Application and Development of a New AGV in Sprinkler Irrigation

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ABSTRACT

The new technologies play a more and more important role in improving the productivity over the agriculture industry. In this way, the irrigation machines as well as technologies have significant roles. Nowadays, intelligent systems and Robots are employed supplementary on irrigation systems, aiming to decrease the manpower defects as well as save on energy and time.

In this thesis, the conventional irrigation methods are reviewed briefly. The sprinkler irrigation classic method (moving sprinkler) is considered in detail and some of the shortcomings of this method are highlighted. Since, in sprinkler irrigation classic method after each period of irrigation the position of the sprinklers have to be replaced by manpower, this difficulty makes the method impractical from time, cost and energy points of view. The purpose of this thesis is to application and development a new automatic guide vehicle (AGV) with the capability to change sprinklers timely and on appropriate positions for sprinkler irrigation classic method. The designed AGV is simulated on computer environment and the results show acceptable outcomes.

Keywords: Irrigation; Robot; Agriculture.

ÖZ

Yeni teknolojilerin gelişmesi tarım endüstrisinin verimliliğinin gelişmesinde de çok önemli rol oynamaktadır. Özellikle sulama makinaları tarım ensdüstrisinde önemli bir role sahiptir. Günümüzde robot ve akıllı sistemler insan gücü kusurlarını azaltarak enerji ve zaman tasarrufu sağlamayı amaçlar.

Bu tez çalışmasında geleneksel sulama yöntemlerine kısaca değinilmiştir, yağmurlama sulama klasik yöntemine (hareketli yağmurlama) ayrıntılı olarak yer verilerek yöntemin eksikleri vurgulanmıştır. Yağmurlama sulama klasik yönteminden beri her sulama pozisyonu değişiminde insangücü kullanılmak zorundaydı. Zaman, maliyet ve enerji açısından zorluk oluşturmaktadır. Bu tezin amacı, yağmurlama sulama klasik yöntemindeki sulama pozisyonlarını zamanında değişimini sağlayan telerehber sulama aracını (AGV) araştırmaktadır ve dizayn edilen AGV bilgisayarda kurgulanmış, sonuçlar kabul edilebilir sonuçlar içermektedir.

Anahtar Kelimeler: Sulama, Robot, Tarım.

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Chapter 1

INTRODUCTION

The limitation of Water resources and global population growth has led states and governments worldwide to increase agricultural products per area unit and optimize soil and water resources productivity with using new irrigation methods. Developing irrigation methods and their equipment manufacturing technologies, especially those of pressure irrigation system resulted in inventing new approaches to increase irrigation efficiency. Generally, current irrigations systems are classified into pressure and gravitational systems; the pressure category includes sprinkler and drip irrigation systems and Gravitational system usually involves furrow irrigation. Thus, choosing each system could maximize water productivity and minimize costs of keeping farms.

Considering that most part of Iran lies in desert climate, water is the most important factor in agriculture. Because of the limitation in fresh water resources and fertile lands and the costs of institutions (workforce, energy resources, chemical fertilizers, etc.) which are going to be high, it seems to be necessary employing appropriate methods. Therefore, in order to improve utilization and productivity, it would be possible to optimize economic efficiency through resource management and utilization of water resources at the minimum level.

In comparison with traditional systems, what is expected of automatic irrigation system is decreasing water utilization without diminishing production rate. Although an automatic system could meet the needs without permanent human presence and monitoring during the growing season, continual presence of the worker to control irrigation automatic instruments is not economic. Through advancements in technology and advent of processors and controllers, it will be more serious improving the role of farmer as an observer off-field particularly in the light of new irrigation systems.

Human errors resulted by operators' mistakes or delays in taking required steps, which leads to reduce productivity. Thus, with waterworks development and various instruments, the under pressure units would be contortion, which are allocated the most bulk of sources. Monitoring and observing meteorological parameters, water hydraulic, quality features along with central and local precise controlling irrigation instruments, have provided an opportunity to predict and control unusual reaction of installations and also preventing accidents which lead to increasing productivity of per area unit. Moreover, management level would be able to make acute and rapid decisions depends on various conditions of utilization. Consequently, it would be provided opportunities to improve utilization management and enhance performance of productivity of irrigation units.

To increase irrigation efficiency and performance of water utilization, following proceedings are suggested [1]:

1- Developing and adjusting modern networks of water distribution.
2- Applying a scientific irrigation program according to practical requirements which are calculated in automatic systems using software.
3- Using new irrigation methods regarding automation level of each waterworks unit.
4- Developing, promoting and teaching irrigation methods and enhancing farmers' knowledge about the way in which systems are controlled.
5- Studying cultivation patterns throughout country and changing in order to increase performance of water utilization and introducing it to software controller
6- Use of AGV in irrigation

Thesis contribution

This thesis report a contribution for design and develop a new automatic guide vehicle (AGV) with the capability to change sprinklers timely and on appropriate positions for sprinkler irrigation classic method.

Chapter 2

BACKGROUND

2.1 Definition of Agriculture

Agriculture is the art or science of cultivating the ground, including the harvesting of crops, and the rearing and management of livestock and also cultivation of fungi and other life forms for food, fiber, befoul and other products ,which are used to keep up life. Also, it is known as: tillage; husbandry; farming. In addition, it could include the preparation and marketing of the resulting products. In the formation of non-migratory civilization, Agriculture has played a major role, because of food surpluses provided by this process allowed the development of civilization. The study of agriculture is introduced as agricultural science. Although agriculture generally is perceived as a human activity, it is also observed in certain species of ant and termite [2].

2.2 Role of Water in Agriculture

Chemically water molecule is composed of one oxygen and two hydrogen atoms connected by covalent bonds which leads to H_2O formula [3]. To meet the current food needs, 70 percent of all fresh water is used in agricultural activities worldwide, where several developing countries' share is up to 95%. According to FAO, to maintain with increasing food demand and changing diets over the next 30 years, it is needed to increase the effective irrigated lands by 34% in developing countries, and also 14% extra

water should be extracted for farming activities. It has to be mentioned that irrigated agriculture responds some 40% of the world food demand on 20% of cultivated land.

It is obvious that water is a vital factor in agriculture production in any sense. Any change in climate will affect significantly on agriculture regarding water quantity and quality. This will be worsened by raising globally food demand which could be related to increasing in population and incomes [4].

2.3 Water Sources

1. Rainwater. 2. Springs. 3. Rivers and lakes. 4. Surface wells. 5. Deep or artesian wells.

Dust and gases in the air are absorbed in the rain droplets. In addition, because of dissolving organic compounds in the rain on the roofs over which it is collected, then it could give bacteria opportunity to grow which causes bad taste of water and makes it unsafe to drink.

Springs are a source of pure water supply sometimes with minerals. They are safe to drink as long as they do not pass through soil.

Another source of water supply is river and lake as well. They are useful to provide drinkable water unless towns and cities let drain their sewage into them.

One of the most unsafe sources of drinkable water supply is the surface wells. In this case, it should not be used when there are contaminant sources such as cesspools, drains, barnyards within a radius of 200 feet of them.

Deep artesian wells generally could be a trusty source of pure water, but if the piping is not firmly jointed, then impure water from subterranean currents near the surface may get into the pipes [5].

2.4 Irrigation and Methods of Irrigation

Irrigation is the artificial usage of water in tillage process. It is designed so that watering plants could be performed according certain intervals such as daily basis. It also has a few other applications in agriculture including protection of plants against icy conditions [5]. In other areas such as dust suppression, disposal of sewage, and in mining irrigation systems are also used. Generally, this process is examined together with drainage (the natural or artificial removal of extra water from a given piece of land).

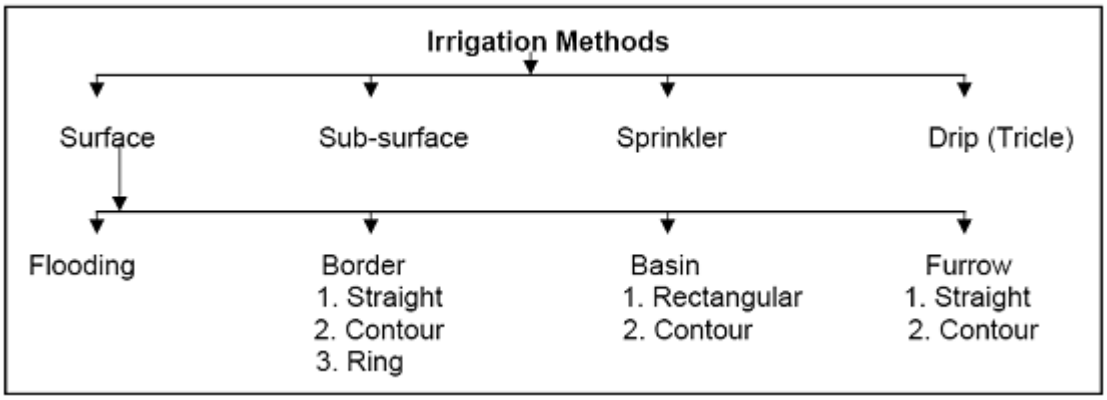


Figure 1: Types of Irrigation Methods

2.5 Types of Irrigation

Depending on how the water should be distributed, different types of irrigation approaches are employed. In general, the purpose is to provide whole land uniformly with water, so that every plant could access to required amount of water.

