Palestine Polytechnic University

College of Engineering

Enhancement of Cleaning Water Properties Through Application of Magnetic Field

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الـشكـر

لا بد لنا ونحن نخطو خطواتنا الأخيرة في الحياة الجامعية من وقفة نعود بها إلى أعوام قضيناها في رحاب الجامعة مع أساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا عظيمة في بناء جيل الغد لتحيا الأمة من جديد...

وقبل أن نمضي نقدم أسمى آيات الشكر والامتنان والتقدير والمحبة إلى الذين حملوا أقدس رسالة في الحياة...

إلى اللذين مهدوا لنا طريق العلم والمعرفة...

إلـى جميـع أسـاتـذتـنـا الأفـاضل

"كن عالما ... فإن لم تستطع فكن متعلما، فإن لم تستطع فأحب العلماء، فإن لم تستطع فلا تبغضهم"

وأخص بالشكر والتقدير:

الـدكـتـور/ حسن صوالـحة و الأسـتـاذ/ علـي عمـرو و الـمـهـنـدسة/ نـاريـمـان زاهدة

على إتمام هذا المشروع وتقديمهم لنا يد العون وتزويدنا بالمعلومات اللازمة

الإهداء

عندما يمتلئ الوجدان سرورا يكبر حبنا للعطاء...

فعندما نعطي بلا مقابل نعطي كماء لا ينضب، وكعمر لا ينتهي، وكزهر لا يذبل، وربيع لا يمطر

نحن نعطي عندما يتعب العطاء من عطايانا

عندما وقفت أقدامنا على مشوار البداية الذي كان طويلا حينها لم تستطع أبصارنا رؤية مداه

فقد كان لا يتجاوز خطواتنا الصغيرة، والآن وقد أوشكنا على النهاية

نشعر بالحنين... إلى أول يوم من أيام هذا المشوار

ولكن لكل طريق نهاية

بـعـد بـسم الله الـرحمن الـرحيم

"وقل اعملوا فسيرى الله عملكم ورسوله والمؤمنون"

إليك يا من لا تتم الصالحات إلا بفضله .. إليك يا إلهي حبي وامتناني .. فالحمد لله .. الحمد لله ..

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أساتذتنا الكرام

Abstract

Food and beverage industries consume large amount of water, detergent substance and energy in cleaning in place system (CIP). This project aims at enhancing the cleaning water properties through application of magnetic field. Caustic soda(NaOH) and Phosphoric acid(H_3PO_4) solutions were used as model cleaning agents dissolved in water. The solutions were subjected to magnetic field at different operating conditions: continuous flow magnetic stone, batch magnetic stone and electromagnetic field and the conductivity of solutions were measured during time. The results showed that the conductivity of detergent solutions increases with exposure to the magnetic and electromagnetic field. In addition, increasing conductivity of detergent solution with increasing intensity magnetic field. The main conclusion of the present study is that the magnetic stone and electromagnetic field could be successfully applied to enhance the solutions of detergents and thus reduce raw materials consumption.

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List of Abbreviations

1) CIP : Cleaning In Place.
2) NASA : National Aeronautics and Space Administration.
3) COP : Clean Out of Place.
4) FAD : Food and Drug Administration.
5) PAA : (Peroxyacetic Acid).
6) NaOH : Caustic Soda.
7) M : Molarities.
8) mT : mili Tesla.
9) ms : mili second.
10) C° : Celsius degree.
11) Hrs : Hours
12) EM: Electromagnetic.
13) EMF: Electromagnetic Field.
14) ELF: Extremely Low Frequency.
15) RF: Radiofrequency.
16) UV: Ultraviolet.
17) Hz: Hertz.
18) T: Tesla.
19) MHz: Mega Hertz.
20) GHz: Gega Hertz.

Chapter One

Proposal

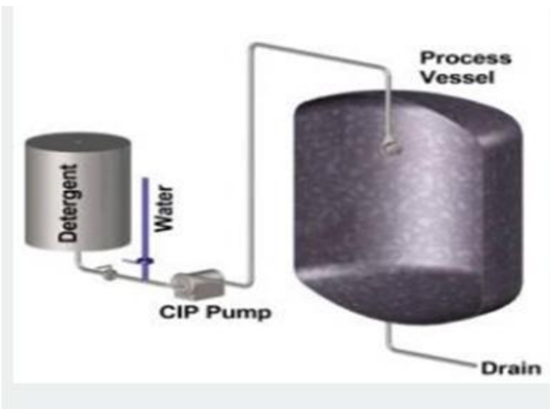
1.1 Introduction

Recently, the industry has evolved dramatically in Palestine. There were many industries such as dairy, leather, plastics, shoes, hygiene critical industries such as pharmaceutical, food, beverages and other industries that have contributed significantly to the growth and prosperity of the country's economy. In general all factories consume a lot of water in their industries. In particulate hygiene critical industries consumes a lot of water, Cleaning In Place (CIP) was estimated on average 25000-30000 gallons a day[1] The factories are one of the reasons water scarcity global problem. This problem is one of the most important problems facing the environment.

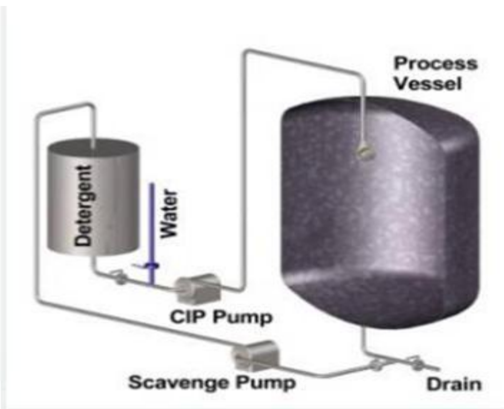
After 1950s the factories used the CIP. CIP used a mix of water, chemicals substance and heat to clean machine, pipes, vessels without dismasting machine [2].CIP is a very efficient way for cleaning in factories especially in hygiene critical industries because the health food and beverage product are very important. The machine must meet a high hygiene standards to prevent degradation and contamination for product during operations [3].

The success of CIP depends on: temperature, pressure, concentrations, time and hydraulics [3]. The types of detergent used for CIP depend on the soils cleaned. If the soils are heavy and contain a lot of fatty nature, it can be removed by a caustic soda, but if the soils are light, it can be removed by a pre-rinse [3].

There are two system for CIP, single pass system and recirculation system; In the single pass system the water enter to machine and then disposal to drain as shown in figure[1.1]. It used in pre-rinse level to remove as much soiling as possible. In the recirculation, system the cleaning solution is produced in an external tank then entered to the machine to be cleaned. The cleaning solution topped and recalculation as required until the cycle is complete then doing a final rinse as shown in figure [1.2]. Recirculation system is excellent system because it use less water and cleaning detergent, but in some cases recirculation system may be un-suitable due to big capital and contamination from one process to another [3].



Figure[1.1]: CIP single pass system[3]



Figure[1.2]: CIP recirculation system[3]

All factories optimize CIP process and their technologies to save water, chemical substance, energy and time. There are many technologies to optimize the CIP process, one of these technologies is exposure wave to the cleaning. However using other types of waves, such as electromagnetic wave on cleaning solution is not examined.

Magnetic field changes the chemical and physical properties of water, such as, the surface tension, electrical conductivity and the proportion of dissolved oxygen in the water. Magnetic field could be generated by two ways, magnetic field from a permanent magnetic and electromagnetic created by current as shown in figure[1.2][4]

A permanent magnet maintains its magnetism over long period of time because is made from a hard magnetic material. It is provide a constant magnetic strength. It is cannot affected by power failure, operating at peak efficiency and there is no heat generation. In the way electromagnetic created by current the current running through a coil of insulated wire around soft pieces of magnetic, in this way the flux of electromagnetic is variable and it is shut off when the current shut off. A significant DC power sources is required. This method creates heat and volumetric to power failures[4][5]

In general magnetic field depends on many factors: temperature, time, material of pipe, stirring. The previous researches define these factors depending on the kind of process (treatment, agriculture medical) and kind of chemical substance in it. There is no effort for industrial water on CIP. This project investigates the technical feasibility of using magnetic field to make optimization for cleaning in place [4][5].

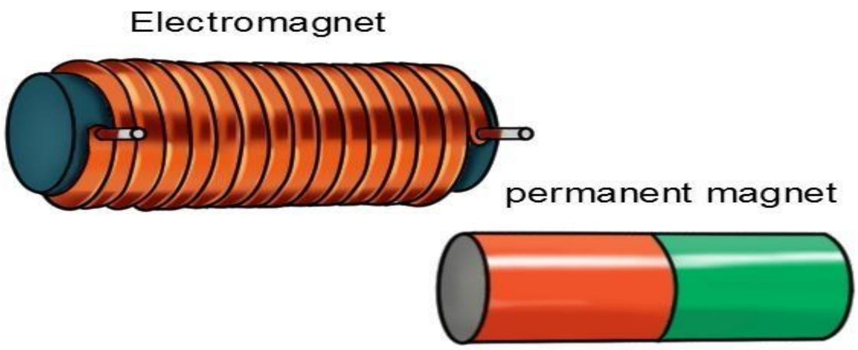


Figure [1.3]: permanent magnetic and electromagnetic created by current

1.2 Scientific Background

All factories consume a lot of water in their industry. The factories are one of reasons water scarcity global problem. Total industrial water use in the world is about 22%, with high-income countries using 59%, and low-income countries using 8%. In particulate factories consume a lot of water CIP estimated on average 25000-30000 gallons a day [1], many previous research studies the problem of water and provide solution for it, but no one provides a solution depends on CIP, which is "consuming a lot of water and chemical substance.

Water is composed from two atoms of hydrogen and one oxygen atom. The bond between them covalent where each hydrogen atom electrons involved. Where it becomes the molecule carries a positive charge on the tip and negative on the other side. It becomes a molecule behaves such as small magnetic field, where it becomes a dipole. When it becomes a dipole is responsible for one of the most important properties of water which is solubility. Water is a universal solvent because it can dissolve most of the compounds such as organic compounds and inorganic, Since the positive portion in the water molecule attract with negative particles and the negative portion attract with positive molecules which affects the melt material in the water. Magnetized water is useful in preventing or inhibiting accumulations that affect the chemical properties of water, thermodynamic properties of water and water flow. Magnetic field consists arranged by lining up positive and negative charges were opposite[6].When the water passes through a magnetic field, there are several important things to achieve the desired results[6]: the path of the water must be perpendicular to the magnetic field lines and the water must first cut the South magnetic field lines and then moves to the north Pole.

The magnetic field technique is applied in several countries in different areas such as in The National Aeronautics and Space Administration (NASA), the use of magnetic treatment technique in the examination of corrosive solids. In the Soviet Union has been using magnetic water treatment widely been regarded as economically useful [6]. There are many areas has been the use of magnetic technology in water treatment such as the use of magnetic resonance technique waste resulting from the extraction of oil sands processing operations. These wastes contain water (58-62%), clay and sand (37%) and other chemicals (1-5%), sand deposition speed was faster than the deposition of clay. Waste deposition rate depends on the particle size, density and surface properties. These properties can be modified and changed by controlling the degree of acidity, salinity or add coagulant factors. Waste management is an important environmental issue. Waste used to monitor changes in sedimentation properties where these changes have been observed by the change in the electromagnetic radiation[7].

