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Palestine Polytechnic University



**College of Engineering & Technology
Mechanical Engineering Department**

Graduation Project

Building an Integrated System for Wastewater Treatment in Dairy Farm Using Algae

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Dedication (Arabic)

إلى المعلم الأول .. إلى قائد هذه الأمة وقودتها .. رسولنا محمد صلوات الله وسلامه عليه

إلى من كلله الله بالهيبة والوقار .. إلى من علمني العطاء دون انتظار .. إلى من أحمل اسمه بكل افتخار .. أرجو من الله من الله أن يمد في عمرك لترى ثماراً قد حان قطافها بعد طول انتظار وستبقى كلماتك نجوماً أهتدي بها اليوم وفي الغد وإلى الأبد.
(والدي العزيز)

إلى ملاكي في الحياة .. إلى معنى الحب والحنان والتفاني .. إلى بسمه الحياة وسر التميز إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أعلى الأحباب.
(أمي الغالية)

إلى الشموع التي تحترق لتتبرق لنا الطريق .. إلى منهل العلم والمعرفة .. إلى من عبرنا على أيديهم وبمساعدهم من ذهب وكلمات من درر.
ورعايتهم إلى بر الأمان .. إلى من علمونا حروفاً
(أساتذتنا الأفاضل)

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(الأسرى الأبطال)

إلى من هم أكرم منا مكانة .. إلى من ضحوا بدمائهم في سبيل تحرير هذا الوطن.
(الشهداء الأبرار)

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(الزملاء والزميلات)

إلى رفقاء الدرب .. رجال المواقف .. أصحاب الهمم والطموحات العالية .. عنوان المثابرة .. إلى من تحلوا بالإخاء .. وتميزوا بالصدق والعطاء.
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Palestine Polytechnic University
Hebron-Palestine
College of Engineering and Technology
Department of Mechanical Engineering

***Building an integrated system for wastewater treatment in animal farms
using algae***

Performed By:

Anas Khashan
Omar Da'na
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By the Guidance of the Supervisor, and by the Acceptance of all Members in the Testing Committee, This Project is Delivered to the Department of Mechanical Engineering as a Partial Fulfillment of the Requirements for the Degree of B. Sc. in Mechatronics Engineering.

:

Supervisor Signature:

Name: _____

Chief of Dep. Signature

Name: _____

Abstract (English)

Dairy industry is one of the major polluting industries in Palestine and elsewhere. Locally, dairy wastewater is discharged into sewer system or open spaces without any kind of treatment causing high organic loads and septic degradation.

The wastewater in dairy farms is an important problem in Palestine, where most of the wastewater is dumped into unprepared pits or in open valleys, which causes many environmental problems, for example, bad smells, harmful insects spread, groundwater pollution, and soil pollution, so This water must be used and treated to make it usable again, especially in the presence of the Israeli occupation.

The project aims to design and build an integrated system for treating wastewater in dairy farms using algae. Besides that produce distilled water and biomass. Samples were taken to conduct an exhaustive compilation of dairy wastewater characterization and a comparative study between the different features of dairy wastewater, COD, pH, TDS, NO₃.

Distilled water has been produced around 500ml daily, piece of kink at 20 X 20 cm dimensions was take to check the volume of biomass growth because the results take days as like the features of dairy wastewater .

The sample's measurement was taken four times in different days, at around 5:00 PM. Four tests were taken for each sample TDS, NO₃, pH, the results as shown in the figures.

The pH and NO₃ readings shows positive changes during days, that's where the ratio of pH and NO₃ decreased, this indicates the ability of algae to treat wastewater.

Abstract (Arabic)

تعتبر صناعة الألبان من الصناعات الملوثة الرئيسية في فلسطين وغيرها. محليًا ، يتم تصريف مياه الصرف الصحي لمنتجات الألبان في نظام الصرف الصحي أو المساحات المفتوحة دون أي نوع من المعالجة مما يتسبب في ارتفاع الأحمال العضوية وتدهور الصرف الصحي.

تشكل المياه العادمة في مزارع الألبان مشكلة مهمة في فلسطين ، حيث يتم تصريف معظم المياه العادمة في حفر غير معدة أو في أودية مفتوحة ، مما يسبب العديد من المشاكل البيئية ، مثل الروائح الكريهة ، وانتشار الحشرات الضارة ، وتلوث المياه الجوفية ، وتلوث التربة ، لذلك يجب استخدام هذه المياه ومعالجتها لإعادة استخدامها ، خاصة في ظل وجود الاحتلال الإسرائيلي.

يهدف المشروع إلى تصميم وبناء نظام متكامل لمعالجة مياه الصرف الصحي في مزارع الألبان باستخدام الطحالب وإلى جانب إنتاج الماء المقطر والكتلة الحيوية ، تم أخذ عينات من المياه المعالجة لدراسة المواد العضوية التي تعمل الطحالب على امتصاصها من المياه العادمة الداخلة في النظام . (COD، الرقم الهيدروجيني , N ,TDS)

تم إنتاج الماء المقطر حوالي 500 مل يوميًا ، وتم أخذ قطعة من شبك بأبعاد 20 × 20 سم للتحقق من حجم نمو الكتلة الحيوية لأن النتائج تستغرق أيامًا للظهور ، كما وتم أخذ أربع عينات في أيام مختلفة لفحص ال (pH,TDS,NO3) .

أظهرت قراءات الأس الهيدروجيني أكسيد النيتروجين تغيرات ايجابية خلال هذه الأيام ، وهذا يشير إلى امتصاص الطحالب المواد العضوية من المياه العادمة وقدرتها على معالجتها.

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Abbreviations

a_g : Absorptivity of transparent cover for radiation

a_w : Absorptivity water to radiation

C_{gs} : Heat capacity of transparent over and supports per unit basin area, (kJ /m². K).

C_{wb} : Heat capacity of water basin and contents per unit basin area, (kJ/ m².K).

I_h : Incident solar radiation on a horizontal surface, (kJ/ hr.m²).

L_h : Latent heat of evaporation, (k J/ kg).

m : Mass flow rate, (kg / min).

P_w : Vapor pressure of water at a temperature of water surface, (N/ m²).

P_{wg} : Vapor pressure of water at the temperature of transparent cover, (N/ m²).

q_c : Heat flux by convection from the water surface to transparent cover, (kJ/ hr.m²).

q_e : Heat flux by evaporation condensation from the water surface to transparent cover, (kJ / hr.m²).

q_{ga} : Heat flux from transparent cover to air, (kJ/ hr.m²).

q_r : Heat flux by radiation from cover to air, (kJ/ hr.m²).

t : time, (sec) .

T_a : Ambient temperature, (K).

T_g : Temperature of transparent cover, (K).

T_w : Water temperature, (K).

β : Transmissivity of transparent cover for radiation.

Y : Still productivity, (k g/ hr.m²).

Chapter One: Introduction

1.1 Introduction

1967, Israel seized control of all water resources in the newly occupied territories. To this day, it retains exclusive control over all the water resources on the land between the Jordan River and the Mediterranean Sea. The one exception is a small section of the coastal aquifer where it runs under the Gaza Strip. Israel uses the water as it sees fit, ignoring the needs of Palestinians in the West Bank and in the Gaza Strip to such an extent that the two areas suffer a severe water shortage. In both areas, residents are not supplied enough water. In Gaza, even the water that is supplied is substandard and not potable.

Treated wastewater resource is an environmental, social, and economic good that needs to be managed in appropriate way. Palestinian, as in most of the neighboring countries in the Middle East region, the importance of this resource in improving the water deficit by reusing the treated wastewater in agricultural production and industrial sector. However, this resource is strictly sensitive and has adverse impacts on public health. Both negative and positive impacts of the treated wastewater resource should be considered.

The freshwater becomes increasingly scarce due to population growth and, probably, climate change, the use of wastewater in agriculture, aquaculture, groundwater recharge, and in other areas will increase. In some cases, wastewater is the only water resource available to poor, subsistence-level farming communities. Although there are benefits to using wastewater in agriculture uncontrolled use of wastewater is frequently associated with significant negative human health impacts. These health impacts can be minimized when good management practices are implemented. In relation to water resources availability, wastewater treatment, and reuse in Palestine.

The term "algae" covers many different organisms capable of producing oxygen through photosynthesis (the process of harvesting light energy from the sun to generate carbohydrates). These organisms are not necessarily closely related. However, certain features unite them, while distinguishing them from the other major group of photosynthetic organisms: the land plants. [2]

1.2 Objectives

The main objectives that we want to achieve in our project are the following:

- To Develop an eco-friendly and economically efficient treatment method of wastewater in animal farms.
- To Develop an efficient treatment of wastewater using algae that result in the production of biomass.
- To Achieve a positive environmental and economic impact on agriculture in Palestine
- To Produce of distilled water as a byproduct.

1.3 Project Importance

The importance of the project is summarized by the following:

Because of the lack of water in Palestine and because of the high price of water as a result of Israel occupation, the existence of a system that works to treat wastewater, especially in remote places that consume a lot of water, such as farms to save a lot of money and reduce water consumption in these farms, where water is expected to be the treatment is suitable for use for cleaning and irrigation as the project aims to be dependent on solar energy to provide the energy needed to operate the system.

In addition, the system will be used to collect distillation water, which condenses the vapor rising from the water to be collected in a container as pure water without pollution can be sold or used for drinking and irrigation.

A product fuel that can be used as an industrial-scale fuel source with high production capacity is algae.

Algae using a sun, carbon dioxide, and nutrients are used for growth. In controlled conditions, algae can multiply several times in a few weeks, making algae one of the most valuable, sustainable, and renewable sources.

1.4 Project Idea

- In Hebron there is a lot of animal farms that are produced wastewater from its daily works likes washing, cleaning the animal in the farm or plant irrigation, etc., but in this project focused on water from the animals.
- This project is based on the scientific experimental approach.so that's we have to pick up and choose a farm, the farm was chosen in Dura district.

The description of the general idea as shown in **(figure 1.1)**:

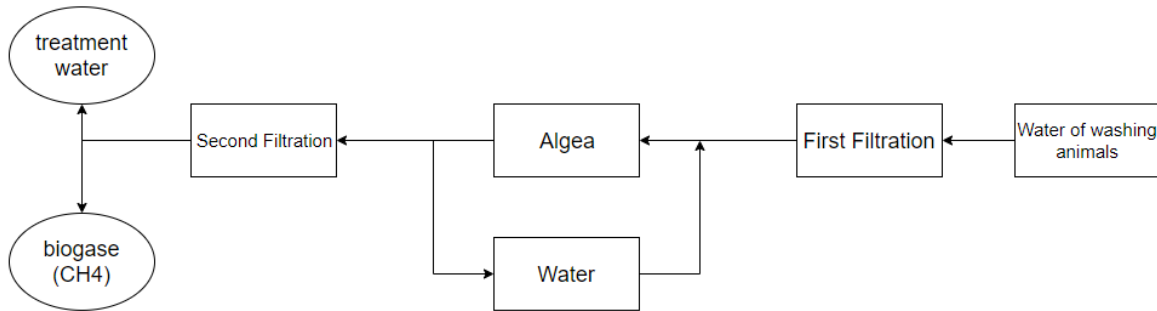


Figure 1.1: The general idea for the project.

1.5. Motivation

- Animal farms, especially in Palestine, suffer from water shortages, starting from here this project help's the farms to reuse the water after the treatment in its work, like a drink for the animal, cleaning animals, etc.
- The economic side also beside the profit of water treatment, the system is produced distilled water daily, it can be sold for a good price.

1.6. Budget

Before making any project it is necessary to know how much money it will cost. And to make and consider alternatives, to minimize the cost as possible as you can, and make a good synergistic integration. **Table 1** shows the budget of the system.

Tabel 1: Budget

Toole&device.	No.	Piece Price(NIS)	Price(NIS)
Plastic cover	1	330	330
Steel	-	500	500
Body	1	1500	1500
Tank	3	50	150
Motor and gear	1	300	300
Pump	1	150	150
Pipes and tools	-	175	175
Sensors and switches	3	-	140
Electric equipments	1	700	700
PLC	1	600	600
Transportation	-	500	500
Total			5045

Chapter Two: Scientific Background

2.1. Overview

This chapter introduces the project, and describes the characteristics of wastewater, taking into to describes the main thing about algae, and then describes the system of collect distilled water.

2.2. Introduction

Various conventional physical, chemical, and biological methods have so far been used to remove pollutants from wastewaters. Despite the good removal of these pollutants by some of the methods either, singly or in combination, factors such as cost, operational difficulties, large chemical requirements, and excessive sludge production have made widespread applications of such methods unattractive. There is, therefore, a requirement for a low-cost simple to operate the system for treating industrial and farming wastewaters. Some research on the development of such a technology, an example of which is the algae-pond has been carried out over the past few years. While the algae-pond is primarily targeted for the removal of nutrients and polishing of effluents, the activated algae reactor with its mixed population of algae and bacteria is intended to treat highly organic and colored, toxic metals and nutrient-loaded wastewaters. This project was undertaken to assess the treatability of wastewaters using the activated algae-system.

Recently algae have been gaining interest due to its dual role of bioremediation of wastewater as well as generating algae biomass, which can be used in bioenergy generation, pharmaceuticals, organic fertilizer, and animal feed. Also, algal wastewater treatment is a more economic and simpler, eco-friendly method for effective removal of an inorganic compound containing nitrogen and phosphorus, bacteria, heavy metals and the reduction of chemical oxygen demand and biological oxygen demand [1], and gives good results in water treatment and has the ability to absorb materials from water. algae are often preferred for the bioremediation process due to its high photosynthetic efficiency, rapid uptake of nutrients, short life span coupled with simple nutritional requirements so that these can be easily cultured and grown rapidly.

The main objective of the project is to help Palestinians in remote and departed Palestinian villages with water for use in farms and thus farming can use treated water to develop these farms. The second objective is to extract biomass, which can be used as fertilizer for the soil since the Palestinian climate is dry especially in the areas east and south of Hebron. The use of open systems causes the evaporation of a certain percentage of water and accordingly the system was covered in such a way that condensed part of the evaporated water from the system and collected as distilled water was used as the third objective of the project so that we do not have to use closed systems due to high cost.

Characteristics of wastewater from animals, algae, and distilled water are reviewed in other sections.

2.3. Characteristics of Wastewater

Characteristic of feed wastewater

The water in which animals are washed on farms is clean drinking water, and after washing, there are some characteristics of this water that can change and become unsuitable for use in the process of growth of algae.

There are some elements that impede the growth of algae, which can be fatal to algae if they are not within the required rate, so must know the proportion of these elements in the wastewater taken to the system before being introduced into this system to ensure the validity of wastewater for algae live.

It is important to check the pH in the wastewater and must be within the allowed rate. To find out, a sample of water need to be taken from the beginning of the washing line and from the end of the washing line (included in the system), to know the change in properties as they go into the system.

Important items to be checked before the water enters the system

- 1- pH.
- 2- Chloride (Cl).
- 3- Total dissolved salts (TDS).
- 4- Electrical conductivity.
- 5- Chemical oxygen demand (COD).

pH:

PH is a measure of hydrogen ion concentration, a measure of the acidity or alkalinity of a solution. The pH scale usually ranges from 0 to 14. Aqueous solutions at 25°C with a pH of less than 7 are acidic, while those with a pH greater than 7 are basic or alkaline. A pH level of 7.0 at 25°C is defined as "neutral" because the concentration of H_3O^+ equals the concentration of OH^- in pure water. Very strong acids might have a negative pH, while very strong bases might have a pH greater than 14.

Chloride (Cl) :

The addition of CHLOR ions is an effect on the algae removal in terms of both the cell density and chlorophyll because active chlorine could be generated in the electro-coagulation-flotation (ECF) when Cl ions were present. The electrochemically generated active chlorine is effective for the inactivation of algae cells with the aid of the electric field in the ECF.

Total dissolved solids (TDS) :

The total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. Therefore, the total dissolved solids test provides a qualitative measure of the number of dissolved ions. Therefore, the total dissolved solids test is used as an indicator test to determine the general quality of the water.

Electrical conductivity :

The electrical conductivity of water is actually a measure of salinity. Excessively high salinity can affect plants in the following ways:

- 1- Specific toxicity of a particular ion (such as Sodium).
- 2- Higher osmotic pressure around the roots prevents efficient water absorption by the plant.

Chemical oxygen demand(COD):

Is an empiric laboratory assay which measures the amount of organic matter contained in a water sample, COD measures the amount of oxygen consumed for the oxidation of total organic matter

2.4. About Algae

The term "algae" covers many different organisms capable of producing oxygen through photosynthesis (the process of harvesting light energy from the sun to generate carbohydrates). These organisms are not necessarily closely related. However, certain features unite them, while distinguishing them from the other major group of photosynthetic organisms: the land plants. [2]

Primarily, algae are not highly differentiated in the way that plants are, they lack true roots, stems and leaves, and a vascular system to circulate water and nutrients throughout their bodies as the (**figure 2.1**). Second, many algae are unicellular, they also occur in a variety of forms and sizes. They can exist as single, microscopic cells; they can be macroscopic and multicellular; live in colonies, or take on a leafy appearance as in the case of seaweeds such as giant kelp. Pico plankton is between 0.2 to 2 micrometers in diameter, while the fronds of giant kelp are as large as 60 meters in length. Lastly, algae are found in a range of aquatic habitats, both freshwater, and saltwater.[3]



Figure 2.1: Algae on the water surface [15]

- **Algae as bio-fertilizer:**

Continuous increasing demand for food in Palestine is a major issue accompanied by the rising world population and shortage in water and cultivable land in agriculture. The use of agrochemicals like fertilizers and pesticides affect the dynamic equilibrium of the soil and its effects on the biodiversity by destroying the useful soil flora. These challenges forced people to find other alternative solutions like breeding of salt-tolerant crops, using salty water in irrigation, and using non-traditional types of fertilizers like algae. Algae as biofertilizer proved to increase the soil fertility, water holding capacity, and many other properties. The polysaccharides derived from algae are major compensates that responsible for soil stabilization. Also, algae biofertilizer has an effect on soil pH and chelation of soil elements, using of algae as biofertilizer will influence soil properties through soil particle aggregation, trace elements release from insoluble minerals and N storage and its slow release these elements. Using algae as biofertilizer have great potential on the soil, and the algae biofertilizer is eco-friendly soil binders and using it as a biofertilizer shown in (**figure 2.2**) will improve the soil nutrients and the mobilization of an insoluble form of inorganic phosphates. [4]



Figure 2.2: Algae biofertilizer.

- **Advantages**

Human beings are benefiting from algae in many ways, some of these benefits are:

1. Part of the food chain for sea animals and fishes.
2. Part of diet due to rich mineral content and a good source of vitamins and fatty acids.
3. Source of agar that is needed in the food industry.
4. A good source of some chemicals like alginic acid, algin, and mannitol.
5. Recently being utilized as a source of clean energy and biofuel.
6. Good option as feed for animals and fish.

- **Algae culture**

All algae-reproduction stages and types occur normally in natural environments; however, algae can also be grown in synthetic media in which classified into three main categories:

- 1) Laboratory (microscale) culture with the possibility of being an axenic culture.
- 2) Photo-bioreactors in greenhouses or open fields.
- 3) Open system culture (raceway large scale system).

- **Algae Turf Scraper (ATS)**

Algae Turf scraper is an open system (**figure 2.3**) or is devices that use light and nutrients that come from wastewater and the algae remove the nutrient from the water to grow on a large scale and to give biomass and this biomass used in several applications. It was developed in the early in 1980 by Dr. Adey. The ATS features, Nonspecific algal biomass, Low in water consumption, Low need to nutrient concentration it produced large biomass.[5]



Figure 2.3: Algae Turf Scraper in large scale.

- **Wastewater treatment by algae (Bioremediation)**

Municipal and industrial waste product treatment could be a key infrastructural method that preserves fascinating water quality for uses. In general, the treatment of domestic and agro-industrial waste products still releases huge amounts of phosphorus and nitrogen, in eutrophication lakes, rivers and seas caused by these nutrients. [6]

In 1960 the interest in biological treatment of water by the use of microorganism, where studied the possibility of treating wastewater, as multiple researchers put microorganisms in wastewater to monitor and identify surviving species and monitor their ability of treatment and nutrient removal, and it gives a good and promising results, wherein this method the organic waste is rotten by the microorganism to inorganic nutrients, and these are incorporated into algal biomass, which can then be separated from the streaming water, therefore the waste is treated and nutrients recycled into algae biomass (**figure 2.4**), and of the varieties used showed good results.

[7]

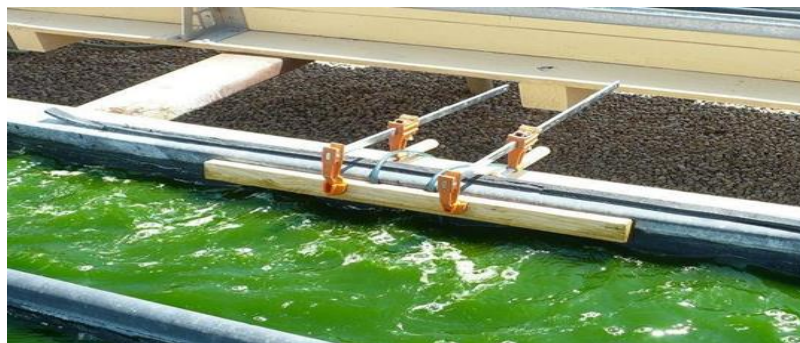


Figure 2.4: Wastewater treated with algae.

2.5. Distilled Water and Solar Distillation

The distribution of water on earth's surface is very much uneven, only, 3% of water is in the form of useful water. Of this useful water, 69% is in the glacial mass, 30% underground and less than 1% is in lakes, rivers, etc. The remaining 97% is in the form of oceans and is salty and thus cannot be used for any household or industrial purposes [8].

The water demand in the world is increased so there is a need a solution to meet this growing water demand the solar stills are used as a good method for obtaining the useful water for even small scale demand because of their economic and technical advantages as it uses the inexpensive technology including the material prices and manufacturing.

