DESIGN AND DEVELOPMENT OF NEW THERMAL MACHINE CONTROL SYSTEM FOR THE STUDY OF ELECTRO-CHEMICAL EFFECT ON CLAY MICRO-STRUCTURE USING PREFABRICATED VERTICAL DRAIN (PVD)

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FUNDAMENTAL RESEARCH GRANT SCHEME
NO VOT 0261

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ABSTRACT

Prefabricated vertical drain (PVD) is one of the new technologies for soil improvement. Because of the high cost of land procurement, land reclamation has become a very promising alternative for expanding and constructing new ports. The presence of soft clay poses a major challenge for port development as it requires ground improvement. The use of prefabricated vertical drain (PVD) with preloading has become a popular method of ground improvement because of ease and speed of installation. The PVD had installed in the soft clay and there will have hot water in the PVD. And the hot water needs to increase in 90 °C to 100°C. When use the PVD in the huge area or land need more energy to run the system. In this case need a lot of energy. By using the electrical energy it can't give good performance for the big system and it costly. There use other alternative, solar energy. The solar energy are save and friendly. When the soil has improved the land will get start to construction.

ABSTRAK

Kini ada satu teknologi terkini untuk membaikpiulihkan tanah iaitu *prefabricated vertical drain (PVD)*. Disebabkan kos yang terlalu tinggi untuk membeli tanah, menembus semula tanah, ia adalah satu alternative yang baik untuk dikembangkn dan membina serta membuka kawasan-kawasan yang baru. Dengan adenya sistem ini, wujudnya satu peluang yang besar untuk membaikpulih bahagian bawah tanah bagi tanah kembut supaya dapat membuka kawasan-kawasan baru. Kegunaan *prefabricated vertical drain (PVD)* yang ditanam telah menjadi satu kaedah yang terkenal untuk membaik pulih bahagian bawah tanah kerana ia senang dan cepat untuk ditanam. PVD yang ditaman didalam tanah lembut akan dilalui air yang dipanaskan dan air panas tersebut akan meningkat dari suhu 90°C kepada 100°C. Selalunya penggunaan PVD dikawasan yang besar memerlukan bekalan tenaga yang banyak untuk system tersebut beroperasi. System ini akan menggunakan tenaga solar untuk membekalkan tenaga elektrik. Sistem solar ini akan membantu untuk memanaskan air didalam tangki dan menggerakkan keseluruhan operasi supaya tanah lembut tersebut dapat dikeraskan. Ia dikeraskn untuk tujuan pembinaan.

CHAPTER I

INTRODUCTION

1.1 Introduction of the study

Solar energy is a very important. It achieve for long lasting, sustainable, environmentally friendly renewable energy resource to fulfill the energy needs for mankind. The same sunny days that dry out plants, make animals thirsty, and heat up buildings and cars just happen to be very good days for generating electricity with solar energy.

The energy supplied from the sun is truly enormous on average; the earth's surface receives about $1.2 \times 10^{17} Watt$ of solar power. Less than one hour enough energy is supplied to Earth to satisfy the entire energy demand of the human population over the whole year. Energy from the sun travels to the earth in the form of electromagnetic radiation similar to radio waves, but difference frequency range. The amount of energy available from the sun outside the earth atmosphere is approximately $1367W/m^2$, that nearly the same as the high power hair drier for every square meter of sunlight. Some of the solar energy is absorbed as it passes through the earth atmosphere. On a clear day, the amount of solar energy are available at the earth's surface in the direction of sun in the typically $1000W/m^2$. At any particular time, the available solar energy is primary dependent upon how high the sun is in the sky and current cloud conditions.

There are many ways for solar energy can be used effectively. The applications of solar energy can be group in three primary categories. There are heating and cooling, electricity production, and chemical processes. The most widely used applications are for water and space heating. The solar energy will correlate with the installation of Prefabricated Vertical Drain (PVD) and also called wick drains or band drains. Utilize solar system for the heating of soft clay in Prefabricated Vertical Drain (PVD). To changes the properties of the soft clay.

The need for additional port capacity has rapidly risen over the last few years due to globalization. Due to high cost of land procurement, land reclamation has become a very promising alternative for expanding and constructing new ports. The presence of soft clay poses a major challenge for port development as it requires ground improvement. Prefabricated vertical drains (PVD) have been used successfully in many soil improvements. It becomes popular method of ground improvement because of ease and speed of installation. But the presence of soft clay deposit makes land reclamation a challenging task. The soft clay are low shear strength, high water content, high compressibility and large settlement of the soft clay make it impossible to do construction on soft clay without ground improvement.

