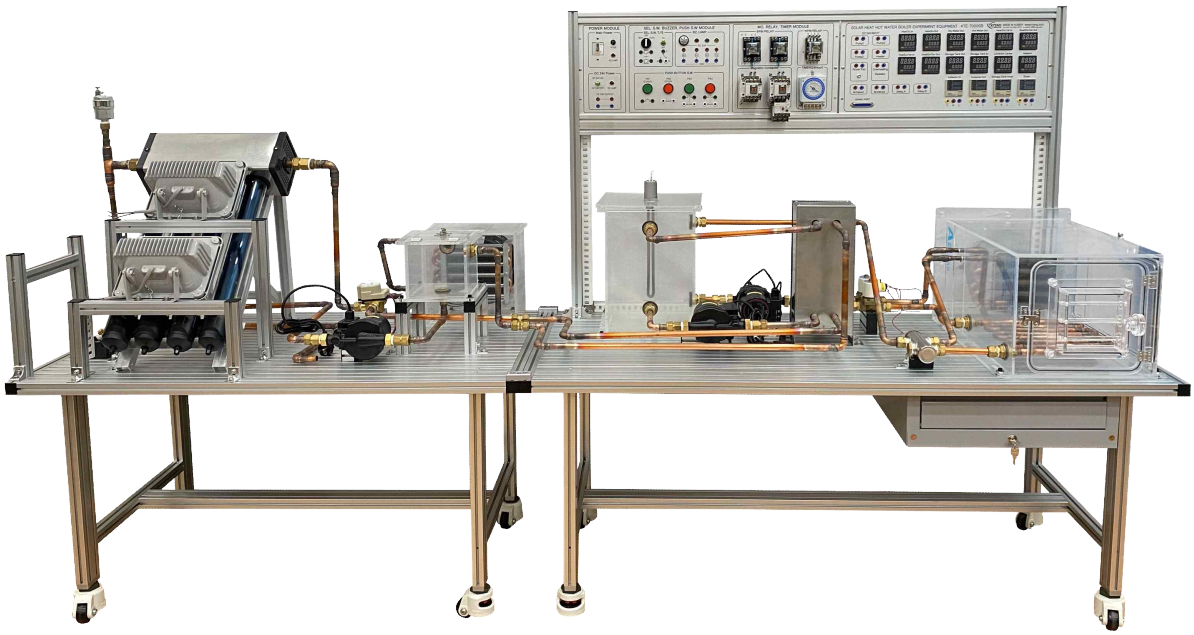
Model : KTE-7000SB

SOLAR HEAT HOT WATER BOILER EQUIPMENT

USAGE MANUAL



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Korea Technology Engineering Co.,Ltd.

CONTNET

1. Explanation of Solar Heat Hot Water Boiler System

1-1. Introduction

Sun holds an infinite amount of energy. Amount of energy the Earth receives from the Sun is incalculably large and the energy will be sustained as long as the Sun exists. 2.4×1015kcal/min or 1.7×1014kW of energy from the Sun is reflected on the atmospheric layer of the Earth and about 35% of the stated amount is reflected out on the atmosphere, 18% is absorbed into the atmosphere, causing wind, and about 47% reaches the actual surface of the Earth.

The solar heat systems can be divided into a passive system and an active system, depending on the existence of a driving gear on the thermal medium. The former mainly uses building constructions, such as greenhouse, south-facing windows and flat screen, to collect and use solar heat. The latter is the so-called solar energy system and it uses a driving gear of the thermal medium, such as pump, by installing a separate energy collector, to collect solar energy.

KTE-7000SB (Solar energy hot water test equipment) is an active system, described above. It uses the solar energy collecting technology, thermal storage technology and system control technology. The system allows its users to easily understand the principles of heating, cooling and hot-water supply in building through absorption, storage and conversion of solar energy.
Moreover, users can test performances of the 3 different types of heat exchanger (Pin, Fan and Coil types) with different ways of heat exchange.

The Sun is the most natural and sustainable energy source, which is critically important now, when there is a global insufficiency of energy and rising importance of the new reuseable energy. Thus, KTE-7000SB (Solar energy hot water test equipment) is an equipment that allows the easiest understanding on the heating and hot-water system using the solar energy.

1-2. Image of experiment equipment

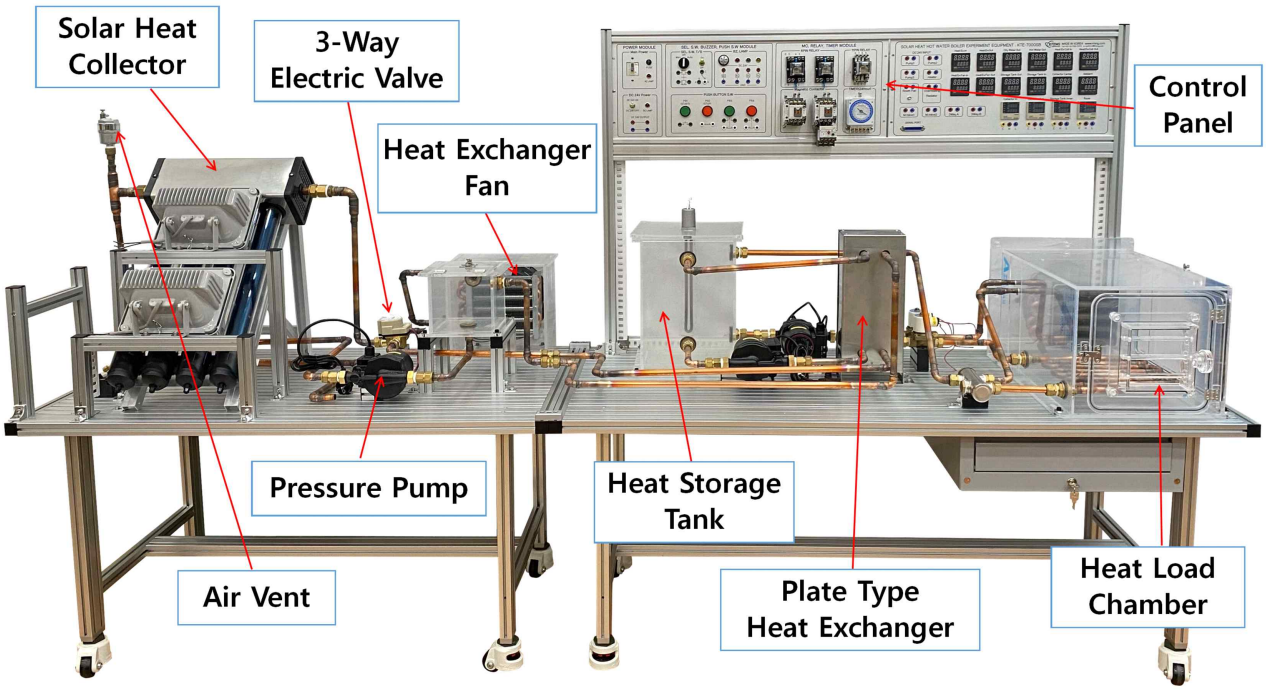


Fig. Image of Solar heat energy hot water boiler experiment equipment

2. Components of the Equipment

2-1. Description of the mechanical parts

(1) Solar Heat Collector

[Fig 2.1] Solar Energy Collector

1. Name: Solar energy collector
2. Type: Heat Pipe Type (ETC)
3. Specification: 400 x 600 x 100 mm
4. The solar energy collector effectively collects the radiant energy from the Sun. It consists of a clear cover, heat absorber plate and insulator.

(2) Heat Storage Tank

[Fig 2.2] Storage Tank

1. Name: thermal storage tank
2. Material: Acrylic
3. Heater capacity: 1 kW
4. The thermal storage tank stores heat collected from the collector so that the heat can be converted into a useful energy later.

(3) Heat Exchanger for prevent overheat

[Fig 2.3] For prevent overheating

Condenser is a device that condenses a high pressure and temperature refrigerant discharged from compressor into liquid by extracting heat of the refrigerant to outside air or cooling fluid e.g. cold water. The reason we make it into liquid phase is to utilize the potential heat when the phase changes. In order to absorb the heat from evaporator, the best performance comes out when using potential heat, that is, when it changes from liquid phase to gas phase.

(4) Heat exchanger fan type

[Fig 2.4] Modified Inside Building (For load)

1. Power : DC24V, 1.2A
2. Capacity : 1/4HP
3. Size : 400×250×250mm
4. Fan speed controll
5. Fan type heat exchanger role is that sending warm air into the room by release boiling water on solar collector into the constant temperature air.
   This device is for release heat source through exchanging between cold air and warm water which was supplied from heat storage or boiler system.

(5) Plate Type Heat Exchanger

[Fig 2.5] Plate type heat exchanger (Blazing Type)

1. Type: Plate type heat exchanger (water-to-water)
2. Capacity: 10,000 kcal/h
3. Specification: 80 × 35 × 190mm
4. The heat exchanges high temperature collected in the heat collector with the low temperature inside the heat tank. The primary heat source is the heat collecting medium, which uses antifreeze substance to prevent freezing in winters, and the secondary heat source is water, which is used as hot water and heating water.

(6) Circulation Pump

1. Name: Pressure pump
2. Flux: Max. 1.8 m3/h
3. Lift: Max. 9m
4. 3 functional modes available
5. The pressure pump supplies water from the make-up water tank to system pipes when there is a lack of circulating water inside the solar hot water boiler system.

[Fig 2.6] Pressure Pump

(7) Air Vent

Once air remains inside the pipes, it disturbs flow of water and vapors as well as significantly deteriorates the performance of radiator. Thus, the air vent discharges air from the top of the pipe.

[Fig 2.7] Air Vent

(8) 3-way electric valve

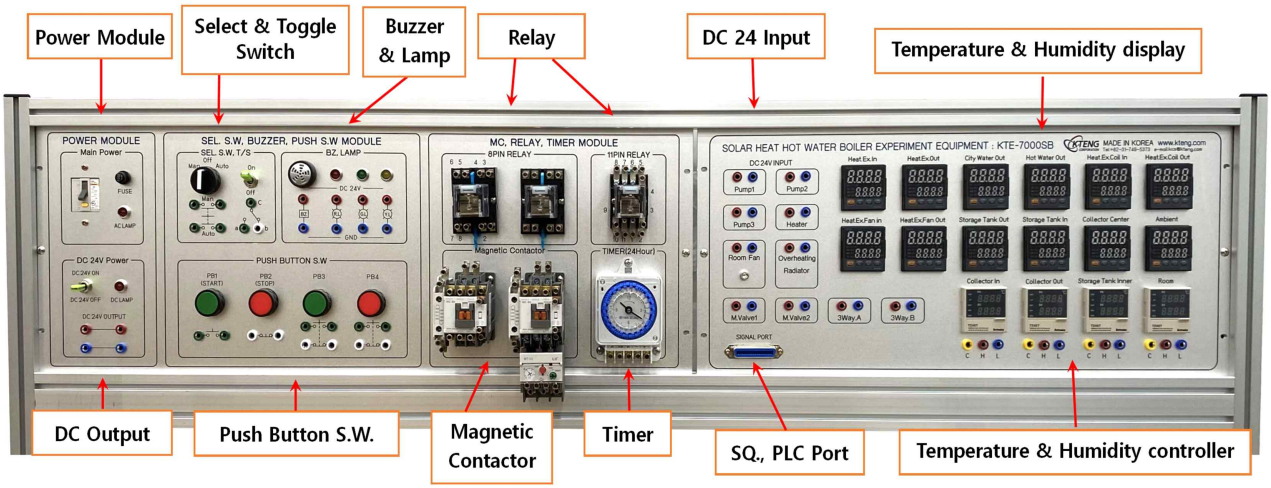
1. Name: 3-way electric valve
2. Model: STV-300
3. Characteristics

The 3-way electric valve is used to tightly close or open the flow ways in both directions and it functions as a convertor of the heating water inside water tank or boiler.