The principle working of solar stills

Solar distillation (**figure 2.5**) is the process which basically uses the heat of the sun directly for obtaining

useful water from the salty or wastewater brackish water. The equipment or the device used is known as a solar still, it consists of a shallow basin that is totally blackened from inside so as to absorb a high amount of incident rays and is covered with a transparent glass cover. The briny water is filled in the shallow basin and the sun's rays that are incident on the glass cover allow the water to heat up until present in the basin causing the process of vaporization. The heated water rises up in the form of vapor and gets condensed on the inner side of the glass surface these droplets run down into the trough collector and the pure or useful water gets collected in the measuring flask through the outlet present on the side of the still leaving behind all the impurities and the salt content. Incoming radiation from the sun is one of the most substantial input variables in solar distillation. Sunbeam radiation voyages directly from the sun to a receiver surface and its rays can be traced from the sun's position and used in determining the solar altitude and azimuth angles. These angles affect the quantity of beam emission openly coming to a given surface.[9]

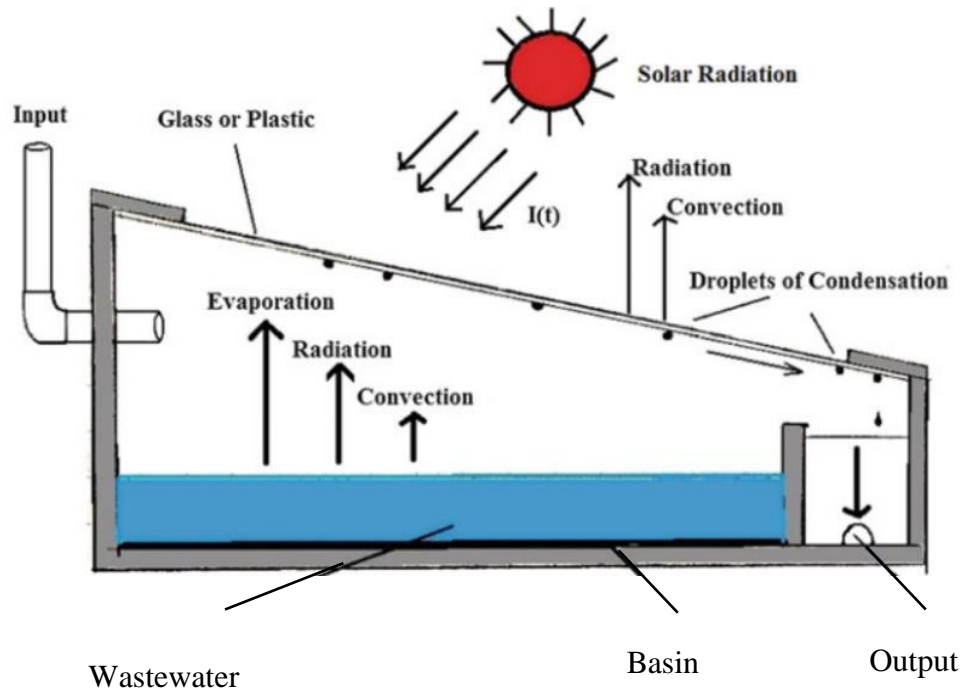


Figure 2.5: Basin type single slope passive solar distillation system

2.5.1 Classification of Solar Still Systems

Different kinds of solar stills have been made known in the literature, including basin and wick stills. In a basin type solar still, briny water is fed into a basin where it is heated by incoming radiation. Then, vapor from the hot saline water is condensed for the production of distilled water. A conventional solar still has one basin with no heat recovery from the transparent cover which results in a low efficiency [10]. Nonetheless, various basins may be piled to improve heat. In this case, the lowest basin liner is blackened while the other basin liners are made of a transparent sheet (such as glass) to allow incoming solar radiation to reach the bottom part of the still. In a wick type solar still, a blackened wick is soaked with saline water and heated by incoming solar radiation. Again, vapor from the hot wet wick is condensed for the production of distilled water. Basin type solar stills (**figure 2.6**) are common and they have been exploited in supplying clean water in areas that cannot be easily accessed.

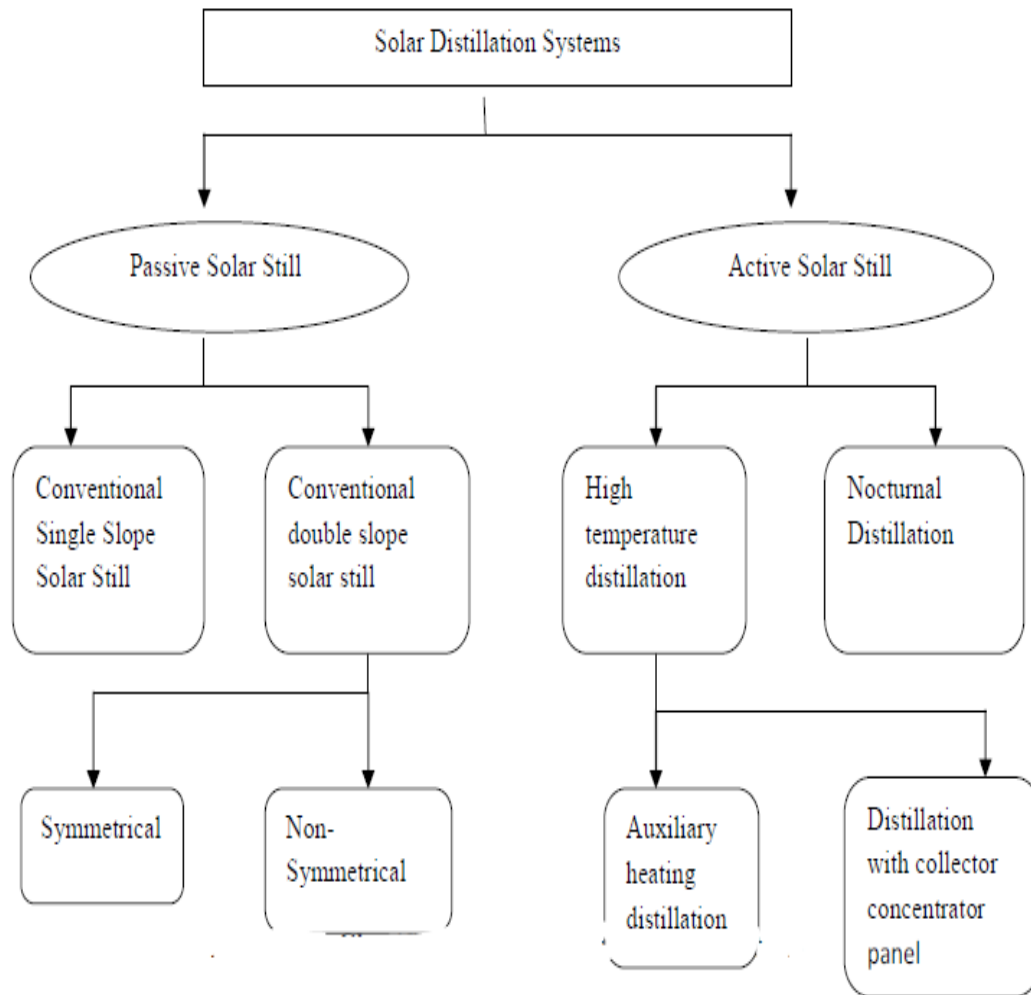


Figure 2.6: Classification of solar desalination systems

single slope passive solar still highly recommended for this integral project, single slope Passive solar stills are the initial stills that are modified agreeing to the working principle. To boost the performance some changes were made in the basic design of single slope solar still. Modification can be done to enhance evaporation, condensation, increasing heat gain, and reducing heat loss from the still (**figure 2.7**). These are inexpensive to mount and require no maintenance, can be installed easily. These structures are the most economical device to obtain useful water for domestic or minimal purposes and so can be used for rural or remote areas. The basic disadvantage that is faced in such type of system is the lower yield of the output.

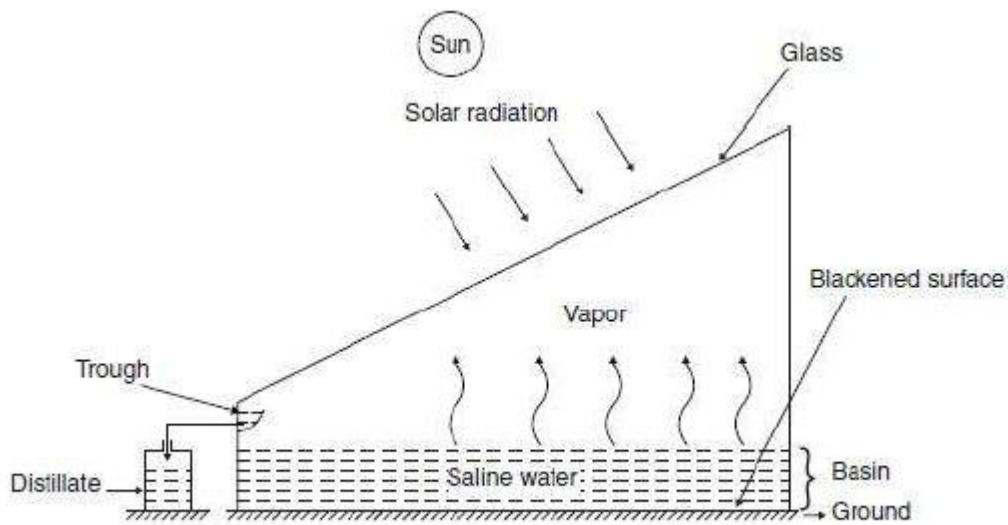


Figure 2.7: Schematic diagram of the conventional single slope passive solar still.

2.5.2 Parameters Affecting the Output of a Solar Still

1) Effect of Water Depth:

The depth of water in the basin affects the performance of a still considerably at low water depth, the thermal capacity will be lower and hence the increase in water temperature will be faster resulting in higher outputs. Water depth becomes important especially in the morning when low energy from the sun is available and it is required to heat the water quickly to producing freshwater. Hence the only solution is to operate the still at a lower depth. An increase in the water depth from 1.27 cm to 30 cm reduces the output by 30%. [11]

2) Effect of the Gap Distance:

Reducing the gap distance between the evaporating surface and the condensing cover improves the still performance. The effect of the gap distance is much important than the effect of the cover slope. Reducing the gap distance will reduce the height of the walls of the still and hence will reduce the shadowing effect of these sides. Also, less time is

elapsed by the saturated air to reach the condensing surface, and therefore continuous and quicker air movement in the still is established. Reducing the gap distance from 13.0 cm to 8 cm for the same cover slope increases the output by 11%. [12]

3) **Effect of Number of Covers:**

Many transparent covers used in a solar still does not increase the output, because it increases the temperature of the inner cover (condensing surface). But it also keeps still airtight. Due to a double glass cover reduction of 25-35% of the output was noticed. Also uses a double glass cover increases the initial cost of them still. [13]

4) **Effect of Solar Intensity:**

The effect of solar intensity has been studied by many researchers and it is observed that the average daily output increase with an increase of total intensity falling on still in a day.

2.6 Effect of Temperature on The Growth of Different Algae Species

Algae are a ubiquitous photosynthetic organism. Various external and internal factors affected algae growth. Light is an essential source for autotrophic growth and photosynthetic activity. Algae contained chlorophyll a and b, which is major light-harvesting pigments are sensitive to blue and red light. Studies have shown that green algae grow better in blue and red light because they contain chlorophyll a and b. Temperature strongly influences cellular chemical composition. The algae require light, carbon dioxide, water, and organic nutrients for photosynthetic growth. Ideal temperature ranges are generally between 20C to 35C.

Chapter Three:

Mechanical Design

3.1 The General Design of The System

Galvanized steel sheet of 3 mm thick will be folded to form a single - sloped tray with a depth of 8 cm, the cover slope of 30 degrees, and an effective base area of 400 x 60 cm. A galvanized steel trough of 60 cm length (**figure 3.1**).will be fixed to the tray for the collection of distillate, The base will be painted black, a 3mm plastic sheet will be used as a condensation surface. The base and sides of the still were insulated with thick polystyrene. Finally, the entire structure will be encased in a wooden container made of a 2cm thick wooden sheet, water tanks with a total volume of 220L, water pump with a capacity of 10L/min with 4m of the water path.

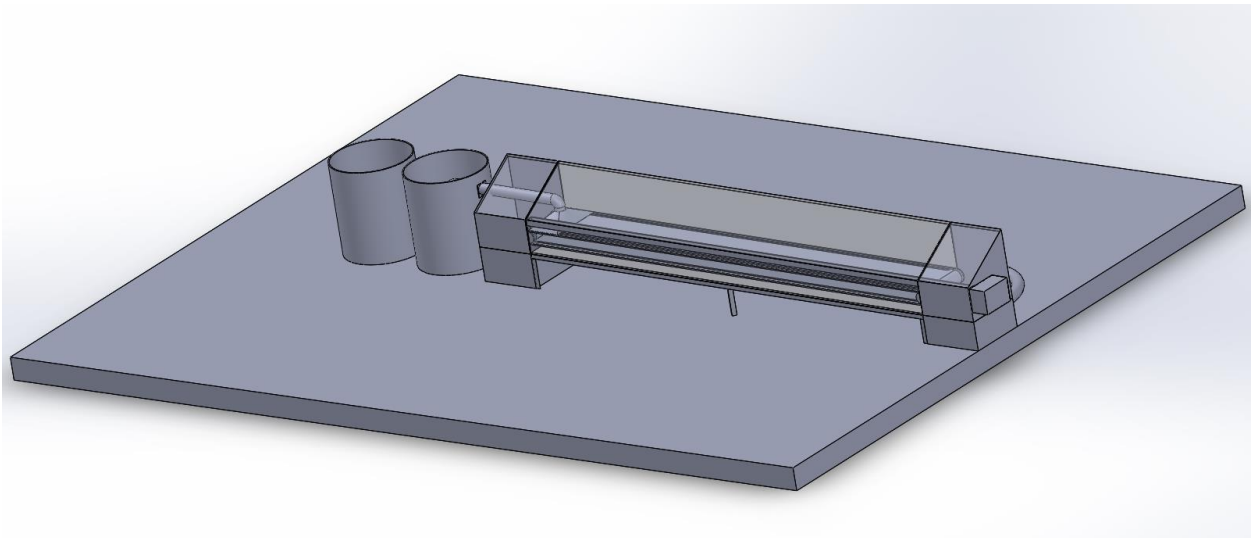


Figure 3.1: Design of the machine

3.2 Static Analysis

Statics deals with stationary situations mostly. It works on rigid bodies with or without an applied force. In both situations, the system should be in an equilibrium, so all forces and counter-forces must be in a balance.

The mass of effect on the polycarbonate sheet is equal weight of the wastewater, algae, wall from sides, plastic cover and other parts above the basin.

Assume maximum high for water equal **2cm**.

The density of water at **30C** equal **997.0479 $\frac{kg}{m^3}$**

$$Voume\ of\ water = L * H * W = 4m * 0.02m * 0.5 = 0.04\ m^3$$

$$\begin{aligned} mass\ of\ water\ along\ 4m &= 0.04\ m^3 * 997.0479\ \frac{kg}{m^3} \\ &= 39.8\ kg \end{aligned}$$

Maximum weight (approximate included the weight of water, algae, polycarbonate from sides and iron structure):

$$Max.\ weight(W_M) \cong 70\ N$$

3.2.1 Calculate Reactions

The first step in any beam problem is to find the reaction forces at the supports. To do this we must consider that the beam is in static equilibrium. This means that we balance or resolve the forces acting on the beam.

By ClearCalcs program calculate reaction:

First enter properties:

Length of beam: $L = 4000\ mm$

Young's Modulus $E = 210000\ Mpa$

Area of cross Section $A = 400\ mm^2$

Second moment of area $I_x = 106666666\ mm^4$

Distributed load: (Figure 3.2)

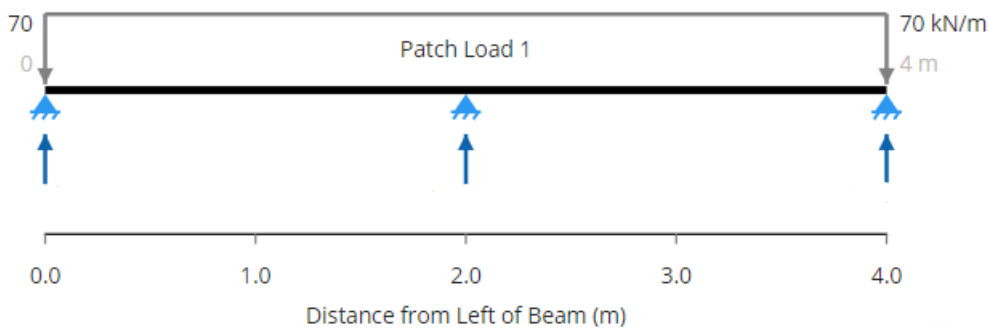


Figure 3.2: Distributed load

Reactions: (Figure 3.3,

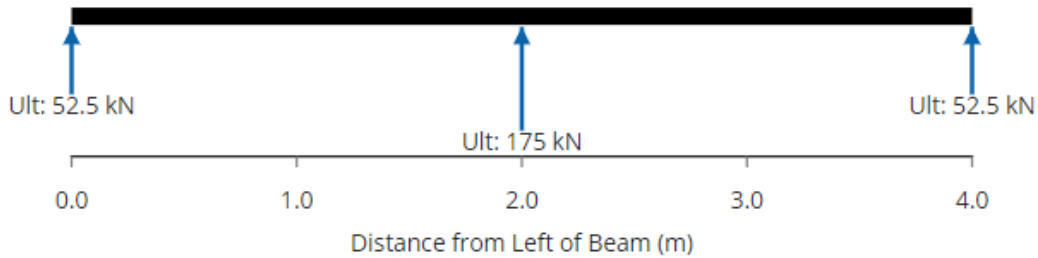


Figure 3.3: Reactions

3.2.2 Calculate Shear Forces (V)

The 'Method of Sections' or 'Method of Cuts' is used to determine the shear force value at locations along the beam. (Figure 3.4)

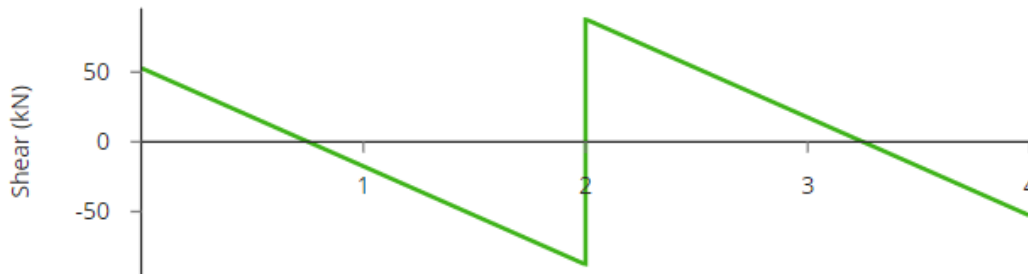


Figure 3.4: Shear forces

The 'Method of Sections' or 'Method of Cuts' is used to determine the bending moment value at locations along the beam. (Figure 3.5)

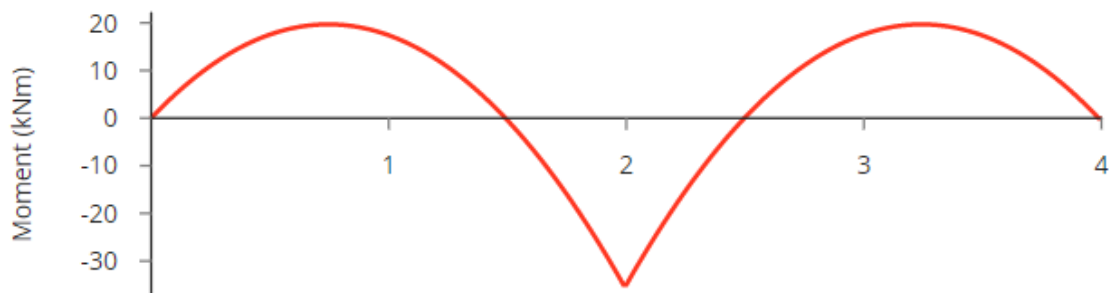


Figure 3.5: Bending moments

3.2.4 Calculate Deflection

In structural engineering terms, refers to the movement of a beam or node from its original position due to the forces and loads being applied to the member. Deflection, also known as displacement, can occur from externally applied loads or from the weight of the structure itself, and the force of gravity in which this applies. (**Figure 3.6**)

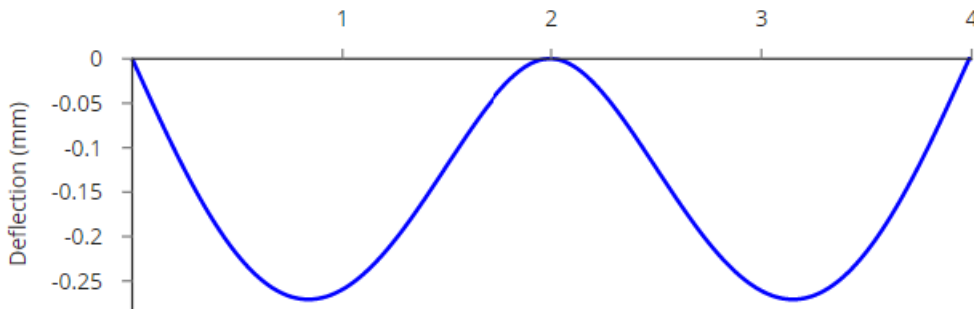


Figure 3.6: Deflection

3.3 Determining The Tension of Cable Harvest

The material of harvest tool is stainless steel clothesline, this is sufficient to carry out the harvesting tool since the tensile strength of the cable equals 400-500 MN/m², the following is the calculation of the tensioning force affecting the cable:

The maximum normal force equal **2kg** (Harvest Tool Weight).