The design of structures on soft clay has created problem for civil engineers. Construction without some sort of soil treatment is usually impractical due to unpredictable long term settlement. Although surcharging increase water pore pressure, settlement can take considerable time, often years, as the water lacks an easy path to leave the soil. Consolidation of soft cohesive soils using prefabricated vertical drains can reduce settlement times from years to months. Most settlement can occur during construction, thus keeping post-construction settlement to a minimum. Consolidation of a compressible soil occurs as pore water is squeezed from the soil matrix. The time for consolidation depends upon the square of the distance the water must travel to exit the soil. The installation of prefabricated vertical drains provides shortened drainage paths for the water to exit the soil.

1.2 Objective

The objective of this project is to study and develop a solar temperature control system for the used in Prefabricated Vertical Drain (PVD).

1.3 Scopes

As a whole, the theses are consisting of the following aspect:

1. To study the potential capability of a solar thermal system in the changing of microstructure of soft clay.
2. To provide a potential thermal control design with analysis within the application in PVD.

1.4 Background study

There are several reasons why this project should be done. The reason is due to high cost of land procurement, land reclamation has become a very promising alternative for expanding and constructing new ports. The presence of soft clay poses a major challenge for port development as it requires ground improvement. And need to know the potential capability of a solar thermal system for the application in PVD.

1.5 Summary

The expected results from this study are as following below:

1. The solar panel can generate enough current to application in the PVD of the soft clay.
2. The change of properties and microstructure of the soft clay by using the solar thermal system.
3. The increasing of the temperature of soft clay, up to 90 °C or 100 °C, on the performance of the PVD during the preloading process.

CHAPTER II

LITERATURE REVIEW

2.1 Soil Settlement

The construction of highway and railway embankment over unconsolidated soft soil deposits has resulted in the advancement of soil improvement techniques. These construction activities are now mainly concentrated on low-lying marshy area, which comprise of highly compressible weak organic and peaty soils of varying thickness. These soft clay deposits have a low bearing capacity as well as excessive settlement characteristics. Therefore, it is necessary to improve the existing soft soils before commencing the construction activities in order to prevent excessive and differential settlement.

2.2 Prefabricated Vertical Drain(PVD)

Prefabricated vertical drains (PVD) are a very effective and economical ground improvement technique for accelerating primary consolidation. PVD have been used successfully in many soil improvement and land reclamation project in Asia and the rest of the world. PVD are positioned vertically through the ground, generally made of coarse granular material, particularly soft clay. Generally used for the acceleration of the rate of consolidation of the clay layer. The permeability of the clay layer is greatly reduced due to the reorientation of the soil particles. Installation can be achieved in a various ways depending upon the type of drain to be installed and the nature of the ground. The installation of vertical drain cause significant disturbance in the surrounding soil.

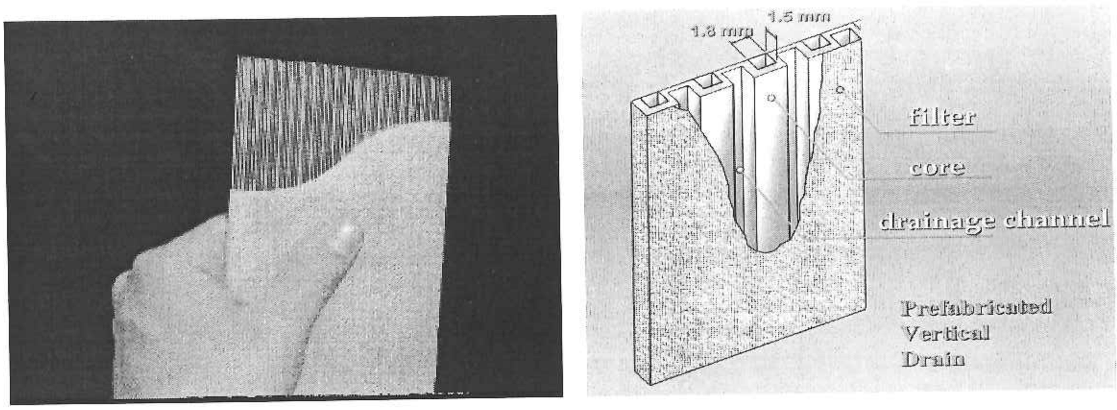

Figure 2.1 Prefabricated vertical drains.[2]