[Fig 2.8] 3-way valve

2-2. Description of control Panel

(1) Control Panel



(2) Control Terminal

· Pump 1 : Heat Collector → Plate HX Circulation Pump
· Pump 2 : Plate HX → Storage Tank Circulation Pump

· Pump 3 : Storage Tank → Heat Coil (Chamber) Circulation Pump
· Pump 4 : Storage Tank → City Water Tank Circulation Pump

· Pump 5 : Supply Water Tank Circulation Pump
· Heater : Storage Tank Heater

· Room Fan : Fan Motor Room Chamber
· Overheating Radiator : Fan Motor For Prevent Overheat

· 3 Way_A : Collector → Plate Heat Exchanger
· 3 Way_B : Collector → Overheating Radiator

· M.Valve 1 : Solenoid Valve for Room Fan
· M.Valve 2 : Solenoid Valve for Heat Coil

Components that input power to each load, Connect to Red (+), Black (-)

(3) Temperature Display

· **Ambient** : Outdoor Air
· **Heat Ex. In** : Collector → Plate HX Inlet
· **Heat Ex. Out** : Plate HX Outlet → Storage tank
· **City Water Out** : Hot Water inside chamber coil

· **Hot Water Out** : Storage tank out → Hot water tank
· **Heat Coil. In** : Heat coil in Chamber Inlet
· **Heat Coil. Out** : Heat coil in Chamber outlet
· **HE. Fan. In** : Heating fan in Chamber Inlet

· **HE. Fan. Out** : Heating fan in Chamber Outlet
· **Storage Tank Out** : Storage tank out → Chamber
· **Storage Tank In** : Chamber → Storage tank in
· **Collector Center** : Center of solar collector

By displaying the temperature of the main part of the solar hot water boiler equipment, the user can see the operating status of the system through the temperature displayed in real time.

(4) Temperature Controller

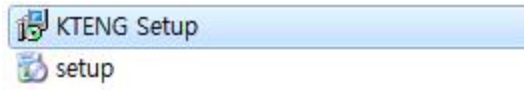
· **Collector In**
: Temp at collector inlet
· **Collector Out**
: Temp at collector outlet
· **Storage Tank Inner**
: Temp inside of storage
· **Room**
: Temp inside of chamber

① Select temperature value to set the value
② Enter the value by raising or lowering the temperature value
③ Select offset value
④ Input to 'C' connect to (=)
⑤ Connect (+) to H or L depending on the load to control

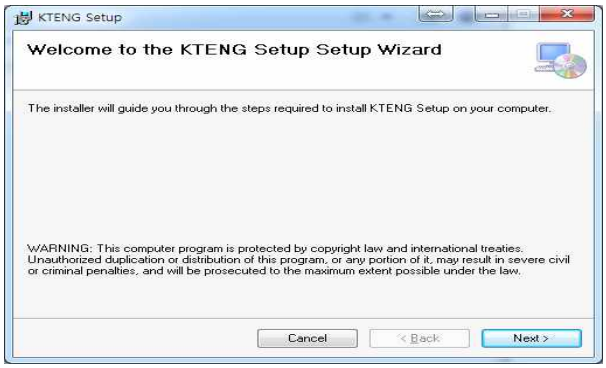
3. Data Acquisition device between PC and machine

3-1. Installation Data Acquisition Program

(1) KTE-DA100 Installation



① You can see a installation files that in CD or USB for installation then double click 'KTENG Setup' file to start installation. If the progrma cannot be installed using 'KTENG Setup', try to 'setup file.



② If you can see a 'Setup Wizard' screen, click the 'Next>'.

③ You can change a installation route. If you want to change a installation route. click the 'Browse..' and find a new route then click the 'Next>'

(2) Installation to USB driver

1) Communication method is using computer and RS232 protocol for communication.
2) If you got a desktop which is connected with Serial Port back. you don't have to install USB To Serial.
3) If you got a desktop which doesn't have note book or Serial Port, you need to install progress for collecting data using USB Port.

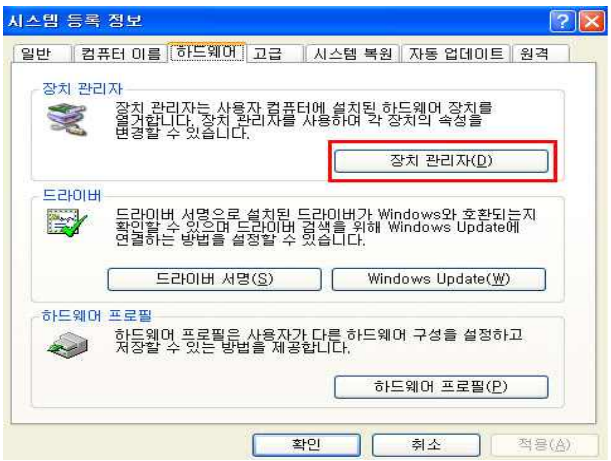
① Installation to USB_RS232 Driver on PC or Labtop

② After reading “2012591631_USB_to_Serial_Converter”, Following screen is indicated. And double click

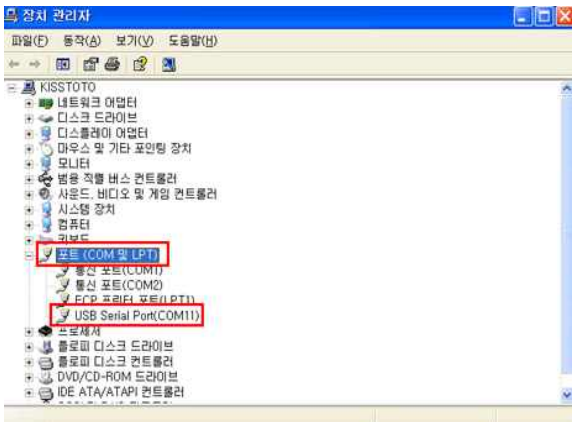
③ You can check this screen as below. Double click this icon “CDM20600”, and after installation to driver on PC or Labtop

④ Method to set Communication Port
Click “Start”//Option//into Control Panel.
Double click “System” in Control Panel.

⑤ Click the “Hardware tap”.

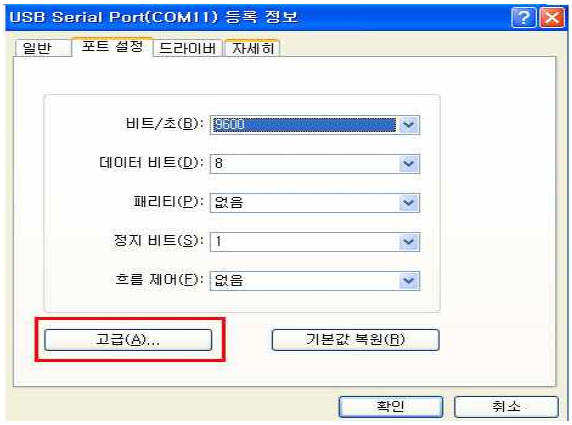


⑥ Click “Device Administrator. Next you can check the USB port number.



⑦ When you click like picture, emerge USB SERIAL PORT. After mouse right click “USB SERIAL PORT” and click “Attribute.”

⑧ Click “Port option”



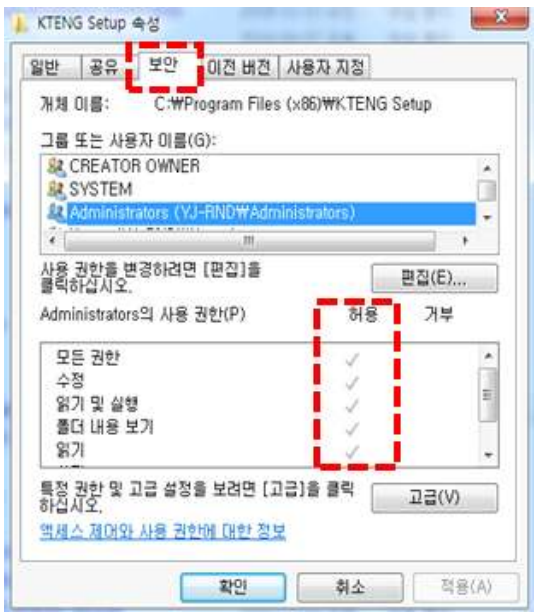
⑨ Click “High rank”

⑩ After setting appropriately to port for user equipment. Click OK.

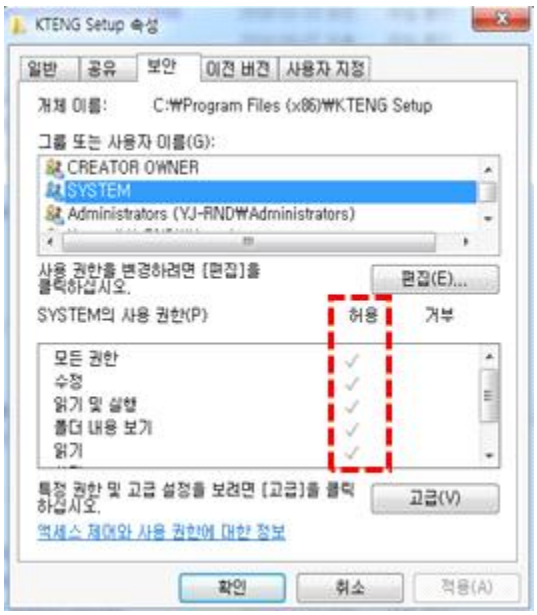
⑪ Locate the folder where DA100 is installed on the Local C:Drive. Find : "KTENG Setup"

⑫ Right Click "Property"

⑬ You should enter the "Security"and Check all allow "Administrations"

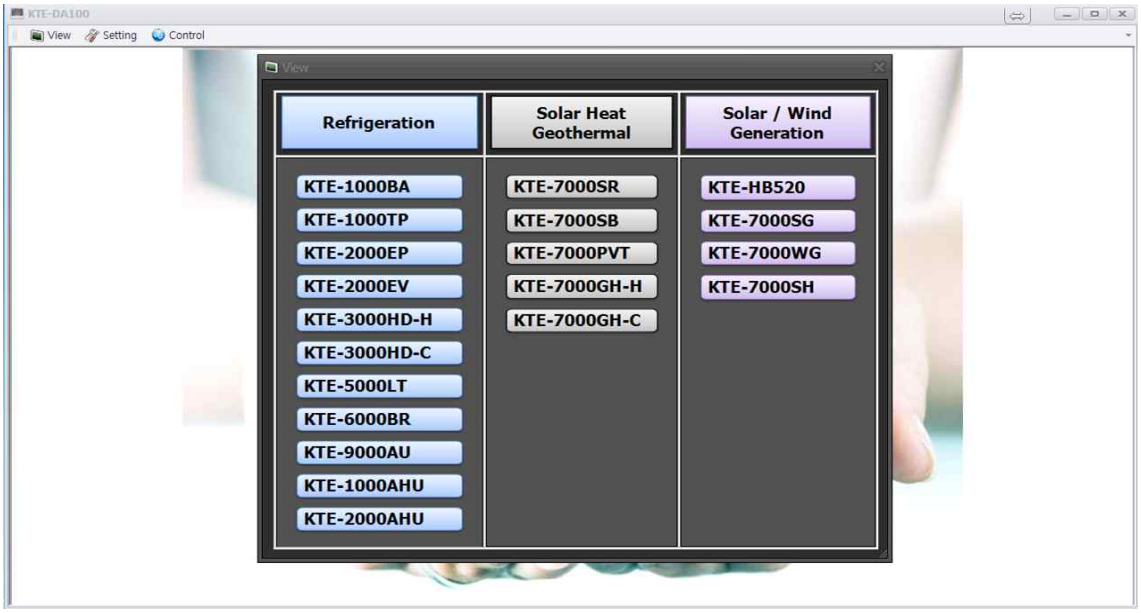


⑭ You should check again all allow "SYSTEM"



(3) Composition of DA100

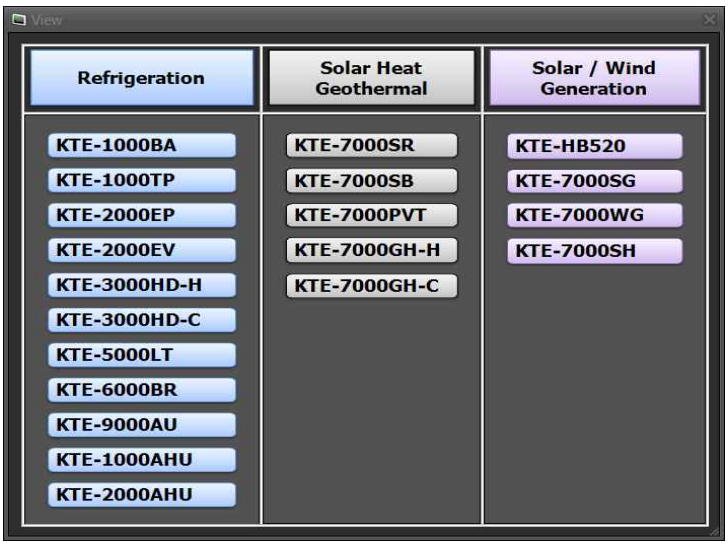
1) Start program by using icon in wallpaper or routing folder then the main page of program come up.



