the purification of liquids

2.3.2 Types of Adsorption

1)Activated Carbon

Activated carbon, also called activated charcoal, activated coal or carbon active , is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions.

Activated carbons are some of the most widespread agents for the treatment and purification of water. Their high porosities, from macro to micro porous structures, make them efficient adsorbents to trap low molecular weight chemicals such as metal ions, dyes and other organic compounds. This is achieved through adsorption processes, where the atoms and molecules are fixed to the carbon via physical interactions or chemical bonds.

The word activated in the name is sometimes replaced with active. Due to its high degree of micro porosity, just 1 gram of activated carbon has a surface area in excess of 500 m^2 (about one tenth the size of a football field.

Figure 2.3 Active Carbon

Benefits of Activated Carbon Filtration

1- Highly effective at removing non-polar organic chemicals from water.
2- Applicable to a wide variety of organic compounds.
3- Very effective at removing colors from waste streams.
4- Effective at removing low levels (ppb range) of inorganic pollutants.
5- Very flexible system allows rapid start-up and shut down as needed.
6- System can be designed so that it is portable.

2) Natural Marl(الحوّر)

Marl or marlstone is a calcium carbonate or lime-rich mud or mudstone which contains variable amounts of clays and aragonite. Stone cutting solid waste Implements the principle of "treating waste by waste. The technical feasibility of chromium removal from wastewater in leather making by its treatment with solid waste from stone cutting industry is demonstrated experimentally, and found to be an efficient approach. Nearly full removal of chromium is obtained at optimum operating conditions using sufficient mass of solid waste (limestone) and allowing enough contact time between the two wastes.

3) Stone Cutting Solid Waste

The principle is "treating waste by waste." The technical feasibility of chromium removal from wastewater in leather making by its treatment with solid waste from stone cutting industry is demonstrated experimentally, and found to be an efficient approach. Nearly full removal of chromium is obtained at optimum operating conditions using sufficient mass of solid waste (limestone) and allowing enough contact time between the two waste.

2.3.3 Mechanism of Adsorption

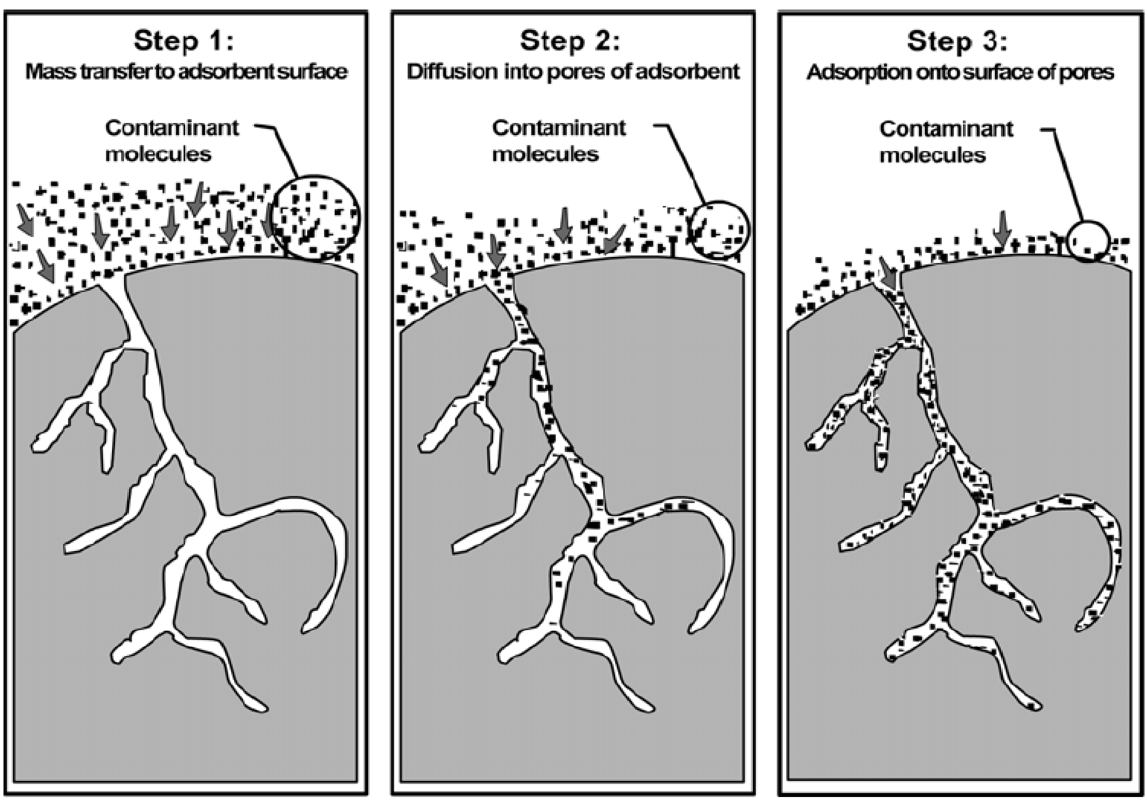


Figure 2.4 Mechanism of Adsorption

2.3.4 Adsorption System

Adsorption process can be made using one of the following options.

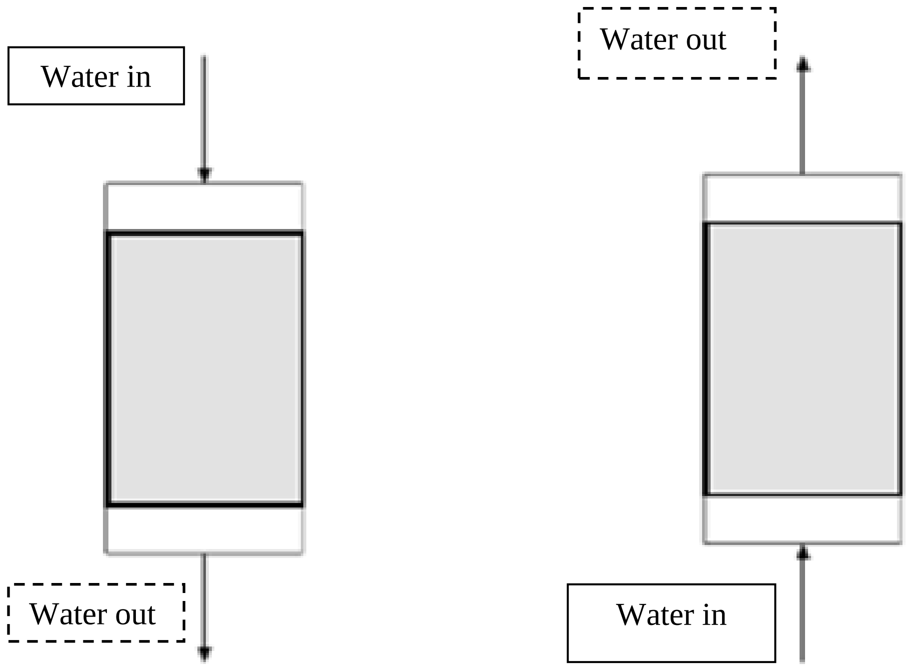
1- Fixed Bed Adsorption System

- This is most common type in adsorption column in waste water treatment.
- These columns must be provided with system for the removal of spent carbon and the addition of fresh or regenerated carbon.
- Because of their construction and operation down flow fixed bed absorbers also acts as depth filters for particles that can be contained in the waste water.
- This adsorption column must also be provided with facilities for backwashing.

2- Expanded Bed Adsorption System

Expended bed absorbers are used when the waste water fed to the column contain a significant fraction of suspended particles.

The adsorbent bed suspends the adsorbent particles and allows particulates to pass upward through the bed during the application of crude feed to the column. The target molecule is recovered by reversal of the flow to pack the expanded bed and by application of the elution buffer.



(a. Fixed bed)

(b. Expanded bed)

Figure 2.5 Adsorption System Type(a- Fixed bed, b- Expanded bed)

Chapter Three

Equipment and Process Design

3.1 Introduction

This project lead to designing and building of experimental system for monitoring and controlling “Industrial Adsorption Process “.

The galvanization wastewater was chosen for experiments of adsorption. Because the galvanization is very important industry, and a lot of company does not take into account the health and safety of workers and the environment and this has a negative impact on public safety and nature.

As noted in this project, the process of electroplating include multiple steps, and that some of these steps result in chemicals are not healthy, some of them cause cancer in addition a negative, except for the negative impact on the environment.

The most serious impact is form the material produced from galvanizing bath and water quench in this steps the chromium (VI) remains in water.

Chromium is widely used in pigments, metal finishing (electroplating), anti-corrosion paints or coatings, so we must think about the right way to get rid of the remains of chromium resulting from industrial processes in a safe side to protect humans and the environment.