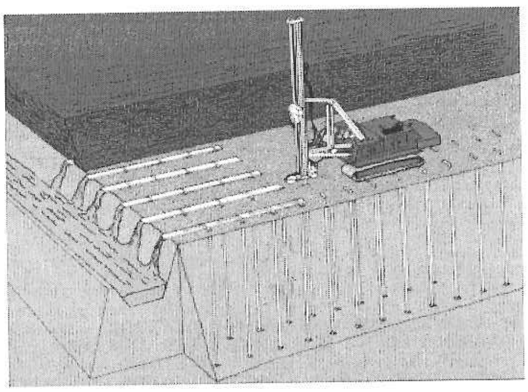

Figure 2.2 Vertical drain installations with horizontal strip drain.[3]

2.2.1 History of PVD

Historically, the design of structures on soft compressible soils (clays) has created problems for civil engineers. Construction without some sort of soil treatment is usually impractical due to unpredictable long-term settlement. Although surcharging increases water pore pressure, settlement can take considerable time, often years, as the water lacks an easy path to leave the soil. This PVD have been employed for more than 60 years ago. The first installation was in California in 1934 using 20 in or 60 mm diameter sand drains at 10 ft or 3m c/c spacing. Until 1970, most of the drains used were vertical sand drains, mainly using close-ended mandrels, which produced a large smear zone. In 1950, jetted sand drains came into use in Netherlands, but it had problems of additional costs of large jetting pumps and difficulties in driving out large quantities of water.[3]

Consolidation of soft cohesive soils using prefabricated vertical drains or also can called wick drains or band drains that can reduce settlement times from years to months. Most settlement can occur during construction, thus keeping post-construction settlement to a minimum. Consolidation of a compressible soil occurs as pore water is squeezed from the soil matrix. The time for consolidation depends upon the square of the distance the water must travel to exit the soil. The installation of prefabricated vertical drains provides shortened drainage paths for the water to exit the soil.

Larger prefabricated drains called strip drains are used for horizontal water removal at the surface replacing the previously used sand blanket. The strip drains are less expensive, install more easily and quickly, and provide better drainage.

2.2.2 Advantage of vertical drain

The advantages of vertical drain are:

1. Increased rate of gain of shear strength of clay. Enables the load to be applied more rapidly, thus better use of construction plant. In case of embankments, steeper slopes and provision of breams can be avoided. Lower amount of fill required. Increased the rate of consolidation. Consequent savings in construction cost.
2. Increased rate of consolidation. Reduction in time required for primary settlement. Structures or embankments can put into commission and use far earlier. Reduction in cost of maintenance.
3. Stability to embankments and tankages. Many soft clay strata contain thin band, or parting, of sand or silt. Excess horizontal spread of pore pressure along these partings take place. Vertical drains installed can relieve these excess pore pressures.
4. The PVD can be attributed to the coincidence of the drainage point and the smear zone at the center of the maximum temperature zone.

2.2.3 Disadvantage of vertical drain

The disadvantages of vertical drains are:

1. The sand to be used for the drains must be carefully chosen to have adequate drainage properties and therefore can seldom be found in the vicinity of the construction site;

2. The drains may become discontinuous due to careless installation or excessive lateral soil displacements during consolidation;
3. Bulking of the sand during its placement in the drain may lead to formation of cavities and collapse on flooding;
4. The large diameter required for the sand drain may pose a construction problem and/or a budgetary burden;
5. The disturbance to the soil surrounding each drain caused by the drain installation process may reduce its hydraulic conductivity and thereby reduce the flow of water to the drain and the efficiency of the system;
6. The reinforcing effect of sand or gravel drains may reduce the effectiveness of the surcharge loading in consolidating the subsoil.

2.2.4 Preloading techniques

Preloading generally refers to the process of compressing the soil under applied vertical stress prior to construction and placement of the final construction load. The two common preloading techniques are conventional preloading, e.g. by means of an embankment, and vacuum induced preloading.

2.2.4.1 Conventional Preloading

The simplest solution is a preloading is a preload, by means of an embankment. When the load is placed on the soft soil, it is initially carried by the pore water. When the soil is not very permeable, which is normally the case; the water pressure will decrease gradually because the pore water is only able to flow away very slowly in vertical direction. In order not to create any stability problem, the load must mostly be placed in two or more stages.