The second application is magnetic water treatment unit, in this technique the magnet is placed inside the tube. In this unit, water is flowing inside the tube and passing around multiple magnets. The inner diameter of the tube containing a magnet works to reduce the pressure drop that occurs in the system. This unit have multiple and opposite poles of the magnetic field to make the biggest strongly flowing, as if it were a magnet bi-polar. The magnetized water the following tasks, prevents the accumulation of sediment, control erosion, control of the rust white [6].

Magnetic treatment technique has been used in more than 300,000 application of which systems and applications are characterized by: Low maintenance operations, a slight pressure drop, chemical additives does not adversely affect the environment, easily integrated into existing installations [6].

There are several research about the magnetic treatment of industrial waste resulting from textile mills and tanning before putting them in water bodies. After magnetic processing on water effluent samples resulted to a significant change in water-related odor, pH, and salinity properties which qualifies these waters with high interest rates where it can be re-used in the field of agriculture and industrial use. There are many kinds of waste from industrial waste as possible to be suspended or dissolved, suspended impurities possible disposal by precipitation, the dissolved impurities that cannot be deposited. Industrial water treatment using magnetic technology provides us with the time, cost and labor[8]

The previous Researches that used magnetic techniques have been used in the field of agriculture, the oil industry, the petrochemical, construction and food technology. Researchers doing experiments on water tanning and textile mills to study these factors change after exposing magnetic field. It is the degree of acidity, salinity and conductivity and solubility, it has been noticed that there is a noticeable change in these properties after exposing the water to magnetic field intensity 0.0085 Tesla for two hours, before exposing magnetic field the water has bad characteristic in terms of exist odor and suspended solids. Which confirms magnetic processing capacity in the dismantling of salt molecules and release hydrogen ion in water is found a better results whenever the increase subjugation of the magnetic field [8].

Ultrasonic cleaning is one of the most effective methods of cleaning for many applications such as pharmaceutical industries, fabrication manufactures and food industry. Ultrasonic cleaning is able to remove contamination and dirt from area which is difficult to access with gentle cleaning action. Ultrasonic energy is produce microscopic bubbles are able to access difficult area but sodium hypochlorite have a strong toxicity[9].

1.3 Problem Statement

This research project answered the question:

Is it technically feasible to make modification on chemical and physical characteristics for industrial water using in internal cleaning operation?

The following sub-problems were answered:

1) Can magnetic field increase the concentration of detergent substance in internal cleaning operation?

2) What is the effect of magnetic field on increasing cleaning operation efficiency?

3) What is the effect of magnetic field on the recycling process?

4) Can magnetic field elimination the sedimentation and erosion inside the pipes?

1.4 Goals and Objective

The main goal of this research project was to prove that the magnetic field can be used to modify chemical and physical characteristics of industrial water used in internal cleaning operation.

The following objectives were targeted:

1) Determining the validity of experimental procedure for modification on industrial water by magnetic field.

2) Optimizing the most efficient temperature, time and material of pipes for water through exposure by magnetic field.

3) Optimizing the best way to generat magnetic field (magnetic or electromagnetic) through experiments.

4) Studying the effect of magnetic field on the concentration of detergent substance.

5) Studying the effect of magnetic field on physical and chemical properties especially Conductivity.

1.5 Research importance

Water scarcity is global problem. Resulted from several reasons, such as the development of the industrial sector, water is consumed in factories without management in the various departments in the factory and disposal water without making treatment threats the quantity and quality water. Water used in internal cleaning operation consume a lot of water average, 25000-30000 gallons a day and detergents [1], also making a lot of corrosion in pipes. Its effluent without any treatment, this problem has not found solution until now. This project aim to find solution by exposure this water to magnetic field in order to reduce chemical substance consumed and corrosion in pipes, hence reducing the damage on environment and reduce the cost.

1.6 Methodology

1) Choose the sort of equipment and material that used such as the kind of chemical substance(acid or base), coverage of pipes (plastic, iron, stainless steel).

2) Generating magnetic wave field in two ways and exposure the water by it.

3) Physical and chemical test will be taken for the sample including conductivity and temperature.

4) Analyze the result.

1.7 Action Plan

The action plan of the project is illustrated in table [1.1] and table [1.2]

Table [1.1]: Action plan for first semester

Task	First Month				Second month				Third month				Fourth month			
	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4
Identifying the project idea																
Reading Literature review																
Visit a dairy industry factory																
Writing proposal																
Writing literature review																
Preparation and chemical substance																
Data analysis and results																
Documentation																

Table [1.2]: Action plan for second semester.

Task	First Month				Second month				Third month				Fourth month			
	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4
Visit a dairy industry factory																
Collecting samples from the factory																
Do the experimental on samples factory by two ways																
Parameter study																
Data analysis and preparation of chart results and tables																
Documentation																

1.8 Budget:

The total estimated cost for implementing this project is estimated at 1500$ as detailed in table [1.3]

Table [1.3]: project estimated cost

No	Item	Quantity	Cost
1	Transportation	_	300$
2	Physical and chemical tests	_	500$
3	Material requirement(caustic soda & phosphoric acid)	_	700$
Total	-	-	1500$

Chapter Two

Magnetic Field

2.1 Magnetic Field Source and Properties

Magnetic field could be generated by two ways, magnetic field from a permanent magnetic (ferromagnetic material) and electromagnetic created by current as shown in figure[2.1][10]. Magnetic lines have many properties such as: they have the same strength ,they tend the path of least resistance between opposite magnetic poles, they do not cross one another because of the separation tendency, when they move from an area of higher permeability to an area of lower permeability their density decreases and spread out, when the distance from the poles increase the magnetic lines density decrease, though no actual movement occurs of magnetic lines but they are considered to have direction as if flowing, they flow from the north pole to the south pole in air and south pole to north within a material, Magnetic field lines always make closed loops and will continue inside a magnetic material, they don't start or stop anywhere[11].

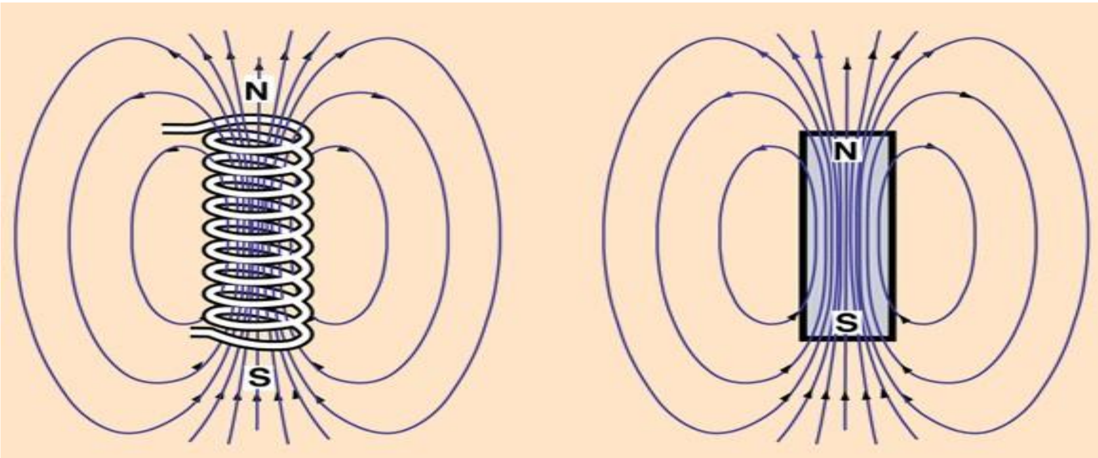


Figure [2.1]: Magnetic lines [11].

The waves which are generated by coupling of electric field with magnetic field are electromagnetic waves. These waves are in perpendicular to each other and perpendicular direction to both the magnetic and electric. The spectrum containing all possible range of frequencies coming in the electromagnetic wave called electromagnetic spectrum. These waves can be polarized and are transverse in nature so these waves do not need the medium for their Propagation [10].

Electric fields are created by differences in voltage; the stronger field will be the resultant by the higher the voltage. Magnetic fields are created when electric current flows, the stronger the magnetic field resulted by the greater the current. Even when there is no current flowing the electric field will exist. If current does flow the strength of the magnetic field will vary with power consumption but the electric field strength will be constant[11]. It's can be either dynamic or static and produced by electric currents as a result of electron movement as shown in figure[2.2][12].

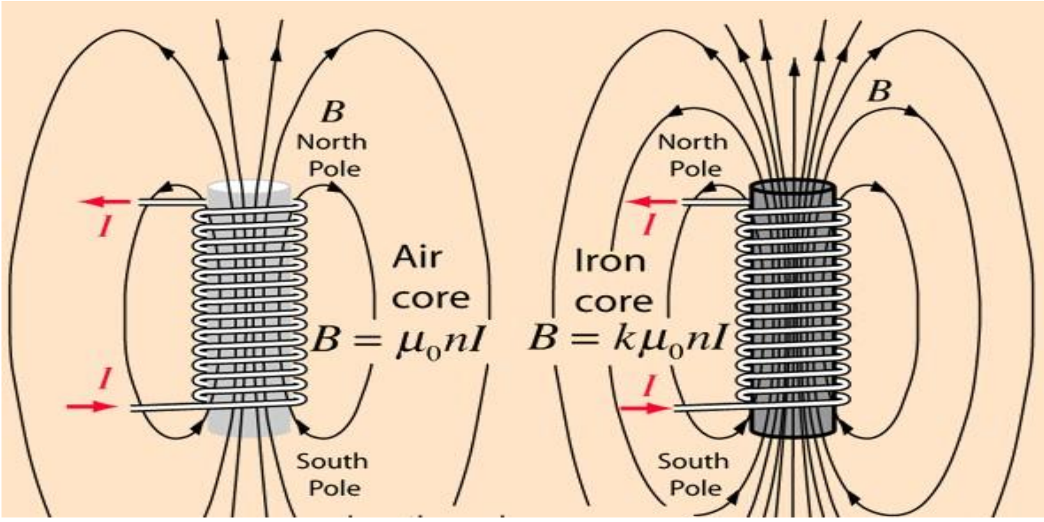


Figure [2.2]: Magnetic field direction [12].

Table[2.1]: Equations that describe magnetic field for air and iron cores.

For air core	For iron core
$B=\mu_0.nI$	$B=K\mu_0.nI$
B=magnetic field	B=magnetic field
μ_0=permeability of free space	μ_0= permeability of free space
n=number of windings per unit length	n=number of windings per unit length
I=current in windings	I=current in windings
	K= relative permeability

The various properties of Electromagnetic waves are: the Velocity of electromagnetic wave in vacuum is 3×10^8 m/s, the existence of medium is not essential for propagation, travel with light velocity, can be polarized, transverse in nature, have momentum, can exhibit diffraction and interference, there is no deflection on account of magnetic or electric field [10].

There are several differences between electromagnet and permanent magnet as shown in table [2.2].