2.5.1 Surface

One of the most privileged kinds of irrigation approaches is the surface irrigation. In this approach the driving force to flow water over the land and to diffuse it into the soil is gravity force by itself. It can be classified into three types: furrow, border strip or basin irrigation.

Figure 2: Surface Method Irrigation

2.5.2 Subsurface

This kind of irrigation which is also called sub-irrigation could be natural or artificial. Natural type is possible only if there is an impenetrable layer below the root zone. Water is allowed in to series of waterway excavated to the impenetrable layer, which then diffuses laterally so that wets root zone.

Figure 3: Subsurface Irrigation Method

2.5.3 Sprinkler Irrigation

It is alike to natural rainfall that is, water is sprayed through sprinkler heads after pumping into a pipe system. In this manner, there will be provided, appropriate coverage for all types of land as small into huge pieces sufficiently. It is also applicable to almost all irrigable soils because sprinkler heads could be discharged in a wide range. Sprinkler Irrigation method might be used lands that have unsmooth contours and where erosion threats are great.

Figure 4: Sprinkler Irrigation Method

As mentioned before, in this irrigation system, water is carried under pressure through pipes to the land to be irrigated.

2.5.4 Drip or Trickle Irrigation

In this approach water reaches the root zone slowly. In this approach, water is delivered as drops just at the position of roots. This system could be the most water-saving system if applied properly, because evaporation and runoff wastes are decreased as much as possible.

The head is composed of a pump to elevate water and create the suitable pressure (about 2.5 atmospheres) to distribute water through nozzles. It is equipped with a fertilizer tank which could apply fertilizer solution directly to the soil along with the water. This is done through a filter which screens the solid impurities in irrigating water to prevent the obstruction of holes and passage of trickle and nozzles.

Figure 5: Drip or Trickle Irrigation Method

These nozzles are regulated at certain intervals which sprayed water laterally. They are also called emitters or valves made by PVC which permit water to flow at the extremely slow rates, i.e., from 2 to 11 liters per hour. These valves are designed in different shapes [6].

2.6 Method of Sprinkler Irrigation

2.6.1 Sprinkler Irrigation Tumble (Vilmo)

This device is used so much in flat and smooth farm that plants are cultivated in a rows. Constitutive component of vilmo irrigation device consist of: engine, chassis, main pipe and hose connection pipe wheels, Sprinkler. Main pipe in device is made of aluminum that has 10 cm diameter and passes in the middle of wheels, this pipe conveys the water to Sprinkler and causes to move the wheel. Device is moved from place to another by gasoline engine that is connected to the side wheels through gear box and chain.

Figure 6: Sprinkler Irrigation Tumble (Vilmo) Method

In this method device should transmit to the location, after that pipes join to injector pipe by those connector pipe, then open the control tap so that water flows in pipes and irrigation is done through Sprinkler, after irrigation of one area, it is disconnected the Flexible pipe and extract water from pipes and turn on the engine for moving device in order to irrigation of other area which is not irrigated, this action is repeated until all areas become irrigated. As mentioned above the device is suitable for irrigation of short legs plant like grain, forage and beet.

2.6.2 Center Pivot Irrigation: (Center point)

This device is used for irrigation of long and short leg plants which consist of vertical pipe, main pipe (horizontal), the control panel, dispersive and wheels. For irrigation by the help of device, water enters to the dispersive intensity, mail pipe put on the triangular stand that has two wheels.

Figure 7: Center Point Sprinkler Irrigation Method

Water enters to the Sprinkler that has 10 meter distance from surface of earth and irrigation is done. Device path is like circle so irrigation area is circular, device has control panel which stops irrigation automatically if a problem occurs in duration of irrigation. Path of wheels should be soft and smooth and partly hard. This method is recommended for irrigation of sandy soil, soft area and partly soft area.

2.6.3 Spool Sprinkle Irrigation (Gun)

This device is used for irrigation in flat, rough, area and long and short legs plants. Different component of device consist of spool, turbines, gear box, polyethylene pipes and Sprinkler, device has big spool that places on the chassis and polyethylene pipe is made of semi- hard wind around the spool which is about 300 m long. First, for irrigation by the help of device, it should be placed at the beginning of area, then, the

Sprinkler has been put on the stand, which is called chariot, whereas polyethylene pipe join to the Sprinkler.

Figure 8: Spool Sprinkle Irrigation Method

Diesel engine or electro pump are used for causing water pressure in the pipe, after turning the engine on, water enters to the turbine intensity and turn it then, water enter to the polyethylene pipe and spread through the Sprinkler in the farm. Turbine turning transfer to the spool via gear box and chain, when irrigation starts, spool turns automatically and slowly and polyethylene pipe winds on the spool regularly. If Sprinkler reaches to the spool, irrigation automatically is stopped.

In this method Sprinkler spreads water as circle with a radius of 40 to 50 m and consumed amount of water is adjusted through spool speed control. If spool speed control gets high, pipe winds and low water will spread rapidly, and vice versa.

It’s important to mention that polyethylene pipes should be treated with more caution and avoid contact with sharp and rough objects because these pipes are so expensive. The required time for Sprinkler rotation is 2 to 5 minutes, by placing a mesh in path of water entering to the device, straw and mud can’t enter to the turbine. Easy moving and transferring is advantage of this device also amount of irrigation depth is adjusted.

2.6.4 Sprinkler Irrigation Linear (Linear)

This device is like center pivot Sprinkler irrigation but moves directly and irrigates the foursquare of field. Flat and foursquare field are suitable for irrigation via device, another advantage of device is uniformity Sprinkler flow so that wind can’t disturb it and irrigate the field equally [7].

Figure 9: Sprinkler Irrigation Linear Method

2.6.5 Sprinkler Irrigation Classic System Method

In this method main pipe joins to subsidiary pipe and special Sprinkler is installed on the subsidiary pipe that turns around itself and spreads water like a circle. The pipes that Sprinkler is installed on them are called wing, in this method irrigation is done by pump engine and several numbers of pipes and Sprinklers. If all component can be removable, we call it classic movable , in cases main pipe and pump engine are fixed but wings and Sprinklers are installed in another place after irrigation, for the sake of cost saving in buying pipes and piping , we continue these action until all field is irrigated , this method is called classic semi- movable , sometimes main or subsidiary pipes, wings, Sprinklers and pump engines are fixed and total field is irrigated by them, furthermore, pipes are put in the earth which is called fixed method .

This method is applied in Iran and other countries so much. Fixed classic system is divided into two sections according to work method and design.

2.6.5.1 Sprinkler Irrigation Classic System by Fixed Sprinkler

Fixed classic: in this method pump, main and subsidiary pipes, wings and sprinkler are fixed, because there are enough irrigation wings. So, there is no need to move them, considering circumstance of wing, Sprinkler distances are adjusted, so that total area is covered. In fixed system, wings have been put inside the earth and always be fixed them on the surface at the beginning of grow season. In addition, it removes them at the end of season which is called permanent fixed system. Then, season system, select of systems depends on type plant, respectively.

Figure 10: Sprinkler Irrigation Classic System by Fixed Sprinkler Method

2.6.5.2 Sprinkler Irrigation Classic System by Movable Sprinkler (SICSMS)

In this method irrigation wings fixed but Sprinkler are movable. For reducing expenses, big Sprinkler is used that numbers of fixed Sprinkler irrigation wings are reduced significantly. This method has easier utilization, lower expense and alternative moving compared with other method.

Figure 11: Sprinkler Irrigation Classic System by Movable Sprinkler

Useful life of equipment and pipes are suitable, if pipes are put inside of earth, there is no danger of theft, also the long leg plants can be irrigated. Because, there is possibility of installation of long stand for Sprinklers, for the sake of these advantages farmers welcome to this method so much and the method has developed in recent years [8].

In this system Irrigation riser is fixed while sprinklers are connecting on riser during irrigation. Likewise, Irrigation riser is separated and transferred to the next one after

each irrigation. One of the disadvantages of this method is explained as follows. The main pipes are fixed during the irrigation season but irrigation risers are moved by human labor with the sprinkles which are installed on each riser.

2.7 AGV (automated guided vehicle)

AGV can be defined as a programmable, self-controlled device consisting of electronic, electrical, or mechanical units. More generally, it is a machine that functions in place of a living agent. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand [9].

2.1.6 AGV (Automated Guided Vehicle) in Agriculture

Developed agriculture needs to find new ways to improve efficiency. One approach is to utilize available information technologies in the form of more intelligent machines to reduce and target energy inputs in more effective ways than in the past. Precision Farming has shown benefits of this approach but we can now move towards a new Generation of equipment. The advent of autonomous system architectures gives us the Opportunity to develop a complete new range of agricultural equipment based on small Smart machines that can do the right thing, in the right place, at the right time in the right Way [10].