Adsorption is good method to reduce the pollutants from wastewater in galvanization process. Adsorption is expected to lead results to save the people and environment from any negative effects from wastewater.

This chapter summarizes design work for the selected adsorption process.

3.2 Determination Pollutant

Hexavalent chromium Cr (VI) is specified as the major pollutant in galvanization process this project will focus in its treatment.

Hexavalent chromium, sometimes referred to as “Chrome Six,” or “Cr (VI),” is a hazardous form of the element chromium that is rarely found in nature and is generally man-made. Hexavalent chromium is widely used in pigments, metal finishing (electroplating) anti-corrosion paints, coatings, and in chemical synthesis as an ingredient and/or catalyst.

Heavy metals are usually present in wastewaters which are released into the environment from various industries the adverse effects caused by these heavy metals are of great environmental concern. Heavy metals are non biodegradable and accumulate in living organisms thereby causing various diseases and disorders . Chromium and nickel are frequently used in industrial processes such as metal plating industries, galvanizing industries, mining operations and tanneries and are usually present in high concentrations in the liquid wastes which are released directly into the environment without any pre-treatment. Once in the environment, chromium exists mainly in two oxidation states (Cr(III) and Cr(VI)). While Cr(III) is relatively innocuous, Cr(VI) is toxic, carcinogenic and mutagenic. It is highly mobile in soil and aquatic system and is a strong oxidant capable of being absorbed by the skin.

3.3.1 Selection of Adsorbents

There are various adsorbents utilized in industry for treating waste water with heavy metals, in general this section present potential adsorbent for chromium. This include

1- Stone Cutting Solid Waste[2]

Stone cutting is important and traditional industries in Palestine and this adsorbent use to chromium from waste water in leather making by its treatment by solid waste from stone cutting industry .

Previous investigation made in experiment the adsorption capacity increase with increasing solid waste (limestone) to liquid ratio (solid content) , until nearly full removal of chromium was obtained 5mg/100ml or higher .

Leather tanning is based on chromium , but waste water other common application of chromium in Palestine include aluminum powder coating and Electro plating .

Chromium (VI) is more toxic and more stable than Chromium (III) .water soluble Cr(VI) is externally irritant and toxic to tissues of human body .

2-**Active Carbon**

Cost-effective alternative technologies or adsorbents for the treatment of metal-containing wastewaters are needed. Activated carbons are more effective in the removal of heavy metals due to some specific characteristics that enhance the use of activated carbon for the removal of contaminants including heavy metals from water supplies and wastewater Natural materials.

That are available in large quantities or certain waste products from industrial operations and agricultural by-products , may have potential as inexpensive adsorbents. Generally, adsorbents can be assumed as low cost if they require little processing, are abundant in nature, or are a by-product or waste material from another industry . Low cost activated carbon adsorption is an attractive method because its cost and possible regeneration of the carbon.

Table 3.1 summarizes this option for adsorbents and selection priority in this project. In this project, one of these adsorbents will be used for the main study. Other adsorbents may be tested.

Table 3.1: Potential Adsorbents for Removal of Chromium

Adsorbent	**Refer with**	**Priority**	**Priority Clarification**
Stone Cutting Solid waste	AL-Jabari *et al.* [2]	I	Available Waste by waste Tested for Cr(III)
Natural Marl	AL-Jabari *et al.* [1]	I	Available Tested for Cr(III)
Active Carbon		II	Tested for Cr(III) and Cr(VI)

3.3.2 Adsorption Process Operation

Figure 3.1 below refer to the processing operation of the system, first of all the waste water move to the adsorption column through pipe and three way valve, pump, flow meter passing a sensor.

In the adsorption column the adsorbent start to reduction the pollutants by adsorption. With time and high amount of waste water the carbon grains will reach a saturation limit, this condition will observable by the out let sensor data curve.

At the moment the three way valve controlling which flow will pass to the adsorption column, clean water flow to adsorption column to start wash back the grains carbon, in next section will discuss the principle operation of each part of block diagram fig.3.1 shown below.

Figure 3.2 shows process diagram illustrating process components which are described in the following section.