Table[2.2]: Differences between electromagnet and permanent magnet[13]

	Permanent Magnet	Electromagnet
Magnetic Properties	Exist when the magnet is (magnetized).	Displays magnetic properties when an electric current is applied to it.
Magnetic Strength	Depends upon the material used in its creation.	Can be adjusted by the amount of electric current allowed to flow into it.
Loss of Magnetic Properties	Permanent magnet loses its magnetic properties, as it does by heating to a (maximum) temperature, it will be rendered useless and its magnetic properties can be only recovered by re-magnetizing.	Electromagnet loses its magnetic power every time an electric current is removed and becomes magnetic once again when the electric field is introduced.
Advantages	Permanent magnet does not require a continuous supply of electrical energy to maintain its magnetic field.	Electromagnet's magnetic field can be rapidly manipulated over a wide range by controlling the amount of electric current supplied to the electromagnet.

2.2 Magnetic and Electric Fields Radiation

Magnetic and Electric fields are invisible areas of energy, it's referred as radiation, that are associated with the use of electrical power and various forms of man-made lighting and natural as shown in figure [2.3].

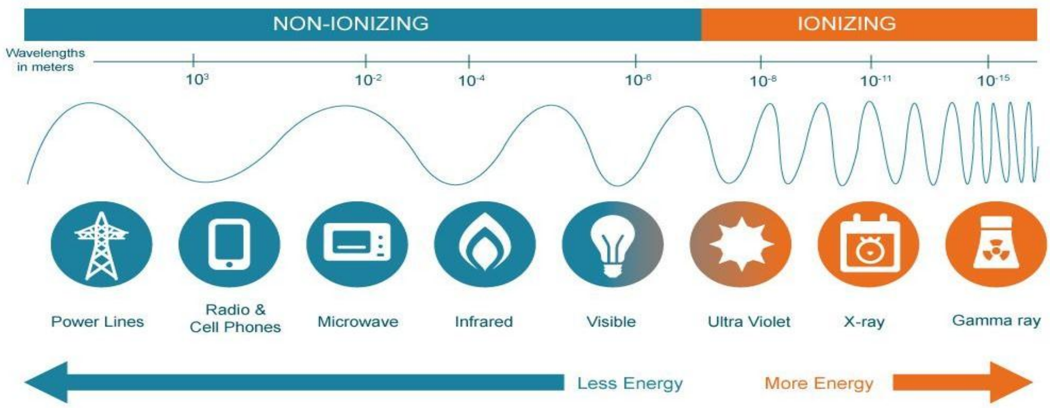


Figure [2.3]: Radiation Types [14].

Magnetic and Electric fields are typically characterized by frequency or wavelength into one of two radioactive categories:
Non-ionizing: low-level radiation which refers to types of radiation that do not have enough energy to cause ionizations in atoms.

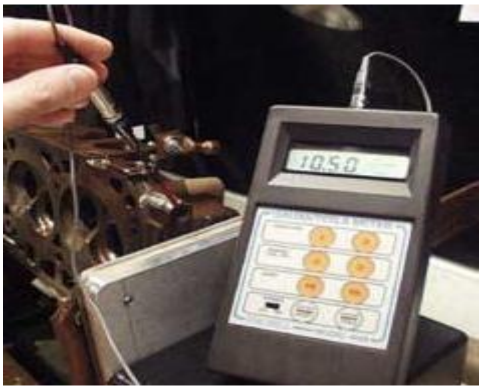
Ionizing: high-level radiation which refers to types of radiation that carry enough energy to cause ionizations in atoms as shown in table[2.3] [14].

Table [2.3]: Radiation Types [14].

Radiation Type	Definition	Forms of Radiation	Source Examples	Effects
Non-Ionizing	Low-level radiation (Can only excite electrons from a lower level to a higher level upon encountering).	Extremely Low Frequency (ELF) Radiofrequency (RF) Microwaves Visual Light.	House energy smart meters Wireless (Wi-Fi) networks Cell Phones Bluetooth devices Power lines Microwave oven Computers.	Have the ability to cause cancer.
Ionizing	High-level radiation (Can emit electrons or other particles from atoms when they collide).	Ultraviolet (UV) X-Rays Gamma.	Ultraviolet light X-Rays ranging from $30 * 10^{16}$ Hz to $30 * 10^{19}$ Hz Some gamma rays.	May cause cancer, but there is no direct evidence to support this.

2.3 Measuring Magnetic Fields

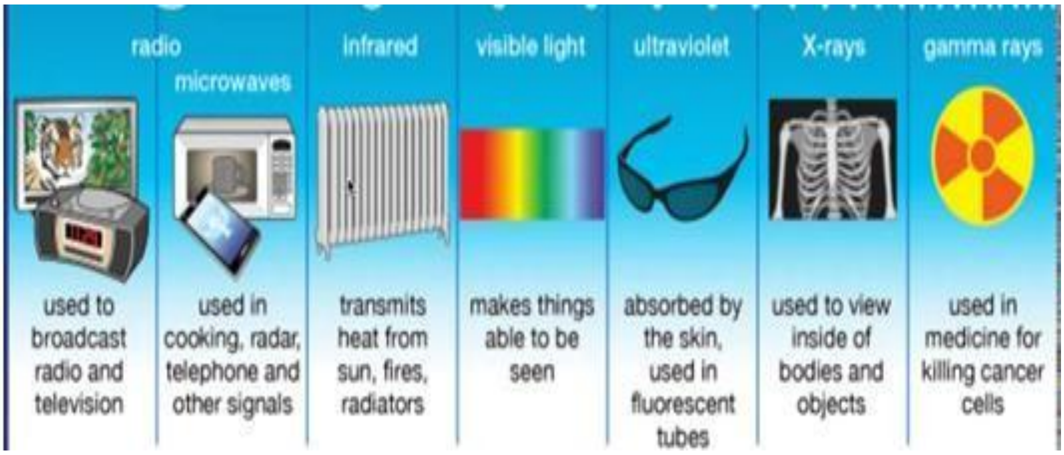
The magnetic field inside the material cannot be measured so the magnetic field outside the material can be measured by many devices such as the field indicator and the Gauss meter as shown in figure [2.4]. The Gauss meter is an electronic device that provides a digital readout of the magnetic field strength in Gauss or Tesla units [11].



Figure[2.4]: Gauss meter[11].

2.4 Application of Magnetic Field

Electromagnetic waves have many uses in many applications as shown in figure [2.5]. Electromagnetic waves used in communication through radio wave, in cooking through microwave, in remote controlled and tester through infrared radiation, in medicine to treat some of disease such as cancer, in agriculture and industry to treat the effluent water[15].



Figure[2.5]: Application of magnetic field[15].

2.5 Magnetic Field Effects on Water

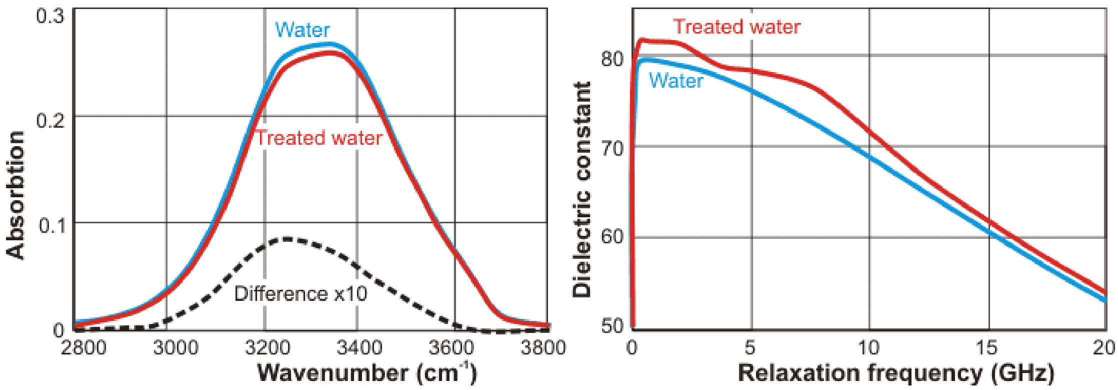
2.5.1 Magnetic Effects on Water

Liquid water is affected by magnetic fields, and these fields can help to purify it. Water is diamagnetic and can be raised in very high magnetic fields [10T]. The studies show an increase in mass volume in liquid water caused by a magnetic field. In contrast, it has been shown that the friction coefficient of water in thin films to reduce in the magnetic field [0.16-0.53T], indicating a potential reduction in the strength of hydrogen bonding. Salt mobility is enhanced in strong magnetic fields [1-10T] causing some disruption in hydrogen bonding. However, this only leads to a net reduction in the hydrogen bondation in high salt concentrations [e.g.5M NaCl], whereas at lower concentrations [1M NaCl] the increase in water hydrogen bonding in the presence of such higher magnetic fields which makes up for this effect. The increase in the refractive index with the magnetic field is due to increased hydrogen bond strength. The weak magnetic fields [15mT] and the strongest vertical magnetic fields [75mT] have also been shown to increase evaporation rate. These effects correspond to the magnetic fields weakening Van der Waals interconnecting between water molecules and the binding water molecules more closely, because of the magnetic field limiting the thermal movement of the inherent charges by generating forces of modulation. The magnetic susceptibility of water to the positive with magnetic frequency increases, and is said to be positive in the range of[0.4-1 MHz] for surrounding water[16].

2.5.2 Electromagnetic Effects on Water

Unregulated water with fewer hydrogen bonds is a more interactive environment, as evidenced by enhanced supercritical water interaction. The open, hydrogen-rich network structure slows interactions because of its increased viscosity, decreased proliferation and the involvement of less active water molecules. Any factors that reduce the correlation of hydrogen and the strength of the hydrogen bond, such as electrical fields, should be encouraged to react. Water groups (even with random arrangements) have an equal hydrogen bond in all directions. As such, electrical or electromagnetic fields that attempt to redirect water molecules must entail breaking some hydrogen bonds[16].

The properties of water solubility will change in the presence of these fields, and can result in the concentration of dissolved gases and hydrophobic molecules on surfaces followed by reaction. Extremely Low Frequency Electromagnetic Fields (ELF-EMF) have significant and lasting effects on liquid water. Using a soft field, modify them to give a magnetic field of [45μT]. Using only water and spectral spectrometer. Figure [2.6] showed the lower energy portion of the absorption band stretching, which relates to the fully bonded hydrogen bond population are decreases. Stronger fields of ELF-EMF [~ 0.15T] were applied to water, their relative permittivity (electrostatic insulation) and compared with untreated water. It was found that the relative permittivity (electrostatic insulation) of the ELF-EMF -treated field water was 3.7% higher than the control of the frequency range of [1GHz], which may indicate higher molecular polarization in the treated water[16].



Figure[2.6]: Effect of ELF-EMF on liquid water[16].

2.6 Effect of Magnetic Field on Detergent

2.6.1 Caustic Soda (NaOH)

There is no chemical reaction but there is a reaction in that the disassociation of the sodium and hydroxide ions and the hydration of those ions releases a lot of heat, enough to boil water in some circumstances. The reaction will be exothermic, where heat will be released. The heat evolved as a result of mixing caustic soda with water is due to the OH- ions incredible stability, as shown in follow reaction:

$NaOH_{(S)} + H_2O_{(L)} => Na^+ + OH^- + H_2O$ + Heat [16].