Advantages of AGV are as follow:

- Replace human power and removes the drudgery associated with the use of human power.
- It carefully controlled the irrigation process

- High quality of irrigation is achieved as there is no tradeoff between the time and quality
- It has also low maintenance cost

The disadvantages of using AGV in agriculture as follow:

- High cost of construction
- The problem associated with assembling and disassembling after harvesting period.

Chapter 3

SPRINKLER IRRIGATION CLASSIC SYSTEM BY MOVABLE SPRINKLER (SICSMS)

This section features detailed explanation of SICSMS components, the factors that affect its design and the approach adopted during the design. Finally, advantages and short comings of SICSMS are discussed and the problem statement is introduced in detail.

3.1 Components of SICSMS

3.1.1 Pressure Supply Part

Electro pump is used direct the flow of water through the pipe to the sprinklers, in case where there is no electricity supply, Diesel engine can also be used to achieve this aim.

3.1.2 Pipes in Classic Sprinkler Irrigation

Transferring water from source to farms, main pipe, semi main and subsidiary pipes is used which made of aluminum, polyethylene or asbestoses. In addition, since transfer of water is from sub-surface of earth, the pipes are connected serial with the use of tee joints to direct the flow of water to the surface.

Asbestoses pipes are joined to each other by asbestoses and cast iron connection. Besides, Polyethylene pipes are joined by special polyethylene connection which its diameter is less than 90 mm, if diameter is more than 90 mm, Welding connection will

be used, but connection parts are utilized, which can be opened and closed easily; therefore, for aluminum connection rubber washer is used as sealed.

3.1.3 Wings or Quick Valve

The wings are pipes made of aluminum or polyethylene material, it provides stand for installation of the sprinklers

3.1.4 Valve and Manometer

Pressure in pipe is partly adjusted by valve, in order for irrigation risers sprinkler to work properly; the valve is opened so that water pressure reached desired measure. Monometer is used for pressure measurement thus the indication of the amount of pressure is normally shown by the gauge. In this irrigation method, manometer is installed after pump or at the beginning of main pipe so as to indicate the amount of pressure of the sprinkler.

3.1.5 Sprinkler Stand or Riser

Sprinkler stand is such a narrow pipe that its height depends on the type of plant which is irrigated. The short stand is useful for irrigation of short plant and long stand for long plant.

3.1.6 Sprinkler

Each type of Sprinkler has a performance range for proper operation and these ranges must fit within the available flow and pressure criteria, both of which are a function of the water supply.

Rotary Sprinkler: this is a type of sprinkler in which the sprinkler moves 180 degree or 360 degrees about an axis in-order to sprinkle the water on the farm. There are different kinds of rotary Sprinkler;

1) Low pressure

2) Average pressure

3) High pressure

4) Extraordinary pressure

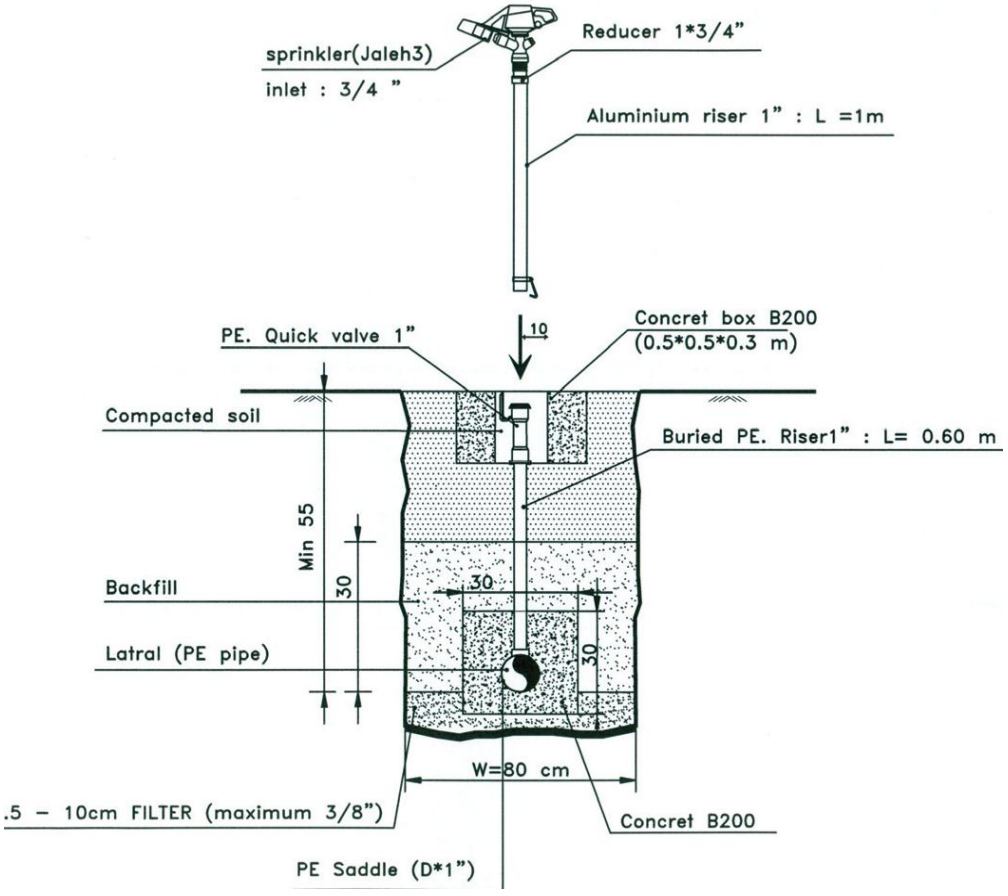


Figure 12: Components and Different Parts of Classic System with Moving Sprinkler

According to the previous explanation about different parts of classic system with moving sprinkler (Figure12) shows design of the whole the system [11].

Chapter 4

SICSMS DESIGN FACTORS

4.1 Design and method of sprinkler irrigation classic system

There is some important factor in designing of classic irrigation system which consists of:

1. Water
2. Energy supply condition
3. Soil
4. Topography condition
5. Continent condition
6. Product type
7. Human power
8. Maintenance and exploitation
9. Under cultivation surfaces
10. Environmental Impact

4.2 Implementation Properties

Based on the factors of design listed, it is possible to design constant classic system irrigation with below properties:

It is will be discussed, that land is considered for designing the following data

4.2.1 Water Quantity

Water for this land is supplied by a well and the quantity that flows through the pipe is determined to be 30 $^{l}/_{s}$

4.2.2 Water Quality

The quality of water must be high thus clean water is used with high PH.

4.2.3 Energy Supply Condition

Since the water has a depth of 30 meter below the surface, to direct the flow of the water to the surface, an electric power is needed.

4.2.4 Soil

This is one of the most important parameter; clay soil that has good texture is used with PH of 7.

4.2.5 Climate Condition

Climate condition of region is moderate semi dry type.

4.2.6 Topography Condition

According to plots raining irrigation design is done on flat surface.

4.2.7 Product Type

According to region, continent, soil and water and economical condition, potato is selected.

4.2.8 Human Power

Required human power is semi-skilled worker

4.2.9 Under Cultivation Surface

Under cultivation surface of this land is about 60 hectare but after ratio of water to cultivated surface, only exploitable surface is calculated.

4.2.10 Maintenance and Exploitation Condition

All parts and repairing are considerable.

4.2.11 Environmental Effects

This part is ranked after designing and installation of the system. [12].

4.3 Implementation levels

4.3.1 First Step is Selection of Sprinkler

Based on different kinds of sprinkler as discussed previously, with consideration given to the intended output of $100\,l/min$, it is possible to determine the number of sprinklers required for every period of irrigation, this calculation is based on the input and output rating of the sprinkler.

- Source water: 30 l/s
- Output of sprinkler: 100 l/min
- $^{100l}/_{60s}$ =1.66 l/s Water output from each sprinkler
- $^{30}/_{1.66}$ =18 sprinklers.

Thus using 18 sprinklers, it will be possible to reach the intended result of 30 l/s.

One horizontal electro pump is used for supplying the needed pressure, and about 5-6 atmospheric pressure is needed for each sprinkler according to clay soil condition with PH of 7 used.

To find how much water needed for the cultivation of the potato give birth to questions such

- Irrigation duration or period?
- Plant water requirement after every period?

4.4 Cultivated Plant Properties

Considering that the density of the potato is about 5500 per hectare and the distance between two potato crops is 20cm and each has a depth of 15 cm approximately, the sprinkler will operate for 6 hours per day and the sprinkling operation must be repeated every 6 days base on the texture of the soil.

The 18 sprinklers as installed as shown in the figure below, 6 and 3 sprinklers on the rows and column respectively, the distance between two sprinklers is 25m both on the rows and column in-order to answer the question of how much area can the 30 l/s of water irrigate.