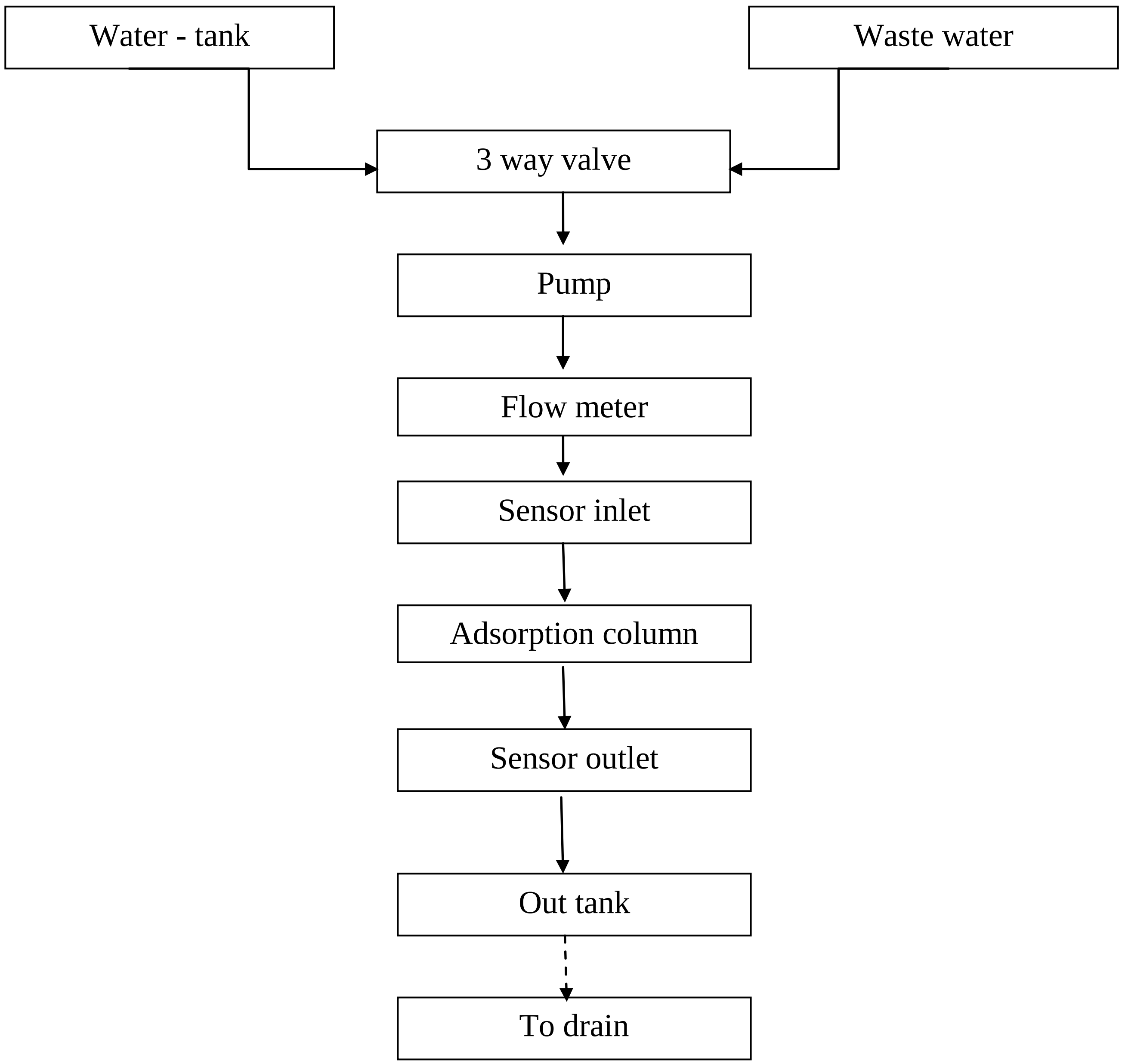


Figure 3.1 Block Diagram of Adsorption Process

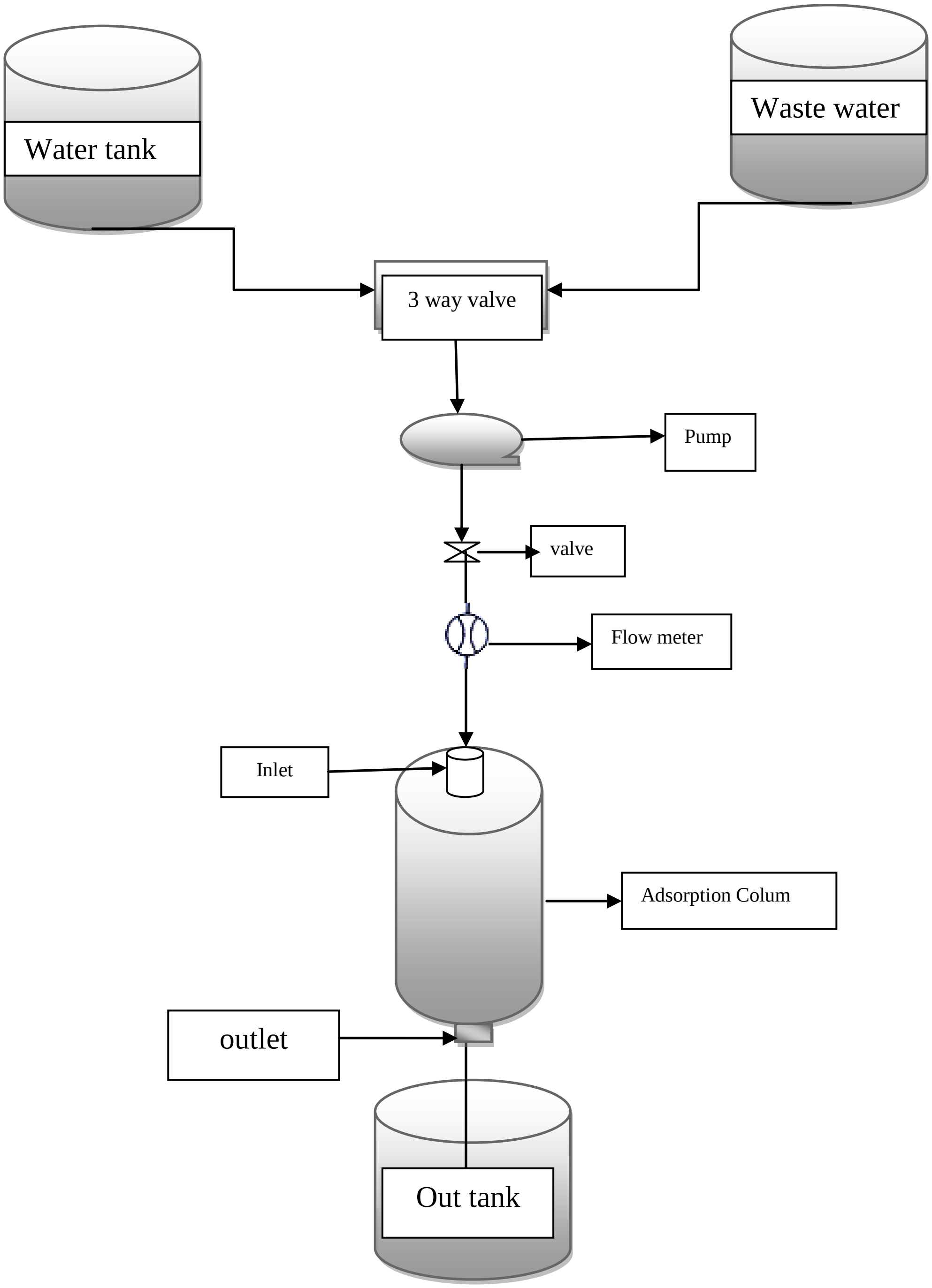


Figure 3.2 Process Diagram of Adsorption Process

3.3.3 Process Component

Process component for the desired adsorption process include the following

1) **Three Way Valve**

We need three way valve to control the water input to column, because we need two source to supply water to the adsorption column , first source used to supply adsorption column of waste water and other source to supply adsorption column of fresh water ,we need fresh water to backwash the adsorption column .

2) **Pump**

Pump used pumping water from waste water tank and fresh water tank .

3) **Valve**

Valve used to control the flow water rate to adsorption column .

4) **Flow Meter**

Flow meter used to measure the flow rate after the passage of water from the valve , so we need determine the flow rate to for the work of different experiment and measure the flow rate effect in adsorption .

5) **Flange**

Flange used to connect the both sides of the adsorption column , we choose the flange to connect to easy of cleaning the adsorption column.

6) **Adsorption Column**

Adsorption column is stainless steel cylinder contain grains of carbon and has inlet and outlet.

7) Outlet Tank

Out tank used to drain the water after adsorption process .

8) Sensors

sensor to measure the chromium in the waste water.

3.4 Process Design

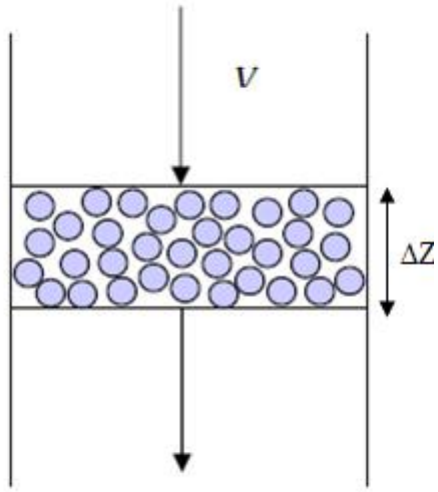


Figure 3.3 Mass balance in element of fixed bed

V total = V fluid + V particles (1)

$$\theta = \frac{V\,fluid}{Q} \quad (2)$$

fluid Void = $\epsilon * Vtotal$ (3)

$$Vpr = (1 - \epsilon)Vtotal \quad (4)$$

Where:

V fluid = volume of fluid (m^3).

V particles = volume of particles (m^3).

V total = total volume of fluid and particles(m^3).

θ = Residence time (second), of fluid in the column.

Q = Volumetric flow rate (m^3/s).

Residence time :is the average amount of time that a particles spends in a particular system. This measurement varies directly with the amount of substance that is present in the system.

ϵ = void fraction.

Void fraction :is a measure of the void spaces in a material, and is a fraction of the volume of voids over the total volume, between 0–1, or as a percentage between(0–100%).

Vpr = total volume of the material (m^3).

3.4.1Mathematical Model :

The generalized model corresponding to the pore diffusion mechanism,

following assumptions are made:

1. The system operates under isothermal conditions.

2. The equilibrium of adsorption is described by Langmuir isotherm.

3. Intra-particle mass transport is due to Fickian diffusion, and it is characterized by the pore diffusion coefficient, DP (m^2/s)

4. Mass transfer across the boundary layer surrounding the solid particles is characterized by the external-film mass transfer coefficient, kf (m/s)

5. The macro porous adsorbent particles are spherical and homogeneous in size and density.

$$-Dl\ \frac{\partial^2 C_b}{\partial z^2} + V\frac{\partial C_b}{\partial z} + C_b\ \frac{\partial V}{\partial z} + \ \frac{\partial C_b}{\partial t} + \rho_p\left(\frac{1-\epsilon}{\epsilon}\right)\frac{\sigma_{q_P}}{\sigma t} = 0 \qquad (5)$$

This is a partial differential equation that need two boundary condition and one initial condition

The following initial condition is considered

$C_b = C_{bo}$ $\qquad$ $z = 0\ , t = 0$

Boundary conditions:

B.C.1 z = 0 C= C .

B.C.2 z = c

Cb = bulk phase dye concentration, mg/ml.

z= axial coordinate (m).

L= column length (m).

3.4.2 Operation Parameter :

1- measure of the time during which a water to be treated is in contact with the treatment medium in a contact vessel, assuming that all liquid passes through the vessel at the same velocity. EBCT is equal to the volume of the empty bed divided by the flow rate."

$$EBCT = \frac{V}{Q} \qquad (6)$$

Or $$\frac{LA}{Q} \qquad (7)$$

Where :

V= volume of adsorbent m^3

A = cross sectional bed area, m^2

L = bed depth, m

Q = volumetric flow rate, L/s .

2-Adsorbent volume

$$V = \frac{(CUR * COP)SF}{\rho} \qquad (8)$$

Where

V = volume of adsorbent .

CUR = carbon usage rate, g/day.

COP = carbon change out period, days

ρ = bulk density of carbon, g/cm^3 .

3- Bed Depth. Bed depth is a direct function of the column diameter and volume.

$$L = \frac{V}{A}$$

Where

L = the bed depth.

A = adsorber bed area.

4-Carbon Usage. Carbon usage can be estimated several ways. One method to estimate GAC usage is based on isotherm data using the relationships

$$CUR = \frac{Co\ V}{\left(\frac{X}{M}\right) Co} \qquad (10)$$

Co = initial concentration (mg/L)

$\left(\frac{X}{M}\right) Co$ = $\left(\frac{X}{M}\right)$ value of concentration Co$\left(\frac{mg\ contam}{g\ carbon}\right)$

3.4.3 Design of Adsorption Column

To design adsorption column there are two way to choose the column .

Building the adsorption column depend on the data and the variable factor , and this variable are :
Flow rate

Bed depth

Choosing the diameter and length of adsorption column determine the diameter of adsorption column depend on the hydrodynamic , that means depend on the flow rate in adsorption column and the pressure drop.

determine the length of adsorption column depend on mass transfer in adsorption process .