The principle is shown in Figure 2.3. If the temporary load exceeds the final construction load, the excess refers to as surcharge load.

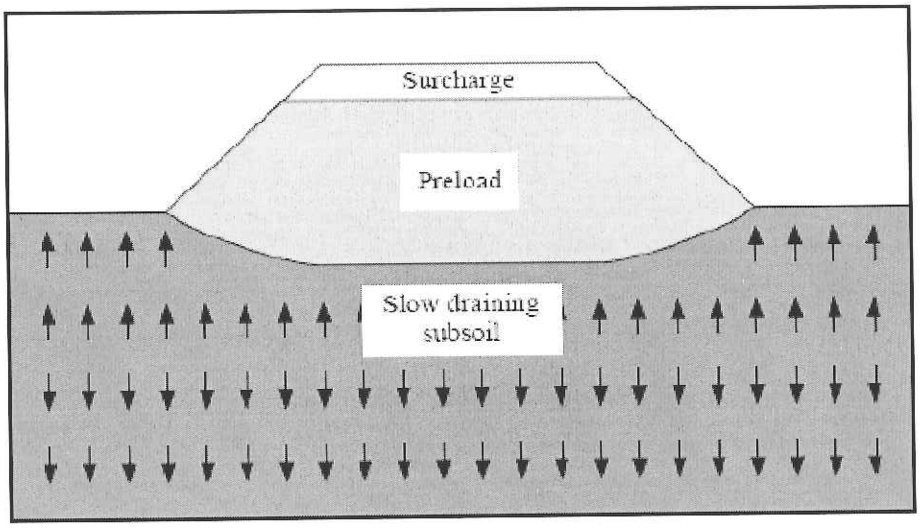

Figure 2.3 Preloading of subsoil.[4]

The temporary surcharge can be removed when the settlements exceeds the predicted final settlement. This should preferably not happen before the remaining excess pore pressure is below the stress increase caused by the temporary surcharge. By increasing the time of temporary overloading, or the size of the overload, secondary settlement can be reduced or even eliminated. This is because by using a surcharge higher than the work load, the soil will always be in an over consolidated state and the secondary compression for over consolidated soil are much smaller than that of normally consolidated soil. This will benefit greatly the subsequent geotechnical design.

2.2.4.2 Preloading principles

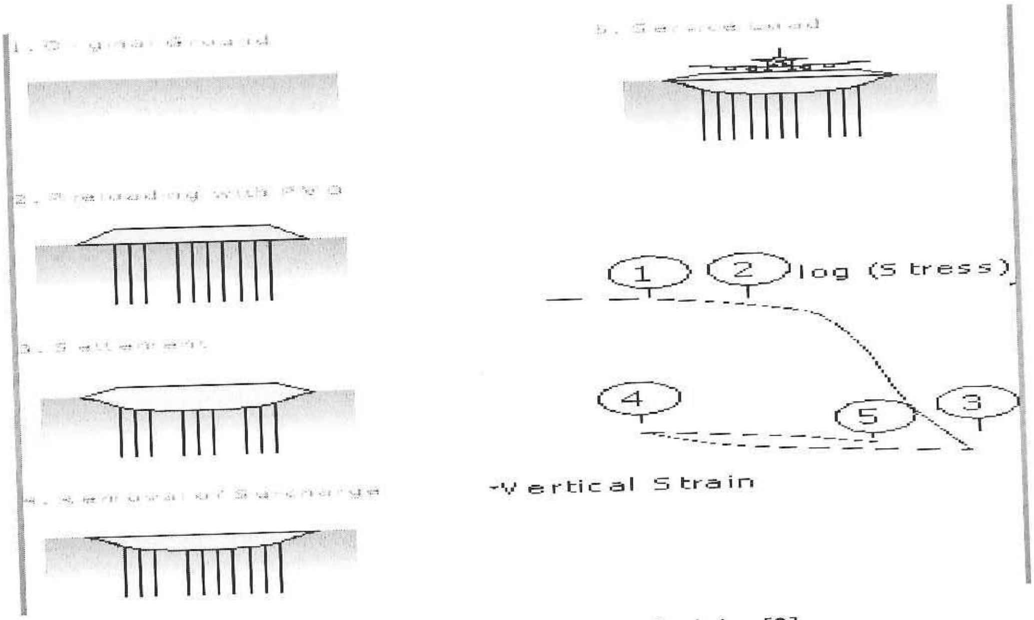

Figure 2.4 Preloading principles.[2]

2.2.5 Type of vertical drains

Various types of vertical drains including sand drains, sand compaction piles, prefabricated vertical drains and gravel piles have been commonly used in the past. As conventional sand drains are susceptible to damage from lateral ground movement, the PVD systems with fast installation have replaced the original sand drains and gravel piles. The PVD are composed of plastic core for protected by fabric filter with a longitudinal channel. The most common band shaped drains have dimensions of 100mm$\times$ 4mm.