2.6.2 Phosphoric Acid (H_3PO_4)

Phosphoric acid has three acidic and replaceable H atoms. Thus, it reacts differently from other mineral acids, as shown in follow reaction:

$H_3PO_{4(S)} + H_2O_{(L)} \rightleftharpoons H_3O^+_{(aq)} + H_2PO_4^-{}_{(aq)}$
$H_2PO_4^-{}_{(aq)} + H_2O_{(L)} \rightleftharpoons H_3O^+_{(aq)} + HPO_4^{2-}{}_{(aq)}$
$HPO_4^{2-}{}_{(aq)} + H_2O_{(L)} \rightleftharpoons H_3O^+_{(aq)} + PO_4^{3-}{}_{(aq)}$

At high temperatures, phosphoric acid molecules can react together and combine (with loss of water molecule) to form dimers, trimmers, and even long polymeric chains such as polyphosphoric acids and metaphosphoric acids[17].

Chapter Three
Cleaning in place
(CIP)

3.1 Introduction

Food industry such as dairy industry, proceed food, soft drinks, ice tea, mineral water. Making cleaning which is complete process through manufacturing food industry to remove films and food soil using many methods such as foam, high pressure, mechanical cleaning, clean out place, clean in place under special conditions. The purposes from cleaning are remove films and residues of food using detergent chemical. There are methods used for cleaning for example foam, high pressure, clean out of place (COP), cleaning in place (CIP) and mechanical cleaning. Several factors affect cleaning efficiency such as contact time, temperature, mechanical force and chemical concentration.

CIP uses a mixture of water and chemicals substance and heat to clean machine, pipes and vessels[2]. There are factors affect CIP such as water properties, food soil and these factors should be taken into the efficient of CIP and be assessed through method for ensuring cleanliness such as conductivity and pH.

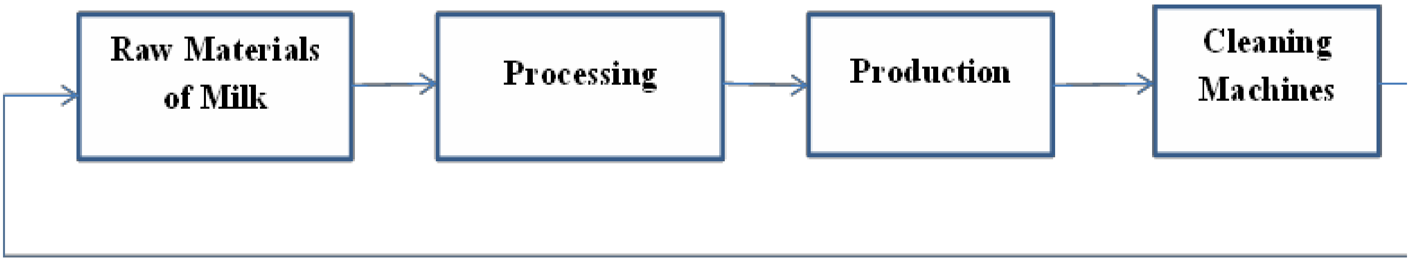
CIP system uses a large amount of water about (25000-30000) gallons a day [, chemicals and energy. Recent technology enable plant operators to calculate the optimum mixture of chemicals, water, temperature and flow required to save at least 20 % of the down time and average cost[9].

In Palestine, the number of Palestinian industrial establishments (11,351) (49990) employees. The annual milk production in Palestine is 172,200 cubic meters worth $ 96.6 million. The annual milk production in Gaza is 24,300 cubic meters worth $ 12 million. The annual milk production in the West Bank is 147,900 cubic meters worth $ 84.6 million[18].

3.2 Dairy Industry

Dairy is a commercial establishment established for harvesting or processing (or both) of animal milk such as cattle or goats, sheep and camels for human consumption. The milk produced has been domesticated for thousands of years, the processing and the milking took place close together in time and space[19]. In the early 17th century, migrants brought cattle from Europe to supply their families with dairy and meat products [19]. After the federal government issued unclassified land for settlement in 1889, dairy cow numbers rapidly grew in Oklahoma County from 22,000 in 1890 to 275,000 in 1900. This growth has been compounded by several technological advances, including Pasteurizers commercial and automatic milking machines and refrigeration. The number of cattle in Oklahoma increased during the great depression and peaked in 1943 at 912,000. Each producing an average of 2,240 pounds of milk for a total of 2.7 million pounds. In 1986, many Oklahoma dairy farmers benefited from the government's herd program in the United States, sold their cows, and left the industry. By 2003, the number of dairy cows had dropped to 80,000. Each produced an annual average of 15,000 pounds of milk for a total of 1.31 billion pounds [19].

Dairy industry includes manufacturing raw milk into product such as milk, cheese, yogurt and butter. Large quantities of water are used through processes production. Some of series of physical and biological processes especially through CIP [19] as shown in figure [3.1].



Figure[3.1]: Dairy industry processes.

Huge amounts of water are used during processes producing effluents containing dissolved proteins, sugars, by-products buttermilk, whey, fat, and their derivatives, lactose, nutrients, as well as detergents and sanitizing agents. The dairy industry wastewaters are primarily generated from the cleaning operations in the dairy processing plants.

Boding product is one of the most widely consumed products of chemicals and water. The focus will be on the CIP lines used in the boding product. CIP for pasteurizers, milk storage tanks, fermentation tanks for yogurt production (boding). Generally, the temperature that used for CIP must be above 85C, the concentration of the all cleaning agents used is around 2.5%[1], so these factories improve CIP with small modification such as altering the time and chemical concentration for each stage of the CIP process.

3.3 Cleaning in Factories

The objective of cleaning food contact surfaces is to remove films and food soil which bacteria need to grow, in order to kill those bacteria's. Cleaning is complete process to remove food soil using detergent chemicals under special conditions[20]. There is several methods of cleaning in factories are used such as:

1) Foam: is produced through injection air into a detergent solution as it sprayed on to the surface to be cleaned. This kind of cleaning will increase the contact time of the chemical solution and improve cleaning with less temperatures and mechanical force.

2) High Pressure: is used to remove soil through high pressure cleaning chemical detergent and usually used with high temperatures, to increase the mechanical force and to make the process of soil removal more efficient.

3) Clean Out of Place (COP): is used to clean parts of equipment which require disassembly for proper cleaning and teardown parts of fillers. A heated chemical solution and agitation used to clean parts removed for cleaning in a circulation tank.

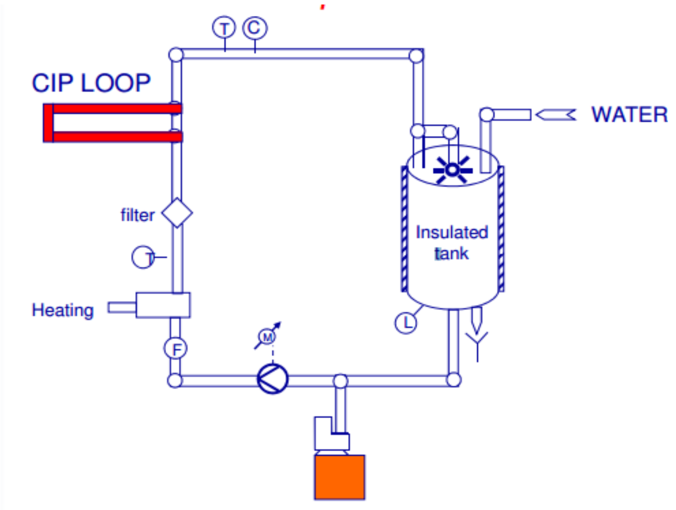
4) Cleaning In Place (CIP): cleaning Interior surface of equipment such as pipes, tanks and pumps. Its consist of the following elements: supply pump, return pump, heat exchanger with black plant steam supply, chemical tanks i.e. acid, alkali tanks, supply pressure gauge or transmitter, supply temperature sensors and conductivity meter with sensor. The equipment cleaned automatically at the approach time to give the most effective and repeatable cleaning.

3.3.1 CIP System

CIP used a mix of water, chemicals substance and heat to clean machine, pipes, vessels without dismasting machine[21]. Cleaning in place is a very efficient way to cleaning in factories especially in hygiene critical industries because the health food and beverage product are very important. The machine must meet a high hygiene standards to prevent degradation and contamination for product during operations[3].

There are two major systems for CIP:

1) Single Use System: in this type the cleaning solution kept in single tank and used only once then discharged to drain after use, as shown in figure[3.2][22].



Figure[3.2]: CIP single use system [22].

The advantages and disadvantages of single use system shown in table [3.1].

Table [3.1]: The advantages and disadvantages of single use system[22].

Advantage	Disadvantage
Simple for instillation and not very costly	Effect on environment
Could be applied for decentralized CIP system which is small installations, with process have a Crosse contaminations and heavy soiled equipment	High operational costs

2) Recirculation System: in this type the same cleaning solution kept in multi tanks and used for a large number of cleaning operations, as shown in figure [3.3][22].

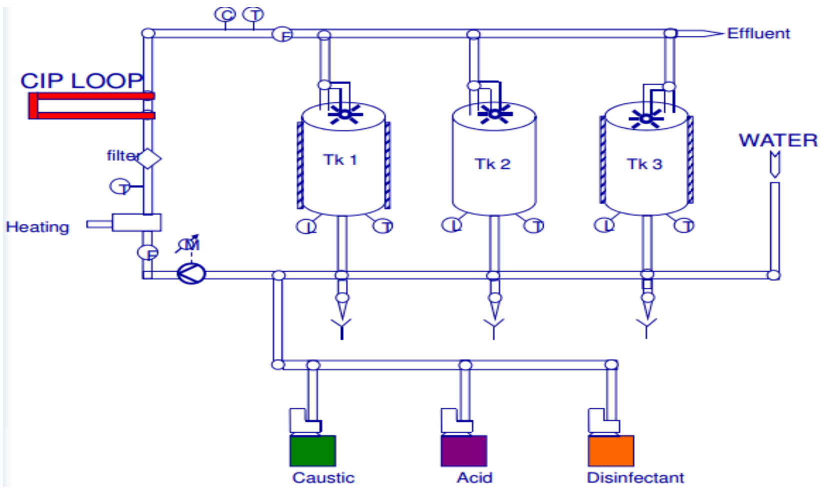


Figure [3.3]: CIP Recirculation System[22].

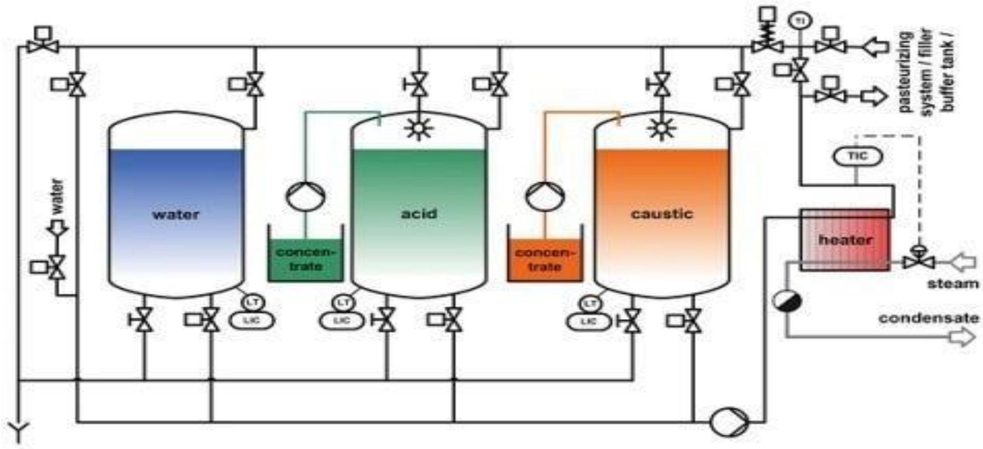
The advantages and disadvantages of Recirculation System shown in table [3.2].