Maximum normal force:

$$F_N = m * g = 2kg * 9.81 \frac{m}{s^2}$$

$$F_N = 19.62 N$$

A force from kinetic friction:

A force from friction between two objects is calculated as it would be in any other situation - via the following equation: Force due to friction (usually written F_r) = $(\mu)N$.

where (μ) is the friction coefficient between harvest tool (**Figure 3.7**) and polycarbonate plate, and N is the normal force between the two objects or the force with which they are pressing into each other.

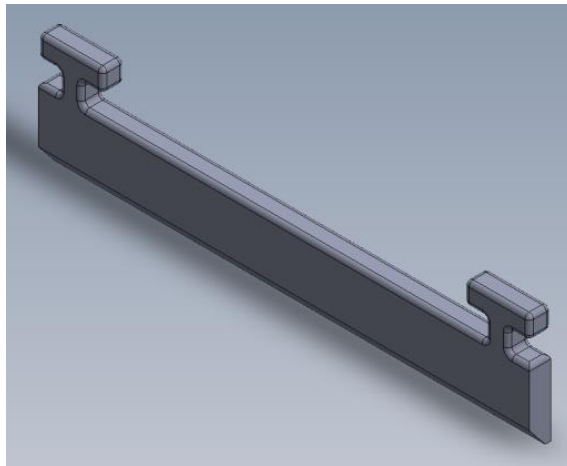


Figure 3.7: Harvest tool

Coefficient of friction (μ) for polycarbonate equal **0.31** .

*Maximum force from kinetic energy (F_r) = $\mu * F_N$*

$$F_r = 0.31 * 19.62$$

$$F_r = 6.082 \text{ N}$$

Force from acceleration :

$$F_a = m * a$$

$$F_a = 2 \text{ kg} * 0 \text{ m/s}^2$$

$$F_a = 0 \text{ N}$$

Total tension on cable:

$$F_t = F_a + F_r$$

$$F_t = 0 + 9.1233 = 9.12 \text{ N}$$

Cross section area of the cable:

$$A = \frac{\pi d^2}{4} = \pi * \frac{0.03^2}{4}$$
$$= 7.06 * 10^{-4} m^2$$

Tensile strength:

$$S_{ut} = F_t/A$$
$$= 12.12/7.06 * 10^{-4}$$
$$= 1.716 N/mm^2 = 1.716 Mpa$$

3.4 Determine Total Torque

For conveyor (or any machine), one has to find operational resistance (sum of all resistances to make the machine work at steady speed). To find load torque with respect to motor shaft, the steps are as below. The load torque is always understood as resistance torque.

In modular conveyor to calculate force required for pulling belt & product we use following formula:

$$F = (M_p + M_b) * L * F_{bw} * 9.81$$

Where:

F: pulling force in Newton .

M_p: total algae weight of product in kg.

M_b: total weight of belt in kg.

F_{bw} :coefficient of friction between belt(stainless steel) & roller(plastic).

L: length of belt

Maximum M_p =2kg

Maximum M_b≈0.3kg

F_{bw}=0.6

Applying equation:

$$F = (M_p + M_b) * L * F_{bw} * 9.81$$

$$= (2 + 0.3) * 4 * 0.6 * 9.81 = 54.1 N$$

First: calculate torque , and compare the result with torque of motor:

$$\text{Total torque from calculation} = F * r$$

Where:

r: radius of roller in meter = 5cm.

$$\text{Total torque from calculation} = 54.1N * 0.05m = 2.705 N.m$$

Note: the total torque from calculation does not exceed the torque of motor.

Second: calculate torque of motor:

$$\text{Torque of motor} = \frac{60}{2\pi} * \text{power (W)} / \text{speed(rpm)}$$

$$\text{Torque of motor} = \frac{60}{2\pi} * 373/1370$$

$$= 3.48 N.m > 2.705 N.m \longrightarrow \text{allow to use 0.5hp motor}$$

3.5 Speed Ratio of Harvest-Tool Motor

3.5.1 Speed Ratio Definition

A gear train consists of more than one gear connected to each other, and their teeth interlock. When a machine has two gears of different sizes, the smaller gear turns faster than the larger gear. When the first gear (the driver or input gear) turns, the second gear (the driven or output gear) turns in response. The difference between the speeds of the two gears is called the speed ratio or gear ratio.



Figure 3.8: Motor with gear-box

3.5.2 Gear Ratio Calculation

The ratio is determined by the number of teeth on each gear wheel (**Figure 3.8**). Calculate the speed ratio of two gears by dividing the angular velocity of the output gear (represented numerically by the number of teeth) by the angular velocity of the input gear (represented numerically by the number of teeth).

$$\text{Gear ratio} = 1/100$$

3.5.3 Calculating Speed Output

Calculate the speed output using the formula:

$$\text{output speed} = \text{input speed} \div \text{speed ratio}$$

the input gear revolves at 1370 rpm and speed ratio = 1/100 so,

$$\text{output speed} = n = 1370 / (100 / 1) = 13.7 \text{ rpm}$$

$$v = 2\pi rn/60 = 2\pi * 0.05 * 13.7/60 = 0.072 \text{ m/s}$$

Where:

v: the linear velocity expressed in m/s.

n: the angular velocity expressed in rpm.

r: the radius expressed in m.

3.6 Definition of Parts Machine

The mechanism of a mechanical system is assembled from components called machine elements. These elements provide structure for the system and control its movement. The structural components are, generally, the frame members, bearings, splines, springs, and covers. Explain the function of each part of the machine in the following pictures.

- The plastic structure that covers the sink and works to allow sunlight to pass through it and condensation of distilled water on the top surface. **(Figure 3.9)**

Dimension: 4 x 0.6 x 0.6 m

4 x 0.6 x 0.4 m

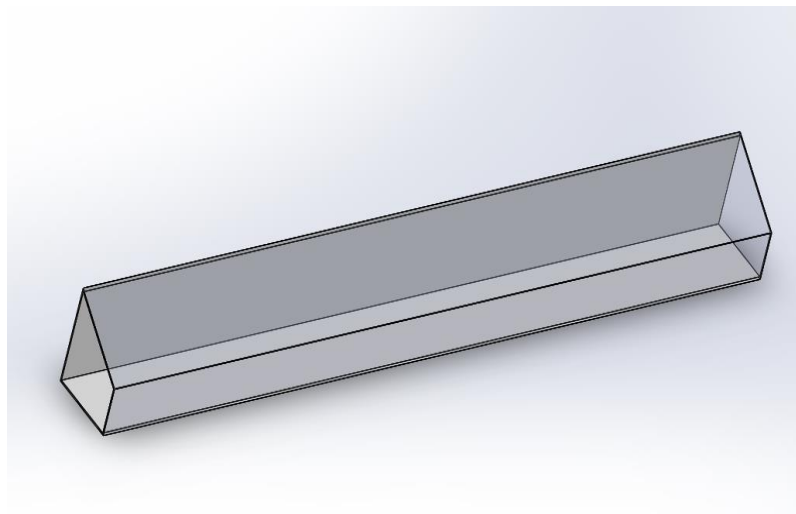


Figure 3.9: Plastic structure

- A basin for collecting distilled water after it descends from the plastic cover to collect in a small tank of distilled water. (**Figure 3.10**)

Dimension: 4 x 0.04 x 0.06 m

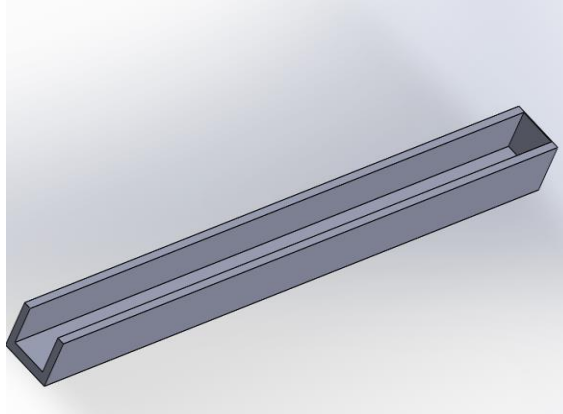


Figure 3.10: Basin for collecting distilled water

- Water spray when entering the basin. (**Figure 3.11**)

Dimension of spray surface: 0.2 x 0.6 m

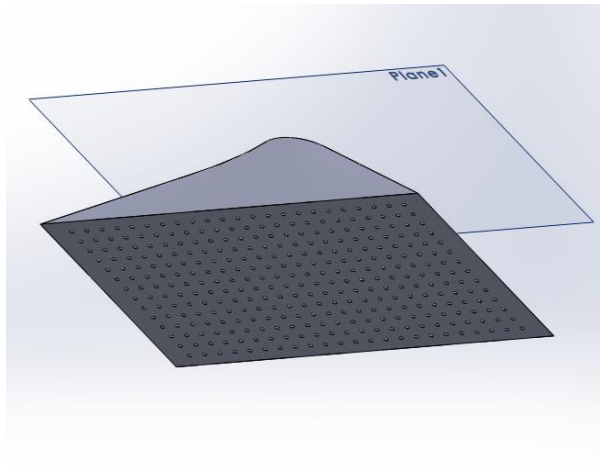


Figure 3.11: Water spray

- Two small tanks ,the first tank to collect water at the end of the stream and re-pump it for use again, and another tank to collect the algae harvested inside. **(Figure 3.12)**

Dimension: 0.6 x 0.6 x 0.8 m

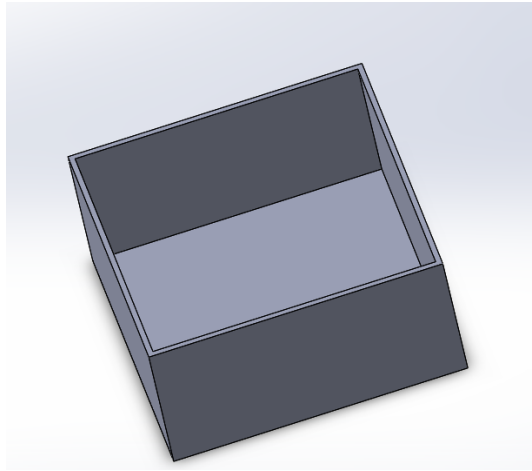


Figure 3.12: Small tank

- A water pipe to return the water to the tank for reuse. **(Figure 3.13)**

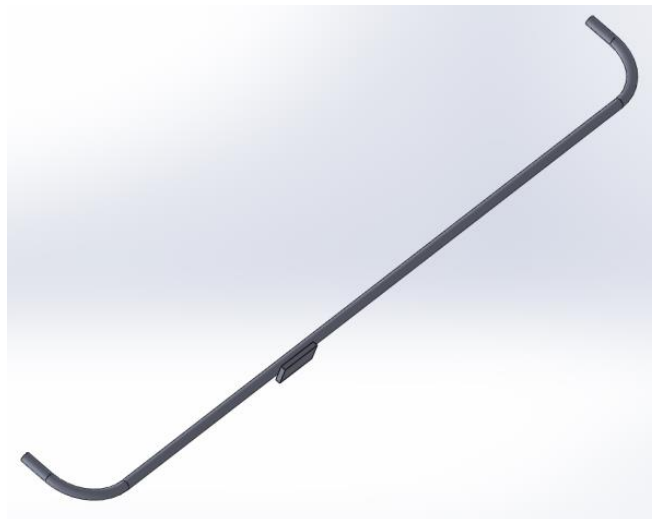


Figure 3.13:Pipe

- The first tank is to collect the wastewater inside it and the water remains in it for 24 hours, so the chloride element inside the water will fly out and collect the Impurities at the bottom of the tank. **(Figure 3.14)**

Diameter: 0.6m **High:** 1.2m

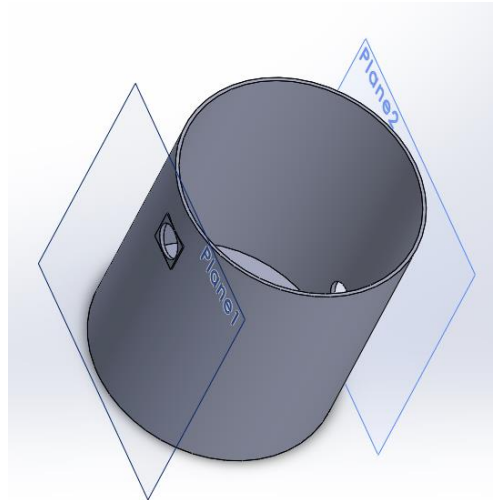


Figure 3.14: Large tank

- Wastewater enters from the first tank to the second tank after it is filtered from impurities, then it enter into the system by control of a solenoid valve. **(Figure 3.15)**

Diameter: 0.6m **High:** 1.2m

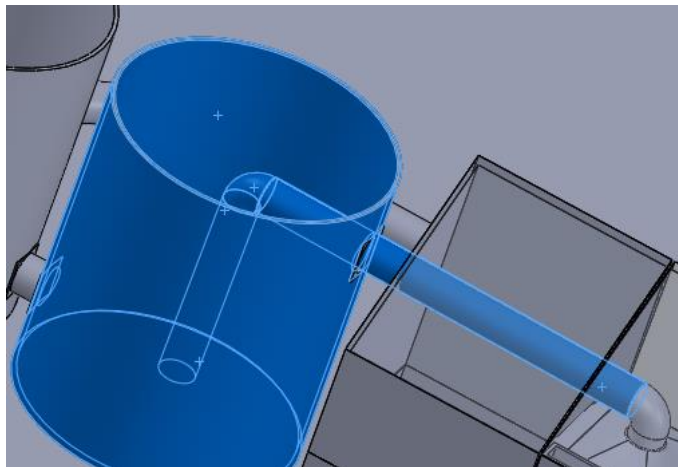


Figure 3.15: Large tank

- Harvesting rollers for the Harvest Tool wire. (**Figure 3.16**)

Diameter: 10 cm

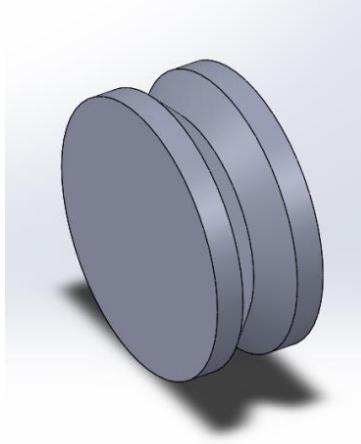


Figure 3.16: Roller

- It works to harvest algae when needed and pull it to collect it in a small tank designated for it. (**Figure 3.17**)

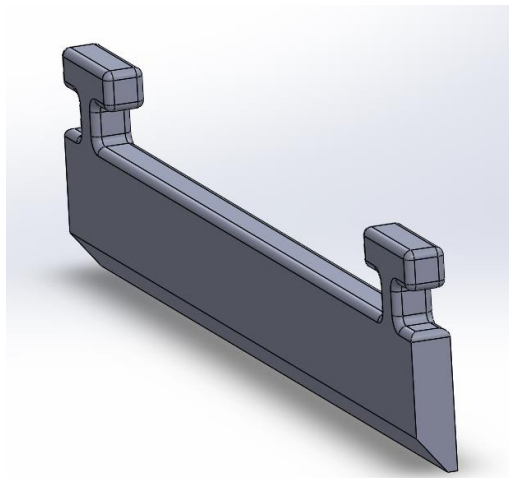


Figure 3.17: Harvest tool

3.7 Software Analysis

To reduce the number of physical prototypes (**Figure 3.18**) and experiments and optimize components in our design phase to develop better products faster. So it is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behavior, thermal transport, wave propagation, the growth of biological cells, etc. Most of these processes are described using Partial Differential Equations (PDEs). And we will use computer program (solid works, MATLAP, etc.) to solve these PDEs by using numerical techniques Finite Element Analysis (FEA) will be used.

Using solid works to design the machine as shown in figures:

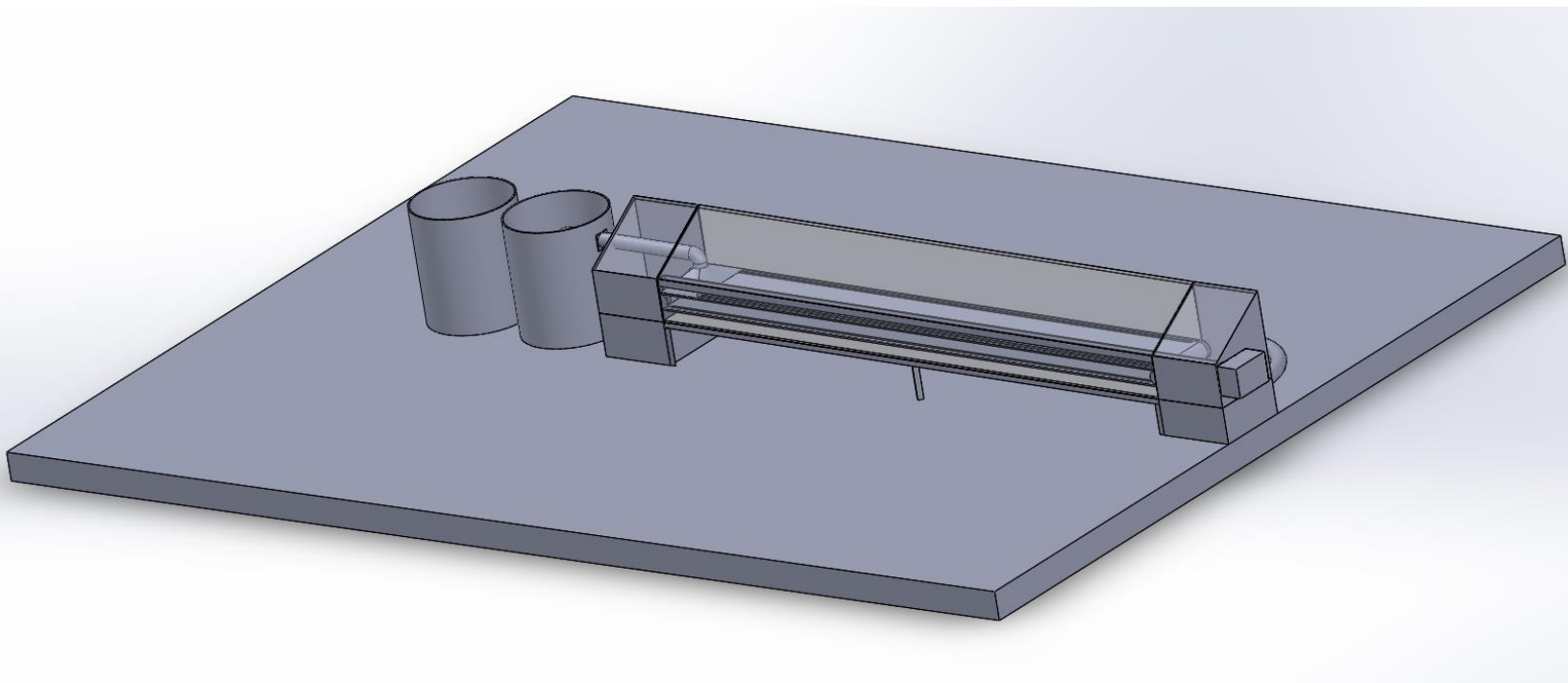


Figure 3.18: Structure of the machine

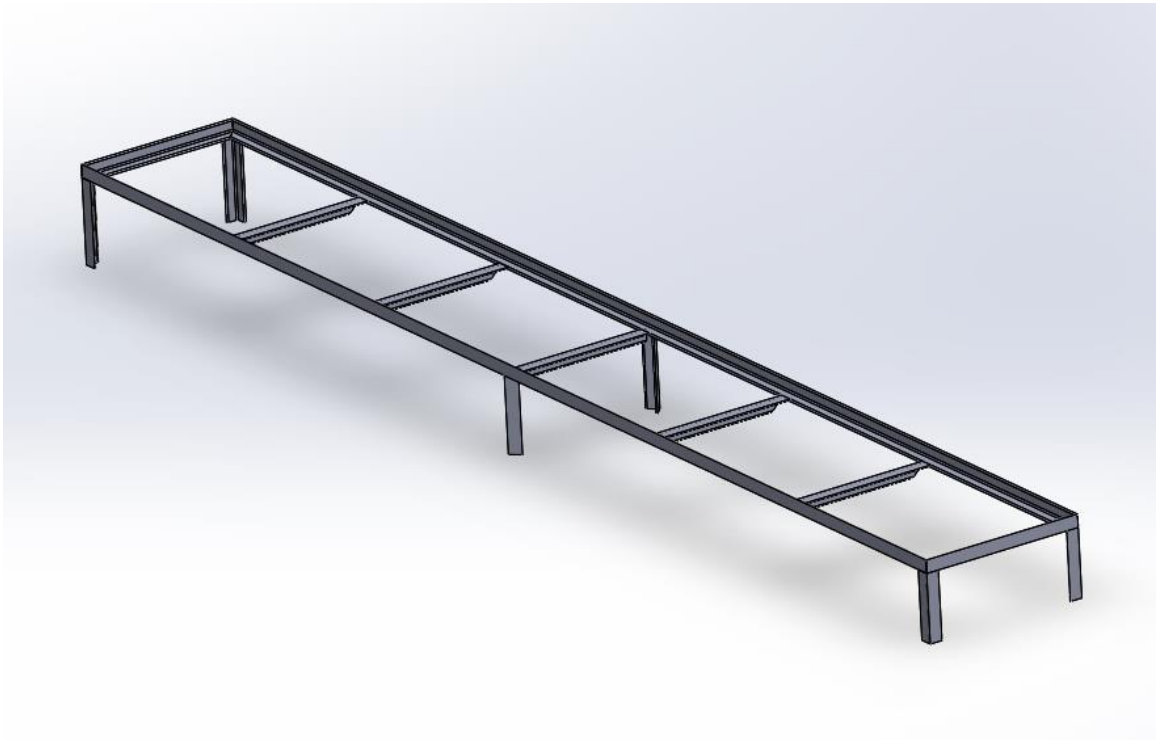


Figure 3.19: Structure of stand that carrier the machine

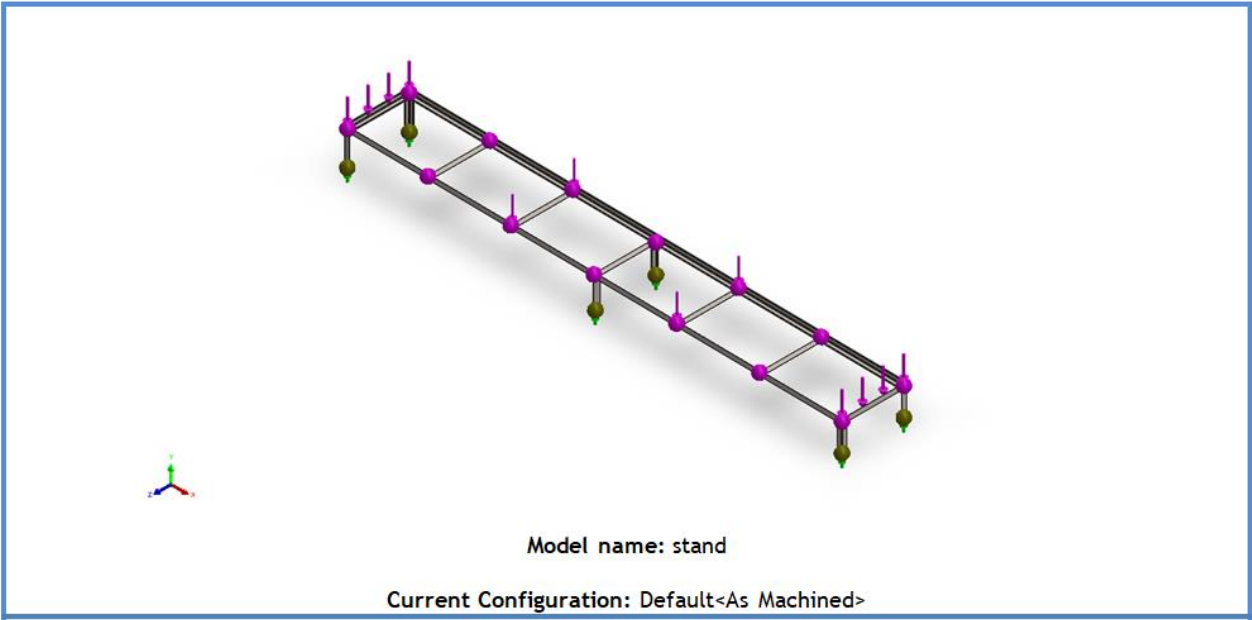


Figure 3.20: Beam Bodies

Then apply the required loaded as a distributed at 473 deferent point on important parts and then get the required results for each part as shown below. **(Figure 3.21)**