Darcy's law is a phenomenological derived constitutive equation that describes the flow of a fluid through a porous medium. It also forms the scientific basis of fluid permeability used in the earth sciences.

Previous investigation model is studied by varying the different important parameters such as flow rate, bed height, inlet adsorbent concentration and particle diameter.

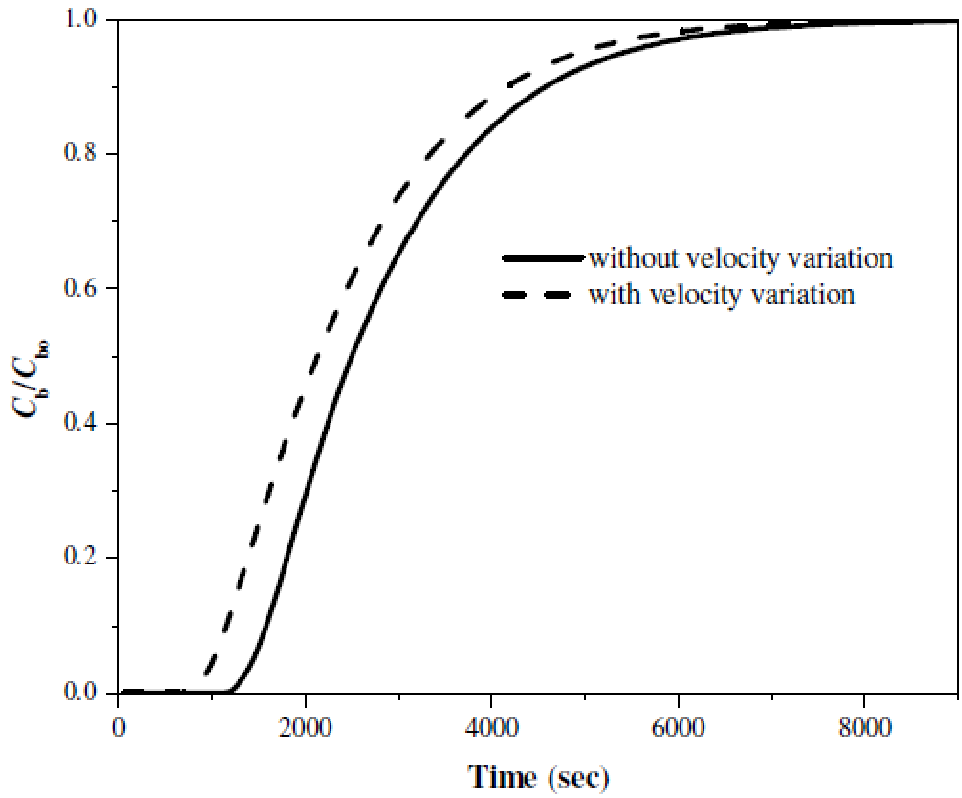


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Figure 3.4 Breakthrough curve with and without fluid velocity variation for a velocity of V=0.0020 cm/sec

The figure 3.4 show the t mass transfer coefficient in adsorption process with variation of velocity ,from figure we can conclude the behavior of adsorption presses where the y axis ($\frac{C}{Co}$) change when the contact time of adsorbent are different .

In the figure the curve is move to the left when the contact time is decreasing .

Effect of Flow Rate

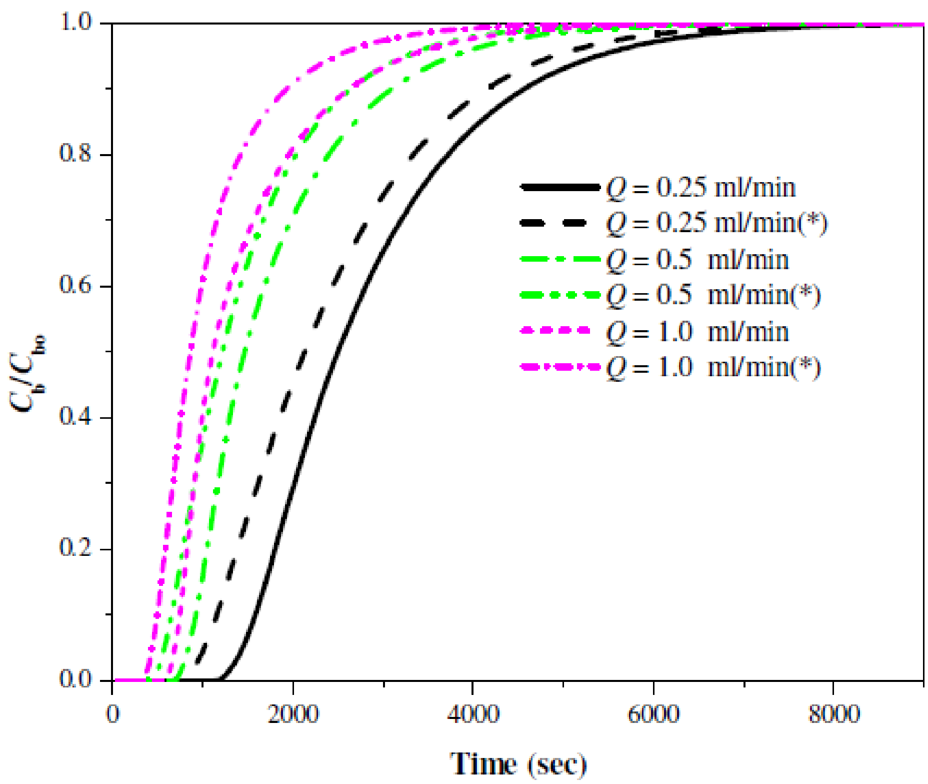

Figure 3.5 Effect of flow rate on breakthrough curve

The figure show the result of the adsorption process at different flow rate at constant bed height ,figure 3.5 show the flow rater increasing from 0.25-1 ml/min , the breakthrough curve become steper.

The break point time decreasing , This is because of the residence time of the solute in the column, which is not long enough for adsorption equilibrium to be reached at high flow rate..

The adsorb ate solution leave from the column at high flow rate before equilibrium accurse.

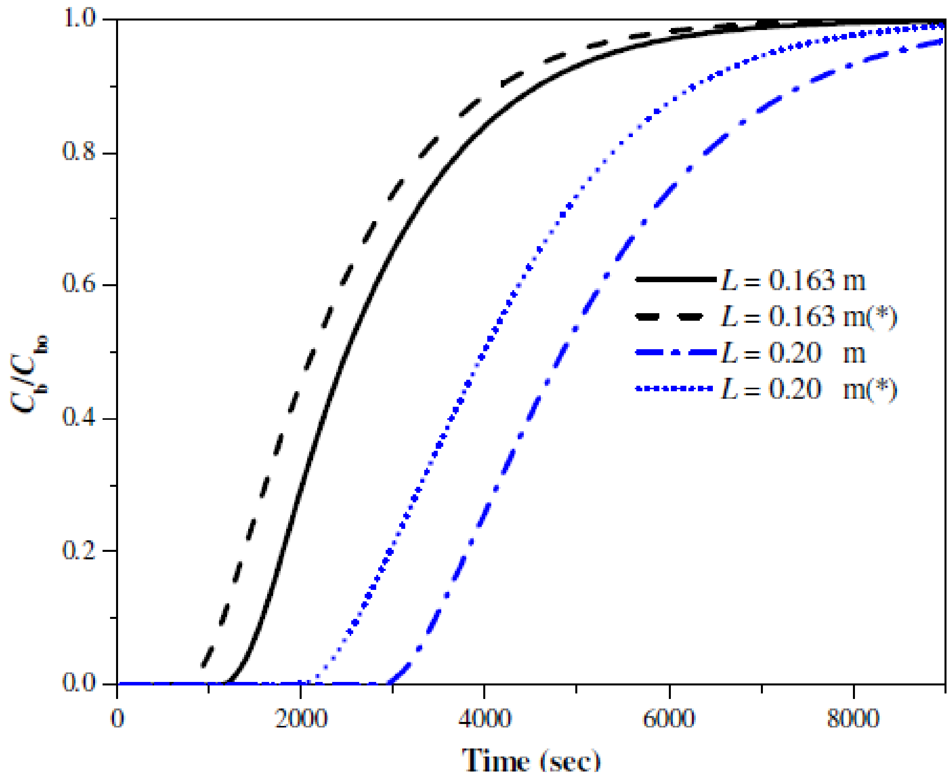

Figure3.6 Effect of bed height on breakthrough curve

The figure3.6 show the effect of the bed height in adsorption process at fix flow rate ,when increase the bed height the break point time increase.

3.5Experimental Work

3.5.1 Measuring Flow Rate

A flow meter is an instrument used to measure volumetric flow rate of a liquid or a gas .