Table[3.2]: The advantages and disadvantages recirculation system[22].

Advantage	Disadvantage
Lower operational cost than the single use system	The installation is complex
Lower environmental impact	The cleaning power of cleaning solution has to be regular controlled
Could be applied for centralized CIP system which is large instillations	

3.3.2 CIP Process

It is an automatic system that does the washing on site without having to dismantle the machine and includes recycling of the detergent through the components of the processing line such as pipes, heat exchangers, pumps, valves, etc. As shown in figure [3.4]. The cleaning solution recirculate at high speed through the friction lines needed to remove the fouling[22]. In the production of food there are very important health aspects. In factories, high quality health standards must be applied to avoid contamination and deterioration of product during operation. Factory cleaning must be done accurately and quickly [3].



Figure[3.4]: CIP process[1]

There are several Steps of CIP Process:

1) Cleaning for waste disposal.
2) Alkaline cleaning process: alkaline detergents dissolve fats and proteins and also when there is sediment, the cleaning process becomes more difficult.
3) Rinse the moderate water.
4) Acidic cleaning process: to neutralize the caustic residue on the factory surface, the acidic material removes the mineral deposits on the equipment.
5) Final Rinse: Purge cold water from remaining acidic materials[3].

It is important to use suitable cleaning materials for all the surfaces in which they rotate and prevent their accumulation at the bottom of the equipment because they lose the strength of sterilization. There are some of advantages and disadvantages of cleaning, the advantages are:

1) Improved hygiene & safety.
2) Conservation of cleaning solution.
3) Reduced labor and minimize cleaning time.
4) Optimization of the use of detergent and water.
5) Improved equipment and storage utilization.
6) Maintain high plant production availability.
7) Difficult to access areas can be cleaned so that this system more effectively then manual cleaning[3].

The disadvantages are:

1) The optimization of cleaning programmers should be carried out by qualified people.
2) Pressure or flow rate of cleaning chemicals through the system should be measured; must be reviewed routinely to ensure that these elements are applied consistently and continuously[3].

3.3.3 CIP Factors

3.3.3.1 Water Properties

The main component of cleaning material is water. It is comprise approximately 95_99% of cleaning solution. The function of water is to carry contamination or soil from the surface. The quality of water is very important especially the hardness of water with high minerals content (hard water) reduce the efficiency of detergent also leaves deposited on the surface of equipment. Softening agent needs to be added to the detergent to bind the calcium and magnesium salt without settling them in order of making soft water, so it's important knowing the water sources available to a feed processing plant.

Temperature of water: in general increasing temperature make a soil more readily soluble in the presence of a cleaning solution, so the temperature depend on type of detergent used, the best temperature is between 54Cº-71C º[23].

Water velocity: increasing the removal velocity of water and detergent (cleaning solution) increase the soil removing from the food contact surface especially CIP and mechanical system. If the effectiveness of the detergent increase, the importance of the velocity of cleaning solution decrease[24].

3.3.3.2 Properties of Food Soil

Food soil is any unwanted substance such as food deposit, minerals deposit and microorganism contact surface. There are many sources of soil; the primary source of soil is from the product being handled. The type of soil as shown in table [3.3]. Detergent is capable of removing all types food soil, but heavy deposit require more detergent to remove[25].

Table[3.3]: Soil types[25]

Type of Soil	Solubility Characteristics	Removal Ease
Salts	Water soluble, acid soluble	Easy to difficult
Sugar	Water soluble	Easy
Fat	Water insoluble, alkali soluble	Difficult
Protein	Water insoluble, acid and alkali soluble	Very Difficult

3.3.3.3 Detergent Types

1) Alkali (Caustic Detergents): it is remove Oils, Fats, Carbohydrates and Proteins.
2) Acids (Acid Detergents): it is remove Minerals, Milk stone. Can be used as raw acids or blended. New technology products include wetting agents and surfactants for improved cleaning with reduced concentrations. Phosphoric, Hydrochloric, Nitric, Sulfuric and Organic are examples on acidic detergents[24].

3.3.3.4 Sterilizers Types

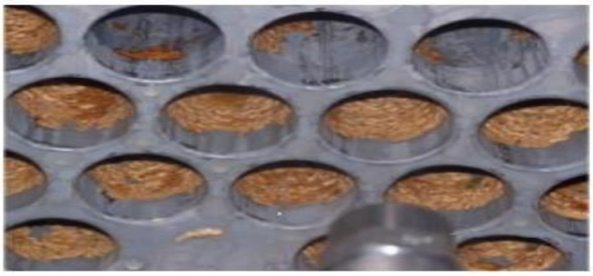
This process can be removal all living organisms, the chemicals described here are those approved by the Food and Drug Administration (FDA) for use as no rinse, disinfectant surface contact food. In food handling operations, these are used as rinsing, spraying on surfaces, or circulating through equipment in CIP operations. In some applications the chemicals are foamed on the surface or mist in the air to reduce airborne pollution[23].

The chemical used for sterilizers are:

1- Chlorine Dioxide.
2- Hypochlorite.
3- Lodophor.
4- Acid Anionic.
5- Quaternary Ammonium.
6- Hydrogen Peroxide.
7- PAA (Peroxyacetic Acid)[26].

3.3.3.5 The Organic Material

1- Proteins: which denature with temperature and develop cross links which reduce solubility.
2- Carbohydrates: include carbonize and become less soluble.
3- Fats: which are burn onto surfaces and combine with other soil types.
4- Minerals: which precipitate out of solution at high temperatures and other substances that form the basis of food for the growth of bacteria as shown in figure[3.5][24].



Figure[3.5]: Minerals which precipitate out of solution[26].

3.3.4 CIP programs

There are three programs of CIP are classified according the type of product and the type of detergent. There programs as shown in figure[3.6][24].

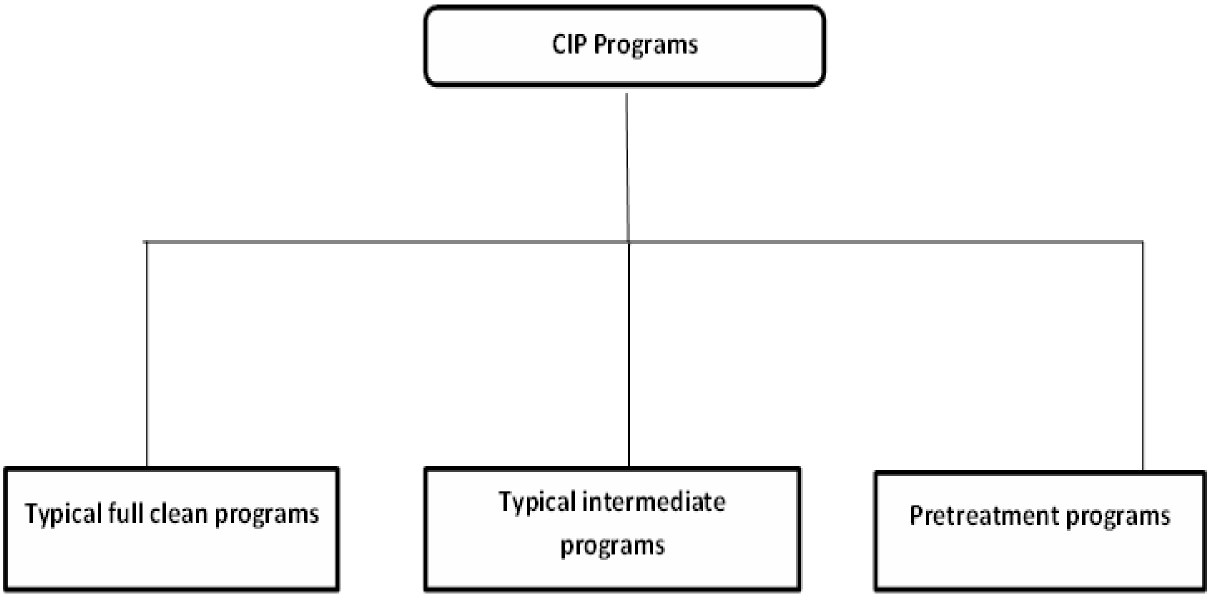


Figure [3.6]: CIP programs types.

Typical full clean program used caustic and acid clean steps without recirculation as shown in figure [3.7]. The main advantage of this program is having a good efficiency of removing soil. The disadvantages are long CIP time and high impact on waste treatment[24].

Intermediate clean program used caustic clean step without acid clean step as shown in figure [3.8]. The advantages of this program are to reduce chemical and water use, having lower impact on waste treatment and shorter CIP time. The only disadvantage is there no complete soil removal[24].

Permanent clean program used caustic and acid clean cycle as shown in figure [3.9]. The advantages are lower impact on waste treatment, high efficiency of removing soil. The only disadvantage is increase in chemical cost[24].