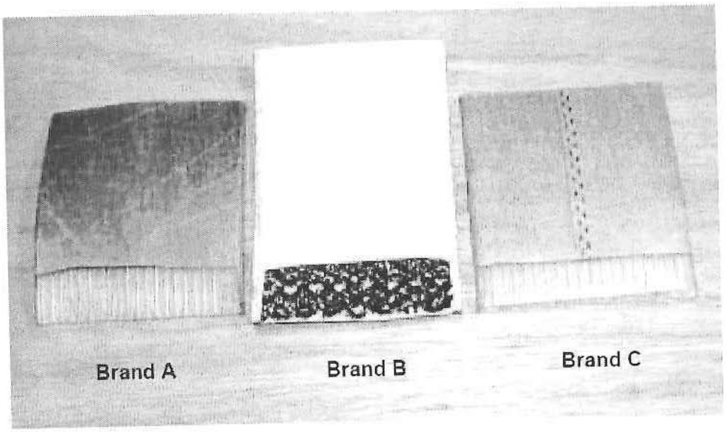

Figure 2.5 A typical Geotextile wrapped Prefabricated Vertical Drain.[5]

2.3 Solar Energy

The energy supplied from the sun is truly enormous on average; the earth's surface receives about $1.2 \times 10^{17} Watt$ of solar power. Less than one hour enough energy is supplied to Earth to satisfy the entire energy demand of the human population over the whole year. Energy from the sun travels to the earth in the form of electromagnetic radiation similar to radio waves, but difference frequency range. The amount of energy available from the sun outside the earth atmosphere is approximately $1367 W/m^2$, that nearly the same as the high power hair drier for every square meter of sunlight. Some of the solar energy is absorbed as it passes through the earth atmosphere. On a clear day, the amount of solar energy are available at the earth's surface in the direction of sun in the typically $1000 W/m^2$. At any particular time, the available solar energy is primary dependent upon how high the sun is in the sky and current cloud conditions.

2.3.2 History of solar energy

The design and construct devices for supplying renewable energy was began some 100 years before that turbulent time-ironically, at the very height of the Industrial Revolution, which was largely founded on the promise of seemingly inexhaustible supplies of fossil fuels. Human believe that in less than 50 years, this pioneers developed an impressive array of innovative techniques for capturing solar radiation and using it to produce the steam that powered the machines of that era. Unfortunately, despite their technical successes and innovative design, their work was largely forgotten for the next 50 years in the rush to develop fossil fuels for an energy-hungry world.

2.3.3 Types of technologies

Many technologies use solar energy. Some classifications of solar technology are active, passive, direct and indirect.

2.3.3.1 Water Heating

Solar hot water systems use sunlight to heat water. Commercial solar water heaters began appearing in the United States in the 1890s. These systems saw increasing use until the 1920s but were thereafter gradually replaced by relatively cheap and more reliable conventional heating fuels. The economic advantage of conventional heating fuels has varied over time resulting in periodic interest in solar hot water; however, solar hot water technologies have yet to show the sustained momentum they lost in the 1920s. That being said, the recent price spikes and erratic availability of conventional fuels is renewing interest in solar heating technologies. [6][7]

As of 2005, the total installed capacity of solar hot water systems is 88 GWth and growth is 14% per year. China is the world leader in the deployment of solar hot water systems with 80% of the market. Israel is the per capita leader in the use of solar hot water with 90% of homes using this technology.[8][9] In the United States heating swimming pools is the most successful application of solar hot water.