We used flow meter to analyze the effect of flow rate in adsorption process, and to get result about the effect of flow rate in adsorption process .

we use mechanical flow meter in experiment, and in experiment we fix the flow rate by using manual valve .

The range of flow meter is (0 – 100 l/hour)

Figure 3.7mechanical flow meter

3.5.2 Solenoid valve

A valve is a mechanical device for controlling the flow of a fluid or a substance. A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid.

Part of solenoid valve Solenoid valve

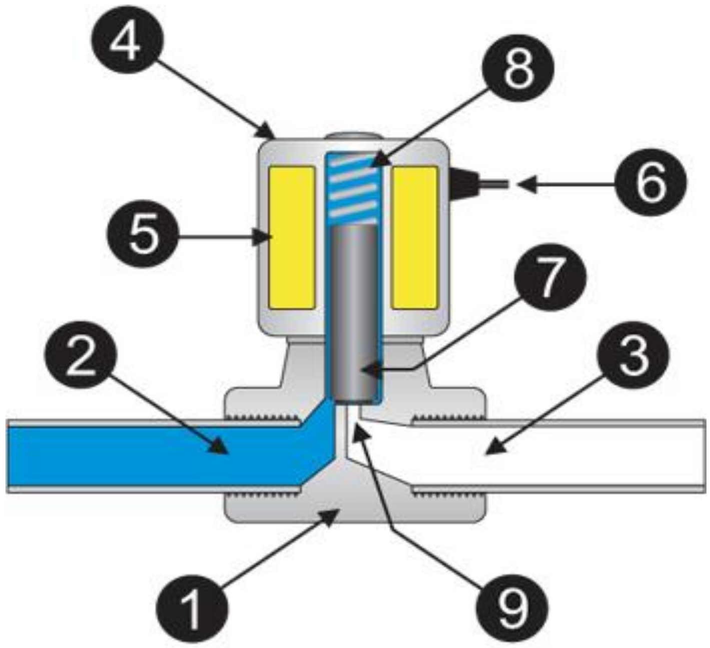

Figure 3.8solenoid valve parts

1. Valve Body	**4. Coil / Solenoid**	**7. Plunger**
2. Inlet Port	**5. Coil Windings**	**8. Spring**
3. Outlet Port	**6. Lead Wires**	**9. Orifice**

The media controlled by the solenoid valve enters the valve through the inlet port (Part 2 in the illustration above). The media must flow through the orifice (9) before continuing into the outlet port (3). The orifice is closed and opened by the plunger (7).

The valve pictured above is a normally-closed solenoid valves. Normally-closed valves use a spring (8) which presses the plunger tip against the opening of the orifice. The sealing material at the tip of the plunger keeps the media from entering the orifice, until the plunger is lifted up by an electromagnetic field created by the coil.

Figure 3.9 Three way solenoid valve

Figure 3.10 Two way solenoid valve

3.5.3 Pump

Pump choosing according the flow rate (L/min),and the head (m) in experimental we need low flow rate (1-2)and head 3meter.

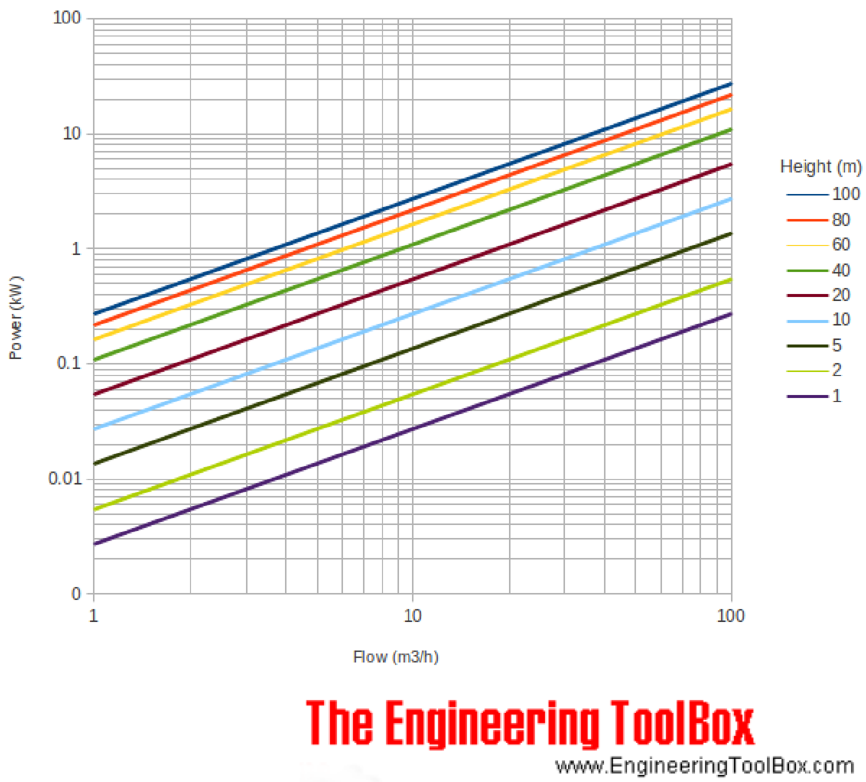

Figure 3.11 pump selection

From figure(3.7) the power of pump is (0.01 KW)

3.5.4 Sensors

Sensor for measure chromium 6 concentration not available locally, alternative solutions for measuring the conductivity of wastewater ,

conductivity sensor are an economical sensor to measure the solution in industrial process. this technology is ideal for harsh environments such as metal plating, wastewater, or any highly acidic or caustic application.

Figure 3.12 Conductivity sensor

3.5.5 Conductivity and total dissolve solid meter

Conductivity and total dissolve solid meter shown in figure (3.14) is a device used for analyzing water samples, and this device used in wide applications such as laboratory, plating industry, quality control,. Thus it can give an impression about the water status weather. Fresh water was used as a reference to compare the samples.

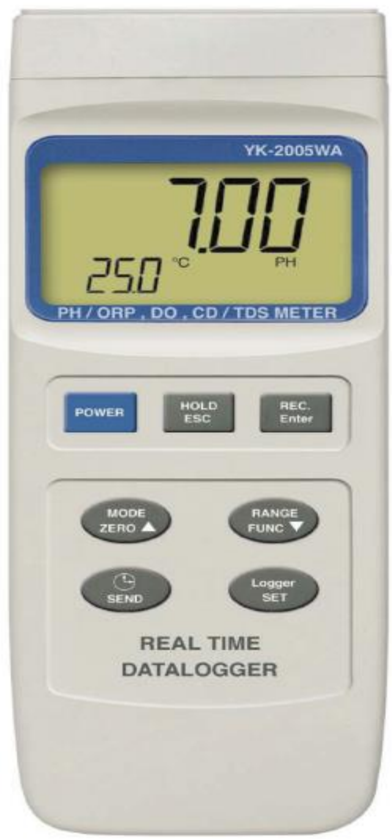

Figure 3.13 conductivity and total dissolve solid meter

3.6 Practical Building of adsorption column

3.6.1 The Upper Part

This part of adsorption Coolum is made of stainless steel as shown in figure it is connected with the middle part by flanges and contains the following main parts:

- Water inlet: is a thin cylinder that the water source pipe is connected with in order to supply water into the column.
- Distributer: distributes the washing water to cover a maximum cross sectional area of the column in order to guarantee that maximum of water parts to be washed.
- Flange: it plays a role of connecting the tower parts together, it has six holes connected directly with the lower flange using screws.
- Manual valve: manual valve connect with upper part to switch on or off the water in adsorption column.

Figure 3.14 Upper flange

Figure 3.15 Manual valve

Figure 3.16 Distributer

3.6.2 The Lower Part

This lower part of adsorption column is made of stainless steel, it includes the following and is shown in figure 3.17

- Water outlet: the treatment water by adsorption process flows into the reservoir through and outlet of 1in diameter at the bottom of the lower part.
- Flange: to connect the lower part with the middle part.
- Sensor : measure the total dissolve solid in the water.
- Solenoid valve : to control of output water.

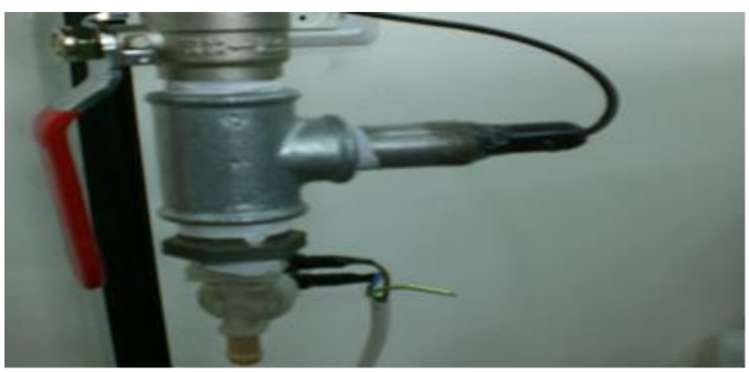

Figure 3.17 lower part component

3.7 Operations within Building Process

Four flanges with 0.8 cm thick for the upper flanges and .8 cm for the lower flanges, and the following operations were carried out:

A – Cutting

B – make the flanges straight

C – Installation(fixing).