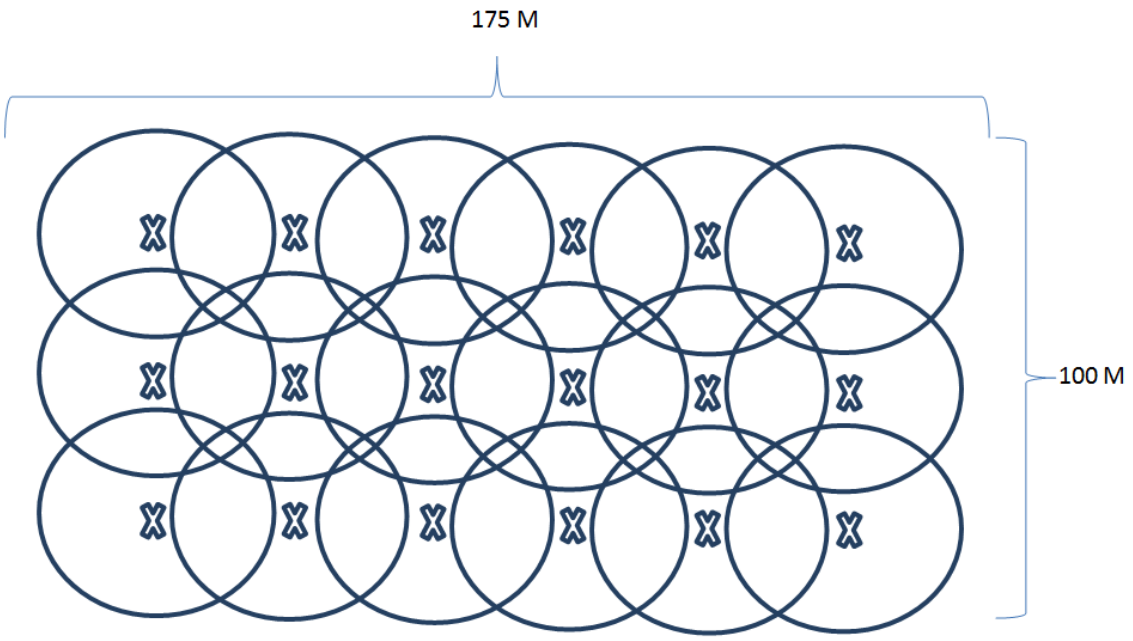


Figure 13: The Covered Area for SICSMS the Method

As figure 13 shows:

$7 \times 25 = 175\ (m)$

$4 \times 25 = 100(m)$

$175 \times 100 = 17500\ (m^2)$

By this calculation, it is noticeable that, nearly $17500\ (m^2)$ can be irrigated in 6 hours. However, since the sprinkler radius is 25m thus every 2 sprinkler overlap with each other as they move continuously so as to cover the area with the 6 hours period. The total area to be covered by the sprinkler is $17500\ (m^2)$ for every 6 hours period of operation; hence within 24 hours period it can cover 4 periods which is about$70000\ (m^2\ per\ day)$ and $420000(m^2\ in\ 6\ days)$ i.e. 42 hectares.

This above calculation and discussion elaborate the principles of the classic system,18 sprinklers placed in specified location, the pump are turned on from the pumping station and irrigation starts and cover the calculated area within the 6 hours period after which the sprinklers are displace.

4.5 SICSMS: Weaknesses and Short Comings

As mentioned on previous sections; also SICSMS is most applicable irrigation method for large scale farms ,but the biggest weakness in this method is on sprinklers changing process, which has a large amount of manpower as well as time have to employed in order to change sprinklers timely for appropriate positions. Since sprinklers changing process normally handling by labors, it may contain not only changing defects and problems, but also it consume huge amount of energy and cost.

4.6 Methods of Sprinkler Replacement

There are basically two different methods, by which the sprinkler can be changed by the Manpower, with each of the method having its own advantages and disadvantages as discussed below.

4.6.1 First Method

This method involves the operator or worker to go the pumping station to turn off the pumping system and then back to the farm to change the 18 sprinklers to another location etc, thus moving to and fro from the farm to the station and back to the farm waste a lot of time.

This method raise questions such as;

1. How much time is spent for replacement?

2. For every turning on and off system, how much electric power is used?
3. What is effect of wasted time in replacement of sprinkle on cultivation surface?

Assuming that it normally take 3 minutes to change each sprinkler, and the time taken to move to and fro the pumping station by the operator is 6 minutes, thus a total of 60 minutes would be spent each period of six (6) hours, for a day period, there would loss of 4 hours and 24hours for 6 days duration.

4.6.2 Second Method

In this method, the duration of irrigation is considered precisely 5:30 minutes; it means that there is a decreasing about 30 minutes from each duration of irrigation. Considering this time period, the maximum of cultivating area will be achieved; while there will trade off of quality of sprinkling in the cultivating area.

In each of these two methods 12 hours will be necessary, thus two operators that will working shifts every 12 hours from 6am to 6pm and vice versa.

This methods is time consuming and energy sapping on the part of the operator, thus there is need to design other tools for sprinkling replacement hence a robot or mechanized system.

Chapter 5

DESIGN AND DEVELOPMENT A NEW AGV FOR REPLACING SPRINKLER IRRIGATION CLASSIC

The advantages of introducing robots to agricultural sector cannot be overemphasized, to eliminate the disadvantages associated with the use of classic sprinkler system, such as the trade-off between duration and quality of sprinkling, energy sapping on the operators part, the use of robot becomes inevitable. This work emphasizes the application and development of automated guided vehicle (AGV) to replace the classic sprinkler systems. This is based on explanation given in the previous sections about AGV in agriculture and the disadvantages of the SICSMS. The propose system has the capability of taking out the sprinkler from its locations after every sprinkling period and move it to another position for continuous sprinkling, without loss of time. The designed system comprises of two parts, the AGV and the moving path (rail and sensor). Figures bellow shows shot screens of the designed AGV. The name and specification of the product components can be found on the table below.

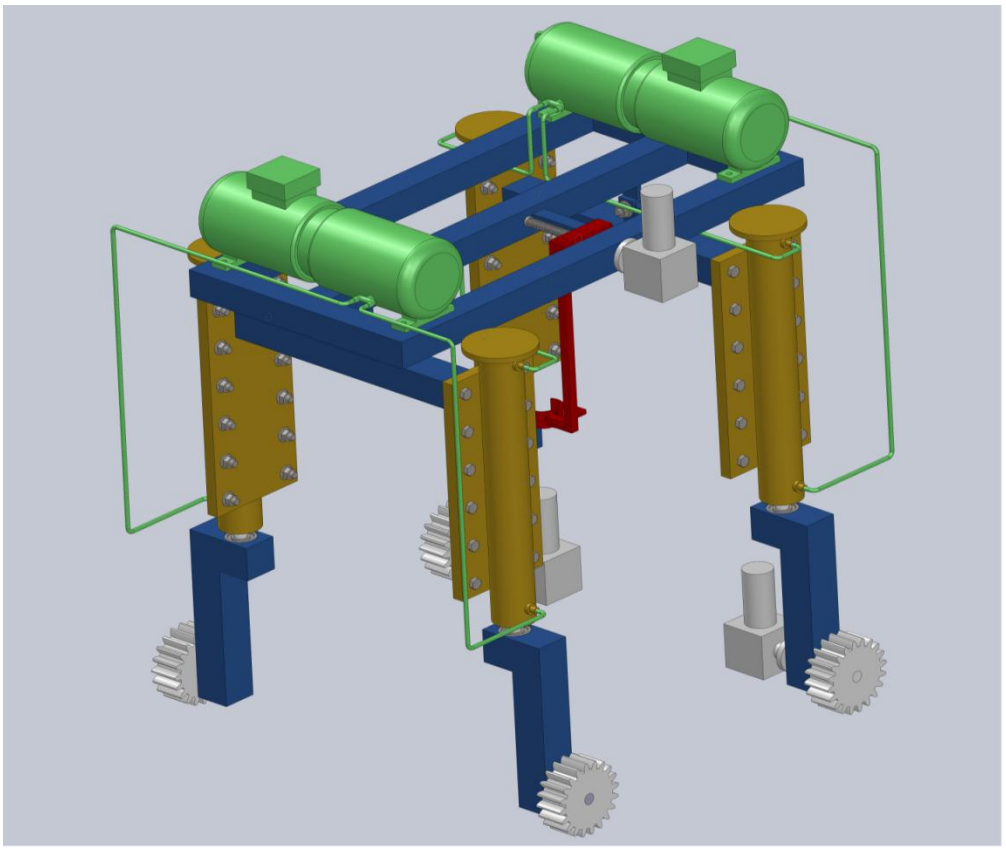


Figure 14 :3D View of the Proposed Automated Guided Vehicle.