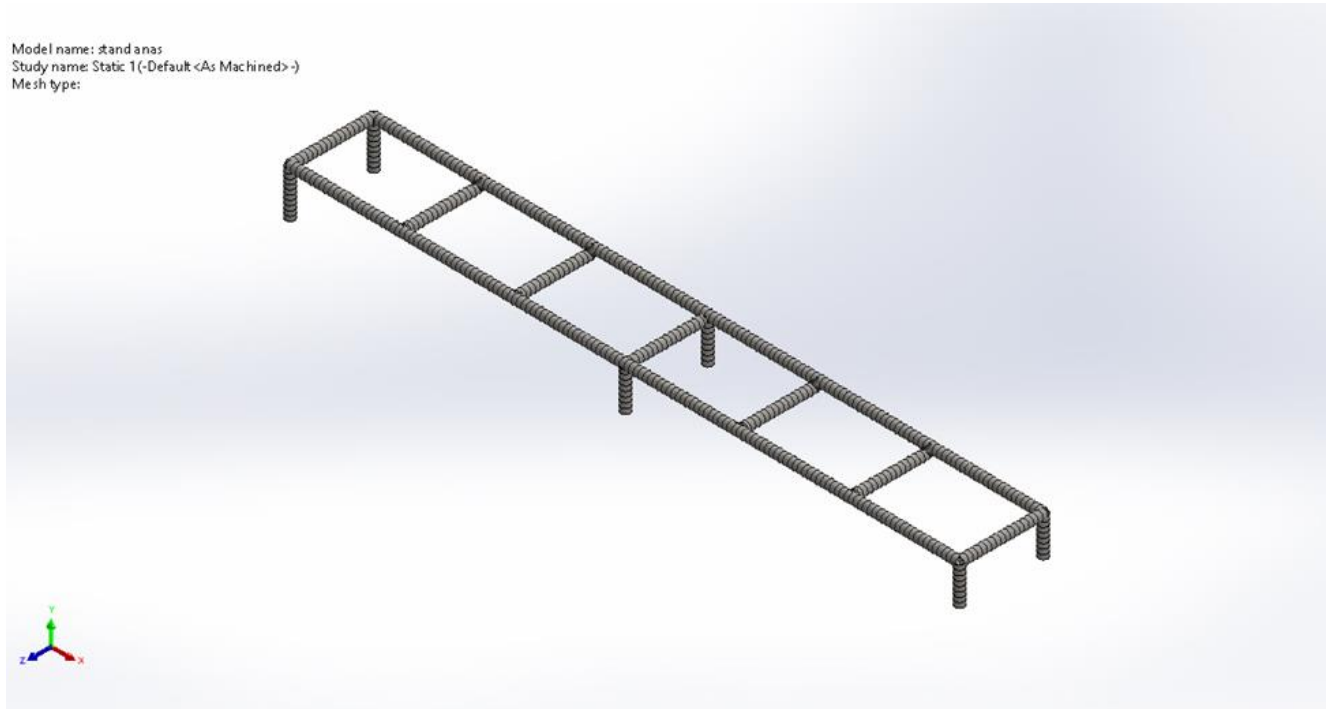
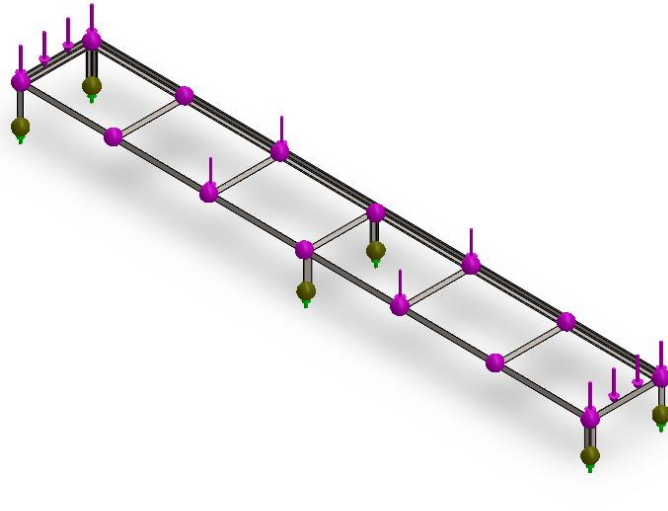


Figure 3.21 :Mesh diagram

Material Properties

Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von <u>Mises</u> Stress Yield strength: 6.20422e+08 N/m ² Tensile strength: 7.23826e+08 N/m ² Elastic modulus: 2.1e+11 N/m ² Poisson's ratio: 0.28 Mass density: 7,700 kg/m ³ Shear modulus: 7.9e+10 N/m ² Thermal expansion coefficient: 1.3e-05 /Kelvin	<u>SurfaceBody 1</u> (Surface-Imported1)(Part1)
Curve <u>Data</u> :N/A		



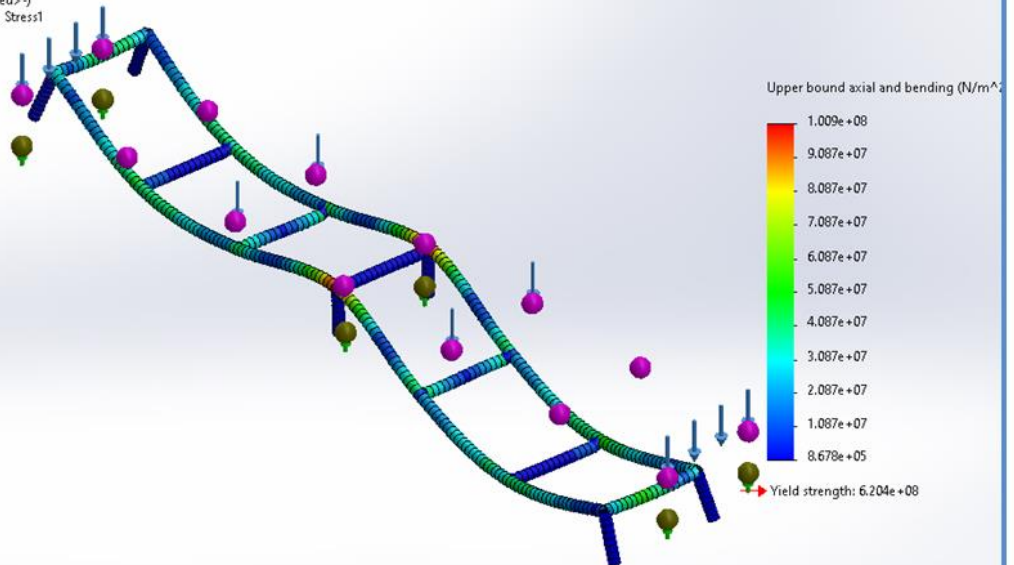
Model name: stand anas
 Current Configuration: Default<As Machined>

Beam Bodies:

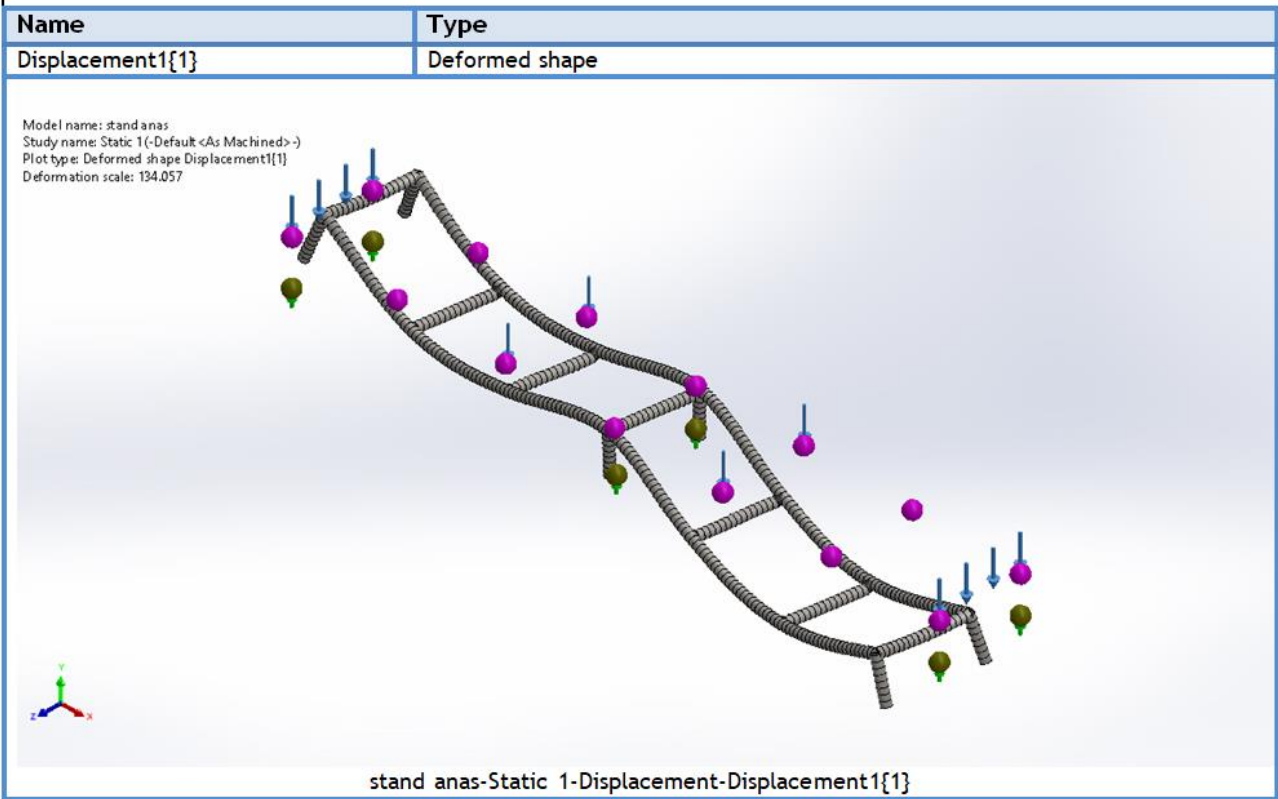
Stress strain analysis:

Name	Type	Min	Max
Stress1	Upper bound axial and bending	0.000e+00N/m ² Element: 452	1.009e+08N/m ² Element: 338

Model name: stand anas
 Study name: Static 1 (-Default <As Machined> -)
 Plot type: Upper bound axial and bending Stress1
 Deformation scale: 134.057



stand anas-Static 1-Stress-Stress1



3.8 Energy Analysis for Solar Still

The paper of Abdul - Jabbar N. Khalifa was adapted for energy analysis [14].

The amount of distillate produced in a solar still depends primarily on the amount of solar radiation available, but it is affected by several other factors. On the other hand, the efficiency of utilization of energy in the solar still is affected by various modes of heat and mass transfer that take place as a result of the total incident solar radiation. identified the energy leaving the

basin as follows:

- 1 - Thermal radiation from water and basin bottom to cover.
- 2 - Sensible heat transferred from the water surface to cover by circulating air in the enclosure.
- 3 - Conduction losses to the ground or other surroundings, which could be neglected in well-insulated stills.

- 4 - Sensible heat in effluent distillate and feeding water.
- 5 - Enthalpy in any vapor or liquid streams which might escape from the enclosure, (assumed negligible).

With these factors in mind, the energy flow diagram for the basin type solar still is presented in **Figure (3.22)**. By calculating the above-mentioned components, it was possible to locate losses in the still, to appraise their importance, and to gain insight as to improvements that might be made in the still design. The values of the above factors were influenced by the temperatures of the basin (T_w), the cover (T_g) and the ambient air (T_a). The basin temperature influenced the thermal radiation from the basin to the cover and the sensible heat transfer between the water and cover which accompanied the useful transfer water vapor. The cover temperature affected the distillation rate and efficiency. All the heat transferred to the underside plus the solar absorption in it ought to be dissipated by convection and radiation to the surroundings. Ambient air temperature and other factors such as wind velocity and atmospheric clarity all affect the heat transfer from the distiller.

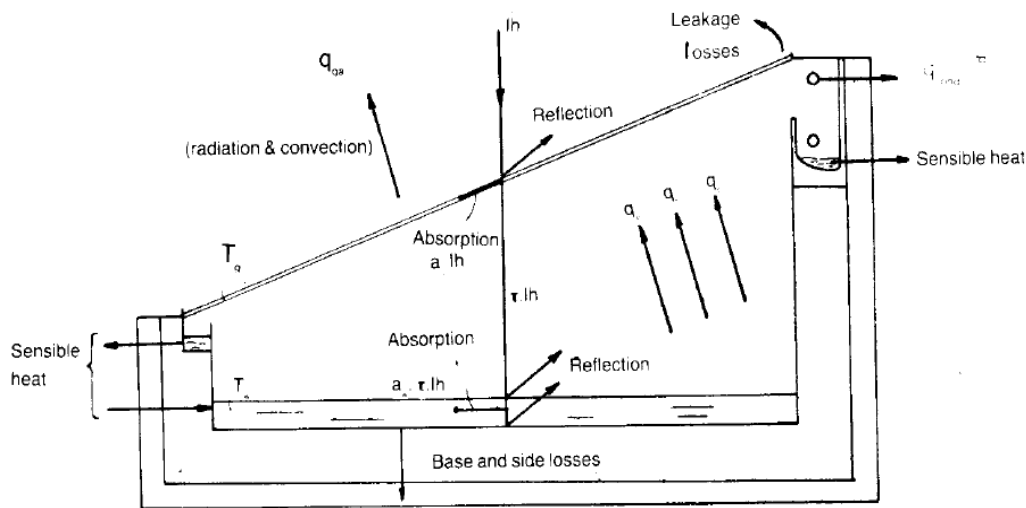


Figure 3.22: Energy flow diagram for the solar still.

Referring to **Figure (3.22)**, heat balance equations could be written for several conditions(S-1 0) as shown below:

1 - Heat balance for basin water:

$$a_b \cdot \beta \cdot I_h = C_{wb} \cdot \frac{dT_w}{dt} + q_e + q_r + q_c \quad \dots\dots\dots (1)$$

2- Heat balance for glass cover:

$$q_e + q_r + q_c + a_g \cdot I_h = q_{ga} + C_{gs} \cdot \frac{dT_g}{dt} \quad \dots\dots\dots(2)$$

The predominant modes of heat transfer in a solar still are convection evaporation and radiation, which could be approximated as that between two parallel planes (6,7,8), using the following equations to describe those modes:

$$q_r = 18.371 * 10^{-8} (T_w^4 - T_g^4) \quad \dots\dots\dots(3)$$

$$q_c = 3.1824 \left[(T_w - T_g) + \frac{P_w - P_{wg} \cdot T_w}{2.65 * 10^5 - P_w} \right] (T_w - T_g) \quad \dots\dots\dots(4)$$

$$q_e = 16.276 * 10^{-3} * q_c \cdot \frac{P_w - P_{wg}}{(T_w - T_g)} \dots\dots\dots(5)$$

The heat flux due to condensation assumed equal to that by evaporation and is given by:

$$q_e = 'Y \cdot Lh$$

Chapter Four:

Electrical Design

4.1 Process Flow Chart

Initially, algae growth will be checked in parallel with the temperature reading, if it is higher than the required temperature, the temperature controller will send a signal to PLC to open the water valve to increase the flow of wastewater inside the system until the temperature reach to the desired temperature.

When the algae growth is complete, the sensor will send a signal to the PLC to start the harvesting process and rotate the motor until the harvesting tool reach limit switch 2, then the harvesting tool will stop for 3second and reverse the direction of rotation until it reaches the limit switch1, which will send a signal to the PLC to stop the motor.

Description of how the system works. (Figure 4.1)

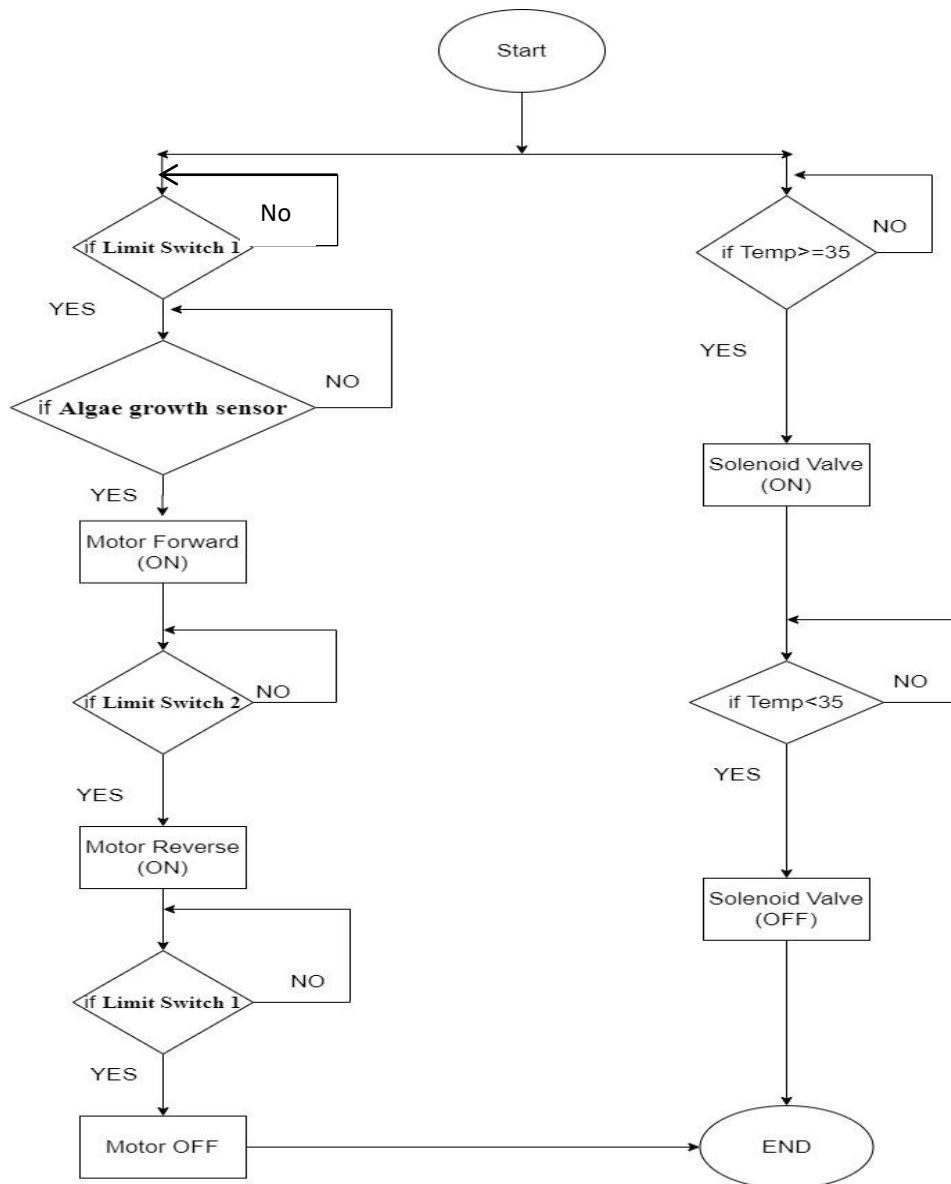


Figure 4.1:Process flow chart

4.2 PLC Control Circuit

Plc type: (Figure 4.2)



Figure 4.2: PLC DVP-ES2

- Control Circuit for all the machine is shown below. (Figure 4.3)