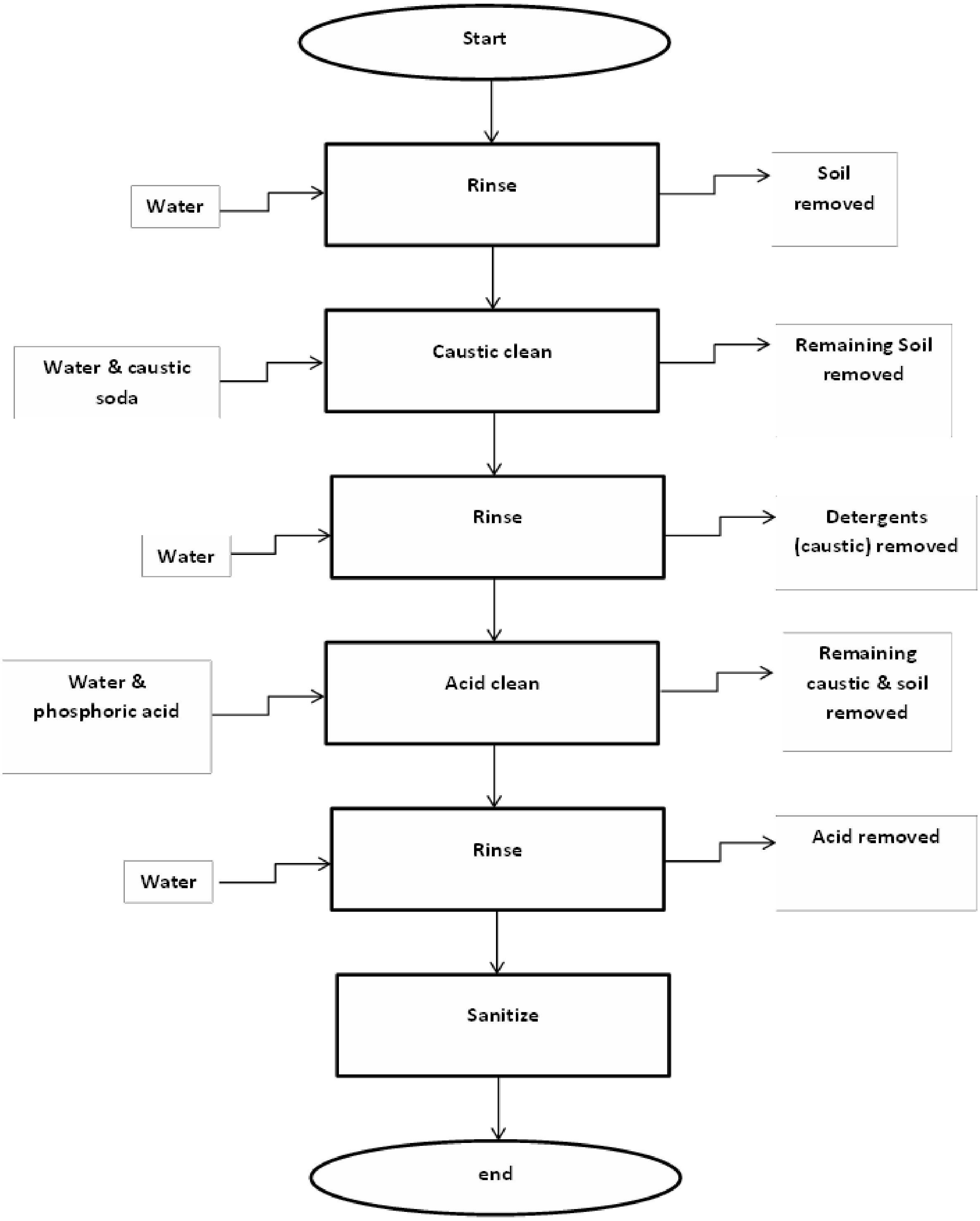


Figure [3.7]: Typical full clean program

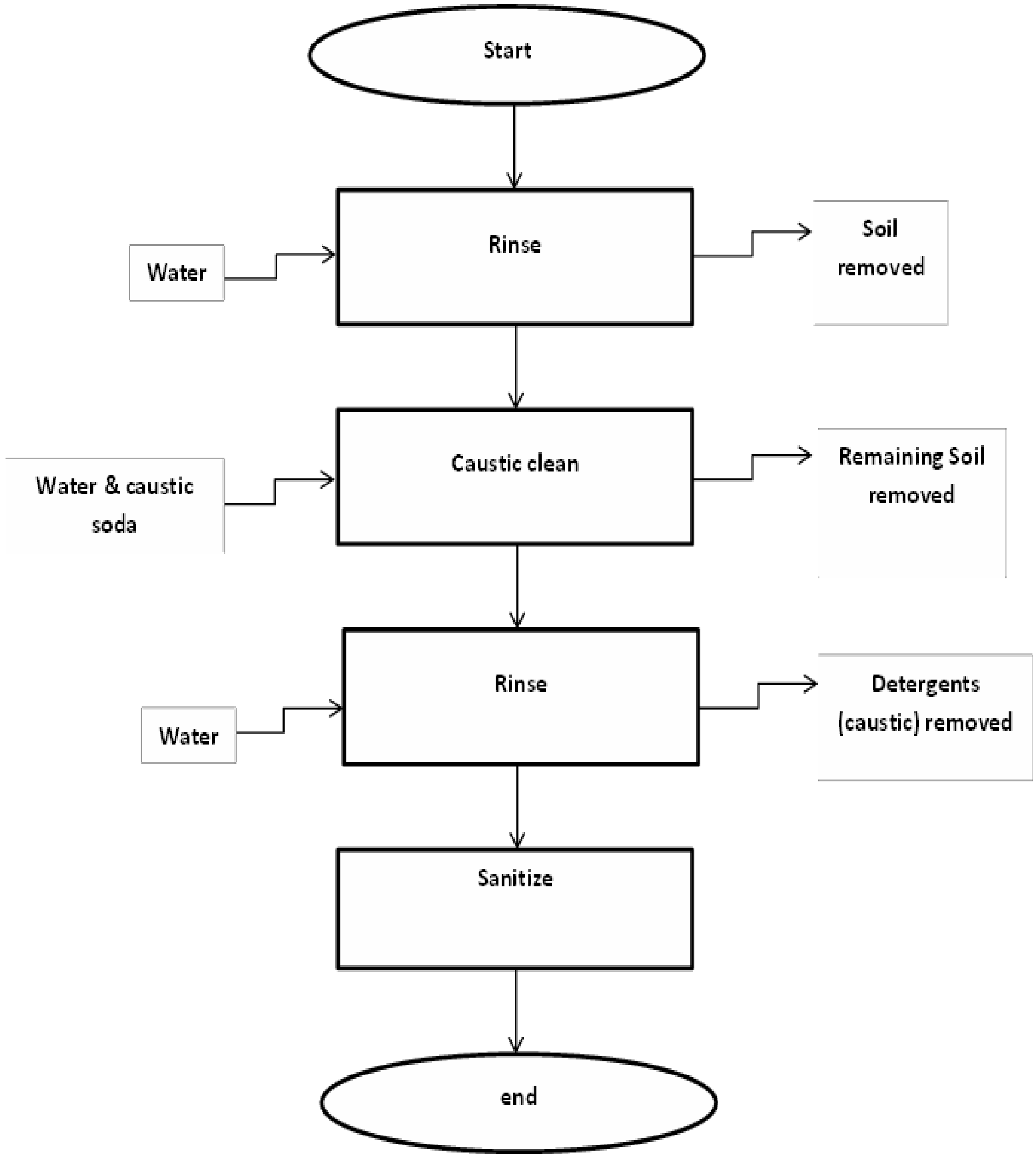


Figure [3.8]: Intermediate clean program.

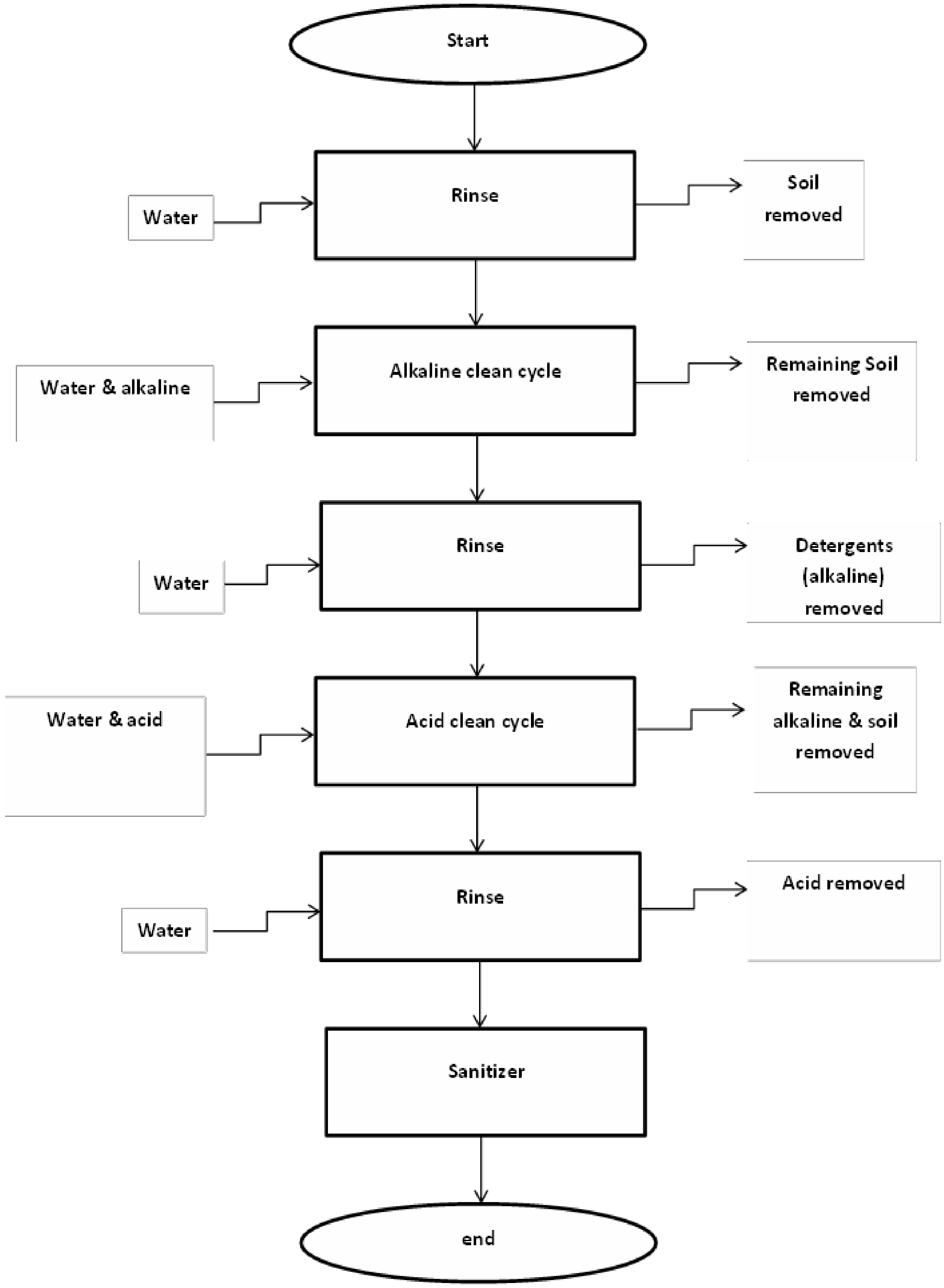


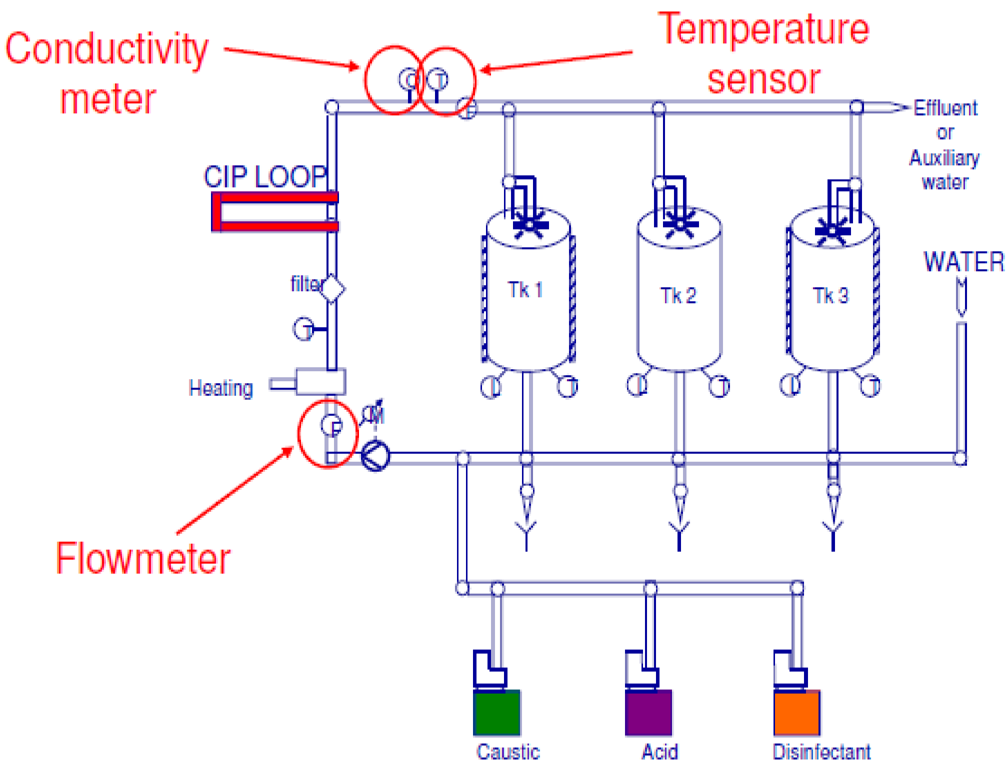
Figure [3.9]: Pretreatment clean programs

3.3.5 Methods of Ensuring Cleanliness

These methods do not require microbiological processes to be performed, but they are important to control the effectiveness of CIP operations. If tests are not in place, cleaning steps will fail. Any investigation of microbiological matters will waste time and effort. There are some steps available to ensure the efficiency of CIP, as shown in table [3.4] and figure [3.10].