Model.	Equipment	Model.	Equipment
KTE-1000BA	Standard Refrigeration Eqxperiment Equipment	KTE-7000SR	Solar Radiation Energy Experimental Equipment
KTE-1000TP	Temperature, Pressure & Defrost Control Refrigeration Equipment	**KTE-7000SB**	**Solar Heating Hot Water Boiler Experimental Equipment**
KTE-2000EP	Evaporation Pressure Parallel Control Experimental Equipment	KTE-7000PVT	PVT Performance Measuring Equipment
KTE-2000EV	Refrigerant Parallel Expansion Valve Experimental Equipment	KTE-7000GH-H	Geothermal Heat Pump Experimental Equipment
KTE-3000HD-H	4-Way Reverse Valve Control Heat Pump Experimental Equipment (Heating Mode)	KTE-7000GH-C	Geothermal Heat Pump Experimental
KTE-3000HD-C	4-Way Reverse Valve Control Heat Pump Experimental Equipment (Cooling Mode)	KTE-HB520	Hybrid Power Conversion Experimental Equipment
KTE-5000LT	Binary Refrigeration Experimental Equipment	KTE-7000SG	Solar Power Conversion Experimental Equipment
KTE-6000BR	Brine Refrigeration Experimental Equipment	KTE-7000WG	Wind Power Conversion Experimental Equipment
KTE-9000AU	Car Air-Conditioner Experimental Equipment	KTE-7000SH	Solar-Hydrogen Fuel Cell Experimental Equipment
KTE-1000AHU	Air-Conditioning Unit Automatic Control Equipment		
KTE-2000AHU	Air Handling Unit Lab-View Programming Equipment		

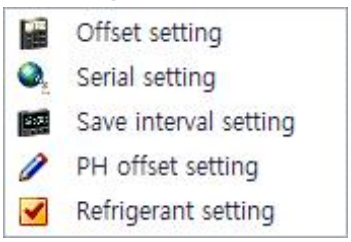
2) Main Menu Composition

3) View

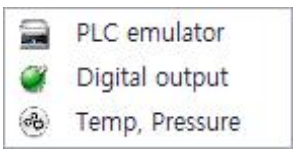


(Refrigeration 11, Solar Heat/Geothermal 5, Solar/Wind Generation 4)

4) Setting



5) Control



6) Setting

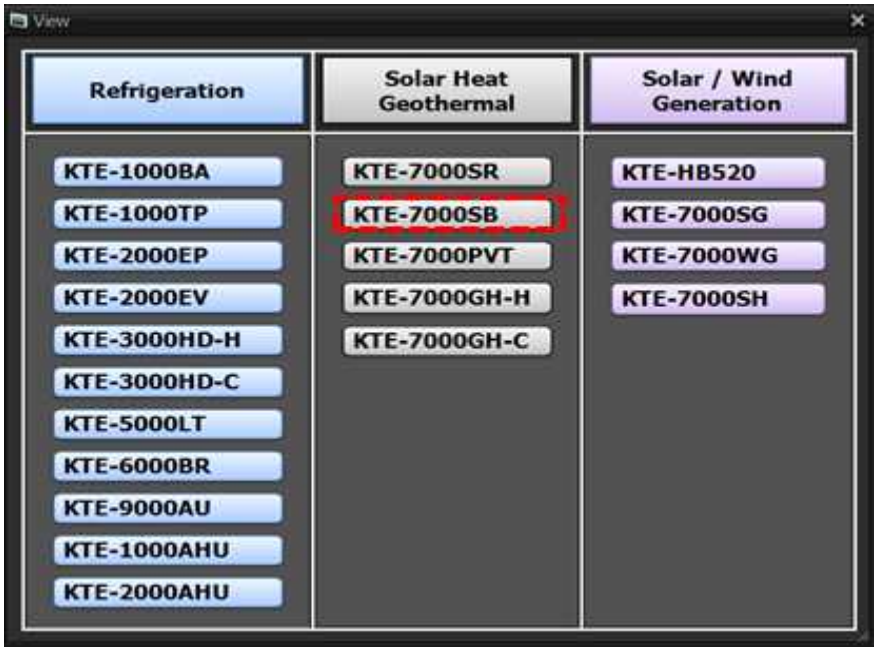
Menu	Explain
Offset Setting	Setting initial pressure, temperature
Serial Setting	Communicating port setting
Save Interval Setting	Setting data acquisition time interval
PH Offset Setting	Setting range of axis at p-h chart
Refrigerant Setting	Select refrigerants

7) Control

Menu	Explain
PLC emulator	Using PLC control
Digital output	Control a Hardware
Temp, pressure	Control a temperature, pressure

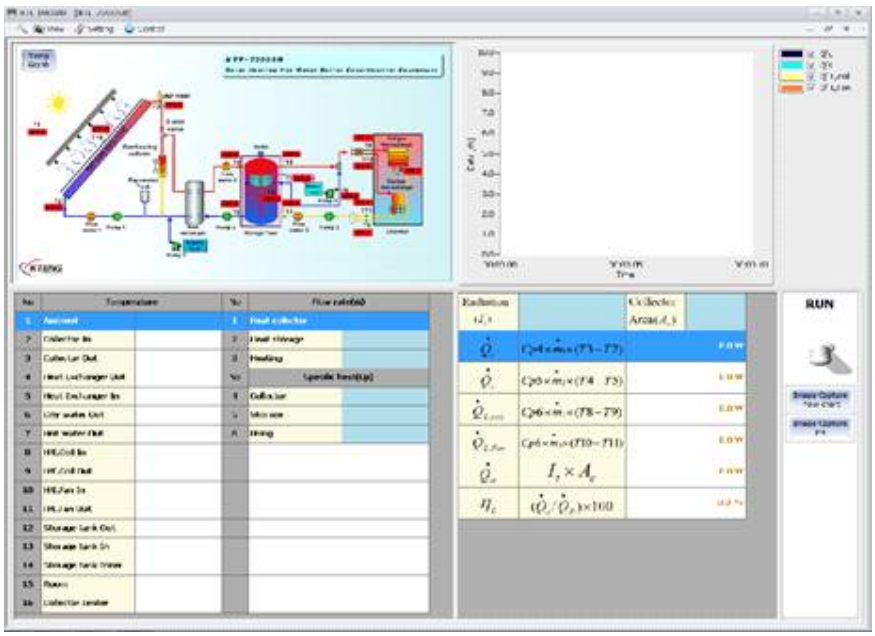
3-2. Utilities of KTE-DA100

(1) Selection of Model



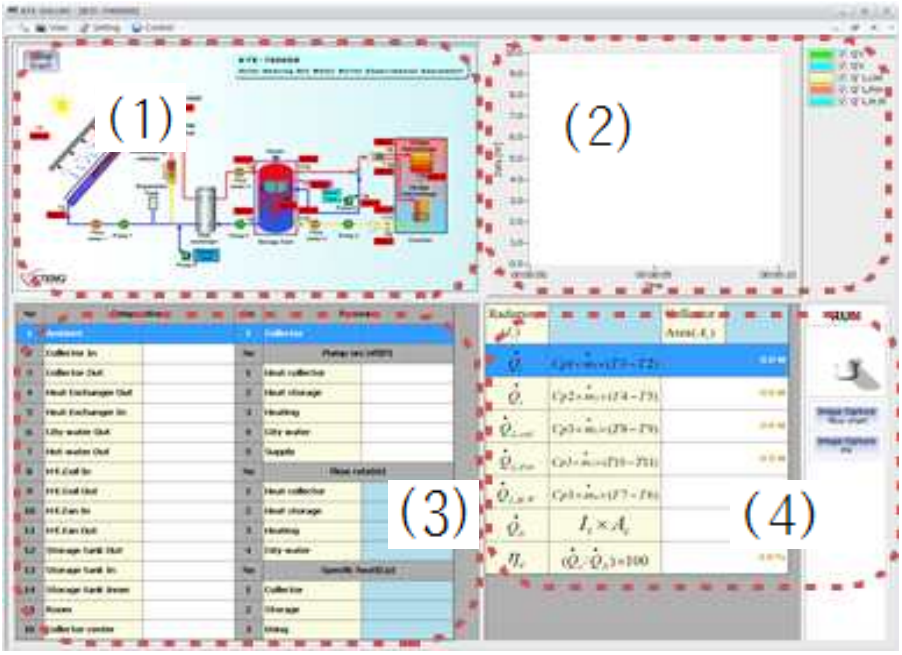
① When program started, 'View'screen is activated.

② Select a model what you want. (Click the KTE-7000SB)



③ Main user interface of KTE-7000SB(Solar Heating Hot Water Boiler Expermental Equipment) is activated.

(2) Composition of main user interface



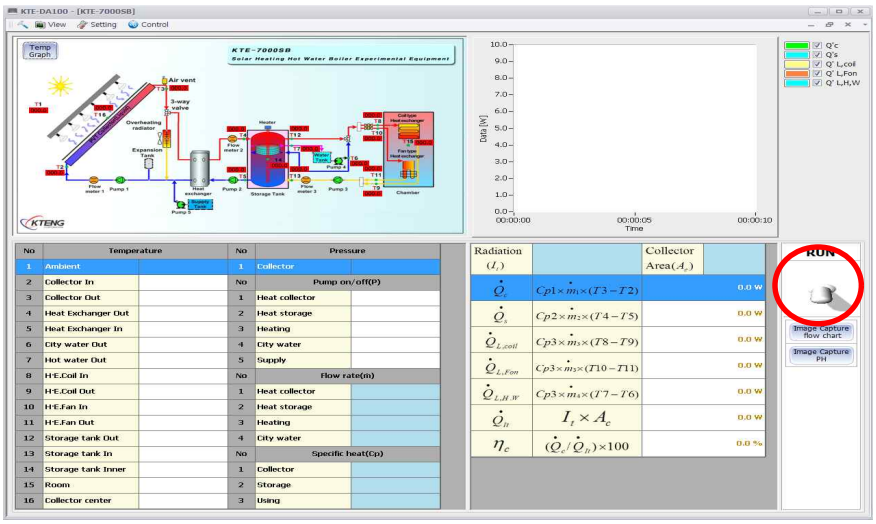
① Schematic diagram of system show temp, press. in realtime

② Temperature

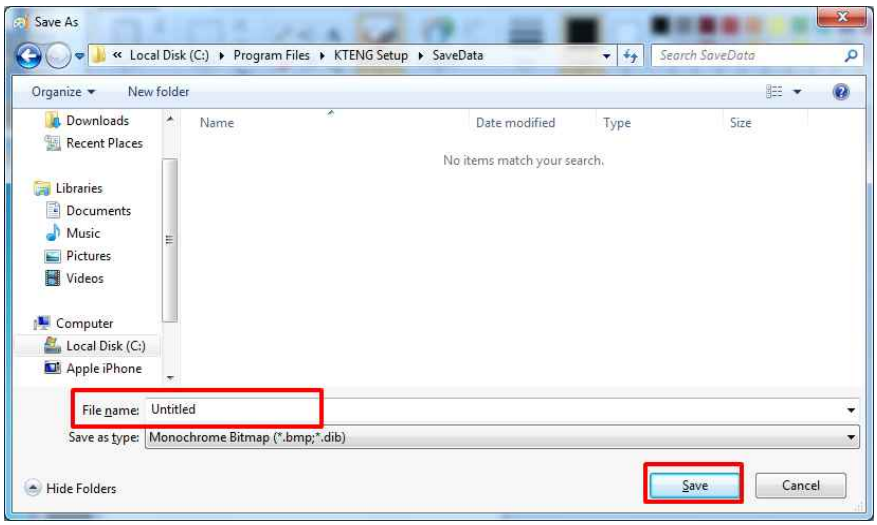
③ Data table of temp, press, and enthalpy

④ Calculation value of COP, cooling capacity, heat capacity in HX.