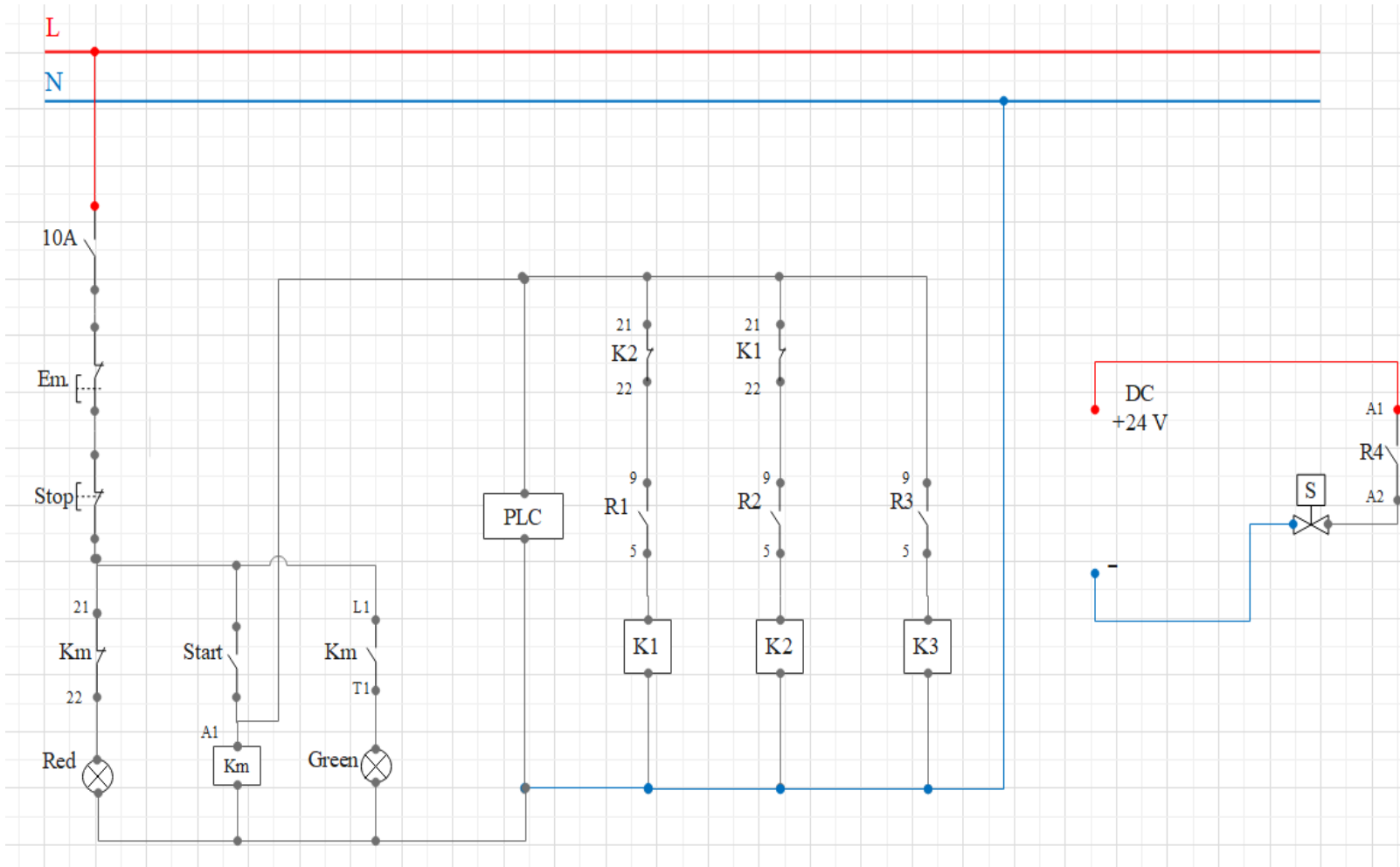


Figure 4.3:Control circuit.

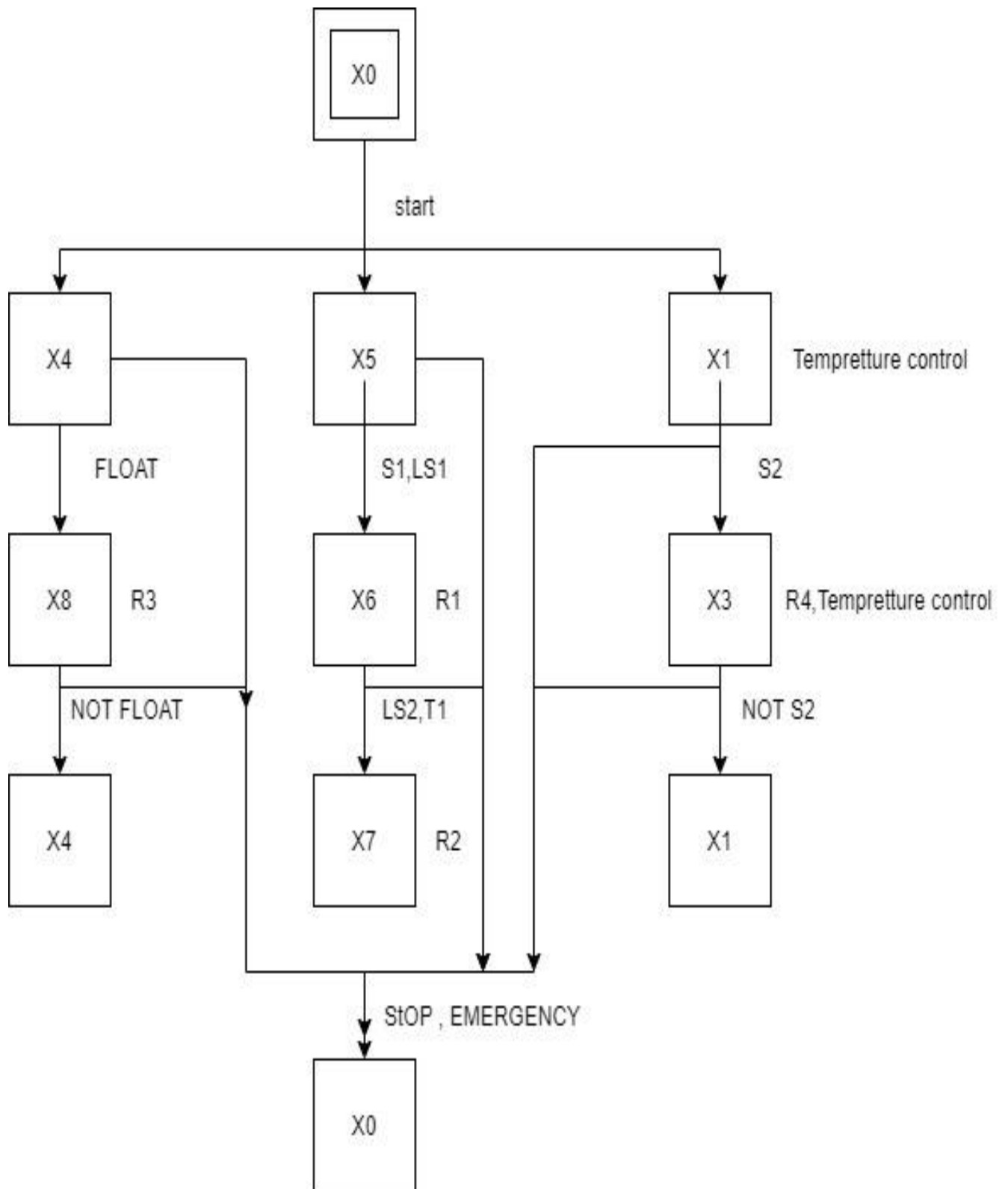
PLC Input-Output table :

The following table shows the PLC I/O's table. (Table 2)

Table 2: PLC I/O's table

Symbol	Function	Address
Inputs		
LS1	Limit Switch (stop)	X0
LS2	Limit Switch (reverse)	X1
S1	Algae growth sensor	X2
S2	Temperature control	X3
Float	Float switch	X4
Outputs		
R1	Motor Contactor (Forward)	Y0
R2	Motor Contactor (Reverse)	Y1
R3	Pump	Y2
R4	Solenoid valve	Y3

4.3 SFC Graph



4.4 Power Circuit

In (figure 4.4) show the power circuit ,and how connect a motor to control in the direction of rotation.

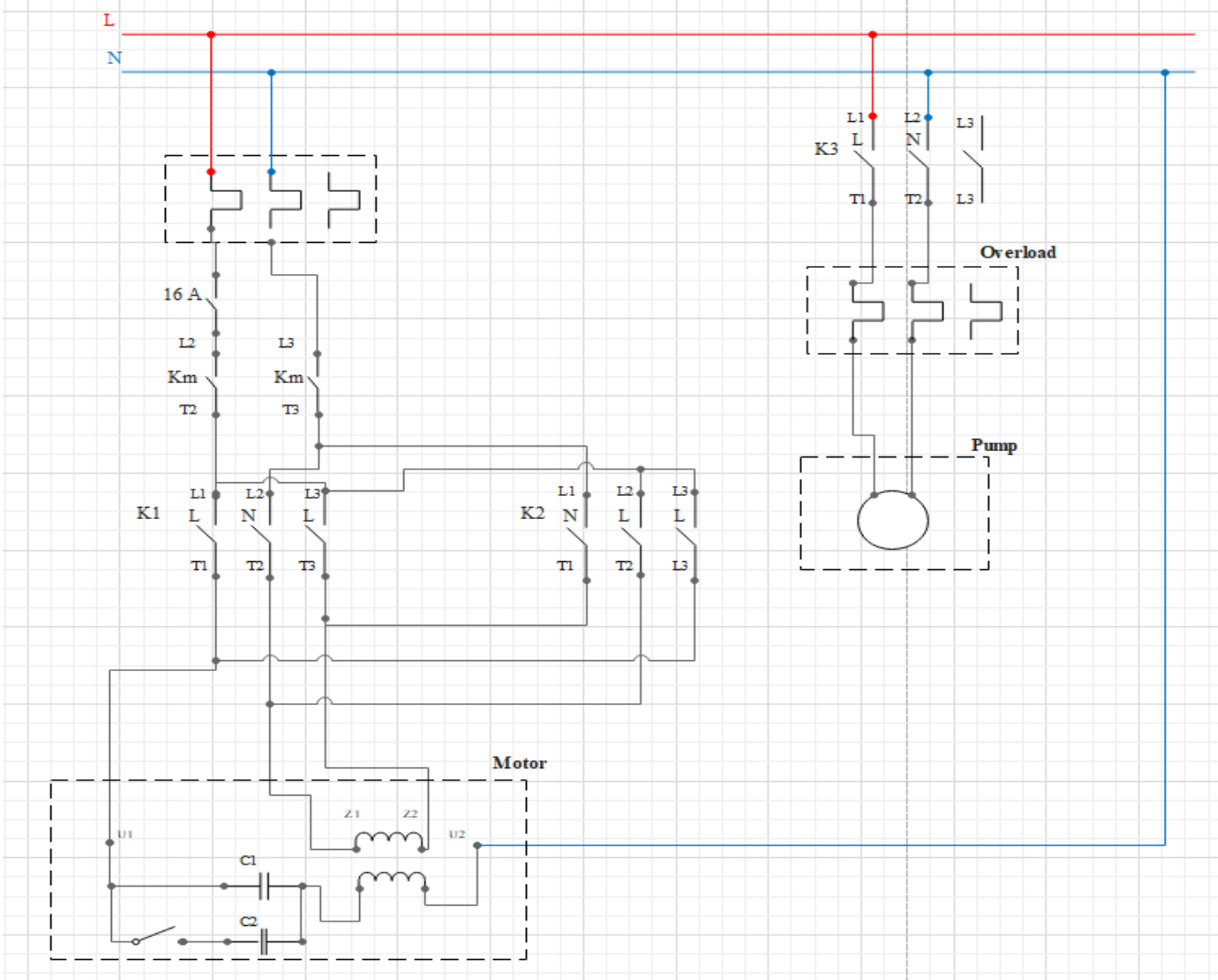


Figure 4.4: Power circuit

4.5 Components:

- **Temperature controller :**

A temperature controller as shown in (figure 4.5) is used to control temperature calculating the difference between a setpoint and a measured temperature. The controller takes input from a temperature sensor and has an output that is connected to a control element such as a heater or

fan. In this project temperature controller was connected with a thermocouple shown in **(figure 4.6)** (type K) as an input to measure the temperature inside the system, as an output temperature controller connected to the PLC, when the temperature reaches 35c the PLC control solenoid valve **(figure 4.7)** for open or close.

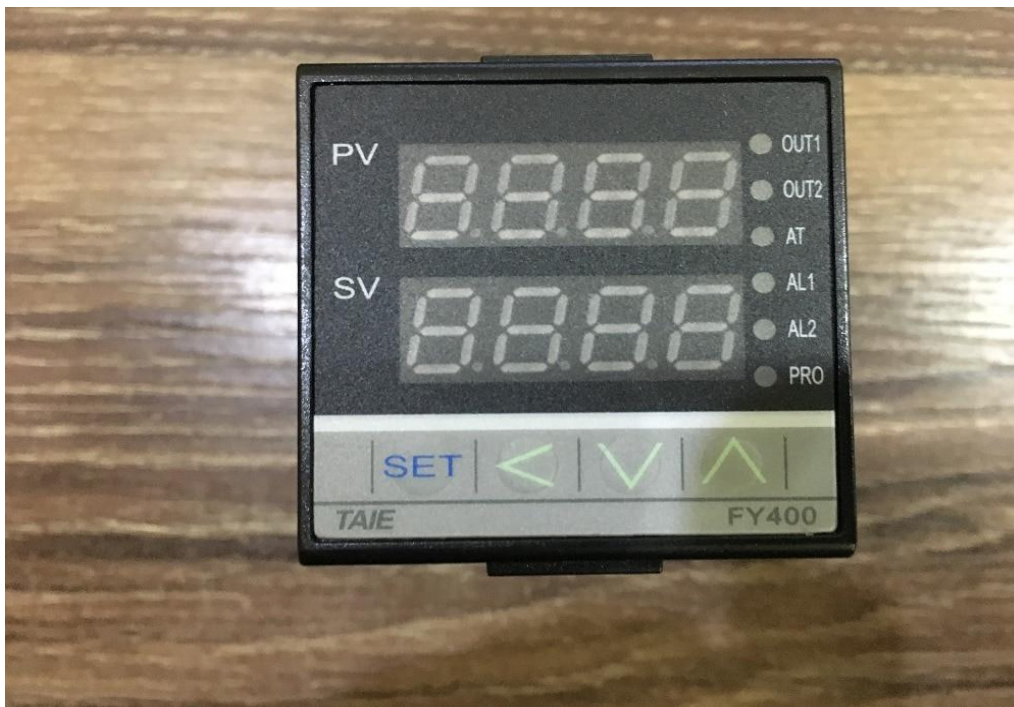


Figure 4.5: Temperature controller.

- **Temperature Sensor**

Use thermocouple **(figure 4.6)** (type K) to measure the temperature in the system.

Type K thermocouples is the most common thermocouple type that provides the widest operating temperature range. Appropriate for use in oxidizing or inert atmospheres at temperatures up to 1260°C (2300°F). Type K thermocouples generally will work in most applications because they are nickel based and have good corrosion resistance.



Figure 4.6: Thermocouple type-K

- **Solenoid valves**

A solenoid (**figure 4.7**) have 2 ports (an inlet and an outlet) and 2 switching states (open or closed) and are electromechanically controlled. They are used to solely start/stop the flow of the media and are most commonly normally closed (power to open), so that if power fails the valve will close. They can also be designed as normally open (power to close) or bi-stable (latching). It is important to first select the housing material of your valve to ensure it is suitable for the media that the valve will be controlling.



Figure 4.7: 2-Way solenoid valves.

- **Float switch**

A float switch (**figure 4.8**) is a device that is used to detect the level of a liquid in a tank or a container. The float switch floats on top of the liquid surface and acts as a mechanical switch as the liquid level goes up or down. They can be used to control devices like pumps (pump water in or out), valves (open or close inlet/outlets), or alarms to notify users. They are cost effective, reliable, and can be used with a wide variety of liquids.



Figure 4.8: Float switch.

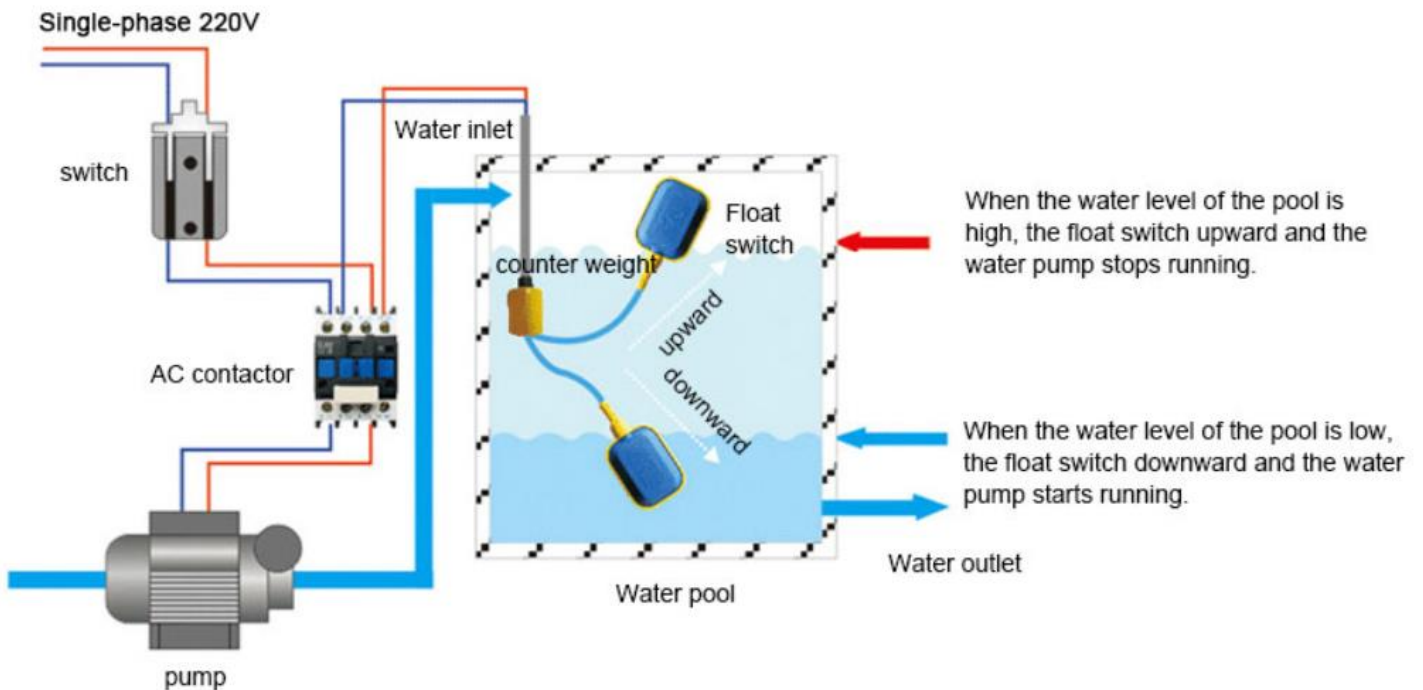


Figure 4.9: Float switch working principle.

- **Contactor:**

A contactor (**figure 4.10**) is an electrically-controlled switch used for switching an electrical power circuit. A contactor is typically controlled by a circuit which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch, so in this system need two contactors to run a motor in two directions and one contactor to run a pump

Operating Principle of a Contactor:

The current passing through the contactor excites the electromagnet. The excited electromagnet produces a magnetic field, causing the contactor core to move the armature. A normally closed (NC) contact completes the circuit between the fixed contacts and the moving contacts.



Figure 4.11: Contactor

- **Relay:**

Relays (**figure 4.11**) are the switches which aim at closing and opening the circuits electronically as well as electromechanically. It controls the opening and closing of the circuit contacts of an electronic circuit. When the relay contact is open (NO), the relay isn't energized with open contact. However, if it is closed (NC), the relay isn't energize given the closed contact. However, when energy (electricity or charge) is supplied, the states are prone to change.

Relays are normally used in the control panels, manufacturing, and building automation to control the power along with switching the smaller current values in a control circuit. However, the supply of amplifying effect can help control the large amperes and voltages because if low voltage is applied to the relay coil, a large voltage can be switched by the contacts, so in this system need 2 relays for motor, one relay for the solenoid, and one relay for a pump.



Figure 4.11: Relay

- **Limit switch**

limit switches (**Figure 4.12**) are used to control the direction of rotation of the motor to reverse the motor direction and to stop it, so this process need 2 limit switches.



Figure 4.12: Limit Switch

- **Overload**

Overload is designed to imitate (on a much smaller scale) the heating patterns of the electric motor it is installed in, and interrupt the current once the heat sensing mechanism in the relay reaches a certain temperature.

An overload is made up of a heater paired with normally-closed contacts that open once the heater gets too hot. The overload contacts are connected in series and located between the contactor and the motor itself to prevent the motor from restarting once the overload trips.



Figure 4.13: Overload

Chapter Five:

Experimental Work

5.1 Working Principle of The System

The wastewater flows in the system to the first filtration to the system, The system set-up consists of a passive single solar distillation unit with a glass cover inclined at an angle of 30 degrees Since the geographical location of the farm in Dura it is justified to take inclination for glass cover to receive maximum solar radiation. This tilted glass cover of 4mm thickness served as a solar energy transmitter as well as a condensing surface for the water vapors generated in the basin of the still. The basin is made up of galvanized steel with an effective area of 1 m². The basin of the distiller was blackened to increase solar energy absorption. The first tank will manually be filled with wastewater and when it filled the water will fill with gravity to the system for treatment by algae which the algae will be in the basin surface for the absorption process, Water gets evaporated and condensed on the inner surface of the glass cover. It runs down the lower edge of the glass cover (**Figure 5.1**). The distillate will be collected in a bottle, the pump returned the water to the first tank and the process will keep on until having pure water when the algae growth complete the harvest process starts.