D - Perforating

E - Grinding

A – Cutting:

Flanges been cut in a circular motion over diameter of 10cm by a special cutting machine, the inner diameter of upper and lower flanges were cut 2.5cm, and the outer 18 cm , the flange connect with column with inner diameter 10 cm and outer diameter 18 cm .

B - Make the Flanges Straight:

Flanges have been made straight as a curvature of the outer structure appeared after the cutting operation.

C - Installation:

Four flanges have been place on top of each other and then were to be installed together for drilling process, to drill a holes in all pieces for identical dimensions, in order to install the columns for supporting the column.

D-Drilling:

six holes were made after determining the places of each hole in the flange (the four flanges were welded together), four holes for the screws and the others are for columns.

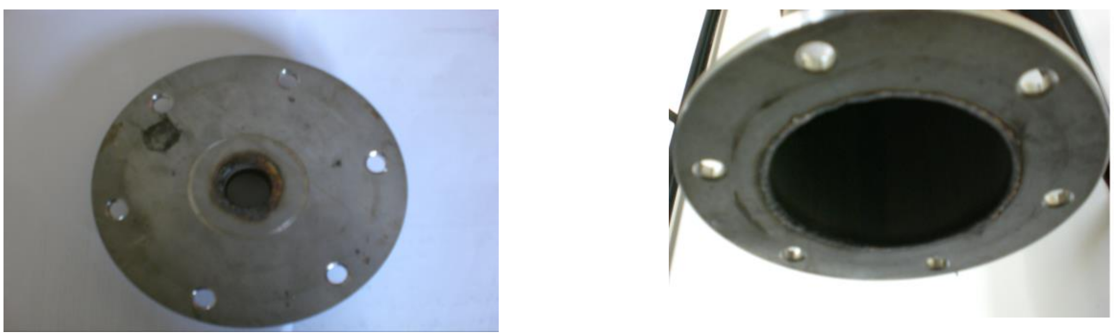

Figure 3.18 Flange

Chapter four

Implementation of Control and Monitoring System

4.1 introduction

This chapter discusses the control and monitoring system in this project. The main aim of this chapter is to show the way of thinking for building the control and monitoring system.

As the data collected by measuring the concentration of pollutants using measurement devices for water ; the results showed that the problem in the factory comes mainly from metal dissolve in water and then the control and monitoring system will be based on them.

4.2 Required Sensors for Control and Monitoring System

The sensing process of a sensor depends on the type of sensor and the manufacturing company of the sensor. almost all sensors have the same strategy in the sensing process, which is that the sensor would be at the place that the reading must be taken at, the reading is voltage or current output and needs a calibration process to become in the form of conductivity output in μs according to the provided datasheets.

4.3 Control and Monitoring Processes

This section discusses the main control and monitoring approaches and descriptions of the implemented control and monitoring system for this project. It is just ON\OFF control system has been implemented, and was preferred to be simple as much as can be done.

4.3.1 Control and Monitoring Approaches

PLC (Programmable Logic Controller):This way is much suggested approach to control, has the ability to deal with analog and digital form of signals.

4.3.2 Processes Sequence of Operation

Figure (4.1) illustrates the system operation flow chart; the sequence of operation is also highlighted in the following main points:

- The dominant input signal is a switch that can be turned ON and OFF manually by the user.
- If the switch turned ON, the pump and valve1 starts working .
- After pump switch ON, the sensors at the input sensor start taking readings within discrete time periods
- After delay input sensor takes reading ; delay time to adsorption process.
- After delay time the outlet sensor start taking readings within discrete time periods

- Sensors readings are displayed at LCD screen .
- compare the output reading with the input. Thus if the output signal is equal the input signal, backwash on by starting the pump and valve3 and input sensor takes reading .
- If backwash Ineffective the system goes off.