(3) Operating and saving data

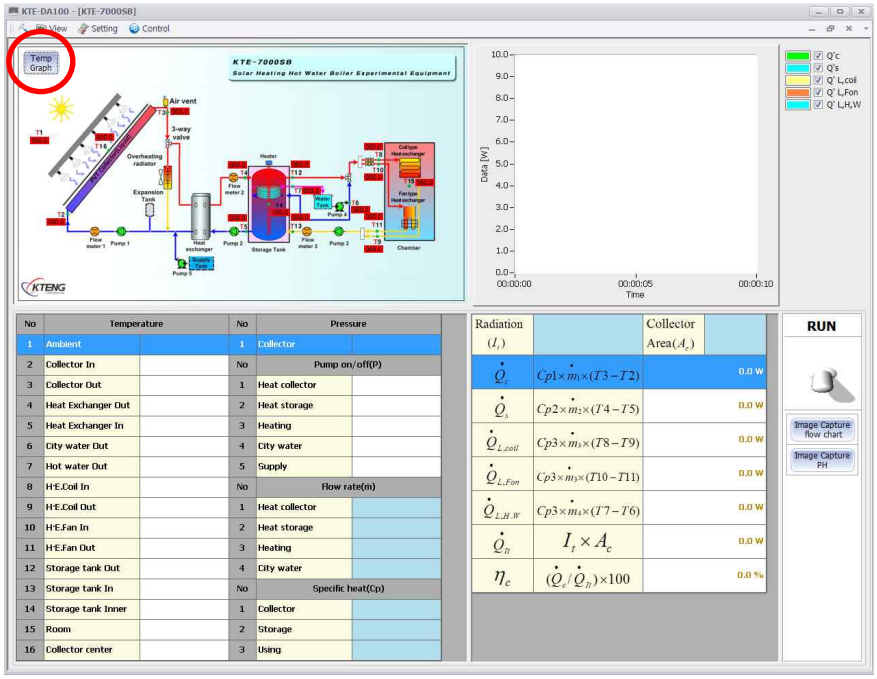


① Click a toggle switch to run program to save data.

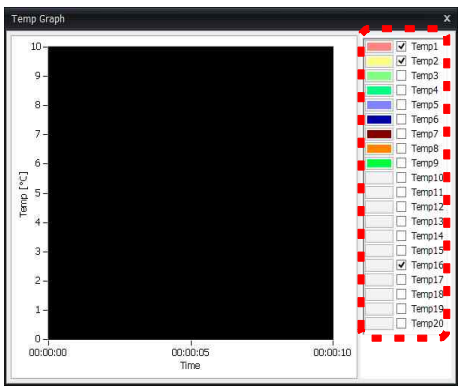


② Write a title and save a file by excel.

(4) Find a graph



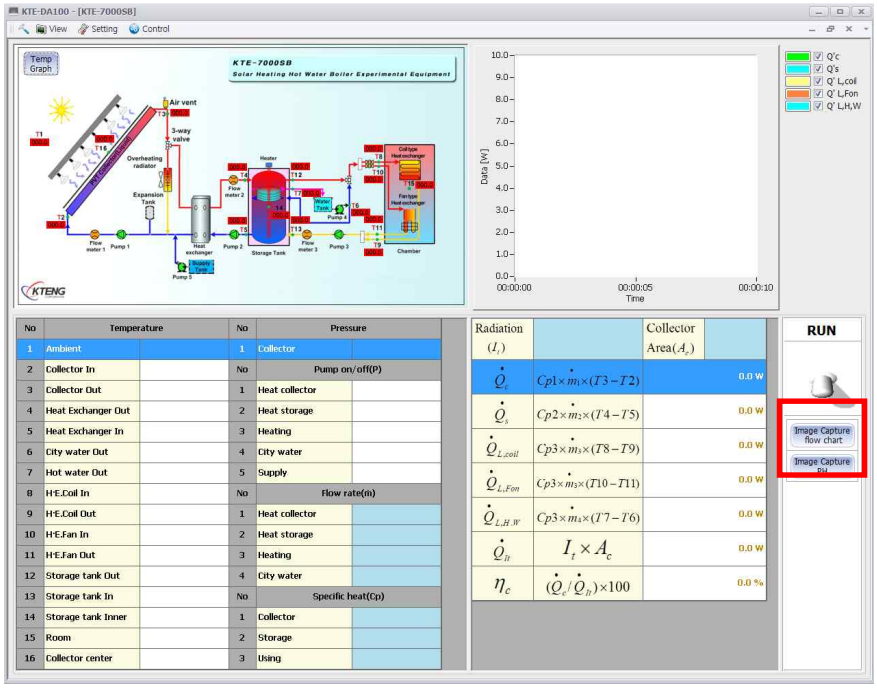
① If you want to see a temp., and press, graphically, please click a icon in red box below.



Temperature Realtime Graph

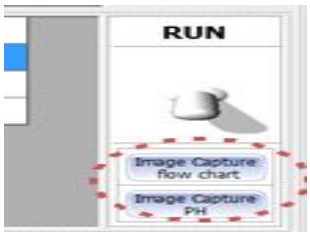
② You can always see the graph for location and figure through checking temperature, pressure

(5) Function for capture



①

The bottom of the right side, click Image Capture flow chart and Image Capture PH then it is saved to JPG files



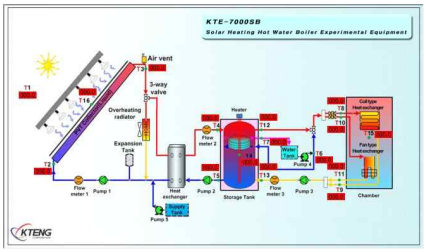
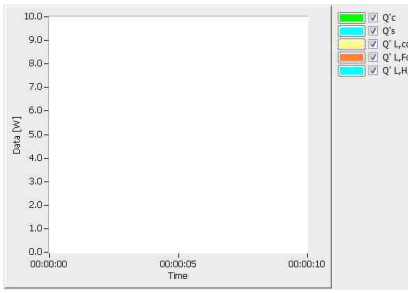


Diagram capture(Flow Chart)

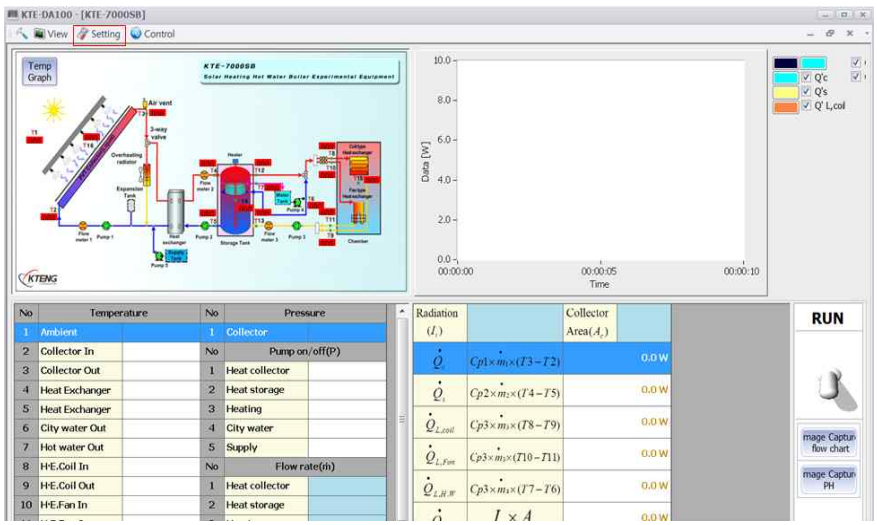


Heat graph capture

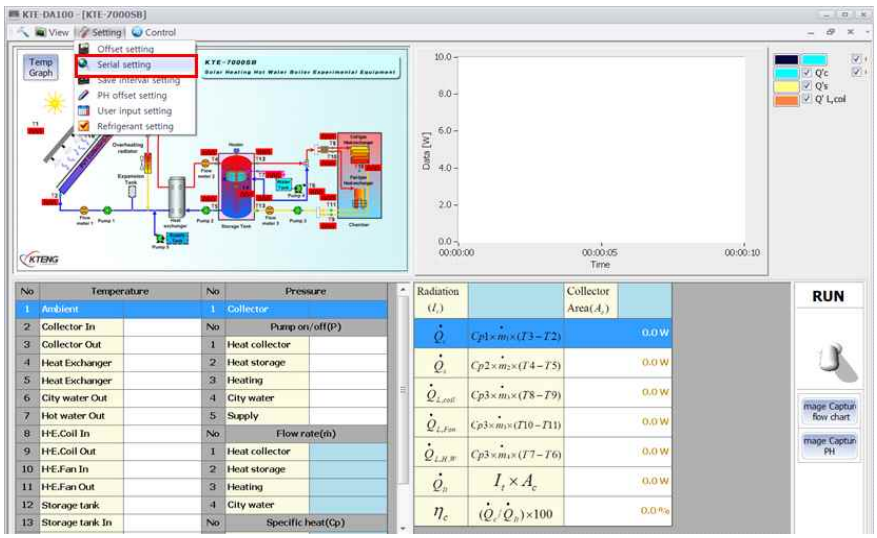
② Monitor when choosing

- Diagram(Flow Chart) capture
- Heat graph capture

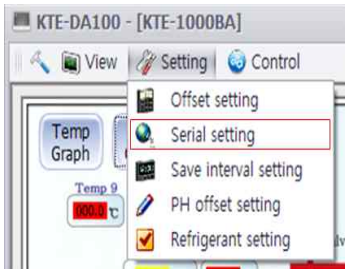
(6) Serial Setting



① Click Setting



② Click Serial setting

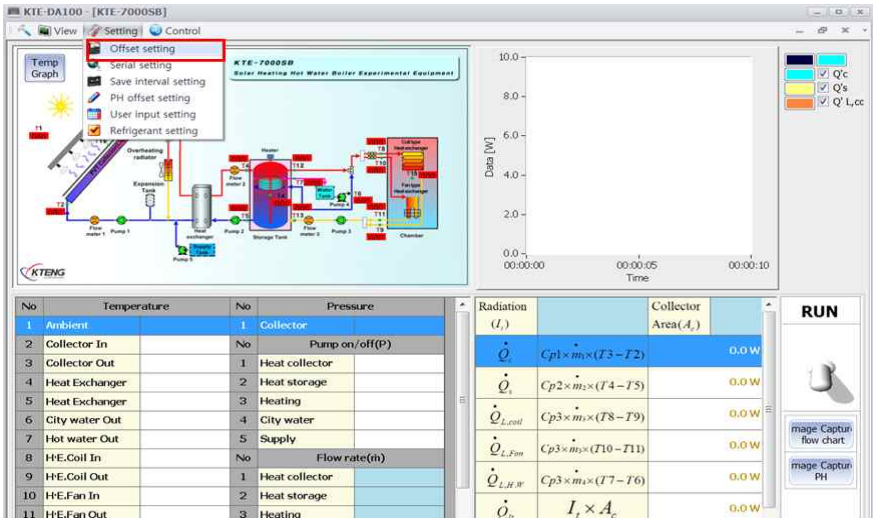


③

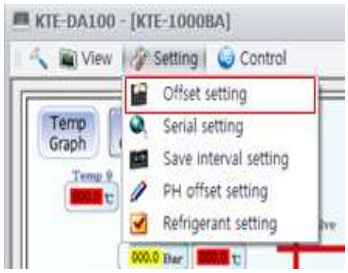
COM No is changed depend on port location. choose COM No and Click OK