Table[3.4]: Methods of ensuring cleanliness[23]

Cleaning methods	Sampling methods	Contaminants	Methods for verifying cleanliness include
Cleaning in place (CIP).	Swabbing surfaces (Direct sampling).	Drug residues.	Direct surface analysis (visual).
Cleaning out of place (COP).	Rinsing (Indirect sampling).	Excipients.	pH.
Manual methods.	Boil out (Indirect sampling).	Cleaning agent residues.	Conductivity.
		Microbiological contamination.	Titration



Figure[3.10]: Physical measurements[22].

In addition we can use a wide range of chemical analyzes including:

1) Concentration of detergents by using conductivity.
2) PH.
3) Alkanality (Either in line or off line).
4) Specific chemical activities.
5) How much the center can carry from the detergent solution? These can be determined by measuring color and suspended material or by forming foam[23].

Using the data obtained in this method is to ensure the steps used will be effective for cleaning and sterilization in plant. Such as the time, temperature and caustic measurements of cleaning materials that can used to ensure proper movement have been given to a piece of equipment by reference to the appropriate data. The main benefit of this type is that the control will be immediate and the operator or the automatic control system can adapt to the results in time to correct any problems. However, despite the existence of advanced control systems and measurements to test the quality of the process, we still need to ensure that this process work [23].

3.3.6 Optimization of CIP process

In factories, many wrong practices of how there CIP system works are performing result in higher consumption of energy, water and chemicals, so these factories improve CIP with small modification such as altering the time and chemical concentration for each stage of the CIP process. Recent technologies calculate the optimal mixture of chemicals, water, temperature and flow required to achieve safety standards while saving at least 20% the drown time for cleaning and in energy cost. Some food manufactures have tried to improve the efficiency of their CIP system[9], the techniques of optimization CIP process :

1) Modifying Chemicals: the concentration of existing chemicals can be altered or new chemicals can be operational to achieve more easily cleaning. this process may be more costly.

2) Adjusting Water Temperature: it could be increasing or decreasing the temperature. Increasing temperature of water to decrease the cleaning time or decreasing temperature of water to decrease energy cost.

3) Altering Cleaning Time: increasing or decreasing the time taken for chemical solution cycles or rinse may increase the process efficiency, but it may effect on safety tolerance level, so this way need to reconsider.

4) Maximizing Chemicals Effectiveness: the maximizing chemical effectiveness by using membranes to filter chemicals and enable them to be reused in order

to save resource for longer time or by using enzyme to speed up chemicals reactions.

5) Using Ozonized Water: the way making disinfection with ozone water of microorganisms to save chemicals, water and energy. It is extremely safe for the environment because its byproduct is oxygen, but it may be more costly.

6) Developing Conservation Mindset: installing monitor water consumption switching of hoses and water spray when it doesn't use and replacement of faulty valves and removing redundant pipework in order to improve efficiency.

7) Reconfiguring Settings: using CIP lines can be good way to improve product efficiency, for example a simple re balancing by movement the cleaning equipment from line 1 to line 2.

8) Eco-Friendly Solutions: using solution to reduce the amount of time, energy and water for cleaning process by bio decontamination eliminate the need for the use of harsh chemical such as electrolyzed water[9].

Chapter Four

Experimental work

4.1 The Effect of Electromagnetic and Magnetic Field on Conductivity of Detergent Solution Test

Materials

Distilled water, Caustic Soda (NaOH) (Source: Occidental Chemical Corporation, Dams, USA), Phosphoric Acid (H_3PO_4) (Source: Hanover, PA, 17331), Magnetic stone from microwave, Plastic bottle and Stainless steel container.

Experimental Set-Up

The cleaning solution such as caustic soda and phosphoric acid were prepared and filled into 100 ml plastic bottles, and subjected to electromagnetic felid through pairs of Helmholtz coils as shown in figure [4.1]and Solenoid as shown in figure [4.2] for different intervals times [0, 2 and 4] hours. The value of conductivity measure through conductivity meter device (JENWAY 41510 Conductivity Meter, United Kingdom).

Figure [4.1]: Exposing detergent solution to electromagnetic field intensity.

Figure [4.2]: Electromagnetic field.

The equations (4.1and 4.2) used to determine electromagnetic field intensity inside solenoid, DC current source (0.25A) was used, the number of windings was (2850wind) and the length of coil was(7cm), according previous values and by using following equation the magnetic intensity was 0.01278T.

$B=\mu_0.nI$……………………….(EQU 4.1)

$=4\pi*10^{-7}*\frac{T.m}{A}\frac{N}{L}*I$……………..(EQU 4.2)

$=4*3.14*10^{-7}*\frac{T.m}{A}\frac{2850}{0.07}*0.25A$

B=0.01278T

Detergent Solution was prepared and filled into 100 ml plastic bottles. The plastic bottle which labeled "2.5, 1.6 and 1mT" were subjected to different electromagnetic felid intensity through pairs of Helmholtz coils for two hours as shown in figure[4.3]. The value of conductivity was measured by Conductivity Meter device after two hours.

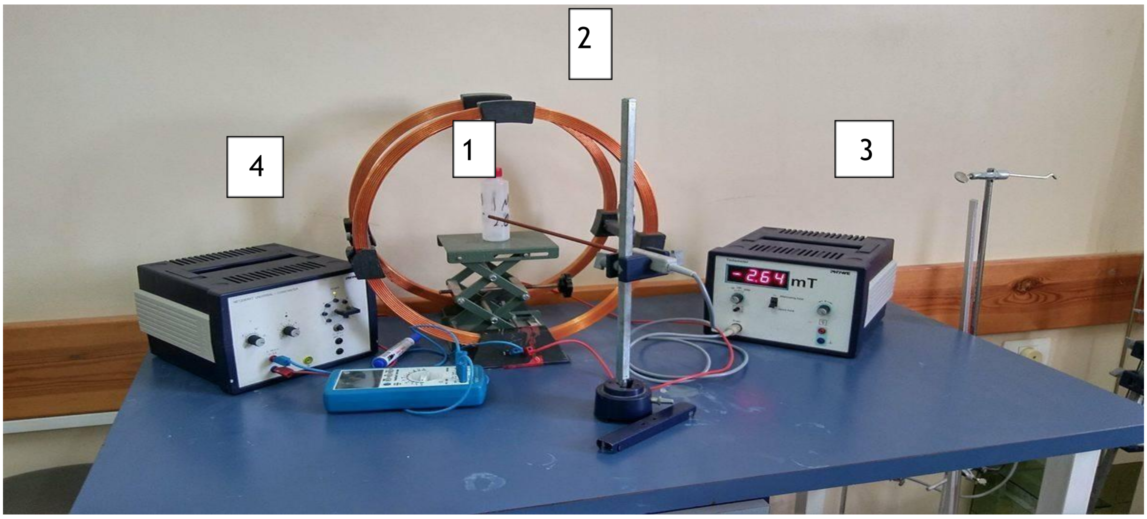


Figure [4.3]: Exposing detergent Solution to electromagnetic field intensity.

1. 100ml plastic bottle of caustic soda solution. 2. Pair of Helmholtz coils,

3. Tesla meter digital. 4. Power supply

The cleaning solution such as caustic soda and phosphoric acid were prepared and filled into continuous flow through plastic bottle with magnetic stone as shown in figure [4.4.a]. The cleaning solutions were filled into stainless steel Container that magnetized through magnetic stone as shown in figure [4.4.b]. The value of conductivity measure before and after exposure to magnetic field through conductivity meter device (JENWAY 41510 Conductivity Meter, United Kingdom).

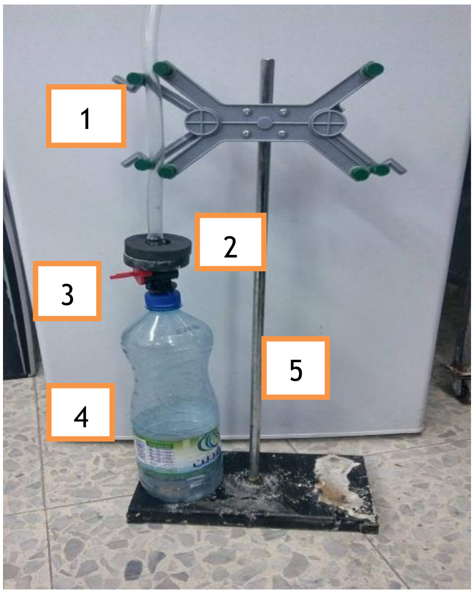


Figure [4.4.a]: Continuous flow stone magnetic field.
1. Pipe. 2. Magnetic Stone.
3. Valve. 4. Plastic Bottle.
5.Stand

Figure [4.4.b]: Batch stone magnetic field without stirring.

Chapter Five
Results
&
Discussion

5.1 Results

This chapter summarized the results for the conductivity of detergents solution after exposure to magnetic stone field and electromagnetic wave.

The effect of electromagnetic field intensity (2.5mT) on the conductivity of solution of caustic soda of different times period [0, 2 and 4 hrs.] is shown in table [5.1].

Table [5.1]: Conductivity and temperature of 1M caustic soda solution

Time (hrs.)	Conductivity
0	201ms
2	210ms
4	210ms

The result shows that the conductivity of caustic soda increases after exposure to electromagnetic field up two hours then it remains constant(i.e., at 4 hours) at temperature (20Cº). Increasing conductivity of caustic soda after exposure to electromagnetic field is due to the increasing of kinetic energy of the molecules and ions in the solution, hence: conductivity of aqueous solution is governed by concentration of ions in solution.