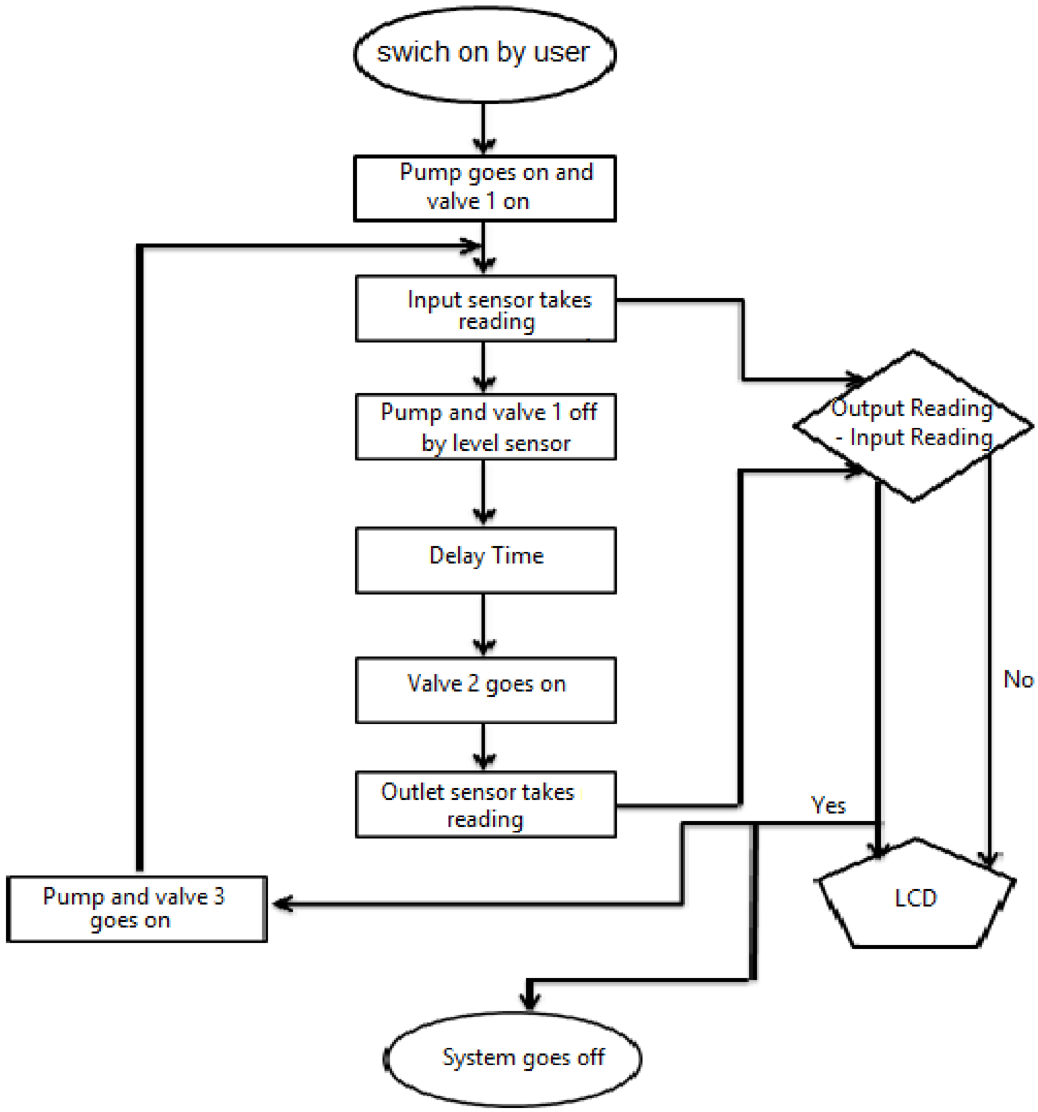

Figure 4.1 System Operation Flow Chart

4.3.3 Implemented System Hardware Connection

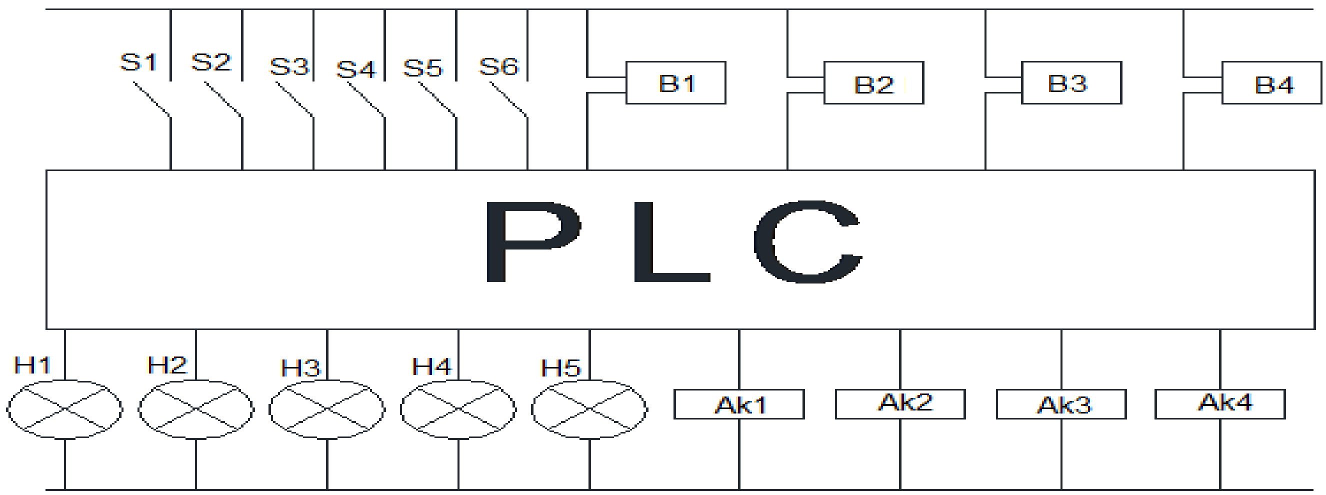

Figure 4.2 Control Circuit of PLC

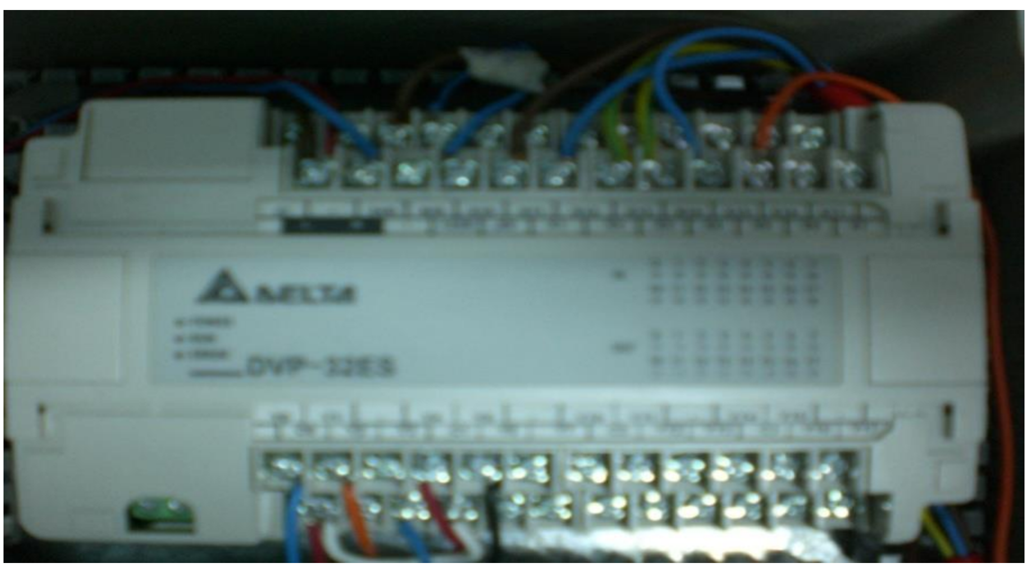

Figure 4.3 PLC use in Project

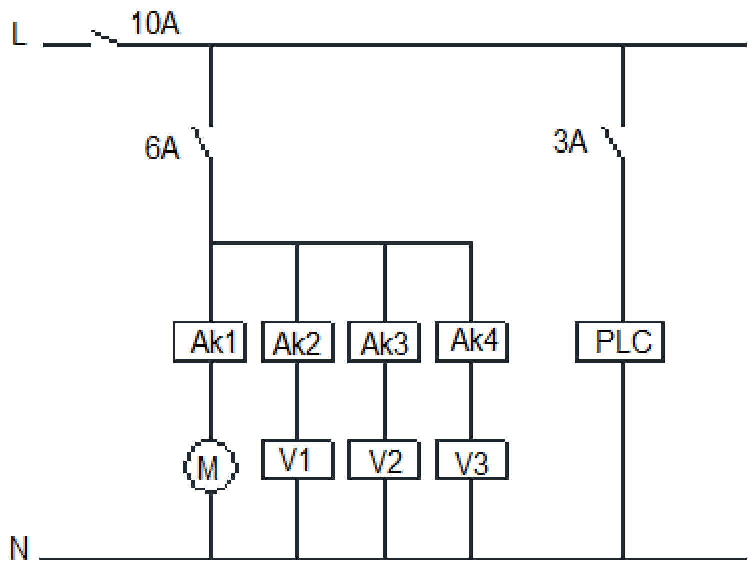

Figure 4.4 Power circuit for the System

Figure 4.5 Circuit breaker for the System

Figure 4.5 Relay for the System

Figure 4.6 Box contain PLC and other hardware for the System

1) Inputs include the following:

- Sensors for conductivity
- The user input which is an ON\OFF switch turns the system either ON or OFF.(S1,S2).
- Sensors for conductivity readings at both sides of the column (B1,B2).
- Emergency switch(S6).
- Three switch to is an an ON\OFF switch turns every valve in system either ON or OFF(S3,S4,S5)
- Two level sensor to indicate the level of fluid in the column(B3,B4).

2) Driving circuits include the following:

- Four 5V relays for each output(AK1,AK2,AK3,AK4)

3) Actuators are:

- Water pump(M).

4) Outputs include:

- Five lamp(H1,H2,H3,H4,H5)
- Pump is ON\OFF
- Solenoid valves ON\OFF(V1,V2,V3).
- LCD screen displays the conductivity at the inlet and outlet.

Chapter Five

Result and discussion

5.1 Data Analysis

The project aim is dialing with wastewater caused by galvanized industry to get rid this pollution from waste water by adsorption column, many test were made, and different data were taking the table below show the data that taken.

Table 5.1: Total Dissolved Solid

# Data	TDS	Time (minute)
1	500	5
2	550	10
3	615	20
4	780	30
5	1030	60
6	1110	120
7	2460	360

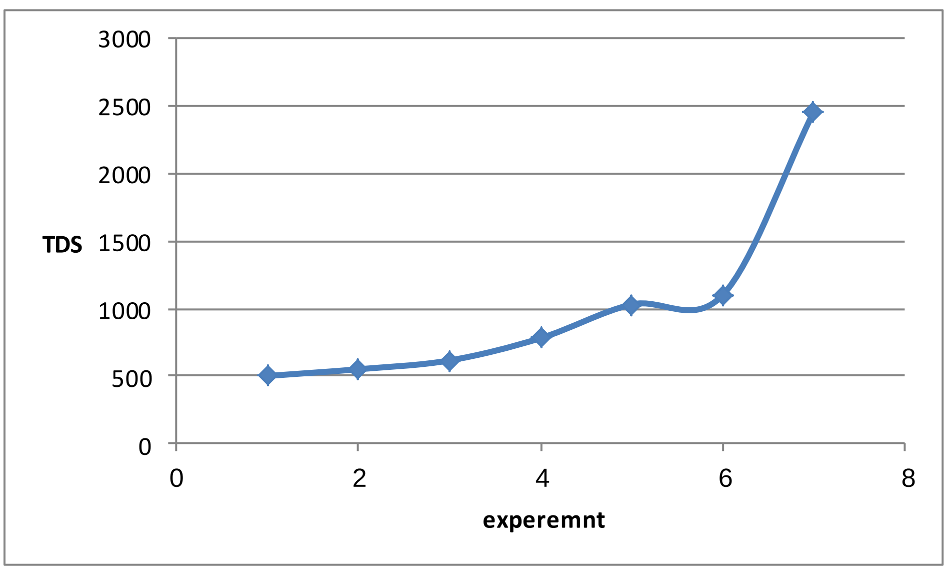

Figure 5.1: TDS Curve

By using activated carbon. As the figure 5.1 shown above the capability of adsorption by activated carbon was high and within time the activated carbon became saturation and the ability of adsorption decrease.

At the beginning activated carbon adsorb e high level of pollution, then the ability decreasing with time and flow of wastewater, the table below describe the percentage adsorption TDS for the wastewater without adsorption was (4260).