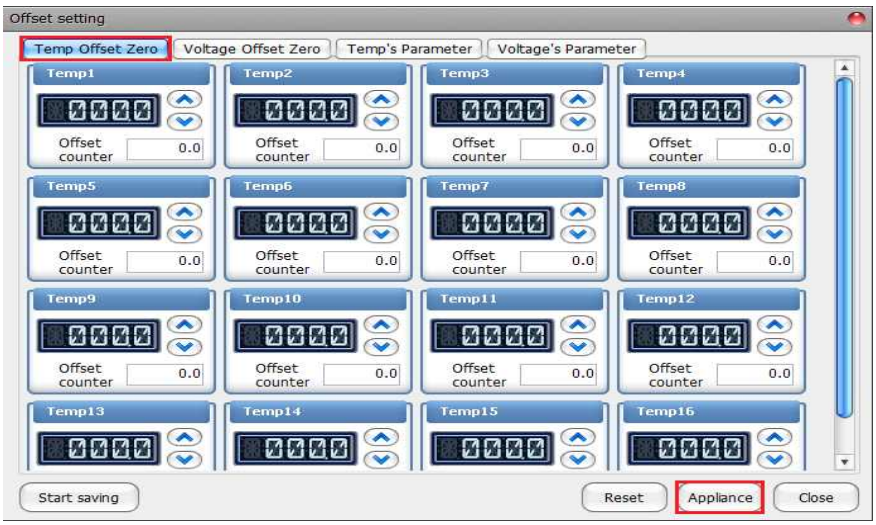
※Chcking port No is on Page_1-1 use to serial installation

(7) Offset Setting



① Click Offsetting





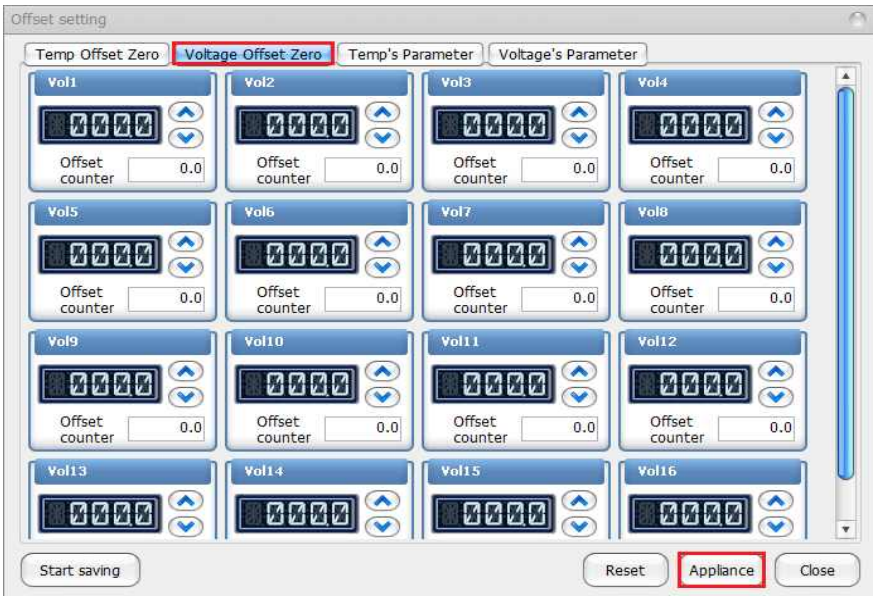
② Temp Offset Zero is that can control temperature

: You can control using direction key

: It is indication for temperature figure

Click the application then click the Close for applying the figure

*Refer : Temp No has twenty section which is separated as a sensor

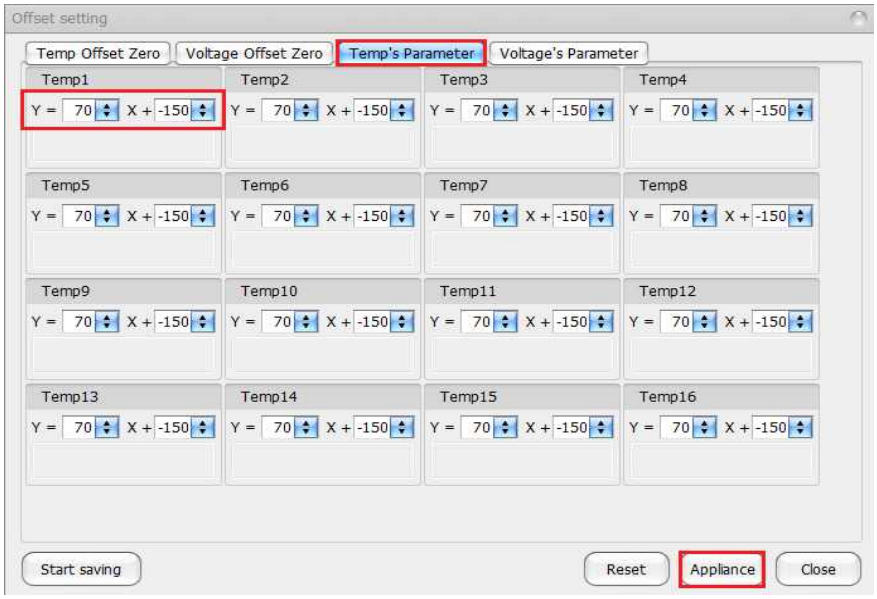


③ Voltage Offset Zero is a part of can control voltage

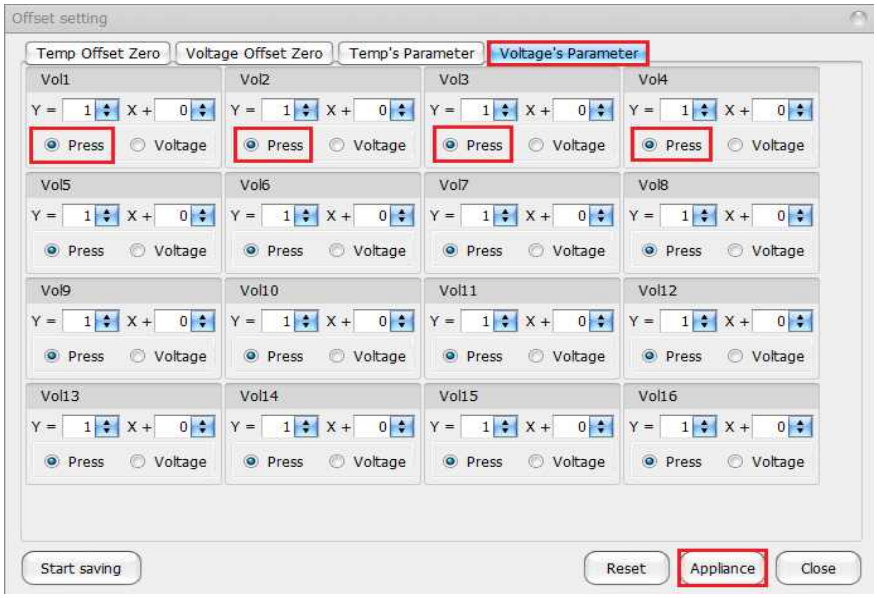
: You can control using direction key

: It is indication for voltage figure

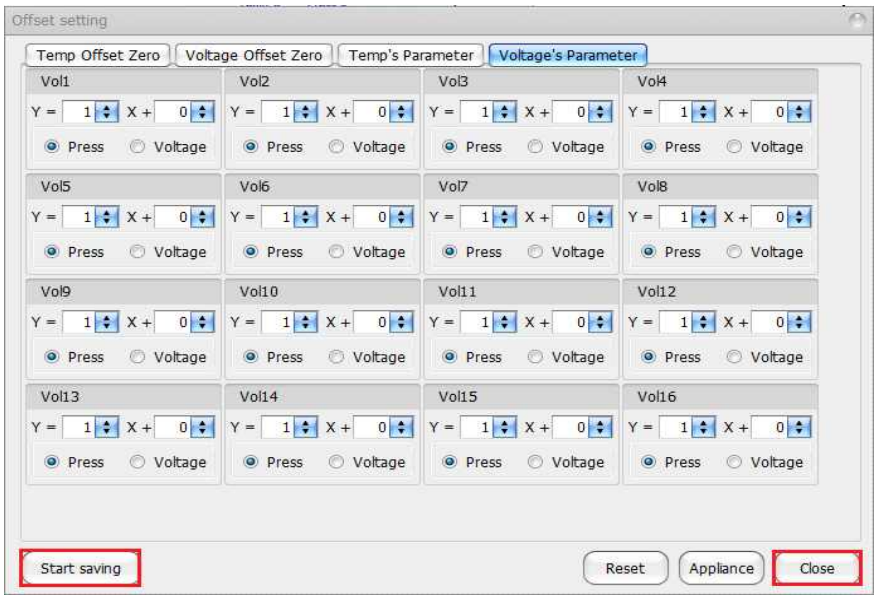
Click the application then click the Close for applying the figure



④ Temp's Parameter must enter a value of Y = 70X-150 on all of the items is a place to enter a formula that converts the output signal of the thermometer with temperature. click the "Application" and click "Close" for Application

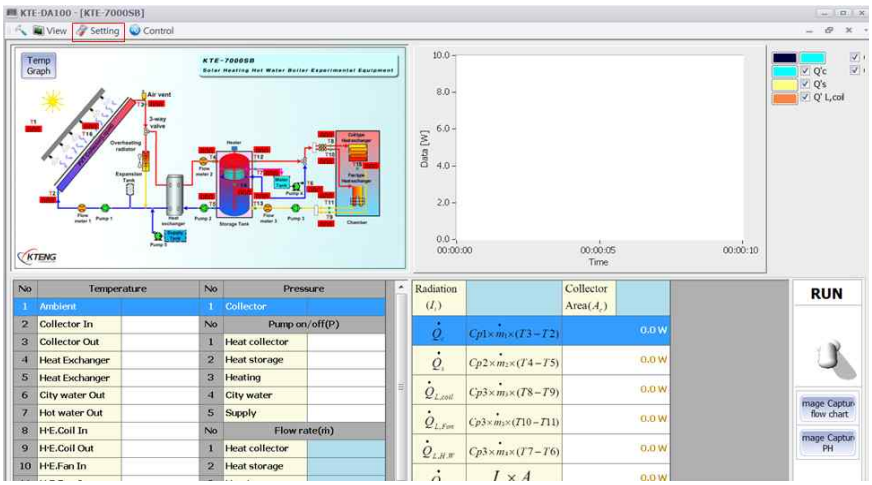


⑤ Voltage`s Parameter has a function which can input the figure for changing input figure, You can set as choosing Pressure, Voltage. Click“Application" and click "Close" for Application.