Solar water heating is highly efficient (up to 87%) and is particularly appropriate for low temperature (25-65 $°C$) applications such as domestic hot water, heating swimming pools and space heating. The basic components of a solar water heating systems are solar thermal collectors, a storage tank and a circulation loop. The three basic classifications of solar water heaters are:

1. Batch systems which consist of a tank that is directly heated by sunlight. These are the oldest and simplest solar water heater designs, however; the exposed tank can be vulnerable to cool down.
2. Active systems which use pumps to circulate water or a heat transfer fluid.
3. Passive systems which circulate water or a heat transfer fluid by natural circulation. These are also called thermo siphon systems.

Solar water heaters are also classified by the type of circulation loop used to transmit and deliver heat. These can be direct and indirect.

1. Direct solar hot water systems use a single loop to heat and deliver hot water.

2. Indirect solar hot water systems use a primary loop to capture heat, a heat exchanger and a secondary loop to deliver hot water.

2.3.3.2 Photovoltaic

Solar cells, also referred to as photovoltaic cells, are devices or banks of devices that use the photovoltaic effect of semiconductors to generate electricity directly from sunlight. Until recently, their use has been limited because of high manufacturing costs. One cost effective use has been in very low power devices such as calculators with LCDs. Another use has been in remote applications such as roadside emergency telephones, remote sensing, cathode protection of pipe lines, and limited "off grid" home power applications. A third use has been in powering orbiting satellites and spacecraft.

To take advantage of the incoming electromagnetic radiation from the sun, solar panels can be attached to each house or building. The panels should be mounted perpendicular to the arc of the sun to maximize usefulness. The easiest way to use this electricity is by connecting the solar panels to grid tie inverter. However, this solar panel may also be used to charge batteries or other energy storage device. Solar panels produce more power during summer months because they receive more sunlight.

Figure 2.6 Photovoltaic (PV) modules are composed of multiple PV cells.[10]

Total peak power of installed PV is around 6000MW as of the end of 2006. Installed PV is projected to increase to over 9000MW in 2007. This is only one part of solar-generated electric power.

Photovoltaic systems come in two general configurations: Flat-plate PV Systems and Concentrator PV Systems.

Flat-plate PV System- Flat-plate collectors typically use a large number of cells mounted on a rigid flat surface installed at fixed angle optimal for year-round collection of sunlight. Flat-plate systems use both direct sunlight and diffuse sunlight that is reflected from clouds, the ground, and objects.

Concentrator PV Systems- Concentrator systems which use a limited number of small, specialized, efficient solar cells and concentrating optics to increase the intensity of sunlight striking the cells, come in two configurations: point-focus and line-focus.

Point-focus systems use reflective parabolic dishes or circular Fresnel lenses (which use saw-tooth grooves in a plastic sheet) to focus sunlight onto cell mounted at the focal point. Figure 2.7 show how a solar dish engine system is an electric generator that "burns" sunlight instead of gas or coal to produce electricity. The dish, a concentrator, is the primary solar component of system, collecting the energy coming directly form the sun and concentrating it on a small area. A thermal receiver absorbs the concentrated beam of solar energy, converts it to heat, and transfers the heat to the engine or generator.

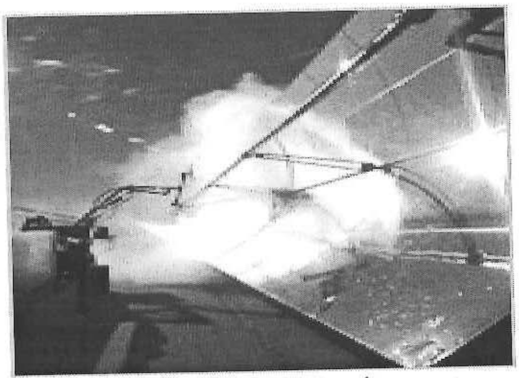

Figure 2.7 A solar dish-engine system. [10]

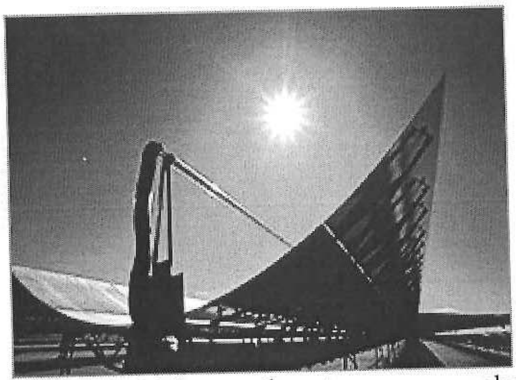

Figure 2.8 The sun bursts over a parabolic trough at Kramer Junction in Boron, California.[10]

Line-focus systems use linear parabolic reflectors a linear Fresnel lenses to focus sunlight on cells mounted along the focal line. Typically, concentrator systems use two-axis tracking to track the sun and minimize the amount of direct sunlight captured. Show in figure 2.8. During operation, oil in the receiver collects the concentrated solar energy as heat and pumped to power block for generating electricity.