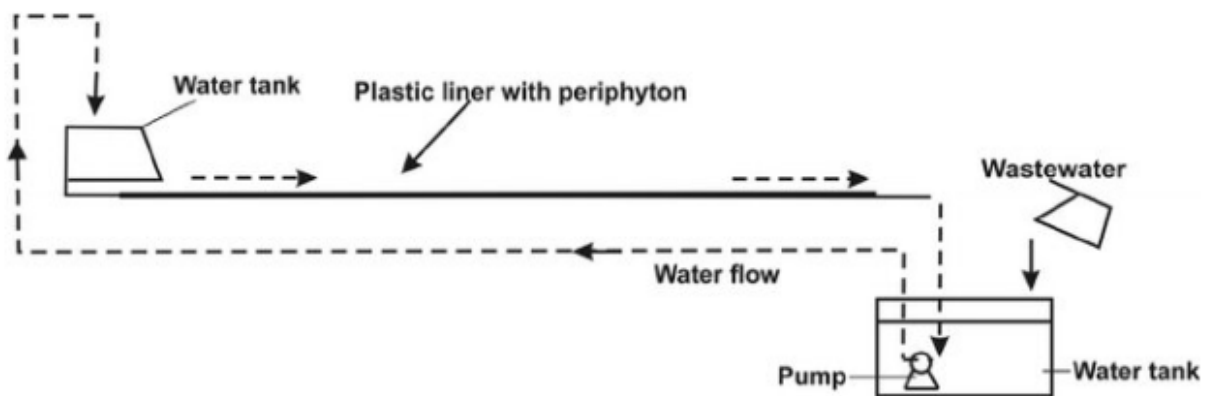


Figure 5.1: A general description of the water path.

5.2 Materials and Methods

In Hebron there is a lot of animal farms that are produced wastewater from its daily works likes washing, cleaning the animal in the farm or plant irrigation, etc., but in this project focused on water from the animals. Al Rayan farm was chosen to build the system. **(Figure 5.2)**



Figure 5.2: The place where the project was built.

The algae require light, carbon dioxide, water, and inorganic nutrients for photosynthetic growth. Ideal temperature ranges are generally between 20 to 35o C.[1], the wastewater must not contain Cl and the pH must be 7 in balance or the algae will die, samples of wastewater from the farm were taken, tests and analyses were taken in college for these samples (**Figure 5.3**).



Figure 5.3: Samples analysis

After taking samples of water, the beginning of the washing line and the end of the washing line showed the following results:

Table3: The results of some elements from wastewater

Material	Start the washing line	End the washing line
pH	7.13	7.01
Cl	<0.2 mg / L	<0.2 mg / L
TDS	943 mg / L	1439 mg / L
E.C.	1569 mV	2400 mV

From the result shown in table the there is no danger in algae growth.

As mentioned above about the temperature range for the algae growth, the system must have controller and sensors to control the temperature water in these ranges 20 to 35o C in the system from an increased or decreased mass flow rate of water.

The wastewater was collected at the first tank around 220L in **(Figure 5.4)** water will fall with gravity to the system for treatment by algae which the algae will be in the basin surface for the absorption process.



Figure 5.4: The first tank

the wastewater will be pass-through filter purify the water from impurities as shown in (Figure 5.5)



Figure 5.5 : Filter

after the filter, the wastewater will pass through a water shower to guarantee the distribution of water to the whole path as shown in (Figure 5.6).



Figure 5.6: Water shower

Then the wastewater will fill to the path has the algae on it.

Kink (**Figure 5.7**) was put in the path with 1mm x 1mm dimensions to catch the algae in the path.



Figure 5.7: Kink

The wastewater will move along the path then will fill in the second tank by water drain as shown in (**Figure 5.8**).



Figure 5.8: Water drain

Then the second tank (**Figure 5.9**) filled with water the pump (**Figure 5.10**) will pump the water from the second tank to the first tank and so on, for that the wastewater will move in the system as cycles.



Figure 5.9 :Second tank



Figure 5.10 :Pump

Cover from plastic was put above the path and sealed for the evaporation process and to condensation of water on the surface as shown in **(Figure 5.11)**.



Figure 5.11: Cover

After condensation water drops in the canal to collect the distilled water as shown in **(Figure 5.12)**.



Figure 5.12: Place of out distilled water

5.3 Automation and Intelligence in the System

automation is defined as the technique of making an apparatus, a process, or a system to operate automatically; the state of being operated automatically; and automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labor. Simply, automation can be described as the construction and application of technology to monitor and control activities for the delivery of products and services. The technology application involves the utilization of a complete system that includes design considerations, sensors, programmable controllers, program algorithms, and controlled devices. The temperature sensor was put inside the system to measure the temperature inside, the sensor was connected to the temperature control to monitor the temperature as shown in **(Figure 5.13)**.

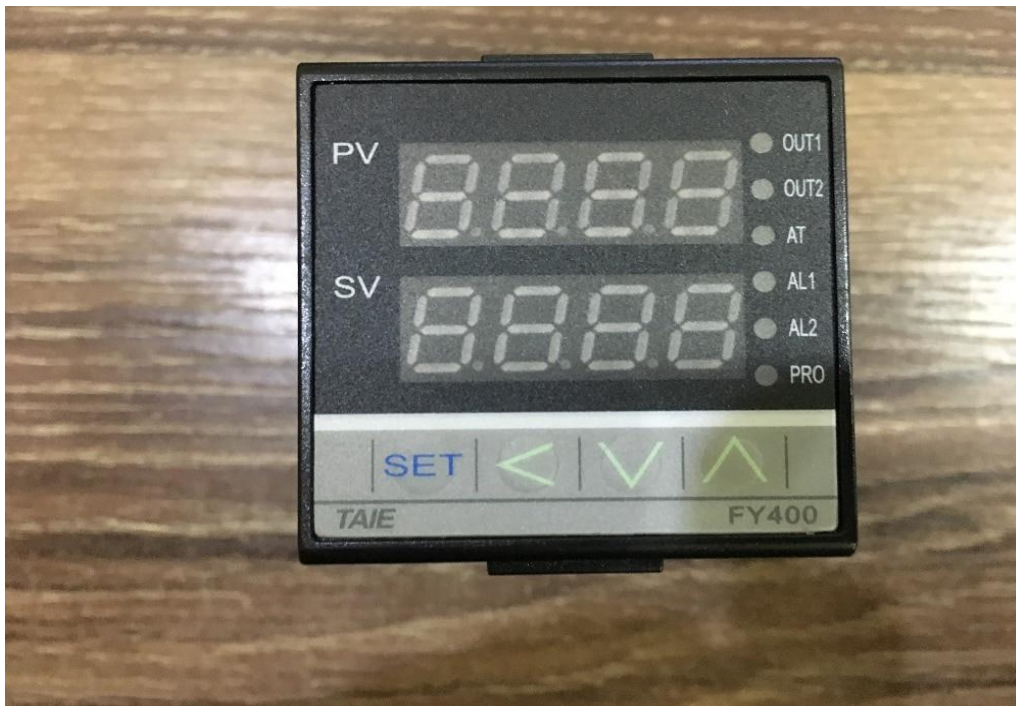


Figure 5.13: Temperature sensor interface with temperature control

To keep the system temperature under 35C to keep algae safe from high-temperature solenoid valve was connected to PLC as output to open the valve when the temperature sensor senses it above 35C as this keep temperature under 35C due to the valve will raise the mass flow rate in the system as shown in **(Figure 5.14)**.



Figure 5.14: Solenoid valve

The algae **(Figure 5.15)** as shown in the figure were put arranged and distributed along the path to growth.



Figure 5.15:A small sample of algae

When the algae growth complete, it takes around 2 weeks, the motor as shown in (**Figure 5.16**) was connected to PLC to move the harvest tool (Scrapers) as shown in (**Figure 5.17**) along the path.

Limits switches also connected to PLC for harvest tool at the start and end of the path to stop and reverse its direction, the algae collected at the end of a path in the tank .



Figure 5.16: The motor with gearbox



Figure 5.17: Harvest tool

5.3.1 PLC Panel

Programmable Logic Controllers (PLCs) are small industrial computers with modular components designed to automate customized control processes. PLCs are often used in factories and industrial plants to control motors, pumps, lights, fans, circuit breakers and other machinery. Integrated PLC Panel 300*400*165 mm (**Figure 5.18**) can monitor any process and provide data wherever and however you need it.

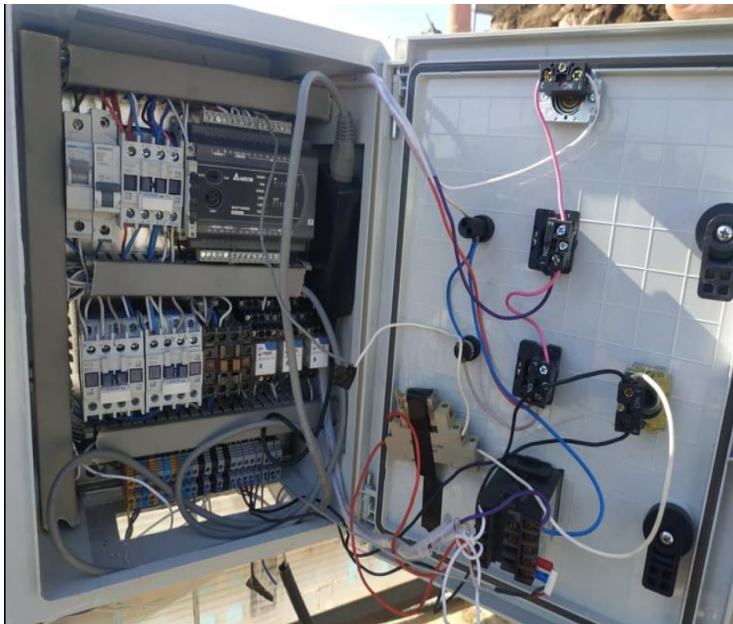


Figure 5.18: PLC panel

Chapter Six: Results and Discussion

6.1 Results and Discussion

- **Wastewater tests**

The sample's measurement was taken four times in different days, at around 5:00 PM. Four tests were taken for each sample TDS, NO_3 , pH, the results as shown in the figures.

The pH and NO_3 readings shows positive changes during days, that's where the ratio of pH and NO_3 decreased, this indicates the ability of algae to treat wastewater.

In this figure, the removal of algae shows the NO_3 , where on the first day of taking the sample the percentage of NO_3 was at the beginning of 46.2 mg/L and then after two days the percentage of NO_3 had decreased to reach 43.4 mg/L until the last sample we took after 5 days of taking the first sample and the amount of nitrates was equal to 42.9 mg/L . (**Figure 6.1**)

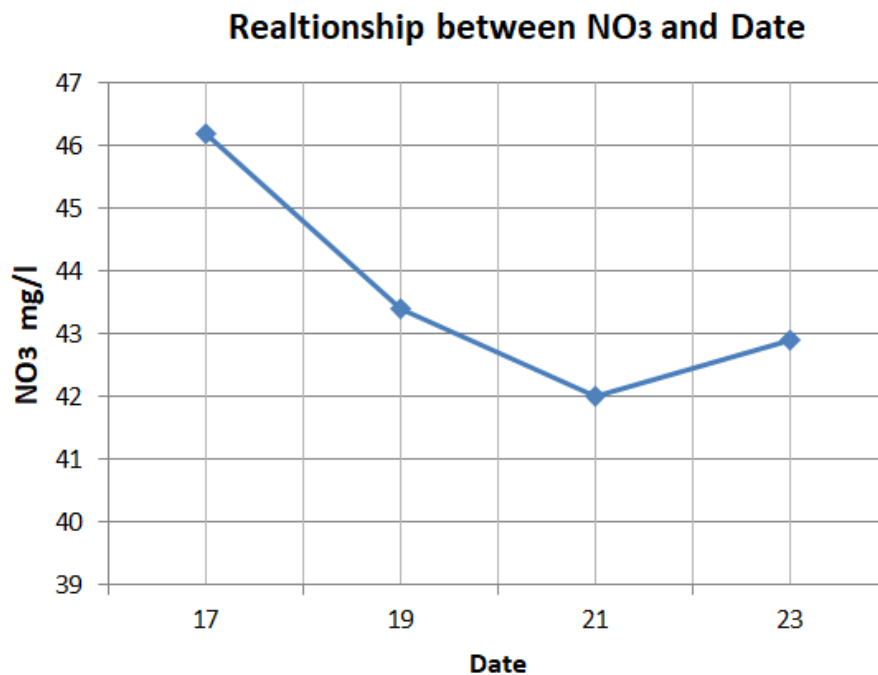


Figure 6.1: Relationship between NO_3 and date .

The effect of algae on the pH was studied, It has been observed to tend to be acidic, because the increased growth of algae that produce acidic compounds, where on the first day of taking the sample the sample was tilted to base 9.03, then after two days the pH decreased to 8.79 , then

after another two days the pH had decreased to 8.47 then after a five days after taking the first sample, the pH became 8.51, that is almost neutral. (Figure 6.2)

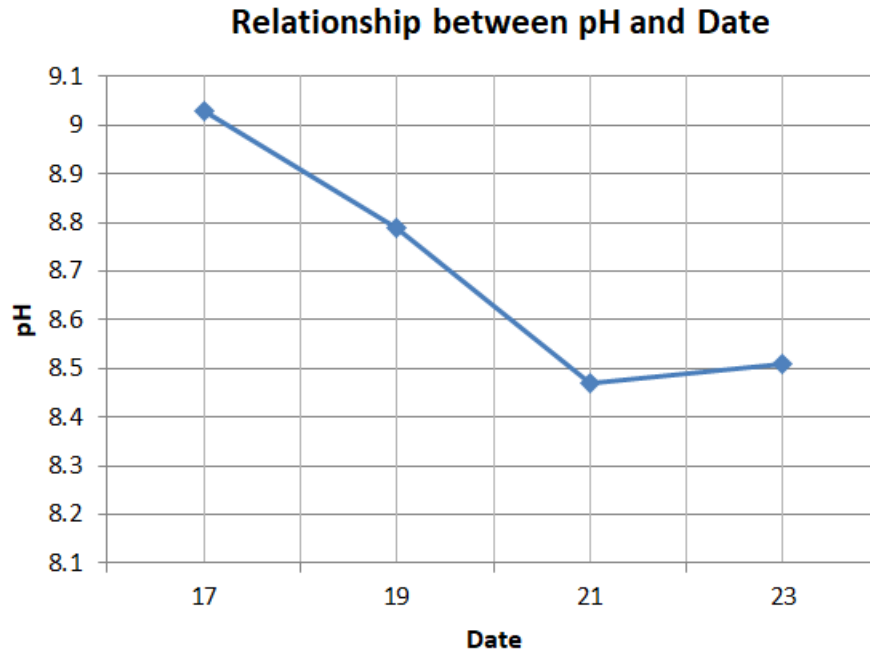


Figure 6.2: Relationship between pH and date.

In this figure, in first and second samples, notice the decrease in the total dissolved salts from the wastewater, then they tended to increase again, because the short period in which samples were taken. (Figure 6.3)

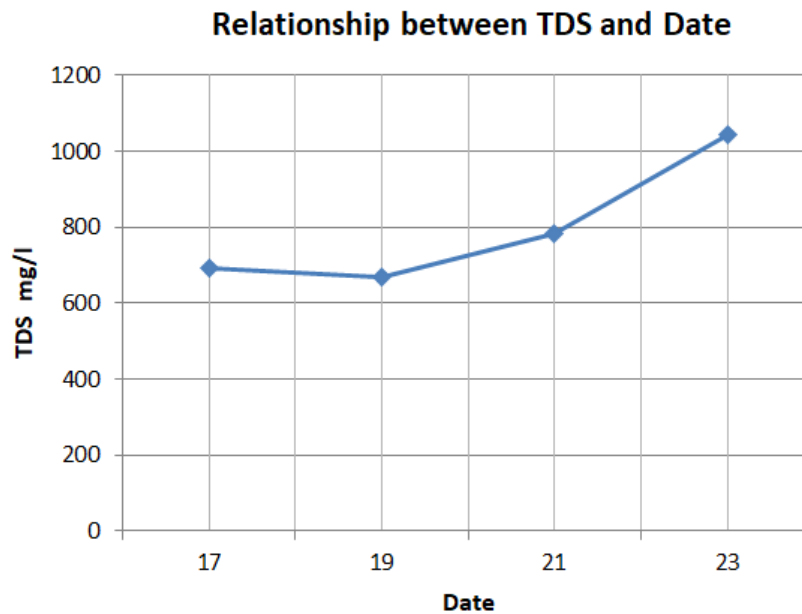


Figure 6.3: Relationship between TDS and date.

- **Algae**

The results of algae growth in the system (**Figure 6.4**) . The weight of algae was measured, where a sample with an area of 20* 20 cm was taken, and it was found that the weight of algae in this sample was equal to 55g.

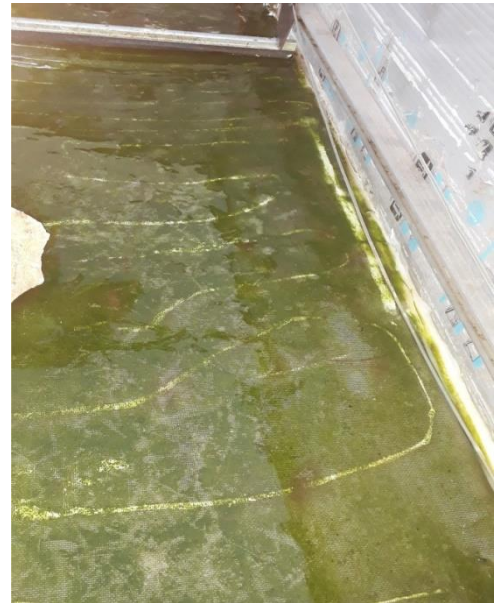


Figure 6.4: Algae growth in the system

- **Distilled water**

The percentage of distilled water produced daily was measured, where its quantity was approximately 500 ml.

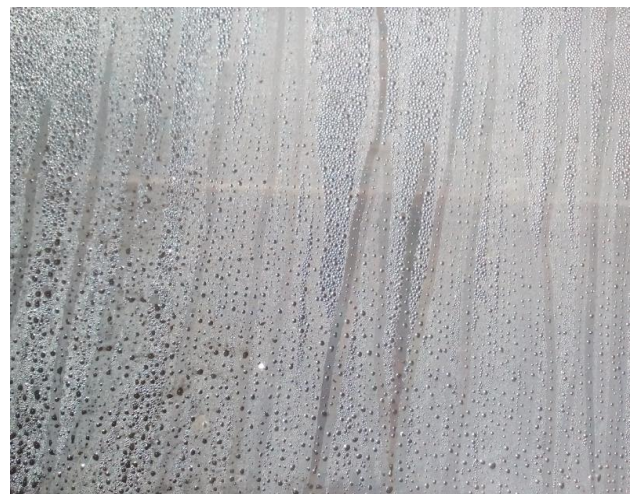


Figure 6.5: Condensation of water on the surface of the inner cover of the system

Chapter Seven: Conclusions and Recommendations

7.1 Conclusions

- One of the advantages of using algae biomass is that it can be grown as a way to treatment wastewater from animal farms. Additionally, algae-based biofuels do not compete with other agriculture food crops. Significant advances in algae production practices, photobioreactor technology and strain selections, have led to additional knowledge about the remarkable potential of algae to serve as a sustainable source of biofuel and treatment a wastewater.
- There is no of absolute components for designing a universal "fits-all" automated system. Some systems may require more functionality and/or flexibility, some may require less. The balance between cost and functionality will vary from project to project. This research focused on treating wastewater using algae and producing distilled water as a by-product, as a new idea is added to this system.
- A still is a cheap and easiest way that can be used to obtain fresh water from the brackish or salty water to make it available for drinking and other expedient purposes. Water quality of the output obtained out from the still has also been tested. The TDS has been measured by the digital meter and pH has been measured by the pH metre.

No.	Element	Symbol	Results Sample 17	Results Sample 19	Results Sample 21	Results Sample 23	Unit
1	pH _{at T=31.6 C}	pH	9.03	8.79	8.47	8.51	
2	Total dissolved Solid _{at T=31.6 C}	TDS	694	668	784	1043	mg/l
3	Nitrate	NO ₃	46.2	43.4	42	42.9	mg/l

The trait of distillate attained, from the set-up was examined in the laboratory. The results attained of the distillate water acquired from the set-up were as given:

- The output was colourless and odourless.
- The pH value of the output was 8.2.
- The value of the Total Dissolved Salt of the output was 45 ppm.

7.2 Recommendations

This study should be further developed to adaptation for various algae photobioreactor systems. However, any steps taken should observe some of the following recommendations to ensure the ultimate goal can be achieved.

- Planning should include collaboration of researchers from various disciplines such as biology, chemistry and engineering.
- Planning must include a thorough study of field site, including environment conditions, existing infrastructure systems and other supporting equipment available.
- Planning team should have a thorough understanding of algae cultivation process/production systems and photobioreactor system dynamics.
- Knowledge of algae strain or strains to be used, environmental effects on the strain and nutrient/treatment sources supporting the algae cultivation will enhance the productivity and value of any planned system.