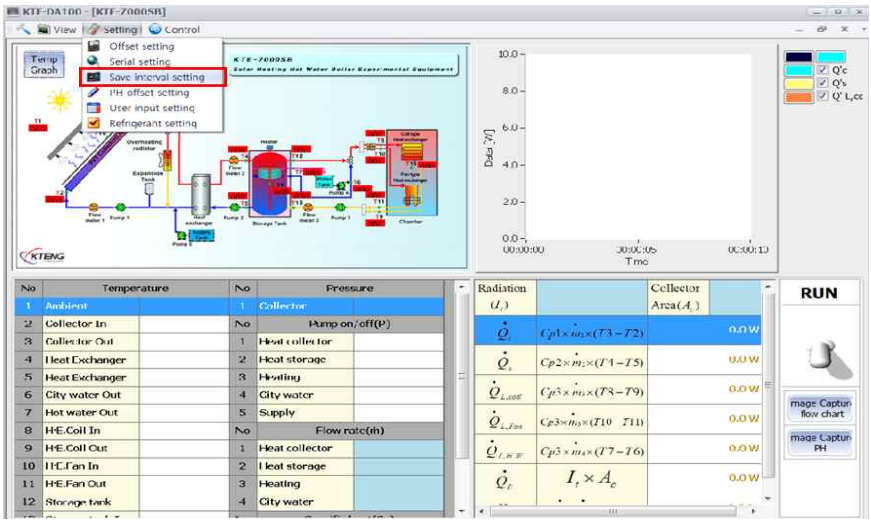


⑥ Start saving set figure and Click "Close" on the left screen

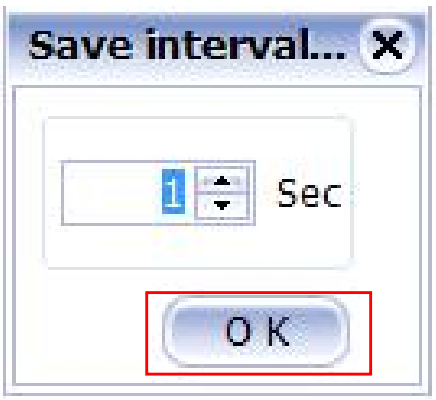
(8) Save Interval Setting



① Click Setting



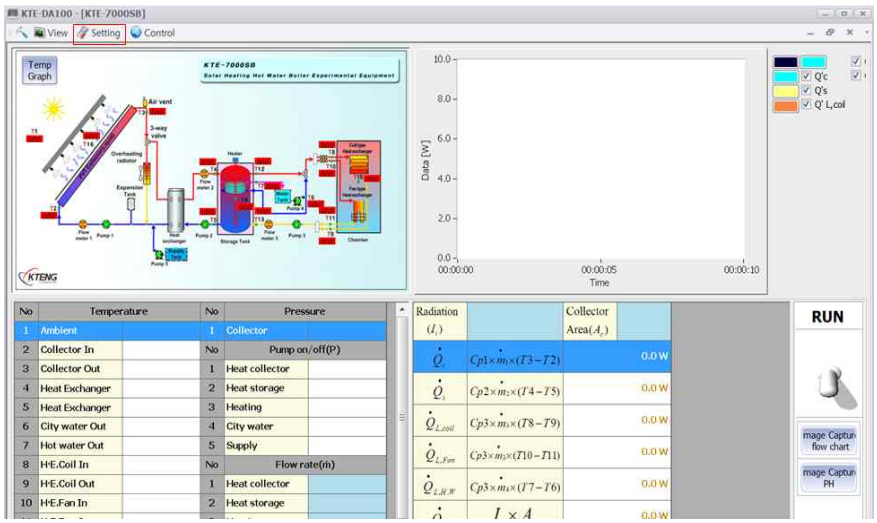
② Click Save interval setting



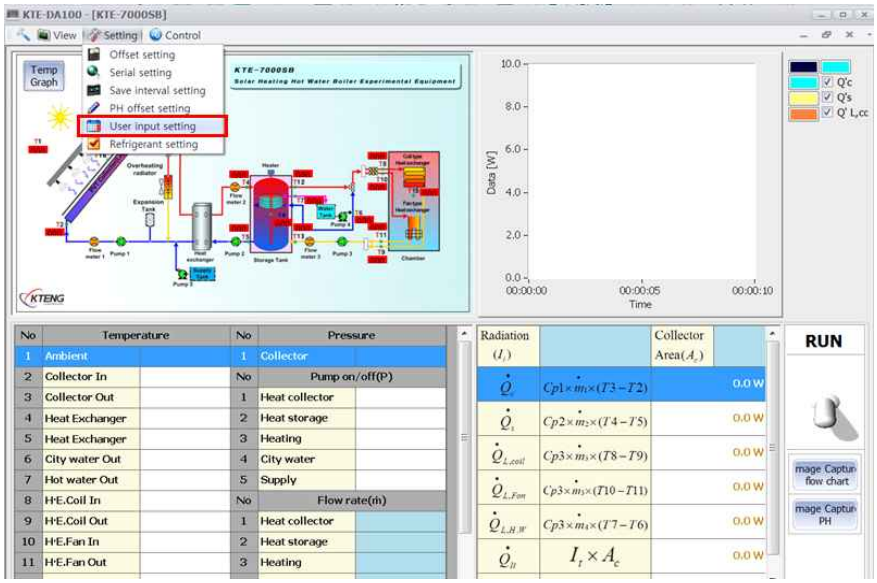
③ Save interval setting

A function for setting a data storage time interval The time interval as an Excel file Can be stored in line.(However, the number of seconds (Sec) because When set to one minute is Set to 60Sec)

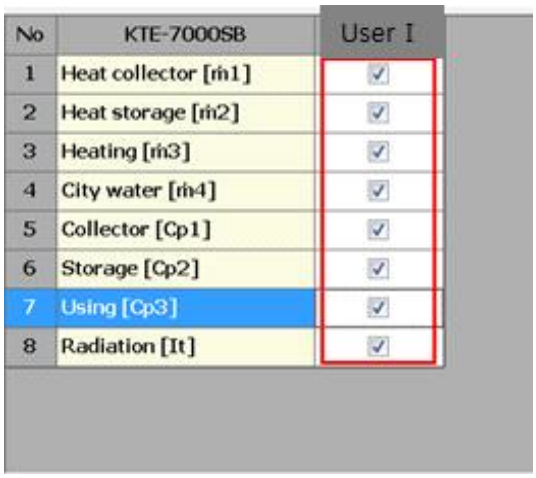
(9) User Input Setting



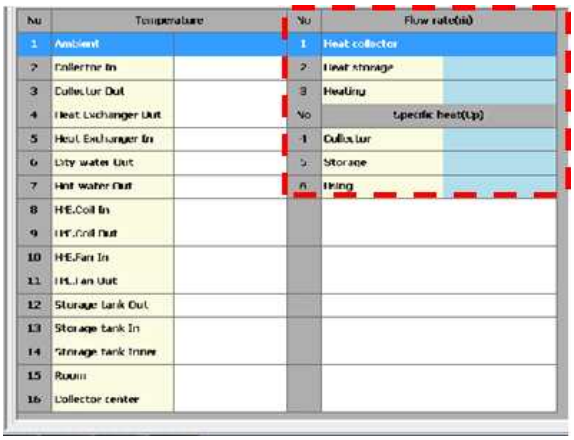
① Click Setting



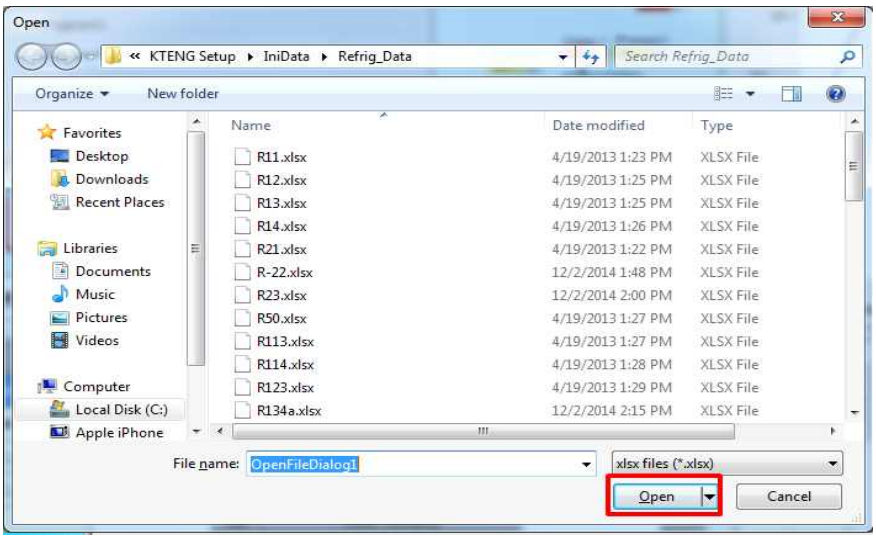
② Click User input setting



③ Click to check Flow meter and Heat capacity and Area



④ User Input Setting click



⑤ Parameter input window in data table.

4. Analysis of Solar Heat Energy Boiler System

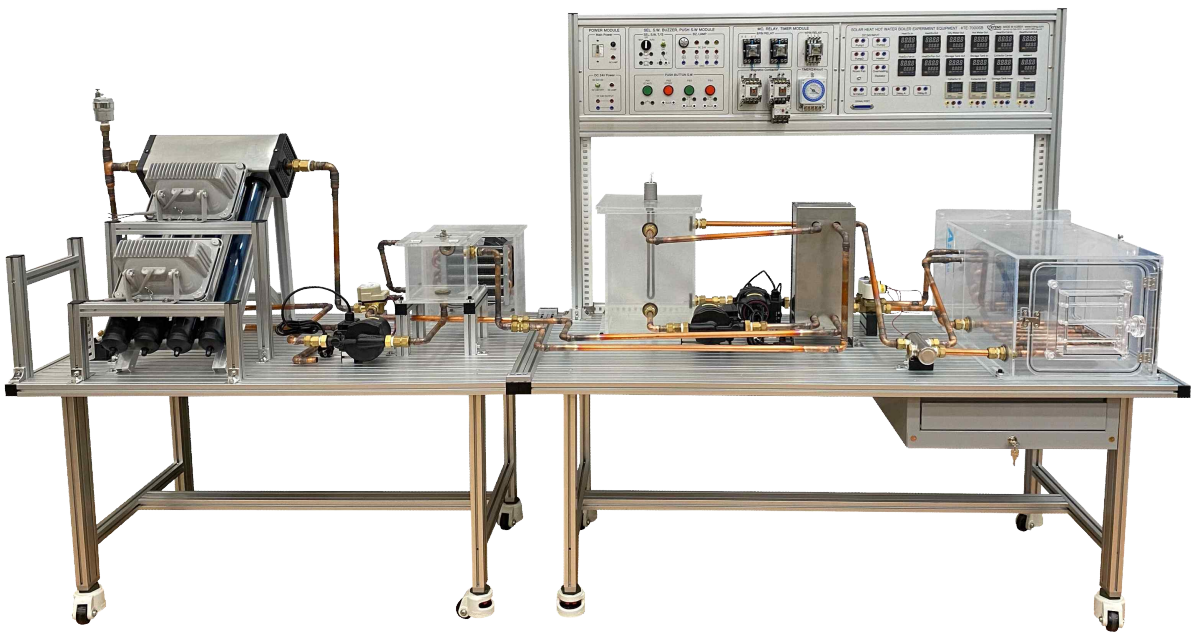
Assignment Title	4-1. Understanding the Operation Principles of Solar Heat Hot Water Boiler	Time Required
		8 Hours
Objective	- To understand the components of the solar heat hot water boiler and the principles of solar heat collecting thereof. - To master usages of Artificial Solar test equipment.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler Test Equipment (KTE-7000SB)			

Components of Solar Heat System

· Diagrams of Equipment

- KTE-7000SB (Solar Heat Hot Water Boiler Test Equipment)



· Background Information

1. Principles of Solar Heat System

① Solar Energy Technology

- Average amount of annual insolation from the Sun to the atmosphere is approximately 1367 W/m^2
- The solar energy that reaches surface of the Earth has lower density (1021 W/m^2) and only exits in day times
- The wavelength range of solar energy used as heat energy is mainly in the visual range (0.4μm ~ 0.75μm).
- Solar heat system is a technology that absorbs, stores and converts the radiant energy from the sun rays for heating, cooling or supplying hot water to buildings.
- The core technologies used in solar ehat system is solar energy collecting technology, thermal storage technology and system designing technology.