The effect of magnetic field (3.5mT) on the conductivity of detergent solution for two hours is shown in table [5.2].

Table [5.2]: conductivity and temperature of 1M acid solution, 2M caustic soda

Material	Conductivity before exposure to magnetic	Conductivity after exposure to magnetic
For water	678ms	690ms
For caustic soda	77.3ms	90.3ms
For phosphoric acid	16.2ms	16.6ms

The result shows that the conductivity of caustic soda, water, phosphoric acid increase after exposure to magnetic field up two hours then it remains constant(i.e., at 4 hours) at temperature (20.5Cº). Increasing conductivity of these detergents after exposure to magnetic field is due to the increasing of kinetic energy of the molecules and ions in the solution.

The relationship between electromagnetic field intensity (2.5mT) and the conductivity of caustic soda solution is shown in Figure [5.1], the result shows increasing in conductivity with increasing in electromagnetic field intensity.

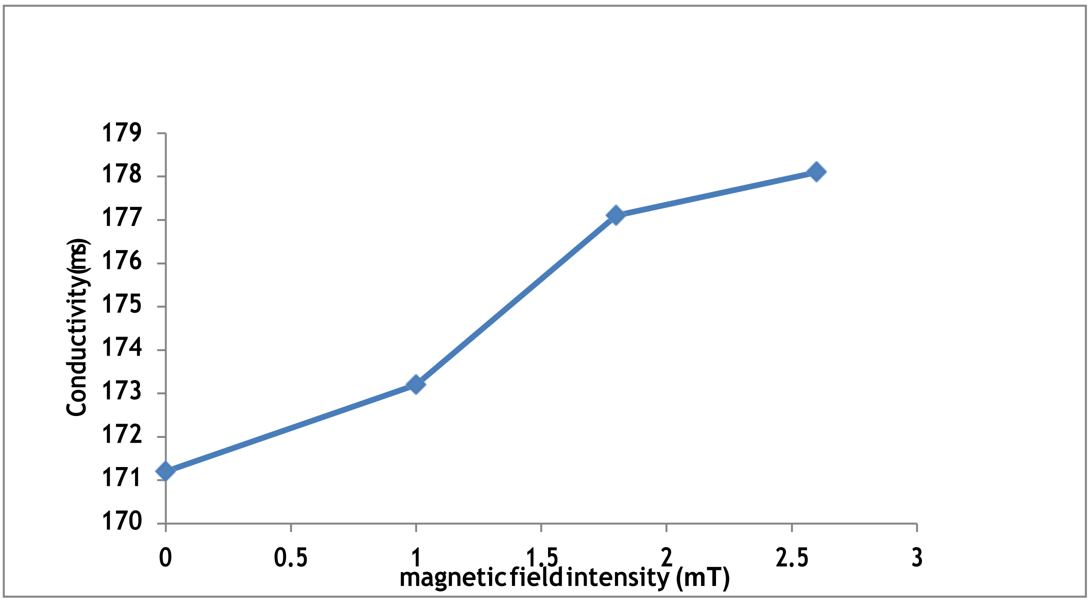


Figure [5.1]: Magnetic field intensity with caustic soda solution conductivity.

The relationship between time and the conductivity of phosphoric acid solution after exposure to electromagnetic field intensity (12mT) is shown in figure [5.2]. The result show increasing in the conductivity after exposure to electromagnetic field up two hours then it remains constant(i.e., at 4 hours).

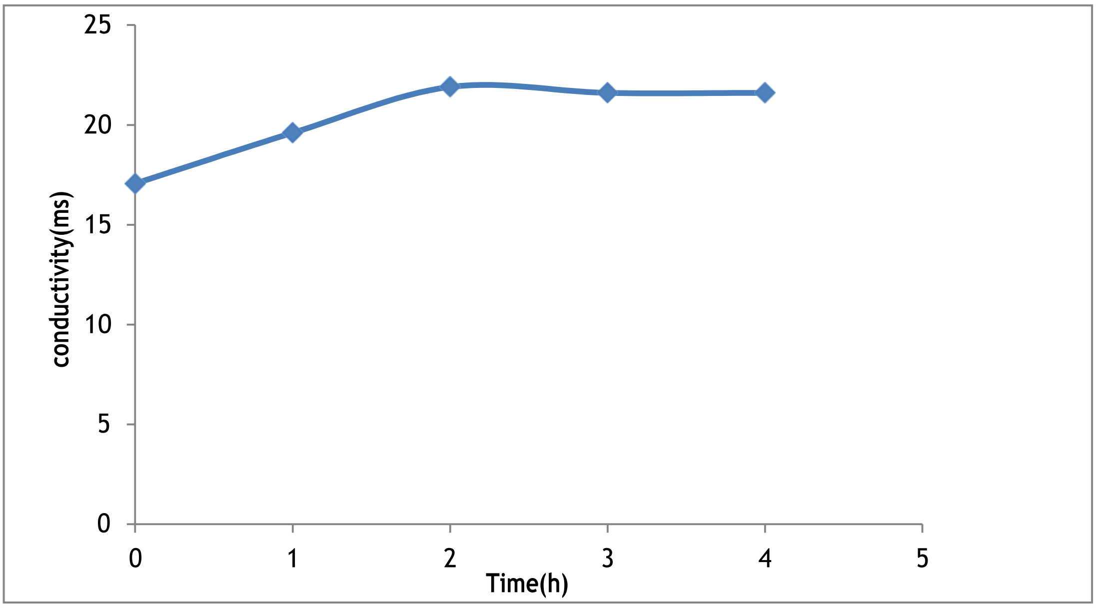


Figure [5.2]: Time with phosphoric acid solution conductivity.

The relationship between time and the conductivity of caustic soda solution after exposure to electromagnetic field intensity (12mT) is shown in figure [5.3], the result shows increasing in conductivity after exposure to electromagnetic with increasing time (i.e., at 4 hours).

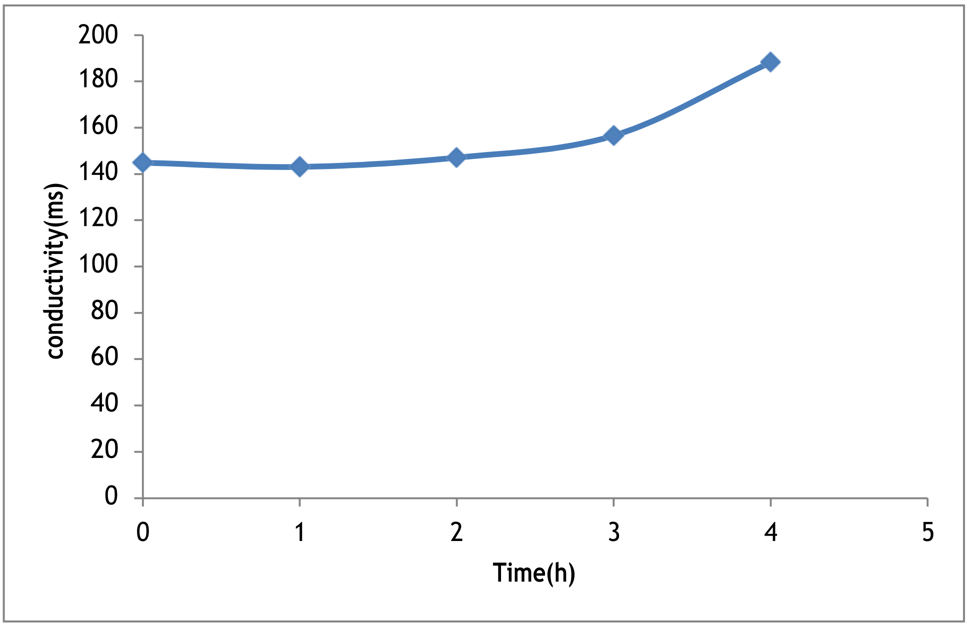


Figure [5.3]: Time with caustic soda solution conductivity.

The relationship between time and the conductivity of water after exposure to electromagnetic field intensity (12mT) is shown in figure[5.4], the result shows increasing in conductivity after exposure to electromagnetic field up two hours then it decreases and then become constant (i.e., at 3 and 4 hours).

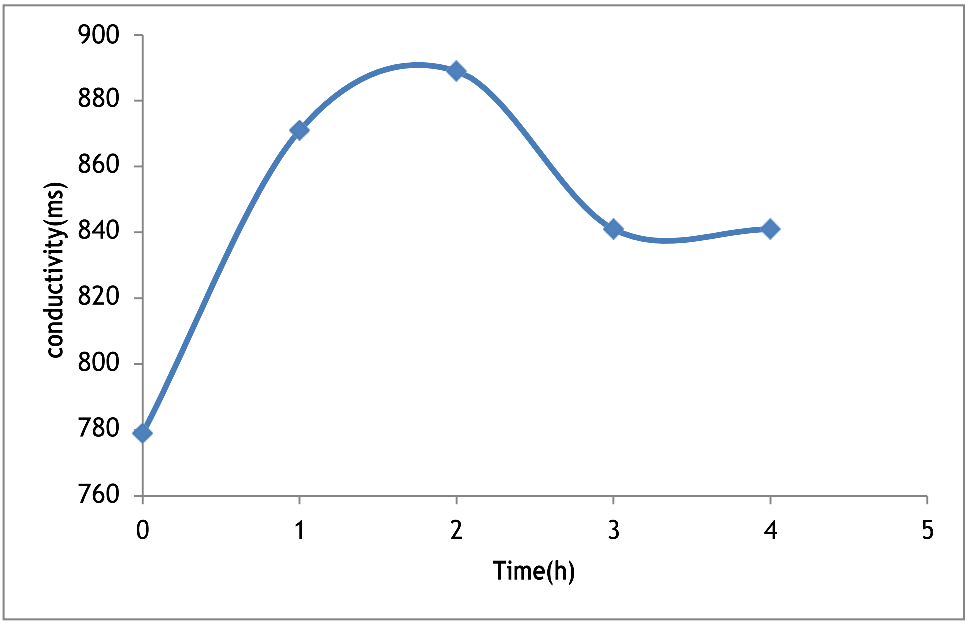


Figure [5.4]: Time with water conductivity.

5.2 Concluding Remarks

The effect of magnetic stone and electromagnetic field on conductivity of detergent solution applied in dairy industry was investigated.

- The conductivity of detergent solution after exposure to magnetic stone field in batch system increases up two hours then remains constant.
- The conductivity of detergent solution after exposure to magnetic stone field in continuous flow system doesn't increase.
- The conductivity of detergent solution after exposure to electromagnetic wave in batch system increases, the conductivity of caustic soda increase after exposure to electromagnetic with increasing time.
- The conductivity of phosphoric acid increase after exposure to electromagnetic field up two hours then it remains constant (i.e., at 4 hours), the conductivity of water increase after exposure to electromagnetic field up two hours then it decreases and then become constant (i.e., at 3 and 4 hours).
- The range of increase of the conductivity for detergent solution after exposure to electromagnetic more than magnetic stone field.

5.3 Recommendations

1) Generate magnetic field from other sources such as microwave.

2) Experiment on a stronger magnetic field with intensity more than 3.5mT.

3) View the results on the al-jebrini industry and choose the type of magnetic field that suits the CIP system.

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