2.3.4 Advantages and Disadvantages of Solar Energy

Solar energy has the following advantages over conventional energy:

1. Solar energy is free. Its needs no fuel and produces no waste or pollution.
2. The energy from the sun is virtually free after the initial cost has been recovered.
3. In the sunny countries, solar power can be used where there is no easy way to electricity to a remote place.
4. Depending on the utilization of energy, paybacks can be very short when compared to the cost of common energy sources used.
5. Solar and other renewable energy systems can be stand-alone; thereby not requiring connection to power or natural gas grid.
6. Handy or low-power uses such as solar powered garden lights and battery chargers.
7. The sun provides a virtually unlimited supply of solar energy.
8. The use of solar energy displaces conventional energy; which usually results in a proportional decrease in green house gas emissions.
9. The use of solar energy is an untapped market.

The Solar Disadvantages

1. Doesn't work at night.
2. Very expensive to build solar power stations. Solar cells cost a great deal compared to the amount of electricity and produce for their lifetime.
3. Can be unreliable unless in a very sunny climate. In the United Kingdom, solar power isn't much use except for low-power applications, as if need a very large area of solar panels to get a decent amount of power.

2.3.5 Comparison of solar energy

No.	Collector	Descriptions	Characteristic
1.	Photovoltaic	1) Semiconductor devices, made of silicon, which contain no liquids, corrosive chemicals or moving parts. 2) They produce electricity as long as light shines. 3) Require little maintenance 4) Do not pollute and operate silently. 5) Making photovoltaic energy the cleanest and safest method of power generation.	1) Size(10 cm by 10 cm) 2) 12-volt module, for example, depending on its power output, could have 30 to 40 PV cells. 3) A module producing 50 watts of power measures approximately 40 cm by 100 cm.
2.	Parabolic	1) This is used to power a furnace producing steel from iron ore. 2) Shaped mirrors (parabolic in shape) 3) This type of set up works at its best in desert areas where there is no shortage of sunlight and very little cloud. 4) This system works well in desert regions due to the hot climate.	1) 63 flat mirrors automatically track the sun and concentrate the light on a reflector. The reflector then concentrates 2) the rays produce 1000 kilowatts 3) The temperature of 33,000degrees centigrade.

3.	Mirror	1) The high heating rates make ideal tool for testing high-temperature materials, coatings on metals and ceramics, and other materials-related applications. 2) To evaluate and develop state-of-the-art measurement systems for the extreme solar environment.	1) 10-kilowatt 2) 25 hexagonal mirrors to concentrate solar radiation. 3) The solar can provide flux at 2,500 suns levels

Table 2.1 Comparison of solar energy

2.4 Thermal Control

2.4.2 History of Control System

The first significant work in automatic control was James Watt's centrifugal governor for the speed control of a steam engine in the eighteenth century. Other significant works in the early stages of development of control theory were due to Minorsky, Hazen, and Nyquist, among many others. In 1922, Minorsky worked on automatic controllers for steering ships and showed how stability could be determined from the differential equations describing the system. In 1932, Nyquist developed a relatively simple procedure for determining the stability of closed-loop systems on the basis of open-loop response to steady-state sinusoidal inputs. In 1934, Hazen, who introduced the term servomechanisms for position control systems, discussed the design of relay servomechanisms capable of closely following a changing input.

During the decade of the 1940s, frequency-response methods made it possible for engineers to design linear closed-loop control systems that satisfied performance requirements. From the end of the 1940s to the early 1950s, the root-locus method due to Evans was fully developed.

A system is a combination of components that act together and perform a certain objective. A system is not limited to physical ones. The concept of the system can be applied to abstract, dynamic phenomena such as those encountered in economics. The word system should, therefore, be interpreted to imply physical, biological, economic, and the like, systems.

2.4.3 Example of Control System

2.4.3.1 Temperature Control System

In figure below shows a schematic diagram of temperature control of an electric furnace. The temperature in the electric furnace is measured by a thermometer, which is an analog device. The analog temperature is converted to a digital temperature by an A/D converter. The digital temperature is fed to a controller through an interface. This digital temperature is compared with the programmed input temperature, and if there is any discrepancy (error), the controller sends out a signal to the heater, through an interface, amplifier, and relay, to bring the furnace temperature to a desired value.