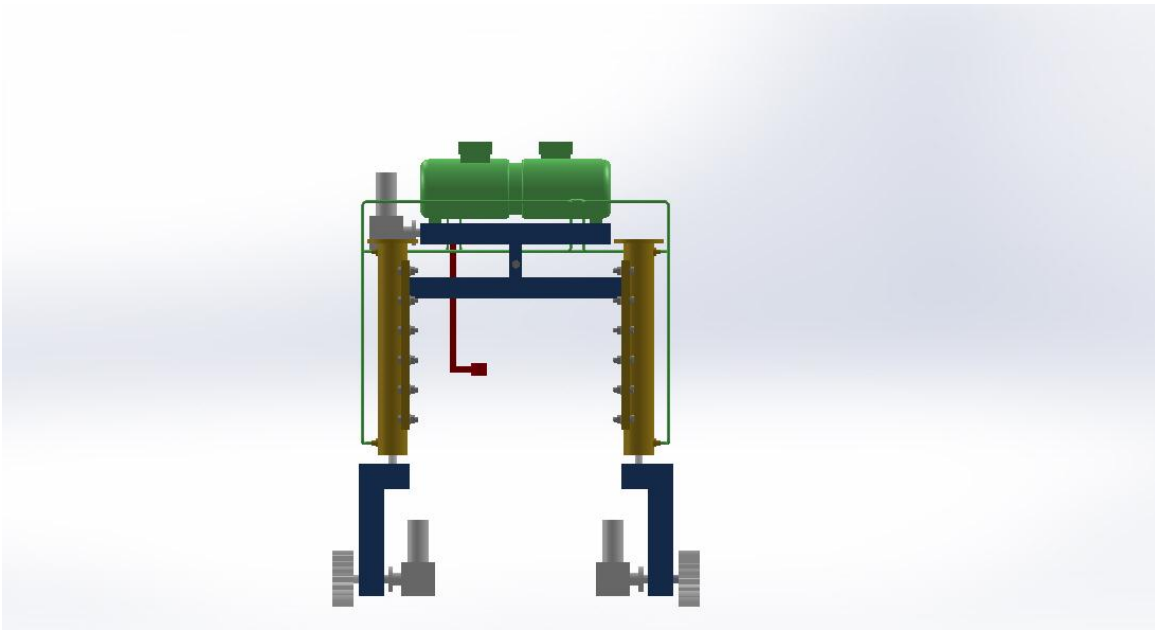


Figure 15: Front View of the Proposed Automated Guided Vehicle.

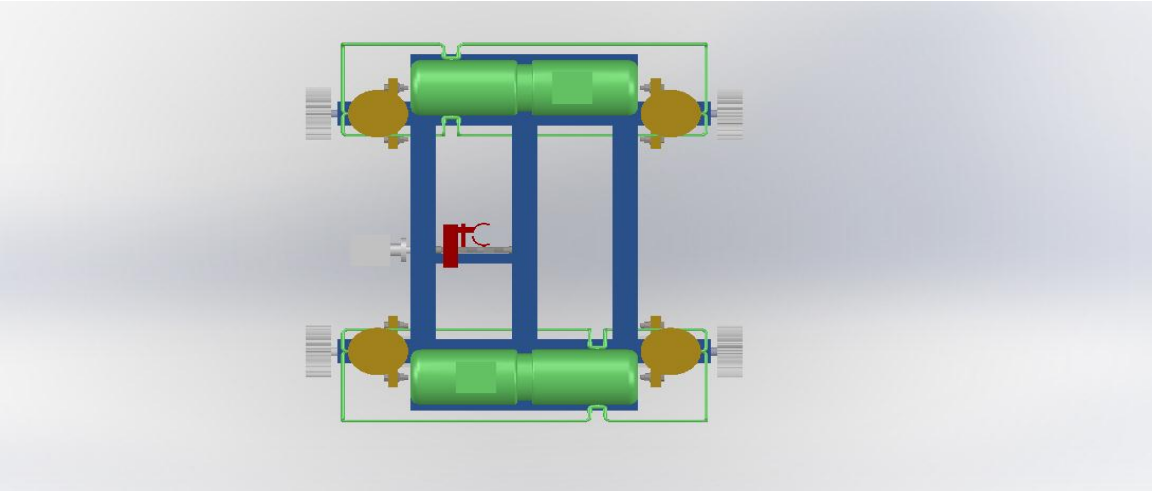
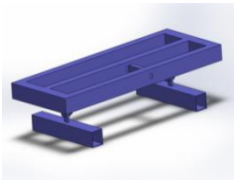
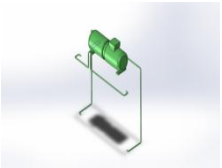
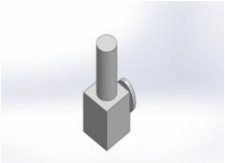
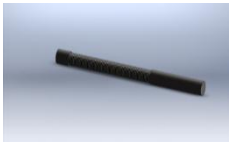
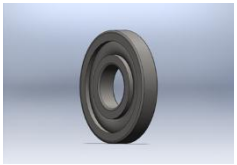
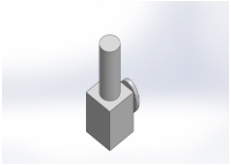
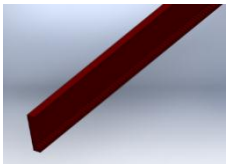


Figure 16 : Top View of the Proposed Automated Guided Vehicle.

5.1 Components of AGV

Table 1: Component of AGV

Name	Properties	Picture
Chassis	The upper and the main chassis is that the retentive of hydraulic system. It has dimension about 50cm_100cm and it is consisted of the Profiles 2×2cm.	
Hinge piece	Hinge piece connected the upper chassis to the lower chassis, it makes a apace between these two chassis.	
Hydraulic lack and Steel Plate	In this kind of robot fluid motion is changed to linear motion by jack's which are kinds of Two-sided, the length of both of them is about 100cm jack s outside diameter is 5cm jack s Shaft diameter2.5cmThe piston course length 60cm.	
Pump hydraulic and oil transfer	In this system, two hydraulic pumps are used which their power is supplied by electro motor, the costal hydraulic pump utilized in this system. Their function is the transferring oil the jacks and back to front (reverse).	
Motor electric and transmission of spiral shaft	In the middle of robot chassis one electric motor box used in the middle of robot chassis Which transfer its power to the spiral shaft and its electric motor has the right and left Rotation motion.	

Spiral Shaft	The task of this piece relates to the moving of hook or riper which one side of this is connected to the electric and the other side is controlled by bearing	
Riper or Hook	This piece consist of two separations that one of them is fixed and the other one is movable. The task of this piece, is keeping sprinkler at the time of exit and installing.Sepration are connected to the spiral shaft at the top. This way of separation motion is magnetic	
Hand Dog	The function of this piece is connection of jacks and the other side is connected to the wheels The type of this piece is steel in addition, the length of out is between 15_20cm and it is width is 5_7cm.	
Bearing	It is used in robot planning on order to conjunction between jacks and hand dog, between wheels and gearbox and also at the beginning and the end of spiral shaft.	
Wheel or Gear	Wheel or gear has a essential role in robot motion. The diameter of gear depends on the speed and distance duration of the robot the material of gear is steel.	
Electric motor and transmission	The Electric motor and transmission are used for supplying the power and motion. These motors are established in the front wheels and they are connected to the wheels by bearing they are fastening by bolt at the end of the wheels.	
Bolts	The bolt are used for connected the jacks to the lower chassis and other piece.	
Rails and Component	Rail's is planned for leading robot the outside diameter depends on the wheels size. There is a direct relation between wheel and rail. As it is seen in the picture, there is some dent inside of the rail which their function is to decrease friction	

Support of rail or foundation	The center part of this piece is a place for automatic valve, for one sprinkler one foundation is needed which consist of 50cm width, 30cm length and 20cm heights moreover it has a place for installing rail.	
Switch or Sensor	This sensor is used at the end line, because at the moment of changing the line, both motors can't move. The sensor is established in the shorter direction line till of the motor would turn off.	
Power of robot	The main and the essential part of the robot is moving is the motor (motion motors) the moving of robot is supplied by electric power, in this kind of robot, the motor power has two part: first is Battery or source of charging energy and second is use of Solar panels.	
Barcode and barcode Reader	The subject of barcode and reader barcode is identifying of sprinkler and automated valve.	
Automated Valve or valve coupling	The subject use of this easy moving of sprinkler for inside or outside.	

5.2 Simulation

Consideration is given to all the factors and assumptions used in the classics system such as soil type (clay soil with PH of 7), quantity and quality of water, types of pipes and pumps, product type, topographical configuration of the area etc but instead of human power, the automated guided vehicle is used as replacement.

The pipes are installed underground and foundation of length 50 cm by 30 cm width with a height of 20cm are built for the rail, on the foundation features the automated coupling value which connect the riser with the pipes, the foundation also provides

support for the rail and they are fastened with the use of bolts. The two rails lines are separated by distance of 50cm and they are design in such a way to allow for line changing as in figure below.

Advantages of using rail instead of tire

- To facilitates the movement of the robot even in wet soil and worst topographic condition (non graded land)
- To decrease friction that produce drag forces, thus teeth's to provide firm grip of the robots on the rail.
- It compensates for the forces of sprinkler for time of importation and exportation.