Appendix

Appendix(A)

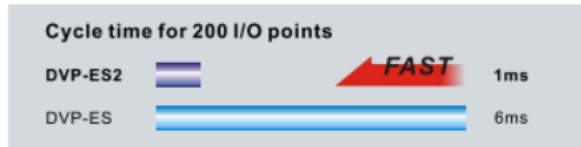
ES2/EX2 Series Specifications

Model name	20EX200T 20EX200R	16ES200T 16ES200R	24ES200T 24ES200R	32ES200T 32ES200R	40ES200T 40ES200R	60ES200T 60ES200R
High-speed input	2 points of 100kHz; 6 points of 10kHz; Max. 8 points for single-phase input; Max. 4 points for 2-phase 2-inputs					
Pulse output	2 points of 100kHz; 2 points of 10kHz					
High-speed comparison interruption	8 points					
External input interruption	8 points					
COM port	Built-in 1 RS-232 port, 2 RS-485 ports					
Built-in analog I/O	Yes	No				
AC motor drive/ Servo drive control commands	Yes					
Extension module connection	Connectable to 8 analog extension modules					
Motion control instructions	Yes, with S-curve acceleration/deceleration function					
Program execution speed	Execution speed of basic instructions: 0.35 ~ 1 μ s					
Program capacity	16k steps					
Function block editing	Yes					
Password protection	Restriction on incorrect password entry, subroutine password and PLC ID					
Max. I/O points	256 input points + 16 output points, or 256 output points + 16 input points					



Enhanced Program Execution Speed

Enhanced Extension I/O Refresh Speed



The refresh speed of extension I/O on DVP-ES2 has been greatly enhanced. Only 5μs is required to refresh one I/O point and 1ms for 200 I/O points, which improves the operation efficiency of the PLC.

Enhanced Program Execution Speed



The execution speed of basic instruction LD has been enhanced to 0.54μs, which is a big improvement on the instruction operation efficiency.



16-bit data movement instruction

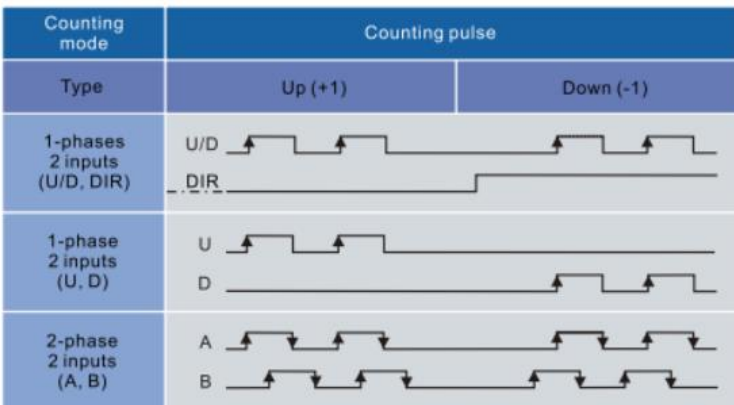


32-bit multiplication instruction

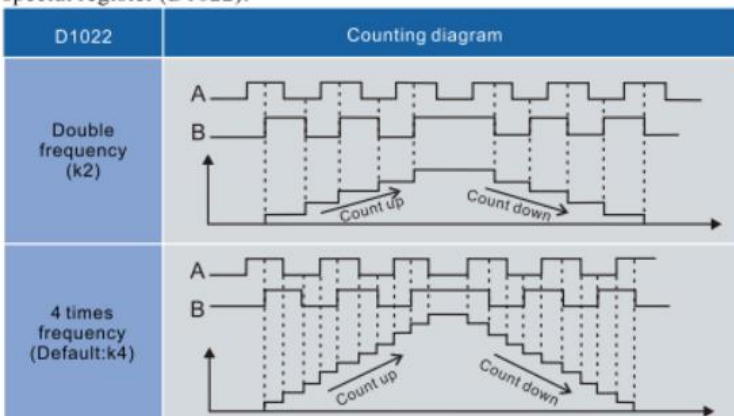


High-Speed Input

DVP-ES2 is built-in with 8 points of high-speed input (2 points of 100kHz, 6 points of 10kHz) and supports U/D, U/D Dir and A/B counting modes.

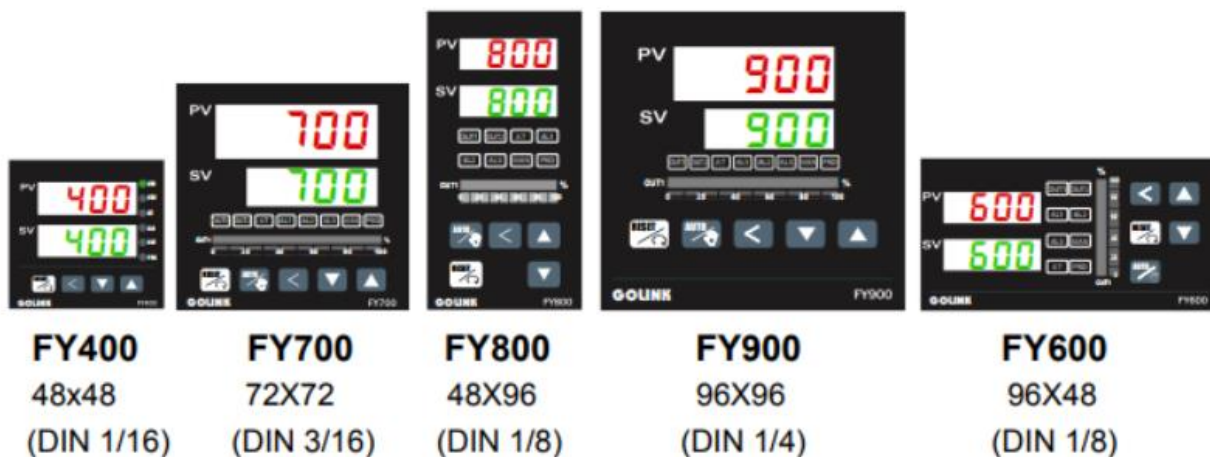


Set up A/B counting mode to double frequency or 4 times frequency in special register (D1022).



Appendix(B)

FY-Series Digital PID Controller Operation Manual



Specifications

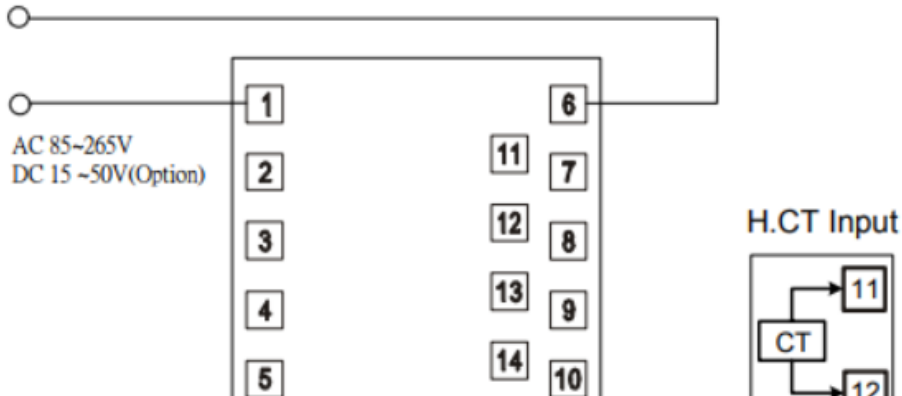
- Standard spec.

Model	FY400	FY600	FY700	FY800	FY900
Dimension	48X48mm	96X48mm	72X72mm	48X96mm	96X96mm
Supply voltage	AC 85~265V · DC 15~50V (Option)				
Frequency	50 / 60 HZ				
Power consumption	approx 3VA	approx 4VA	approx 3VA	approx 4VA	approx 4VA
Input	Accuracy	0.2 % FS ± 1digit			
	Sample time	250ms			
	TC	K , J , R , S , B , E , N , T , W5Re/W26Re , PLII , U , L			
	RTD	PT100,JPT100,JPT50			
	mA dc	4~20mA ,0~20mA			
	mV / V dc	0~1V,0~5V,0~10V,1~5V,2~10V -10~10mV,0~10mV,0~20mV,0~50mV,10~50mV			
	Decimal point position	0000 , 000.0 , 00.00 , 0.000 Available for linear input (mA / mV / V)			
Output 1	Relay	SPST type	SPDT type	SPST type	SPDT type
		3A , 220V , electrical life:100,000 times or more (under rated load)			
	Voltage pulse	For SSR drive. ON : 24V , OFF : 0V , max load current : 20mA			
	mA dc	4~20mA, 0~20mA. Maximum load resistance:560 Ω			
	Voltage dc				
	0~5V . 0~10V . 1~5V . 2~10V . Max load current:20mA				
PID range	P: 0.0 ~ 200.0 % · I: 0~3600s · D: 0~900s				
Isolation	Output terminals(control output , alarm , transmission) and input terminals are isolated separately				
Isolated resistance	10MΩ or more between input and case (ground) at DC 500 V 10MΩ or more between output and case (ground) at DC 500 V				
Dielectric strength	1000V AC for 1 minute between input terminal and case (ground) 1500V AC for 1 minute between output terminal and case (ground)				
Operating temperature	0~50°C				
Humidity range	20~90%RH				
Weight	150g	225g	225g	225g	300g
Display Height	PV:7mm	PV:7mm	PV:14mm	PV:7mm	PV:14mm
	SV:7mm	SV:7mm	SV:10mm	SV:7mm	SV:10mm

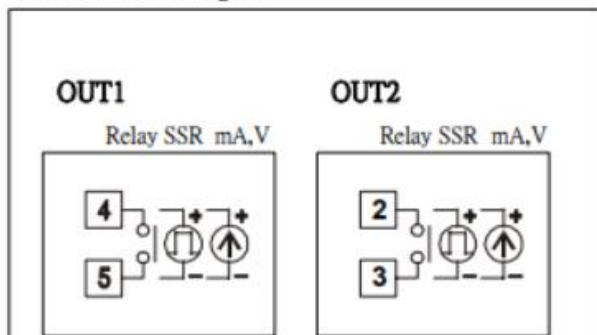
Terminal arrangement

FY400 Terminals (48mm x 48mm , DIN 1/16)

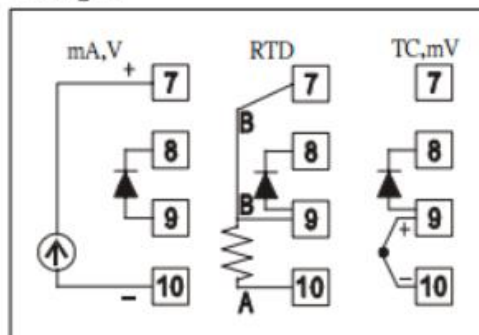
A. Power Supply



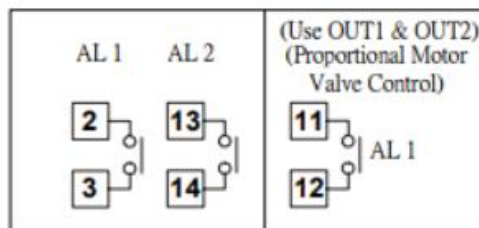
B. Control Output



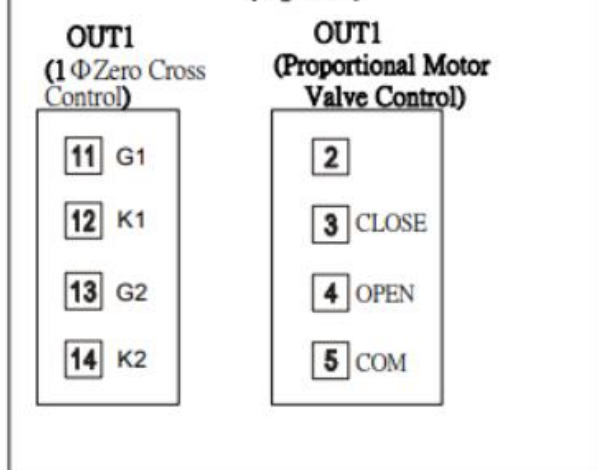
C. Input



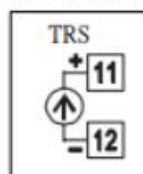
D. Alarm



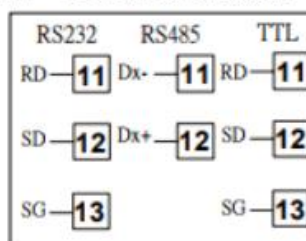
(Option)



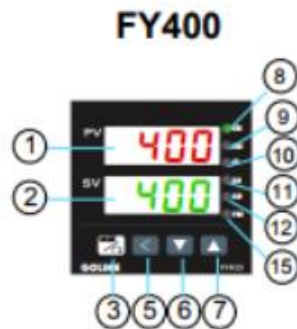
E. Transmission








F. Communication



Parts description

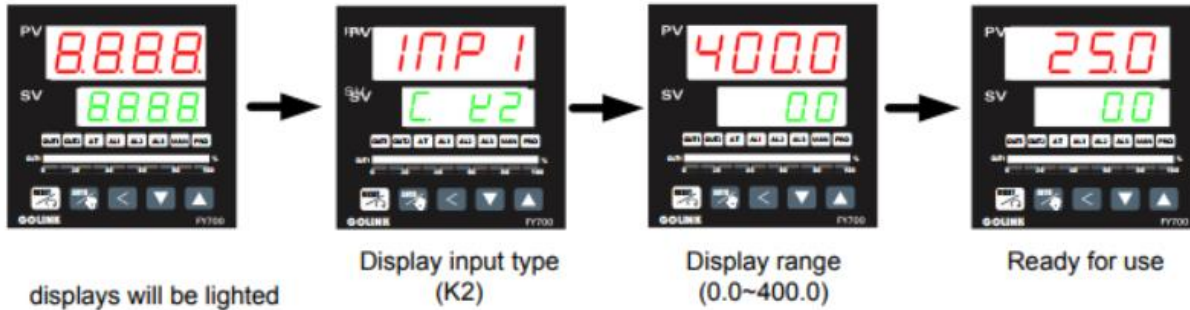


SYMBOL	NAME	FUNCTION
PV	① Measured value (PV) display	Displays PV or various parameter symbols (Red)
SV	② Set value (SV) display	Displays SV or various parameter set values (Green)
	③ Set key	Used for parameter calling up and set value registration
	④ Auto/Manual key	Switches between Auto(PID) output mode and Manual output mode.
	⑤ Shift key	Shift digits when settings are changed
	⑥ Down key <i>*Program hold</i>	Decrease numbers (-1000,-100,-10,-1) <i>* Program hold (Programmable controller)</i>
	⑦ Up key <i>*Program run</i>	Decrease numbers (+1000,+100,+10,+1) <i>* Program run (Programmable controller)</i>
OUT1	⑧ OUT1 lamp	Lights when OUT1 is activated (Green)
OUT2	⑨ OUT2 lamp	Lights when OUT2 is activated (Green) ◦
AT	⑩ Auto tuning lamp	Lights when Auto tuning is activated (Orange)
AL1	⑪ Alarm 1 lamp	Lights when Alarm 1 is activated (Red)
AL2	⑫ Alarm 2 lamp	Lights when Alarm 2 is activated (Red)
AL3	⑬ Alarm 3 lamp	Lights when Alarm 3 is activated (Red)
MAN	⑭ Manual output lamp	Lights when manual output is activated (Orange)
PRO	⑮ <i>*Program running lamp</i>	<i>*Flashes when program is running (Programmable controller) ◦</i>
OUT1%	⑯ OUT% bar-graph display	Output% is displayed on 10-dot LED.

Operations

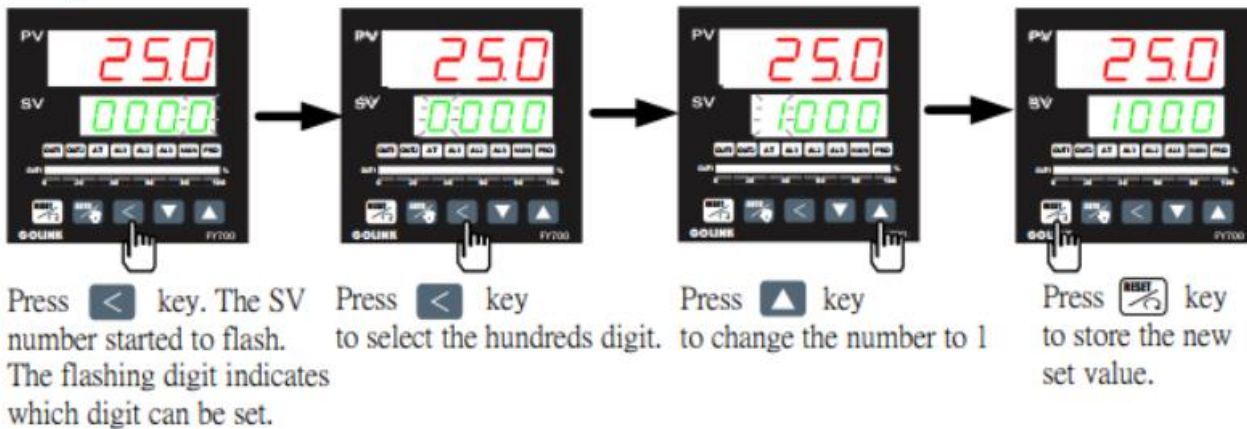
Power On

Controller will display as below



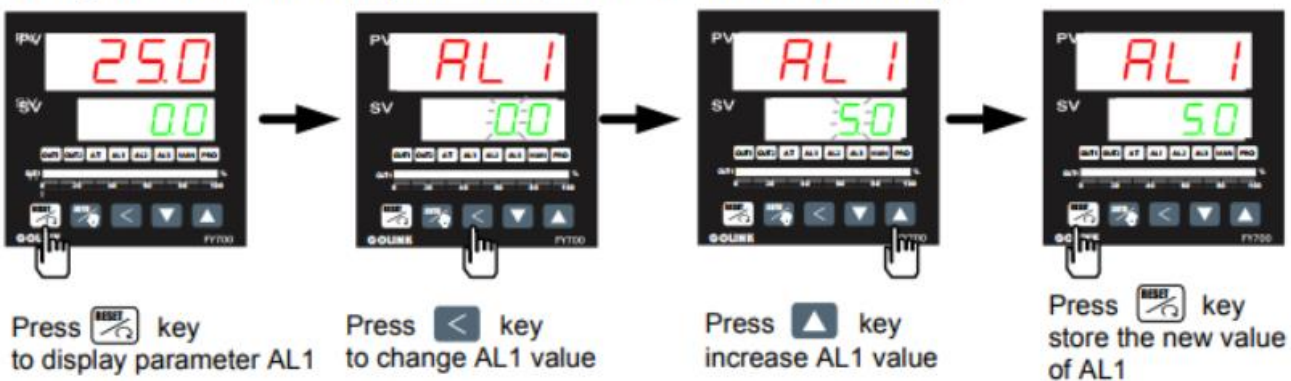
Change the Set Value (SV)

Change SV from 0.0 to 100.0



Change the Alarm Value

Change AL1 value to "5.0" (AL1 active, if PV exceeds SV over 5.0)



Appendix(C)

MAXIMUM TEMPERATURE RANGE

Thermocouple Grade
- 200 to 1250°C, - 328 to 2282°F

Extension Grade
0 to 200°C, 32 to 392°F

LIMITS OF ERROR
(whichever is greater)
Standard: 2.2°C or 0.75% Above 0°C
2.2°C or 2.0% Below 0°C
Special: 1.1°C or 0.4%

COMMENTS, BARE WIRE ENVIRONMENT:

Clean Oxidising and Inert; Limited Use in Vacuum or Reducing; Wide Temperature Range; Most Popular Calibration

TEMPERATURE IN DEGREES °C
REFERENCE JUNCTION AT 0°C

Nickel-Chromium
vs.
Nickel-Aluminum



Revised Thermocouple Reference Tables

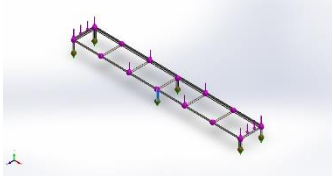
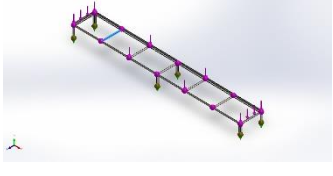
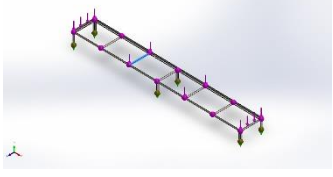
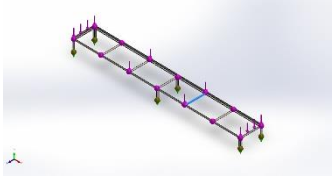
TYPE K
Reference Tables
N.I.S.T.
Monograph 175
Revised to ITS-90