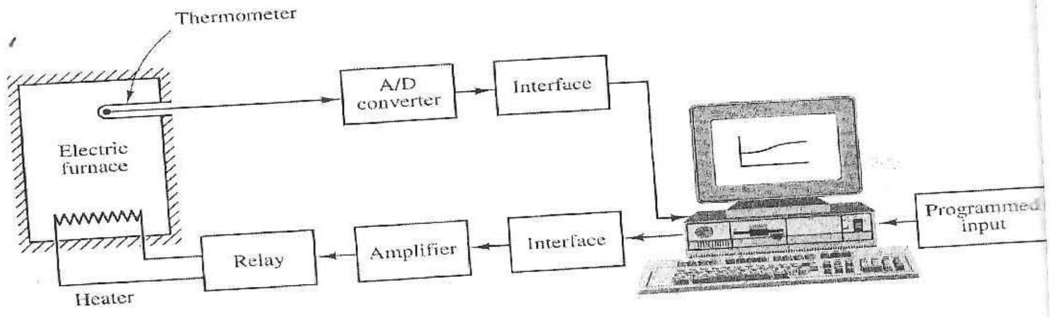

Figure 2.9 Temperature control system.[6]

2.4.3.2 Thermal Control System

The inside of the canister was maintained at a near constant temperature by a closed loop fluid. The fluid loop transferred heat dissipated by the telescope from the canister wall and the cold plates to the radiator. Heat was then rejected to space. The fluid would enter a pump and then it would be filtered and split into two parallel paths. It would then go to radiators and heater legs. A mixing valve, positioned by an Electrical Control Assembly that monitors the canister inlet temperature would proportion the flow through the legs.

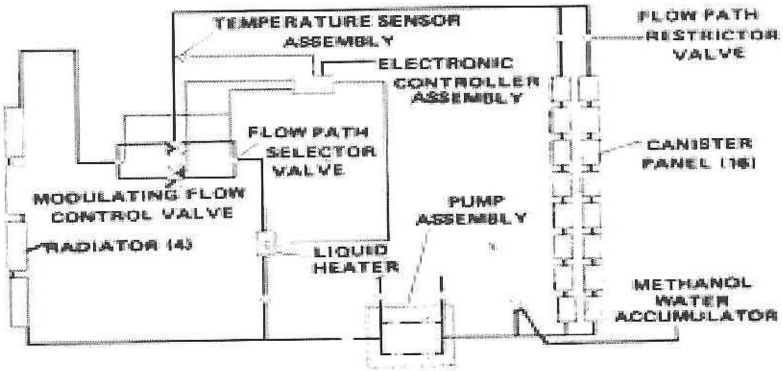

Figure 2.10 Thermal Control System.[19]

2.4.4 Passive Thermal Control Components

2.4.4.1 Phase Change Devices

Phase change devices absorb thermal energy by changing from a solid to liquid. As the temperature decreases, the material re-solidifies. It is especially useful foe electrical equipment that experiences short power spikes. The main disadvantage of phase change devices is that they are unable to absorb any more heat after melting, which allows the temperature to increase. A common type of phase change device is some type of wax in an aluminum container. These devices can be used between the cold plate and the primary heat dissipation device.

2.4.4.2 Thermal Control Coating

Thermal control coating surfaces, such as black and white paints, and gold, silver, and aluminum foils, that have special radiation properties. Coatings may be combined to obtain a more desirable average value for α_s and ε (e.g. a checkerboard pattern). In general, it is desirable to have a high value of ε and low value of α_s in order to minimize the heat rejection into space and to minimize the solar input. Thermal coatings are very efficient and lightweight. Unfortunately, they will degrade over time.

2.4.4.3 Multi Layer Insulation(MLI)

Multi layer insulation closely spaced layers of aluminized Mylar or Kapton alternated with a course net material. Insulation reduces the rate of heat flow per unit area between two boundary surfaces and prevents a large heat influx. Sensor and payloads can be wrapped in insulation blankets to thermally isolate them and reduce thermal control requirements.

2.4.4.4 Thermal Doublers

Thermal doublers a heat sink made of a highly conductive material placed in thermal contact with component. Heat is conducted to the sink during an increase in