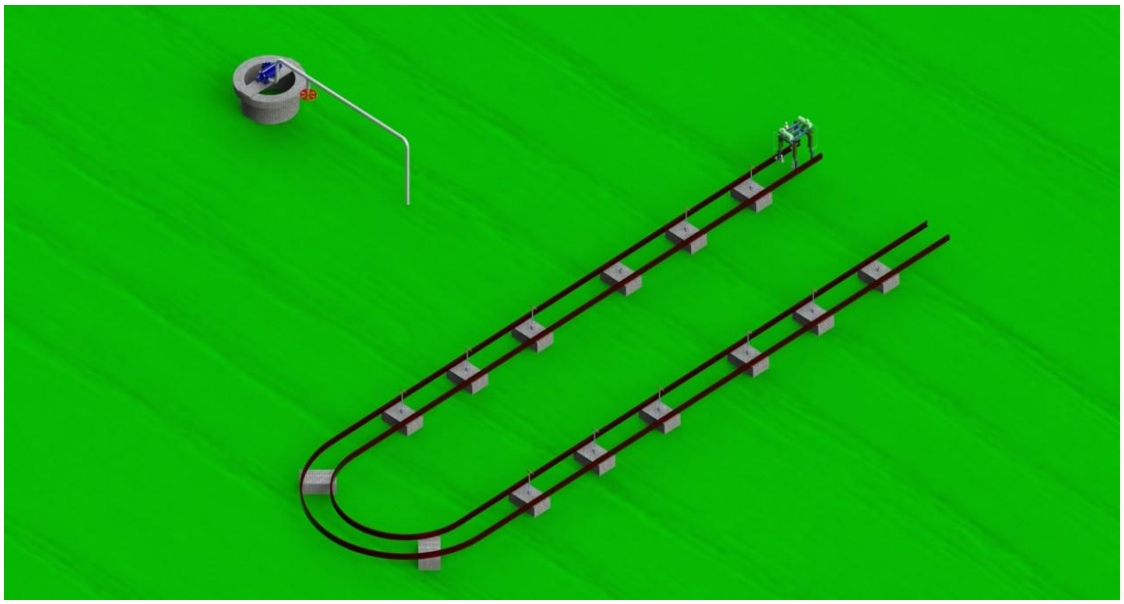


Figure 17: the Robot Path Showing the Foundation

Once the rails are assembled as shown in the figure above, the robots are put in the rail, the operators is saddle with responsibility of putting the riser and the sprinklers on the

foundation just once and turning on the system from the pumping station. After six hours, when it is time for the sprinkler replacement, the robot AGV (figure 17). The robot identifies the sprinkler with the aid of the barcode.

5.2.1 Sprinklers Identification Method

When an item is purchased from any store, there is always a label with thin, black lines across it with different numbers. Once this label is scanned by the cashier, and the item's description and price automatically come up. The word for this is called a barcode, and it is used to read data and information based upon the widths of those small black lines. The barcode has many profits, although most of us think of them as simply a way to price items in the grocery or department store.

5.2.1.1 Reading Barcode

An electronic device scans a barcode by shining a laser beam on it. Barcode readers (unlike magnetic-stripe readers) are 'non-contact' automatic data capture devices, operate only at short distances (a few inches), and (unlike in radio frequency identification) do not provide 'out of line of sight' reading. Barcode readers also called barcode scanner or just scanner [13].

However, based on the calculations done on the classic sprinkler system, 18 sprinklers operating during 6 hours period for 6 days irrigation period, to estimate the number of automated valves needed by the proposed AGV robots, the total operating period within six days would be 24 times multiply by the number of the sprinkler will give the required automated value of 432. Now every sprinkler has a specific automatic valve with 24 same barcode. When a robot identifies a sprinkler by the specified barcode, it

takes it out of location and moves in path to identify another automatic valve with same barcode of sprinkler.

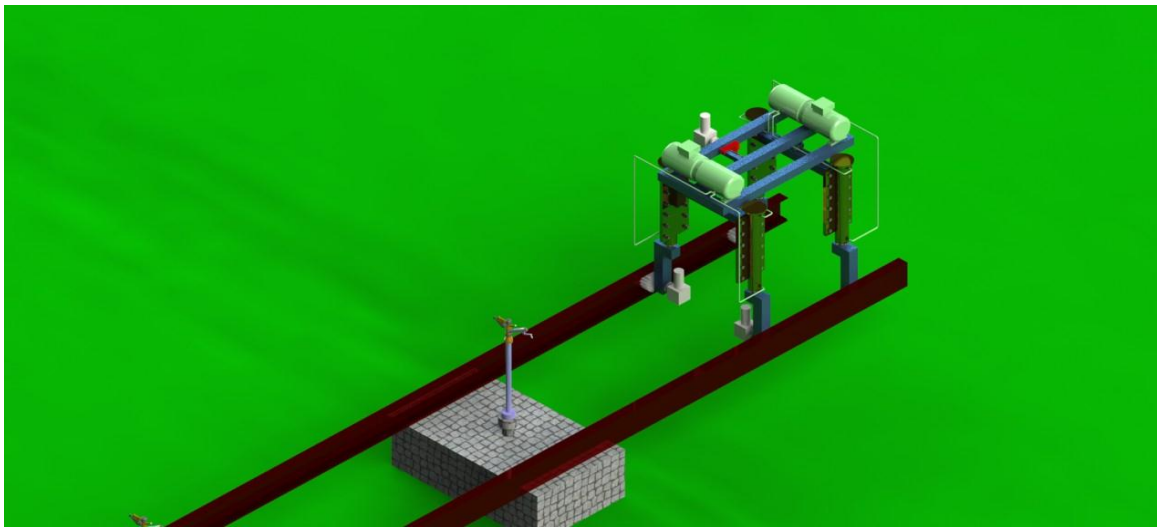


Figure 18: The First Step Robot Moves Toward Sprinkler

As the robots moves towards the sprinkler as depicted in the (figure18) above, it identifies first sprinkler by reader barcode,

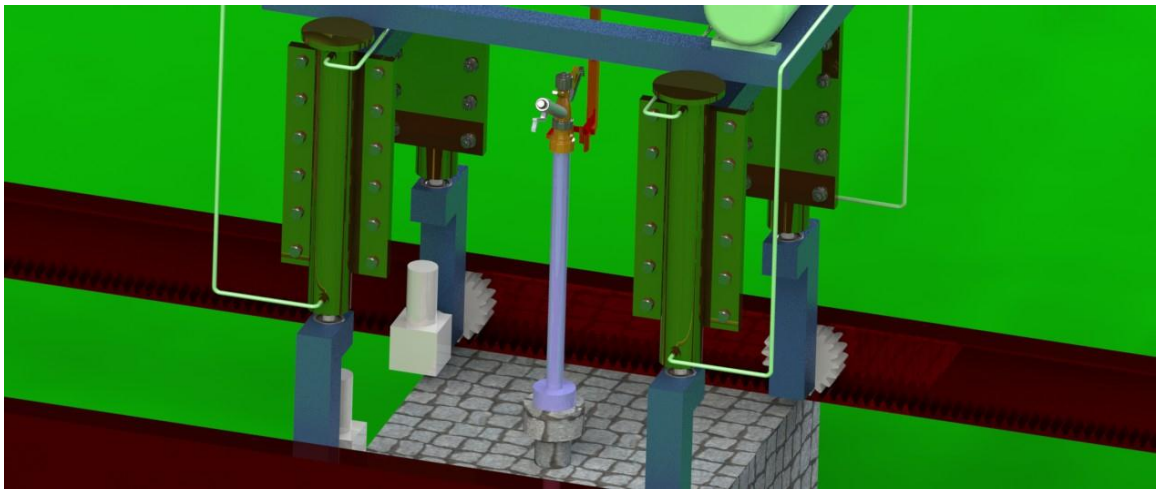


Figure 19: the Electric Motor of a Spiral Shaft Adjusts its Position Toward the Sprinklers

The electric- motor of a spiral shaft adjusts its position toward the sprinklers (Figure20)

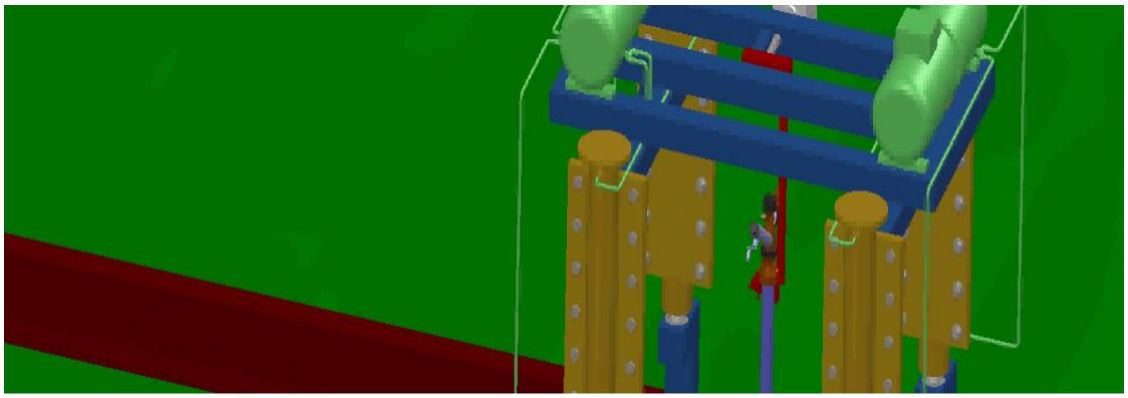


Figure 20: with Aid of the Riper or Hook Along with Spiral Shaft that Moves to and Fro.