Table 5.2:% of adsorption wastewater

# Data	TDS	% of adsorption $(1 - C/Co)$
1	500	88.3
2	550	87.2
3	616	85.7
4	780	81.8
5	1030	76.6
6	1100	74.3
7	2460	42.7

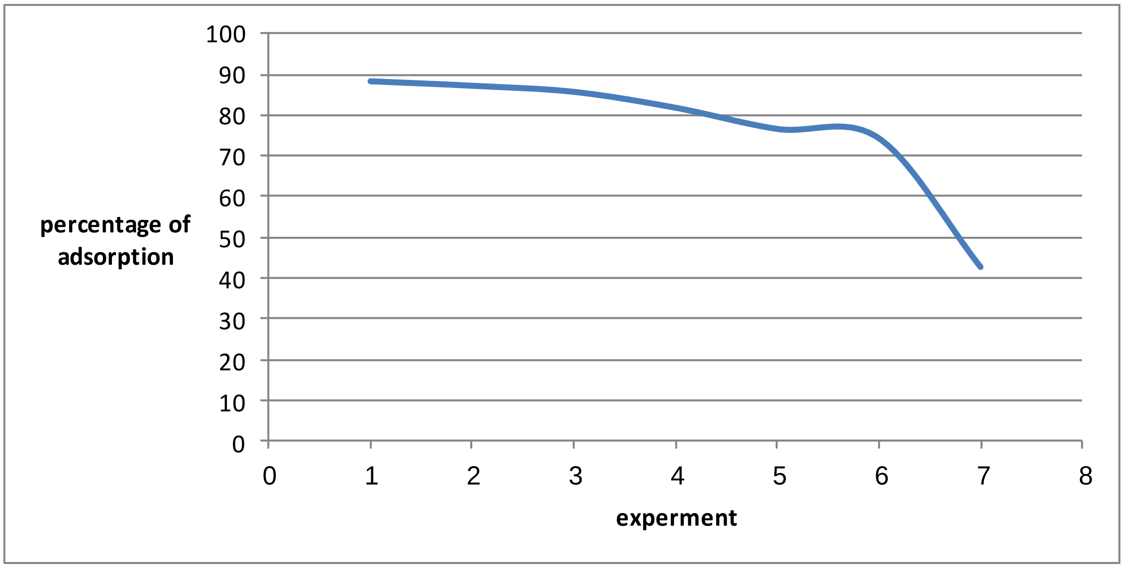

Figure 5.2 Percentage of adsorption

From this Figure % of adsorption by activated carbon was very high at the beginning then start to be in saturation way and decrease the percentage of adsorption.

After this process the water is ready for using in agricultural uses and different application in local industry

5.2 conclusion

This project where design to deal with wastewater caused by galvanization process .

Different experiment were taken on wastewater to show the ability of activated carbon to adsorb the pollution from solution to be able using this water in local uses without any negative effect .

The activated carbon was good metal for release the pollution from waste water .

The percentage adsorption depending on the time taken and amount of activated carbon and the amount of pollution .

The flow rate has negative effect if the process depends on time and has long time to take data.

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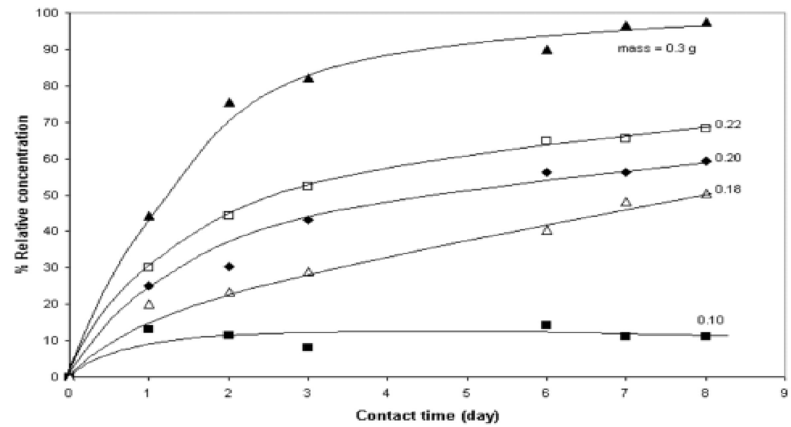
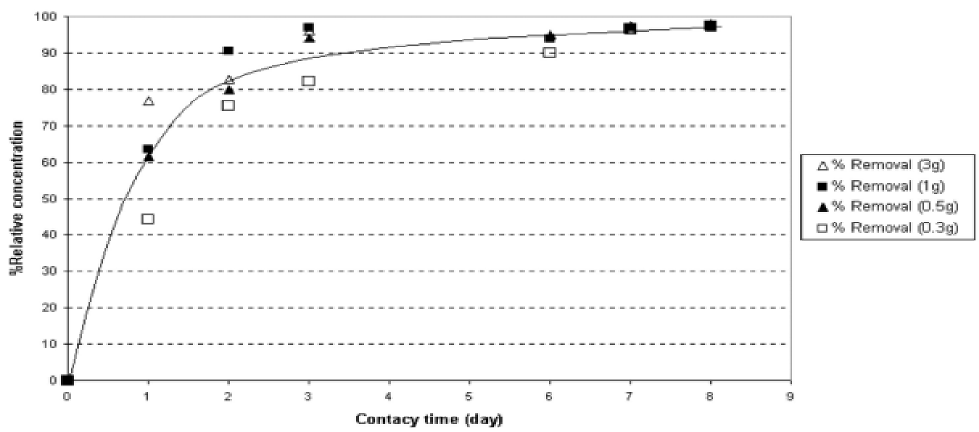
Appendix A



(a)



(b)

Figure (A.1)

Figure A.1 shows the percentage relative concentration as a function of time for various amounts of adsorbent. The samples taken from the solution for testing were returned to it after analysis. Appendix A

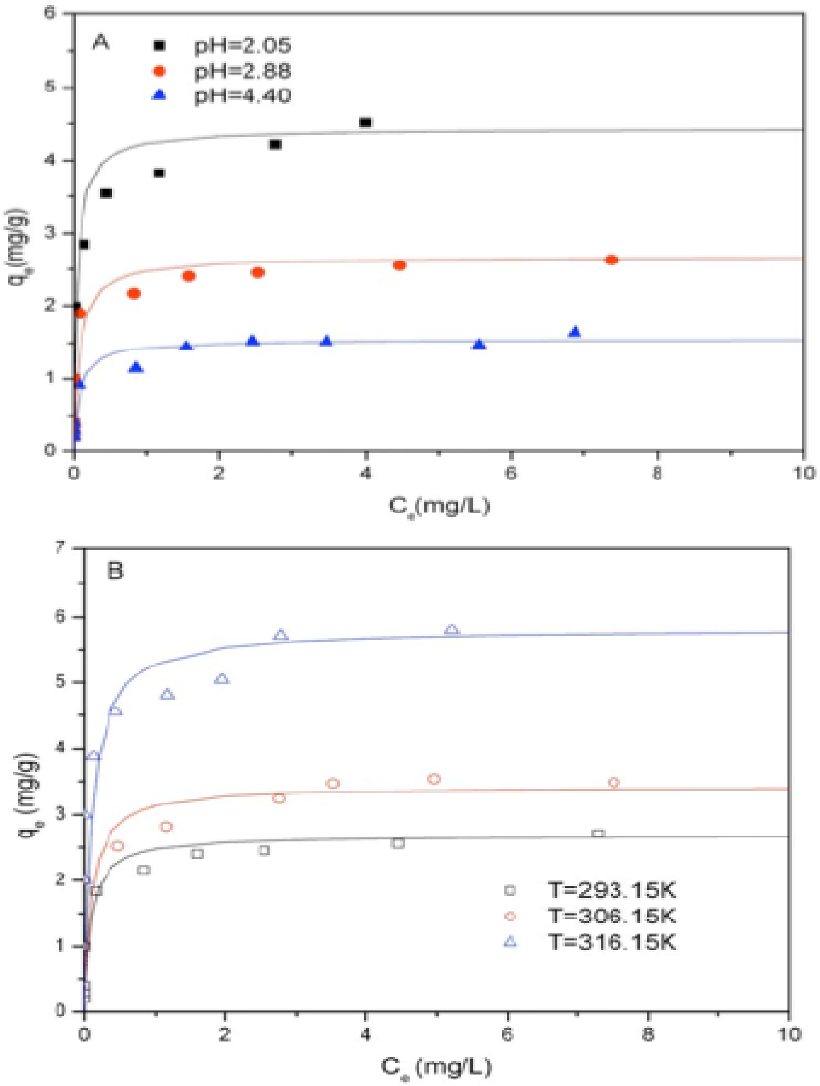


Figure A2 .Adsorption isotherms of Cr(VI) on raw MWCNTs. I=0.01M NaClO4, m/V=1.0 g/L, and contact time=165 h. (**A**): at different pH values at T=20±10 ºC; (**B**): at different temperatures at pH=2.88±0.02. [14]