Thermoelectric Voltage in Millivolts

°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	°C	°C	0	1	2	3	4	5	6	7	8	9	10	°C
-260	-6.458	-6.457	-6.456	-6.455	-6.453	-6.452	-6.450	-6.448	-6.446	-6.444	-6.441	-260	250	10.153	10.194	10.235	10.276	10.316	10.357	10.398	10.439	10.480	10.520	10.561	250
-250	-6.441	-6.438	-6.435	-6.432	-6.429	-6.425	-6.421	-6.417	-6.413	-6.408	-6.404	-250	260	10.561	10.602	10.643	10.684	10.725	10.766	10.807	10.848	10.889	10.930	10.971	260
-240	-6.404	-6.399	-6.393	-6.388	-6.382	-6.377	-6.370	-6.364	-6.358	-6.351	-6.344	-240	270	10.971	11.012	11.053	11.094	11.135	11.176	11.217	11.259	11.300	11.341	11.382	270
-190	-5.891	-5.876	-5.861	-5.845	-5.829	-5.813	-5.797	-5.780	-5.763	-5.747	-5.730	-190	280	11.382	11.423	11.465	11.506	11.547	11.588	11.630	11.671	11.712	11.753	11.795	280
-180	-5.730	-5.713	-5.695	-5.678	-5.660	-5.642	-5.624	-5.606	-5.588	-5.569	-5.550	-180	290	11.795	11.836	11.877	11.919	11.960	12.001	12.043	12.084	12.126	12.167	12.209	290
-170	-5.550	-5.531	-5.512	-5.493	-5.474	-5.454	-5.435	-5.415	-5.395	-5.374	-5.354	-170	300	12.209	12.250	12.291	12.333	12.374	12.416	12.457	12.499	12.540	12.582	12.624	300
-160	-5.354	-5.333	-5.313	-5.292	-5.271	-5.250	-5.228	-5.207	-5.185	-5.163	-5.141	-160	310	12.624	12.665	12.706	12.748	12.790	12.831	12.873	12.915	12.956	12.998	13.040	310
-150	-5.141	-5.119	-5.097	-5.074	-5.052	-5.029	-5.006	-4.983	-4.960	-4.936	-4.913	-150	350	14.293	14.335	14.377	14.419	14.461	14.503	14.545	14.587	14.629	14.671	14.713	350
-140	-4.913	-4.889	-4.865	-4.841	-4.817	-4.793	-4.768	-4.744	-4.719	-4.694	-4.669	-140	360	14.713	14.755	14.797	14.839	14.881	14.923	14.965	15.007	15.049	15.091	15.133	360
-130	-4.669	-4.644	-4.618	-4.593	-4.567	-4.542	-4.516	-4.490	-4.463	-4.437	-4.411	-130	370	15.133	15.175	15.217	15.259	15.301	15.343	15.385	15.427	15.469	15.511	15.554	370
-120	-4.411	-4.384	-4.357	-4.330	-4.303	-4.276	-4.249	-4.221	-4.194	-4.166	-4.138	-120	380	15.554	15.596	15.638	15.680	15.722	15.764	15.806	15.849	15.891	15.933	15.975	380
-110	-4.138	-4.110	-4.082	-4.054	-4.025	-3.997	-3.968	-3.939	-3.911	-3.882	-3.852	-110	390	15.975	16.017	16.059	16.102	16.144	16.186	16.228	16.270	16.313	16.355	16.397	390
-100	-3.852	-3.823	-3.794	-3.764	-3.734	-3.705	-3.675	-3.645	-3.614	-3.584	-3.554	-100	400	16.397	16.439	16.482	16.524	16.566	16.608	16.651	16.693	16.735	16.778	16.820	400
-90	-3.554	-3.523	-3.492	-3.462	-3.431	-3.400	-3.368	-3.337	-3.306	-3.274	-3.243	-90	410	16.820	16.862	16.904	16.947	16.989	17.031	17.074	17.116	17.158	17.201	17.243	410
-80	-3.243	-3.211	-3.179	-3.147	-3.115	-3.083	-3.050	-3.018	-2.986	-2.953	-2.920	-80	420	17.243	17.285	17.328	17.370	17.413	17.455	17.497	17.540	17.582	17.624	17.667	420
-70	-2.920	-2.887	-2.854	-2.821	-2.788	-2.755	-2.722	-2.688	-2.654	-2.620	-2.587	-70	430	17.667	17.709	17.752	17.794	17.837	17.879	17.921	17.964	18.006	18.049	18.091	430
-60	-2.587	-2.553	-2.519	-2.485	-2.450	-2.416	-2.382	-2.347	-2.312	-2.278	-2.243	-60	440	18.091	18.134	18.176	18.218	18.261	18.303	18.346	18.388	18.431	18.473	18.516	440
-50	-2.243	-2.208	-2.173	-2.138	-2.103	-2.067	-2.032	-1.996	-1.961	-1.925	-1.889	-50	450	18.516	18.558	18.601	18.643	18.686	18.728	18.771	18.813	18.856	18.898	18.941	450
-40	-1.889	-1.854	-1.818	-1.782	-1.745	-1.709	-1.673	-1.637	-1.600	-1.564	-1.527	-40	460	18.941	18.983	19.026	19.068	19.111	19.154	19.196	19.239	19.281	19.324	19.366	460
-30	-1.527	-1.490	-1.453	-1.417	-1.380	-1.343	-1.305	-1.268	-1.231	-1.194	-1.156	-30	470	19.366	19.409	19.451	19.494	19.537	19.579	19.622	19.664	19.707	19.750	19.792	470
-20	-1.156	-1.119	-1.081	-1.043	-1.006	-0.968	-0.930	-0.892	-0.854	-0.816	-0.778	-20	480	19.792	19.835	19.877	19.920	19.962	20.005	20.048	20.090	20.133	20.175	20.218	480
-10	-0.778	-0.739	-0.701	-0.663	-0.624	-0.586	-0.547	-0.508	-0.470	-0.431	-0.392	-10	490	20.218	20.261	20.303	20.346	20.389	20.431	20.474	20.516	20.559	20.602	20.644	490
0	-0.392	-0.353	-0.314	-0.275	-0.236	-0.197	-0.157	-0.118	-0.079	-0.039	0.000	0	500	20.644	20.687	20.730	20.772	20.815	20.857	20.900	20.943	20.985	21.028	21.071	500
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397	0	510	21.071	21.113	21.156	21.199	21.241	21.284	21.326	21.369	21.412	21.454	21.497	510
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798	10	520	21.497	21.540	21.582	21.625	21.668	21.710	21.753	21.796	21.838	21.881	21.924	520
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.163	1.203	20	530	21.924	21.966	22.009	22.052	22.094	22.137	22.179	22.222	22.265	22.307	22.350	530
30	1.203	1.244	1.285	1.326	1.366	1.407	1.448	1.489	1.530	1.571	1.612	30	540	22.350	22.393	22.435	22.478	22.521	22.563	22.606	22.649	22.691	22.734	22.776	540
40	1.612	1.653	1.694	1.735	1.776	1.817	1.858	1.899	1.941	1.982	2.023	40	550	22.776	22.819	22.862	22.904	22.947	22.990	23.032	23.075	23.117	23.160	23.203	550
50	2.023	2.064	2.106	2.147	2.188	2.230	2.271	2.312	2.354	2.395	2.436	50	560	23.203	23.245	23.288	23.331	23.373	23.416	23.458	23.501	23.544	23.586	23.629	560
60	2.436	2.478	2.519	2.561	2.602	2.644	2.685	2.727	2.768	2.810	2.851	60	570	23.629	23.671	23.714	23.757	23.799	23.842	23.884	23.927	23.970	24.012	24.055	570
70	2.851	2.893	2.934	2.976	3.017	3.059	3.100	3.142	3.184	3.225	3.267	70	580	24.055	24.097	24.140	24.182	24.225	24.267	24.310	24.353	24.395	24.438	24.480	580
80	3.267	3.308	3.350	3.391	3.433	3.474	3.516	3.557	3.599	3.640	3.682	80	590	24.480	24.523	24.565	24.608	24.650	24.693	24.735	24.778	24.820	24.863	24.905	590
90	3.682	3.723	3.765	3.806	3.848	3.889	3.931	3.972	4.013	4.055	4.096	90	600	24.905	24.948	24.990	25.033	25.075	25.118	25.160	25.203	25.245	25.288	25.330	600
100	4.096	4.138	4.179	4.220	4.262	4.303	4.344	4.385	4.427	4.468	4.509	100	610	25.330	25.373	25.415	25.458	25.500	25.543	25.585	25.627	25.670	25.712	25.755	610
110	4.509	4.550	4.591	4.633	4.674	4.715	4.756	4.797	4.838	4.879	4.920	110	620	25.755	25.797	25.840	25.882	25.924	25.967	26.009	26.052	26.094	26.136	26.179	620
120	4.920	4.961	5.002	5.043	5.084	5.124	5.165	5.206	5.247	5.288	5.328	120	630	26.179	26.221	26.263	26.306	26.348	26.390	26.433	26.475	26.517	26.560	26.602	630
130	5.328	5.369	5.410	5.450	5.491	5.532	5.572	5.613	5.653	5.694	5.735	130	640	26.602	26.644	26.687	26.729	26.771	26.814	26.856	26.898	26.940	26.983	27.025	640
140	5.735	5.775	5.815	5.856	5.896	5.937	5.977	6.017	6.058	6.098	6.138	140	650	27.025	27.067	27.109	27.152	27.194	27.236	27.278	27.320	27.363	27.405	27.447	650
													660	27.447	27.489	27.531	27.574	27.616	27.658	27.700	27.742				

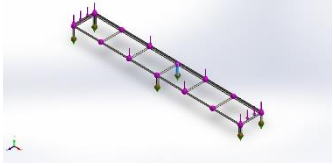
Appendix(D)

Beam Bodies

Document Name and Reference	Formulation	Properties	Document Path/Date Modified
SolidBody 1(Angle iron - configured 35 X 35 X 5(1)[10]) 	Beam – Uniform C/S	Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m ² Length:234.797mm Volume:8.67883e-05m ³ Mass Density:7,700kg/m ³ Mass:0.66827kg Weight:6.54904N	C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020
SolidBody 2(Angle iron - configured 35 X 35 X 5(1)[11]) 	Beam – Uniform C/S	Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m ² Length:424.056mm Volume:0.000156744m ³ Mass Density:7,700kg/m ³ Mass:1.20693kg Weight:11.8279N	C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020
SolidBody 3(Angle iron - configured 35 X 35 X 5(1)[12]) 	Beam – Uniform C/S	Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m ² Length:424.056mm Volume:0.000156744m ³ Mass Density:7,700kg/m ³ Mass:1.20693kg Weight:11.8279N	C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020
SolidBody 4(Angle iron - configured 35 X 35 X 5(1)[14]) 	Beam – Uniform C/S	Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m ² Length:424.056mm Volume:0.000156744m ³ Mass Density:7,700kg/m ³ Mass:1.20693kg Weight:11.8279N	C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020

<p>SolidBody 5(Angle iron - configured 35 X 35 X 5(1)[1])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:3,977.08mm Volume:0.00147006m³ Mass Density:7,700kg/m³ Mass:11.3195kg Weight:110.931N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 6(Angle iron - configured 35 X 35 X 5(1)[5])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:259.826mm Volume:9.60409e-05m³ Mass Density:7,700kg/m³ Mass:0.739515kg Weight:7.24724N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 7(Angle iron - configured 35 X 35 X 5(1)[4])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:496.769mm Volume:0.000183622m³ Mass Density:7,700kg/m³ Mass:1.41389kg Weight:13.8561N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 8(Angle iron - configured 35 X 35 X 5(1)[15])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:424.056mm Volume:0.000156744m³ Mass Density:7,700kg/m³ Mass:1.20693kg Weight:11.8279N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 9(Angle iron - configured 35 X 35 X 5(1)[2])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:496.769mm Volume:0.000183622m³ Mass Density:7,700kg/m³ Mass:1.41389kg Weight:13.8561N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>

<p>SolidBody 10(Angle iron - configured 35 X 35 X 5(1)[8])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:259.826mm Volume:9.60408e-05m³ Mass Density:7,700kg/m³ Mass:0.739514kg Weight:7.24724N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 11(Angle iron - configured 35 X 35 X 5(1)[3])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:3,977.08mm Volume:0.00147006m³ Mass Density:7,700kg/m³ Mass:11.3195kg Weight:110.931N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 12(Angle iron - configured 35 X 35 X 5(1)[6])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:210.113mm Volume:7.7665e-05m³ Mass Density:7,700kg/m³ Mass:0.598021kg Weight:5.8606N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 13(Angle iron - configured 35 X 35 X 5(1)[7])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:210.113mm Volume:7.76651e-05m³ Mass Density:7,700kg/m³ Mass:0.598021kg Weight:5.86061N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
<p>SolidBody 14(Angle iron - configured 35 X 35 X 5(1)[13])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:455.603mm Volume:0.000168378m³ Mass Density:7,700kg/m³ Mass:1.29651kg Weight:12.7058N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>

<p>SolidBody 15(Angle iron - configured 35 X 35 X 5(1)[9])</p> 	<p>Beam – Uniform C/S</p>	<p>Section Standard-weldment profiles/iso/angle iron Section Area: 0.000369635m² Length:234.797mm Volume:8.67883e-05m³ Mass Density:7,700kg/m³ Mass:0.66827kg Weight:6.54904N</p>	<p>C:\Users\sulta\Desktop\stand anas.SLDPRT Jun 26 18:50:35 2020</p>
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Model Information

Beams

Beam Forces

Beam Name	Joints	Axial(N)	Shear1(N)	Shear2(N)	Moment1(N.m)	Moment2(N.m)	Torque(N.m)
Beam-1(Angle iron - configured 35 X 35 X 5(1)[10])	1	435.755	-2.15196e-11	-3.59645e-12	-4.92844e-13	1.21885e-12	1.06095e-11
	2	-435.755	7.48228e-11	-1.15722e-11	1.31294e-12	-3.13569e-11	-1.59833e-10
Beam-2(Angle iron - configured 35 X 35 X 5(1)[11])	1	-21.5573	-0.192549	20.8187	5.07762	-1.42937	-0.0318312
	2	21.5577	0.192572	-20.8183	3.75061	1.51103	0.03181
Beam-3(Angle iron - configured 35 X 35 X 5(1)[12])	1	5.95023	-1.30831	-133.959	-28.9927	-0.618211	0.0139778
	2	-5.95249	1.30831	133.959	-27.8136	1.17299	-0.0139943
Beam-	1	-5.9738	1.23101	135.643	28.1629	-1.26038	-0.00476565

4(Angle iron - configured 35 X 35 X 5(1)[14])	2	5.97494	-1.23101	-135.643	29.3574	0.738368	0.00475697
Beam-5(Angle iron - configured 35 X 35 X 5(1)[1])	1	-50.6302	-4.76015	216.359	83.8035	13.9531	0.488173
	2	65.4541	-17.4321	-18.5849	-49.303	-14.4881	0.69182
	3	84.802	2.65176	99.4589	-22.1956	-22.5988	0.549426
	4	-49.9801	0.0435829	-102.071	-19.7895	12.8068	0.355702
	5	-66.8767	16.0115	132.375	0.497278	25.3003	0.231035
	6	64.4337	-21.0441	131.883	-0.319294	-6.91772	0.148168
	7	84.2011	4.54548	15.7927	-49.2529	-23.834	0.521554
Beam-6(Angle iron - configured 35 X 35 X 5(1)[5])	1	481.943	0.25325	-0.499993	2.97225e-11	3.5915e-12	0.00206681
	2	-481.943	-0.253224	0.508472	0.13651	0.0686727	-0.00213732
Beam-7(Angle iron - configured 35 X 35 X 5(1)[4])	1	-19.3937	-350.98	-66.0839	-6.89876	1.12941	-2.62877
	2	19.3938	-349.019	66.0803	-25.9279	-0.642115	-2.9079
Beam-8(Angle iron - configured 35 X 35 X 5(1)[15])	1	24.1363	0.141921	-18.311	-2.78388	-1.0795	-0.0353482
	2	-24.1363	-0.141947	18.3109	-4.98098	1.01932	0.0353443
Beam-9(Angle iron - configured 35 X 35 X 5(1)[2])	1	17.6634	-350.47	56.4971	25.2829	0.968336	2.97147
	2	-17.6622	-349.312	-73.9535	7.11902	-0.680575	2.70118
Beam-10(Angle iron - configured 35 X 35 X 5(1)[8])	1	482.166	-0.253305	-0.500205	2.85338e-11	-8.52971e-12	-0.00206732
	2	-482.166	0.254375	0.508679	0.136566	-0.0687521	0.00212884

Beam-11(Angle iron - configured 35 X 35 X 5(1)[3])	1	-64.998	17.4347	-18.344	-48.199	-17.9302	-0.809239
	2	-87.2791	-2.66012	98.7924	-21.3352	-20.1583	-0.433689
	3	52.5291	-0.041606	-101.859	-20.368	12.6633	-0.483077
	4	-67.7375	21.0437	131.9	0.0818133	-25.92	-0.225345
	5	-84.5854	-4.55448	15.0677	-48.5596	-18.1026	-0.408109
	6	63.5754	-16.0105	132.134	-0.451041	7.11706	-0.113654
	7	45.2003	4.78223	217.94	84.8529	9.824	-0.57681
Beam-12(Angle iron - configured 35 X 35 X 5(1)[6])	1	-482.301	9.73507e-05	-0.310337	-0.0687314	-2.15601e-05	-0.00259806
	2	482.301	-9.73503e-05	0.310337	-1.0321e-11	-2.81855e-11	0.00259806
Beam-13(Angle iron - configured 35 X 35 X 5(1)[7])	1	-482.008	-0.311332	-	-3.74672e-07	0.0687219	0.0026125
	2	482.008	0.310295	-9.72661e-05	2.92937e-11	5.95457e-12	-0.00259777
Beam-14(Angle iron - configured 35 X 35 X 5(1)[13])	1	-	0.0594262	-3.33055	0.748197	4.56053	0.0620473
	2	0.824779	-0.0594262	3.33055	-2.3168	-4.58852	-0.0620473
Beam-15(Angle iron - configured 35 X 35 X 5(1)[9])	1	-435.827	-6.38059e-11	-1.60698e-10	-2.93676e-11	1.09319e-11	-1.68611e-10
	2	435.827	-7.60929e-12	6.60199e-12	7.83808e-13	-7.36096e-13	1.12606e-11

Beam Stresses

Beam Name	Joints	Axial(N/m ²)	Bending Dir1(N/m ²)	Bending Dir2(N/m ²)	Torsional (N/m ²)	Upper bound axial and bending(N/m ²)
Beam-1(Angle	1	-1.17888e+06	1.02253e-06	1.27602e-06	0.000120732	1.17888e+06

iron - configured 35 X 35 X 5(1)[10])	2	-1.17888e+06	1.66903e-05	2.71804e-05	-0.00181885	1.17888e+06
Beam-2(Angle iron - configured 35 X 35 X 5(1)[11])	1	-58,320.6	5.00586e+06	3.73204e+06	-362,229	8.79622e+06
	2	-58,321.6	-2.42228e+06	-585,136	361,988	3.06574e+06
Beam-3(Angle iron - configured 35 X 35 X 5(1)[12])	1	16,097.6	-2.42208e+07	-1.38819e+07	159,063	3.81188e+07
	2	16,103.7	2.41132e+07	1.48114e+07	-159,251	3.89407e+07
Beam-4(Angle iron - configured 35 X 35 X 5(1)[14])	1	-16,161.3	2.44521e+07	1.50589e+07	-54,231.7	3.95271e+07
	2	-16,164.4	-2.44697e+07	-1.39614e+07	54,132.8	3.84472e+07
Beam-5(Angle iron - configured 35 X 35 X 5(1)[1])	1	-136,974	6.39655e+07	2.98329e+07	5.55526e+06	9.39355e+07
	2	177,078	-3.45122e+07	-1.22389e+07	7.8727e+06	4.69281e+07
	3	229,421	-7.54949e+06	8.09089e+06	6.2523e+06	1.58698e+07
	4	-135,215	-2.3105e+07	-2.06669e+07	4.04778e+06	4.39072e+07
	5	180,926	1.21496e+07	2.11571e+07	2.62911e+06	3.34876e+07
	6	174,317	3.16691e+06	5.69378e+06	1.68611e+06	9.035e+06
	7	227,795	-2.98264e+07	-4.30737e+06	5.93512e+06	3.43615e+07
Beam-6(Angle iron - configured 35 X 35 X 5(1)[5])	1	-1.30383e+06	-2.69297e-05	1.78059e-05	23,518.9	1.30383e+06
	2	-1.30383e+06	149,608	-125,922	-24,321.3	1.57936e+06
Beam-7(Angle iron - configured 35 X 35 X 5(1)[4])	1	-52,467.2	-5.27524e+06	2.47212e+06	-2.99188e+07	7.79983e+06
	2	-52,467.5	2.22541e+07	-1.34253e+07	-3.30957e+07	3.57319e+07
Beam-8(Angle iron - configured 35 X 35 X 5(1)[15])	1	65,297.6	-1.81883e+06	-469,890	-402,252	2.35401e+06
	2	65,297.8	4.72037e+06	3.33712e+06	402,207	8.12279e+06

Beam-9(Angle iron - configured 35 X 35 X 5(1)[2])	1	47,786	2.18705e+07	-1.33809e+07	3.38144e+07	3.52992e+07
	2	47,782.9	-5.68458e+06	2.96128e+06	3.07386e+07	8.69364e+06
Beam-10(Angle iron - configured 35 X 35 X 5(1)[8])	1	-1.30444e+06	-2.83777e-05	-2.1393e-05	-23,529.3	1.30444e+06
	2	-1.30444e+06	149,694	126,016	24,229.5	1.58015e+06
Beam-11(Angle iron - configured 35 X 35 X 5(1)[3])	1	-175,844	-3.1868e+07	-8.77835e+06	-9.20859e+06	4.08222e+07
	2	-236,122	-8.03418e+06	6.45366e+06	-4.93508e+06	1.4724e+07
	3	142,111	-2.35231e+07	-2.0833e+07	-5.49709e+06	4.44982e+07
	4	-183,255	1.29474e+07	2.19691e+07	-2.56427e+06	3.50997e+07
	5	-228,835	-3.20874e+07	-8.81173e+06	-4.644e+06	4.1128e+07
	6	-171,995	3.91766e+06	6.24516e+06	-1.29331e+06	1.03348e+07
	7	122,284	6.69048e+07	3.38475e+07	-6.56371e+06	1.00875e+08
Beam-12(Angle iron - configured 35 X 35 X 5(1)[6])	1	-1.3048e+06	-58,136.3	-34,130.6	-29,564.2	1.39707e+06
	2	-1.3048e+06	-5.27218e-06	-1.87171e-05	29,564.2	1.3048e+06
Beam-13(Angle iron - configured 35 X 35 X 5(1)[7])	1	-1.30401e+06	34,143.8	-58,138.8	29,728.6	1.39629e+06
	2	-1.30401e+06	-2.77411e-05	1.9592e-05	-29,561	1.30401e+06
Beam-14(Angle iron - configured 35 X 35 X 5(1)[13])	1	-2,231.33	-1.6329e+06	-3.48648e+06	706,079	5.12161e+06
	2	-2,231.33	-319,754	-2.73081e+06	-706,079	3.0528e+06
Beam-15(Angle iron - configured 35 X 35 X 5(1)[9])	1	-1.17907e+06	-3.02766e-05	-2.38396e-05	-0.00191874	1.17907e+06
	2	-1.17907e+06	-1.02883e-06	-1.01217e-06	0.000128142	1.17907e+06

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