With aid of the riper or hook along with spiral shaft that moves to and fro, the sprinkler is gripped firmly by the moving hook (figure 20).

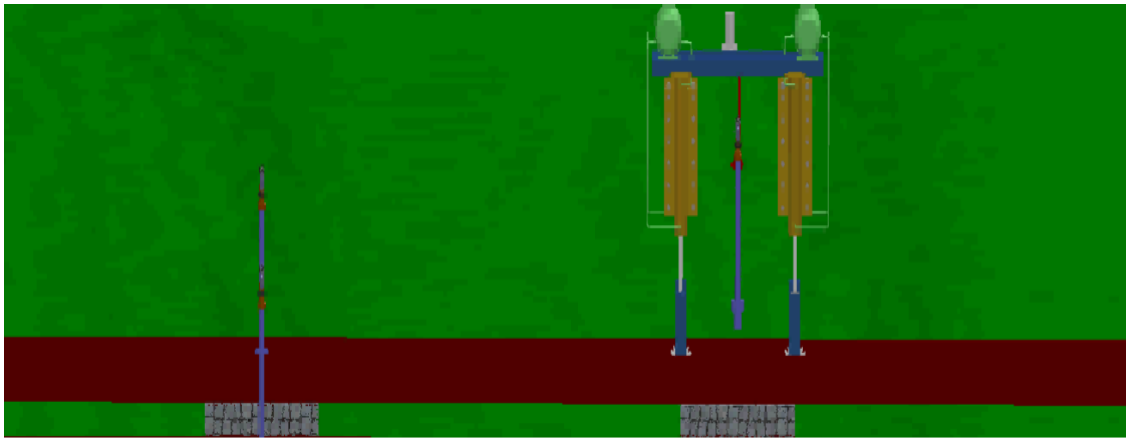


Figure 21: The Hydraulic Jack Moves up so the Sprinkler will be Detached

Once the riper hooked the sprinkler, the sensor notifies the robot and automatically the hydraulic jack moves up so the sprinkler will be detached. The spiral shaft also returns back to its formal position with the aid of electric motor while the riper is still holding the detached sprinkler, this is necessary to avoid collision along the way as the robots moves to the next sprinkler (figure 21).

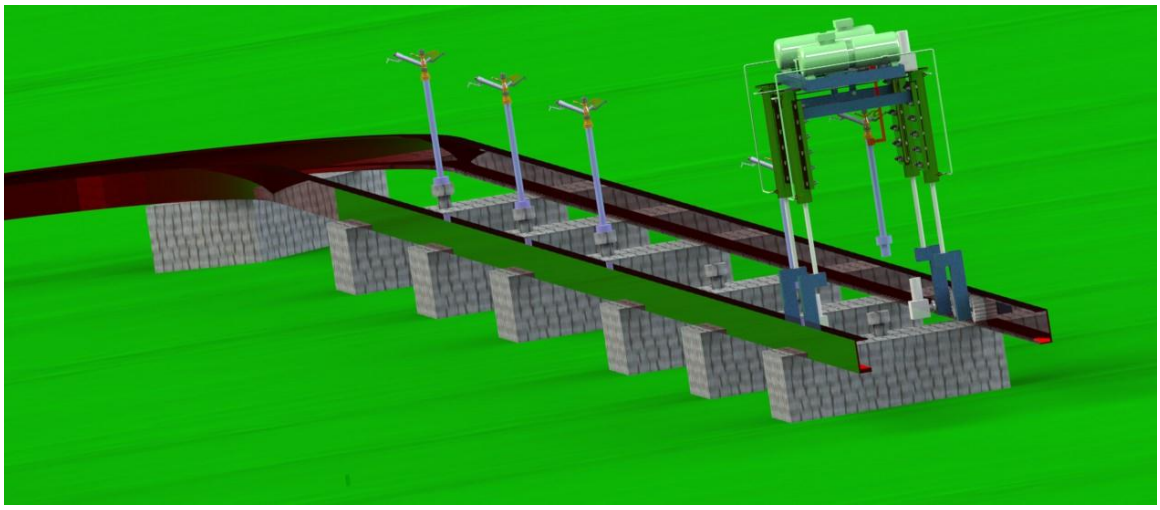


Figure 22: the Spiral Shaft Returns Back to its Formal Position with the Aid of Electric Motor

The robots together with the detached sprinkler movers along the rail in search of automatic valve with the same barcode (figure 22).

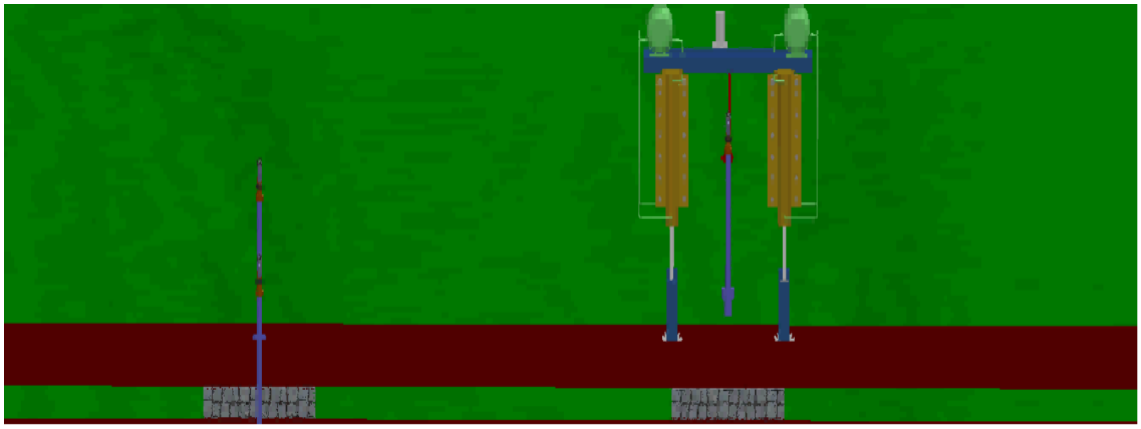


Figure 23: the Robot Together with the Detached Sprinkler Movers Along the Rail in Search of Automated Valve

Once the robots identifies the automatic value control with the same barcode with that of the detached sprinklers. Firstly, it will be stopped, then it will be guided by twisted electric motor shaft to the center of foundation and finally, hydraulic jacks will be started to go down (Figure 23).

After reinforcement of sprinkler inside of coupling valves, static and moving jaws will be separated, in addition, jacks will go up and they moves forward for transition of sprinkler and also identifying sprinkler as discussed before(Figure 24and 25).