② Components of the solar heat system

- Energy Collector: Consists of devices that collects energy from the Sun and converts to heat energy
- thermal storage Tank: Consists of tanks in which collected heat is stored to use it when necessary
- Processing Part: It effectively supplies the solar heat stored in the tank and when there is a lack of usage, it supplies heat through auxiliary heat sources (e.g. boiler)
- Controller: Consists of panels for effectively controlling the collection, storage and supply of solar heat

2. Advantages and Disadvantages of Solar Energy

Advantages	Disadvantages
- Pollutant-free and cost-free natural energy with infinite quantity - Dispersal energy source that has comparatively lower regional deviation than the fossil energy does - Reusable energy that can reduce carbon gas emission to prevent global warming	- High-quality energy with low energy density - Sporadic production of energy - Stable supply to meet the continuous demand is difficult

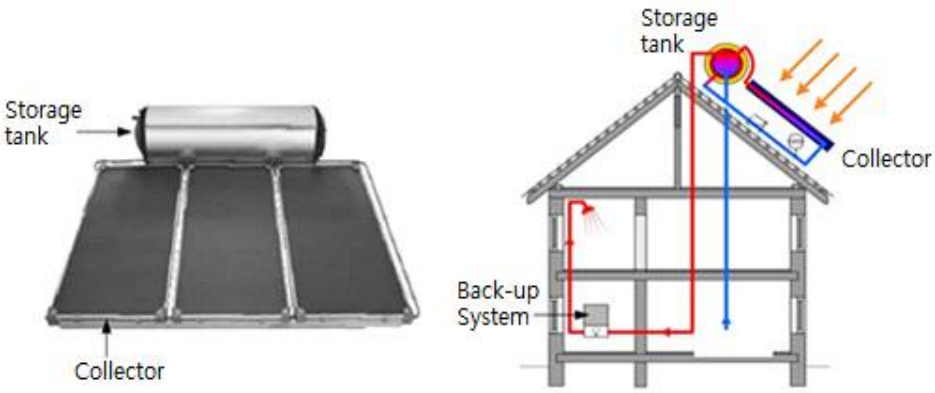
3. Types of Solar Heat System

① The solar heat system can be divided into **Active Solar System** and **Passible Solar System**, depending on the existence of the driving gear (pump or fan) on the heat media

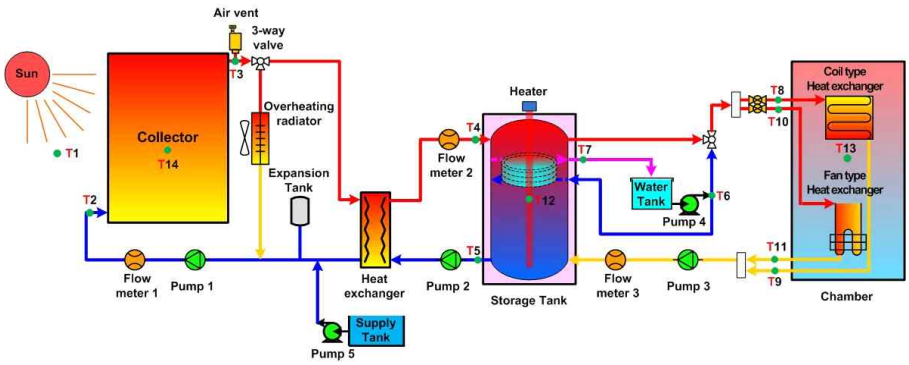
- Passive solar system: Processes the heat energy in a form of natural convection using the density of heat in the solar energy without a driving gear like pump or fan that transfers the heat energy
- Active solar system: Processes the heat energy from the Sun by transferring it using a device like pump or fan to the storage tank or processing part

② Advantages and Disadvantages of active and passive solar system

Division / System	Advantages	Disadvantages
Active	- Easy to control temperature - Stable system	- Low economic feasibility - Hard to design, operate and manage - High risks of damages
Passive	- High economic feasibility (lower initial cost) - Easy to design, operate and manage - Comforter operating conditions (due to the radiant heat)	- Hard to control temperature



(A) Passive Solar System



(B) Active Solar System

③ Operation Principles of Active Solar System

- Heat collecting process: ① Receive heat energy from the Sun, ② Temperature rise in heat collector, ③ Start operating Pump1 and Pump2, ④ Heat collecting medium enters T2 (input of heat collector), passes through T14 to absorb solar energy, which is emitted through 43 (output of heat collector) then enters the heat exchanger. Here, the heat energy is transferred through heat exchanges with the heat storing medium.
- Heat storing process: ① Pump1, heat collecting convection pump, links with Pump2 to run it ② The thermal medium stored in thermal storage tank passes through T5 (output of heat tank), passes through the heat exchanger and enters T4 (input of heat tank) ③ Here, the heat energy is absorbed from the heat collecting medium and transferred to the top part of the heat tank
- Heat processing: ① If temperature of T13, internal temperature of chamber, is lower than the setting value, ② run Pump3. ③ The thermal medium stored in the heat tank passes through a distributor and enters T8 (T10). Then it heats up the chamber through the heat exchanger and returns to the heat tank through T9 (T11)

· Requirements

1. Prepare Solar Heat Hot Water Boiler test equipment (KTE-7000SB) and supply circulating water to run through the pipes.
2. Prepare Artificial Solar test equipment (KTE-7000AS) and supply power.
   ① 5 minutes after started supplying the power, turn on the lamps.
   ② To turn off the Artificial Solar equipment, turn off the lamps in the same order as you did to turn the equipment on.
   ③ Each lamp on the Artificial Solar test equipment has an output of 1kW and emits strong UV waves, so make sure not to stare at the lamps or expose skin to the light for a long time
3. Describe the structure of the solar heat system and the principles of collecting solar energy thereof

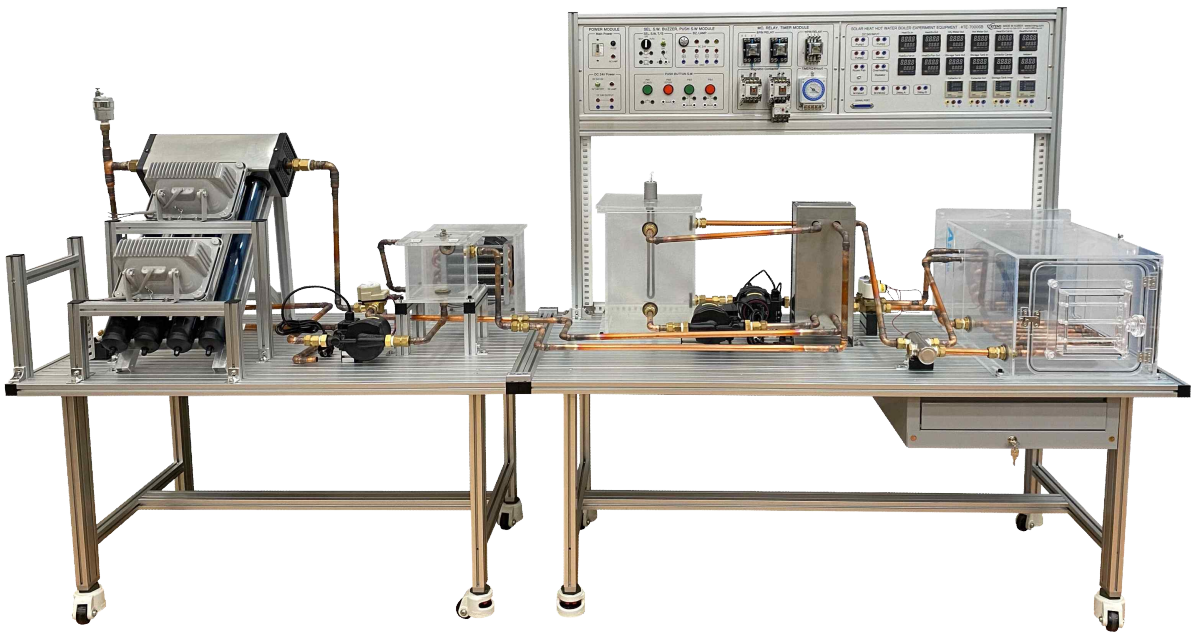
Assignment Title	4-2. Understanding the Components of Solar Heat Hot Water Boiler	Time Required
		8 Hours
Objective	- To understand the types of solar heat collector and the operation principle thereof - To understand the principles of the main components of the Solar Heat Hot Water Boiler system	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)			

Components of Solar Heat System

· Diagrams of Equipment

- KTE-7000SB(Solar Heat Hot Water Boiler test equipment)



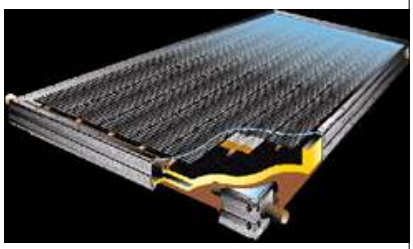
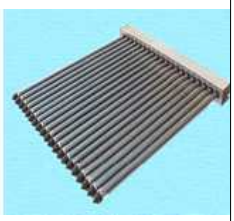
· Background Information

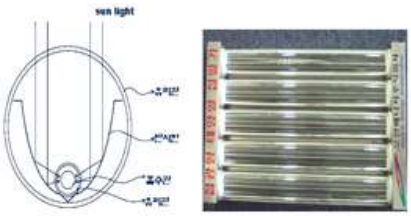
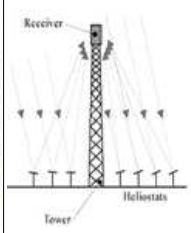
1. Solar Heat Collector

① What is a solar heat collector?

- A mechanical equipment that absorbs the solar energy and converts it to heat energy for use to use

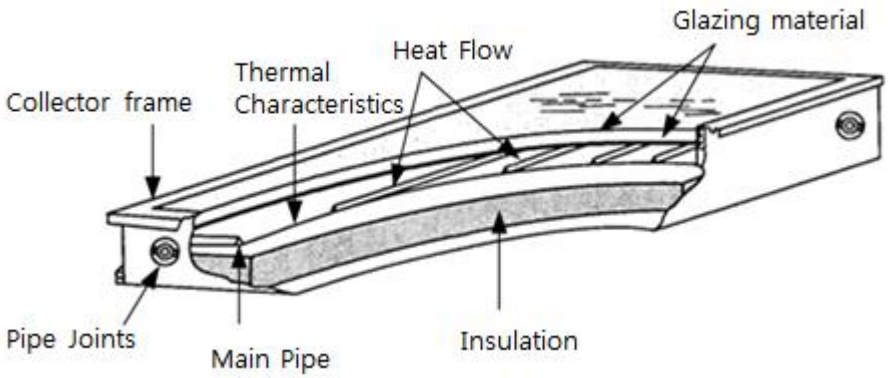
② Types of solar heat collector

Flat Plate Heat Collector (Low Temp.)	Vacuum Pipe Heat Collector (Low/Medium Temp.)	PTC Heat Collector (Medium Temp.)
	 	
- Room heating effect / hot water supply (for small scales) - At commercialization stage	- Water heater/boiler for houses - At commercialization stage	- Heating/cooling buildings, industrial heat processing, waste water processing - Technology development completed. At distribution stage

CPC Heat Collector (Medium Temp.)	Dish Heat Collector (High Temp.)	Power Tower Heat Collector (High Temp.)
		 
- Heating buidligns, large-scaled water boiler - Technology development completed. At distribution stage	- Large-scaled heat development, photochemistry works - In technology development stage. Partially, commercialized	- Large-scaled heat development, photochemistry works - Technology development completed. Promoting commercialization

③ Components of Flat Plate Solar Heat Collector

- Consists of glazing materials, absorbing plates, thermal medium pipes, main pipes, frame, insulator and pipe connectors



④ Principles of solar heat collector

- Solar heat enters through a glass cover or glazing material of the heat collector, absorbed by a metal plate that is colored in black and is converted to heat energy. The solar heat stored in this absorbing plate is transferred to a thermal storage tank by cooling fluids (water or air) to be stored.

⑤ Essential elements of solar heat collector

- Heat efficiency of the collector must be high enough in the desired temperature range
- Must have high durability against corrosion, high temperature occurred in malfunctioning, heat expansion and heat shrinkage
- Cost of the heat collector and installation cost thereof must be low

2. Storage Tank

Storage Tank

① Importance of thermal storage

- There are spatial or time gaps between the source, which produces heat, and the device, which uses the heat. In order to overcome the spatial gaps, a heat exchanger or pipes are required to transfer the heat and for the time gaps, thermal storage is required. Moreover, the thermal storage system fixes the instantly broken balance of loads between the heat source and device, enhancing the performance of the overal system as well as converting low-graded energy to high-graded energy. Thus, the

function of thermal storage system can be defined as reducing the inconsistency in time, quality and quantity aspects of the heat source and device.