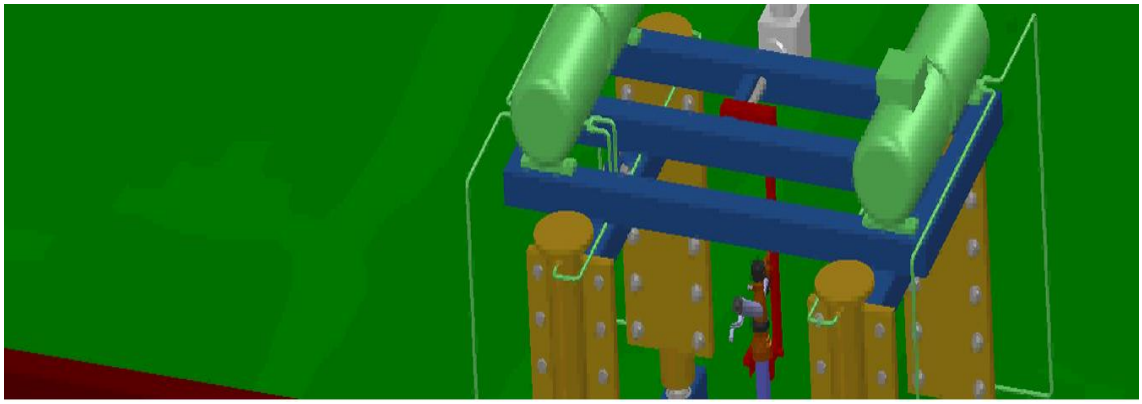


Figure 24: The Sprinkler Inside of Coupling Valves

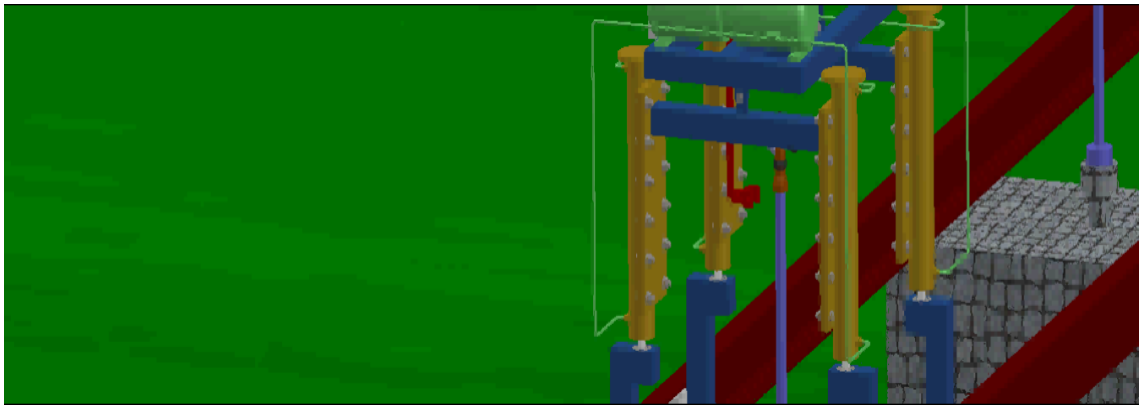


Figure 25: The Static and Moving Jaws will be Separated

After replacement of sprinkler in one line, robot should move to the next line so in the end of line a turn back path should be used (Figure26)

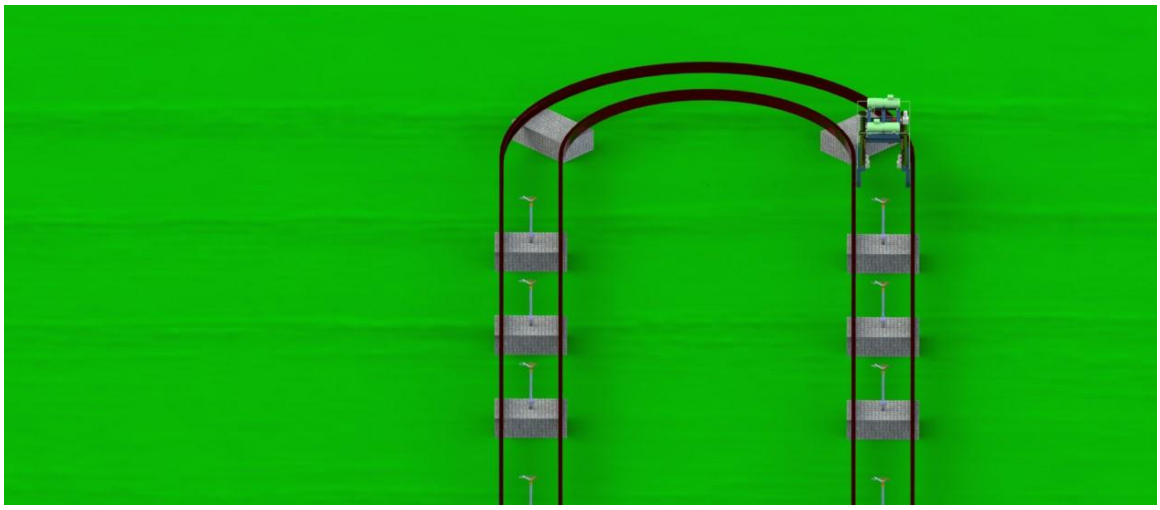


Figure 26: Robot Should Move to the Next Line

To negotiate a bend at the end of the path, there is a sensor incorporated that turn off one of the electric motor driving the robot, thus only one motor would be operating to enable safe turning of the robots, after the bend has been negotiated to the other path, another sensor instructs the robot to turn the other electric motor on as it continues its movement in the other side of the path even as the replacement continues (figure 27).

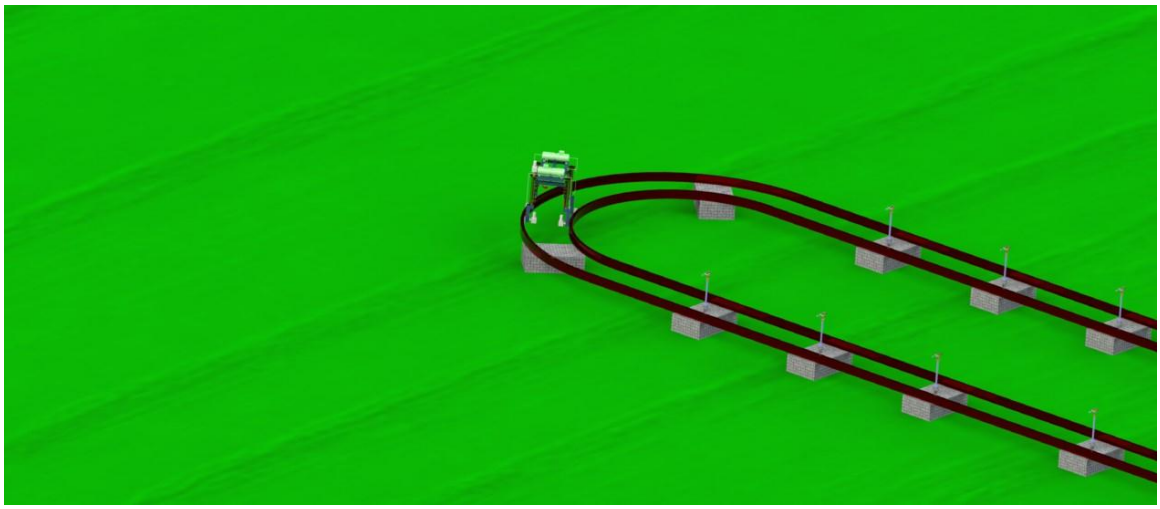


Figure 27: The Robot in Change Line Rail

Chapter 6

RESULTS

The AGV equipped SICSMS method shows the following improvements in compare with conventional SICSMS method.

1- In the first method by human labor, in each 6 hour (one period) irrigation has been lost for changing the sprinkler. This changing time in a day is equal to 4 hour. In a complete irrigation period (6 day) this changing time is equal to 24 hours and it is also equal to 4 period of irrigation. In each period of irrigation 17500 m^2 has been irrigated so for 4 period of irrigation this mount become 70000 m^2. As the figure 13 shows the area which is covered by the first method is 420000 m^2 but with considering the decreased hours just 350000 m^2 will be irrigated and this is the effective area.

Now by utilizing the proposed AGV it is possible to rich maximum irrigated area.

2- As it explained before in second method, soil and type of plant are two important factors in time of irrigation. In this method each irrigation period will be assumed 5 hours and thirty minutes (5hr30min).Now if the time irrigation change from 6 hours to 5hr30min in each period of irrigation for sure desired area surface will be rich but the quality of irrigation will be decreased. Consequently,

it is possible to have appropriate surface and quality of irrigation in a same time by using AGV.

Decreasing the number of human labor is the main aim of previous explained methods.

Chapter 7

CONCLUSION

The research is started with an over view about irrigation and its related methods, two category of irrigation has been explained briefly. The first category includes some traditional methods and the second one includes modern methods. One of the modern methods which are covered in this thesis is classic system. By utilizing classic system some problems encountered such as moving the sprinkles with human labor, labor should move the sprinklers after each irrigation period.

A novel AGV has been designed, which is able to move during a rail way. Aiming to travel on this rail can detect the available irrigation in its path and remove them to their new place. AGV has been designed by the aid of Solid work software in virtual environment for sprinkler irrigation classic system method. Comparison between the methods by utilizing the AGV and the methods by human labor defines that the under cultivation surface has been increased, on the other hand energy consumption has been decreased (saving).

As a further research, it is possible to utilize RFID or wireless sensor networks instead of barcode reading to improve the controller system or AGV motion. On the other hand it is facile to upgrade the platform of AGV by integrating some other technologies.

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APPENDIX

APPENDIX

	Component	Number	Price (USD)	Total Price (USD)
AGV	Chassis	2	50	100
	Motor	3	75	225
	Wheels	4	15	60
	Jack	4	30	120
	Hydraulic Pump	2	80	160
	Spiral Shaft	1	20	20
	Bearing	8	5	40
	Griper	1	30	30
	Electronic Device	1	200	200
	Barcode Reader	1	30	30
	Other	4	25	100
Rails	Rails	2800	15	42000
	Foundation	432	5	2160
			Total Cost	45245

	Covered Area (Hectare)	Human Labor	Working Shifts
Without Utilizing AGV	35	2	2
With Utilizing AGV	42	0	0
Improved Are with AGV	7		

	Number of Human Labor	Price For each Human Labor (USD)	Total Price (USD)
Period of Cultivation	14	500	7000

	Improved Area In each Period of Cultivation (Hectare)	Income Hectare (USD)	Total Price (USD)
Improved Area	7	12500	87500