② Method of Storing Heat

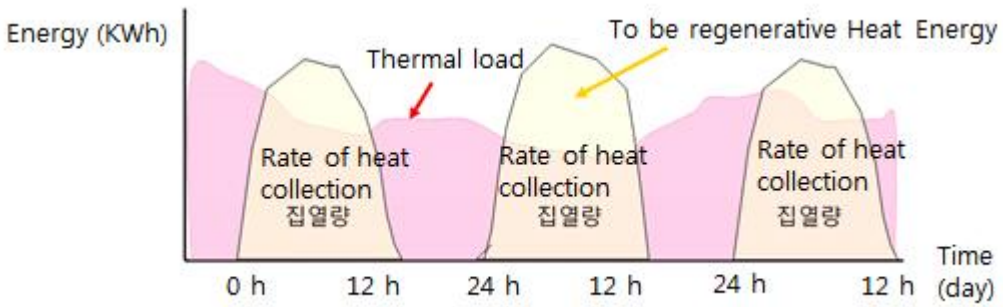
- Solar heat can be stored by either sensible thermal storage or latent thermal storage, but the sensible thermal storage with water as a medium is the mostly used method.

③ Storage categories by the type of energy

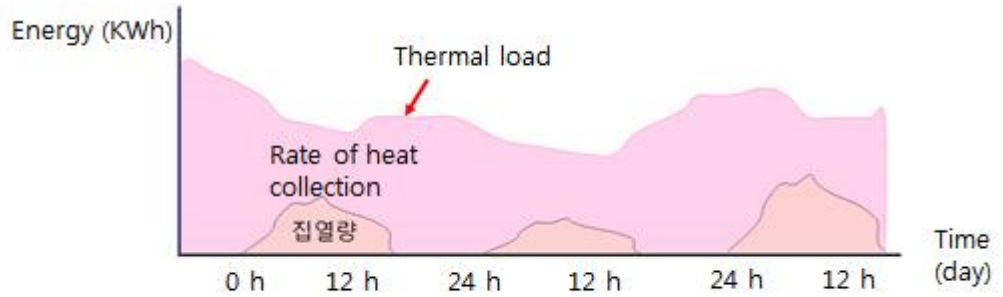
- Thermal Storage
- Electrical Storage: Capacitor, Superconducting, etc.
- Mechanical Storage: pumped power generation, compressional energy, flywheel, etc.
- Chemical Storage: Fuel cell, etc.

④ Case where thermal storage is necessary

- Since there is no thermal load occurred during heat collection in a solar heat system, thermal storage is required. Diagram (A) shows a case in which there is no or less thermal load than collected heat, and thus part of the collected heat need to be stored. Diagram (B) shows a case in which the thermal load is greater than the collected heat so that all collected heat can be consumped and no heat is required to be stored.



(A) In case thermal storage is necessary



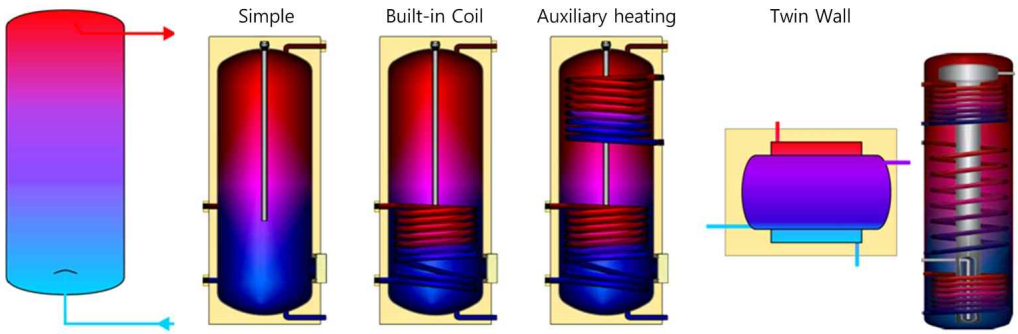
(B) In case thermal storage is unnecessary

⑤ Requirements for thermal storage system

- Volumetric heat capacity must be large.
- Needs to be cheap, harmless on human body and has long durability.
- Rate of thermal storage/discharge must be high with large coefficient of thermal diffusivity.
- Must be easy to work in series with heat collector or emittor systems.

⑥ Types of thermal storage system

- Various shapes (cubic, spherical, cylindrical, etc.) of thermal storage tank are available
- Below are the various types of solar heat storage tank for households



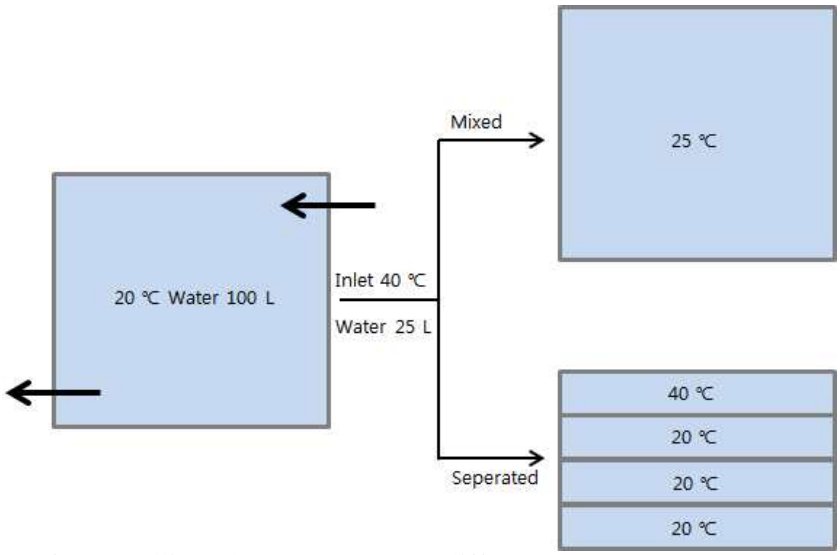
⑦ Thermal storage tank temperature stratification

- Temperature stratification in a thermal storage tank means a process of maintaining a stable condition by layering high-temperature water on top of the tank and low-temperature water at the bottom according to the difference in density caused by the temperature change of the thermal storing medium.
- In such condition, medium with low density (or high temperature) is positioned at the top of the tank and medium with high density (or low temperature) is positioned at the bottom of the tank. Thus, no heat convection occurs in the tank, whereas heat conduction at thermocline still occurs.
- In general, thermal storage tank with temperature stratification is known to have about 10% higher thermal storing efficiency than the completely mixed tank. Such effect is described in below diagram.

3. Control System

① Controlling the temperature difference

- The difference between temperatures of thermal media at the input and output of the heat collector is detected and the circulating pump at heat collector or storage tank is driven accordingly



② Principles of controlling the temperature difference

○ When the circulating pump is stopped

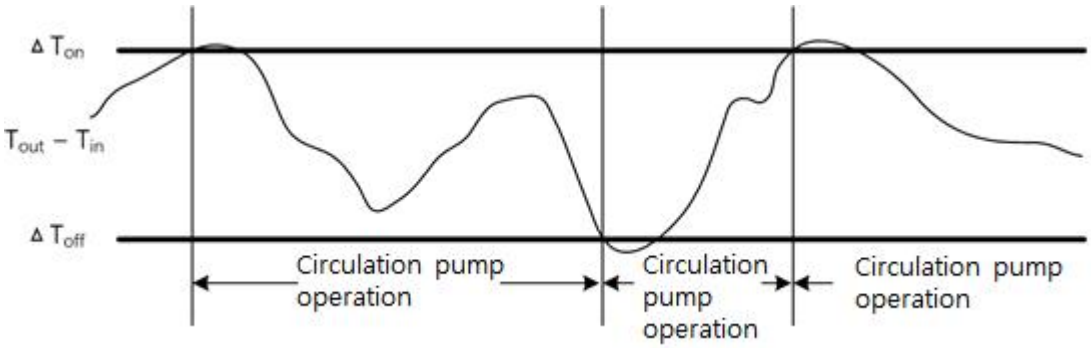
⇒ (Output temp. of collector - Input temp. of collector) > ΔT_{ON} : Run circulating pump

⇒ (Output temp. of collector - Input temp. of collector) < ΔT_{ON} : Keep circulating pump stopped

○ When the circulating pump is operating

⇒ (Output temp. of collector - Input temp. of collector) > ΔT_{OFF} : Keep circulating pump operating

⇒ (Output temp. of collector - Input temp. of collector) < ΔT_{OFF} : Stop circulating pump

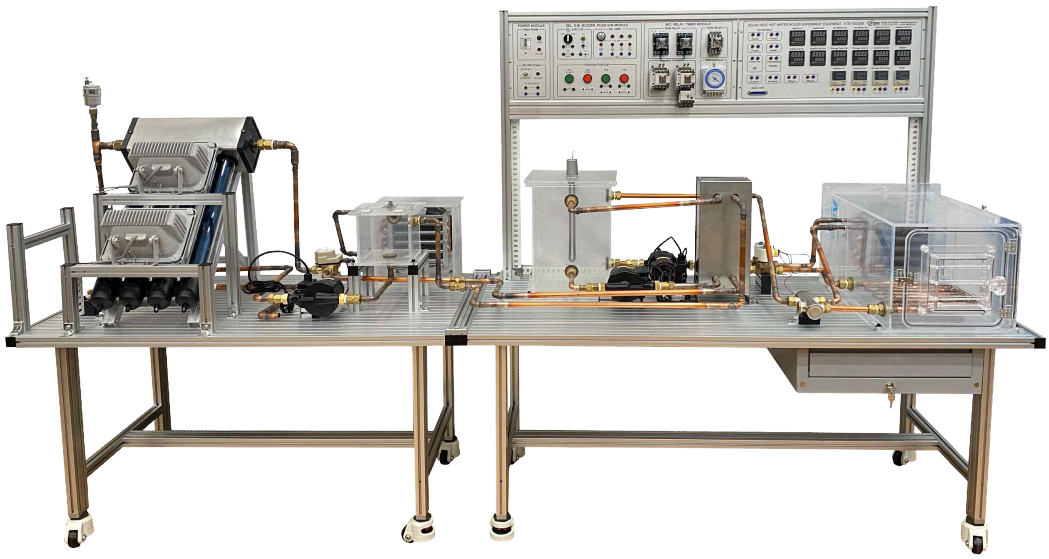


③ Freeze Protection

- The solar heat control system includes prevention of freezing of heat collector or the pipes thereof. Generally, such function is not required in antifreeze system, but in a system that uses water as a thermal medium, the system discharges the thermal medium or circulates water inside tank when the temperature of heat collector drops to 2~3℃.

④ Overheating Protection

- In a solar heat system, there may occur problems with a lack of thermal load compared to the collected amount or with a too high temperature of stored heat. In such cases, measures to protect the collector, tank and system must be performed as a part of the system control.



· Requirements

1. Prepare Solar Heat Hot Water Boiler test equipment (KTE-7000SB) and supply circulating water to run through the pipes.
2. Prepare Artificial Solar test equipment (KTE-7000AS) and supply power.
   ① 5 minutes after started supplying the power, turn on the lamps.
   ② To turn off the Artificial Solar equipment, turn off the lamps in the same order as you did to turn the equipment on.
   ③ Each lamp on the Artificial Solar test equipment has an output of 1kW and emits strong UV waves, so make sure not to stare at the lamps or expose skin to the light for a long time
3. Describe the structure of the solar heat system and the principles of collecting solar energy thereof.

	Criteria		Marks	Scores	Notes			
Evaluation Standards	Works (70)	Describing the types and characteristics of solar heat collectors	20					
		Describing the functions and role of thermal storage tank	20					
		Describing the method of connecting the solar heat collector with the thermal storage tank	20					
		Operating the artificial lighting	10					
	Attitudes (10)	Working attitude and safety issues	5					
		Usage of materials/tools and clean-up work afterwards	5					
	Time (20)	( ) points off for every ( ) minutes over the required time limit			Works	Attitudes	Time	Total Score

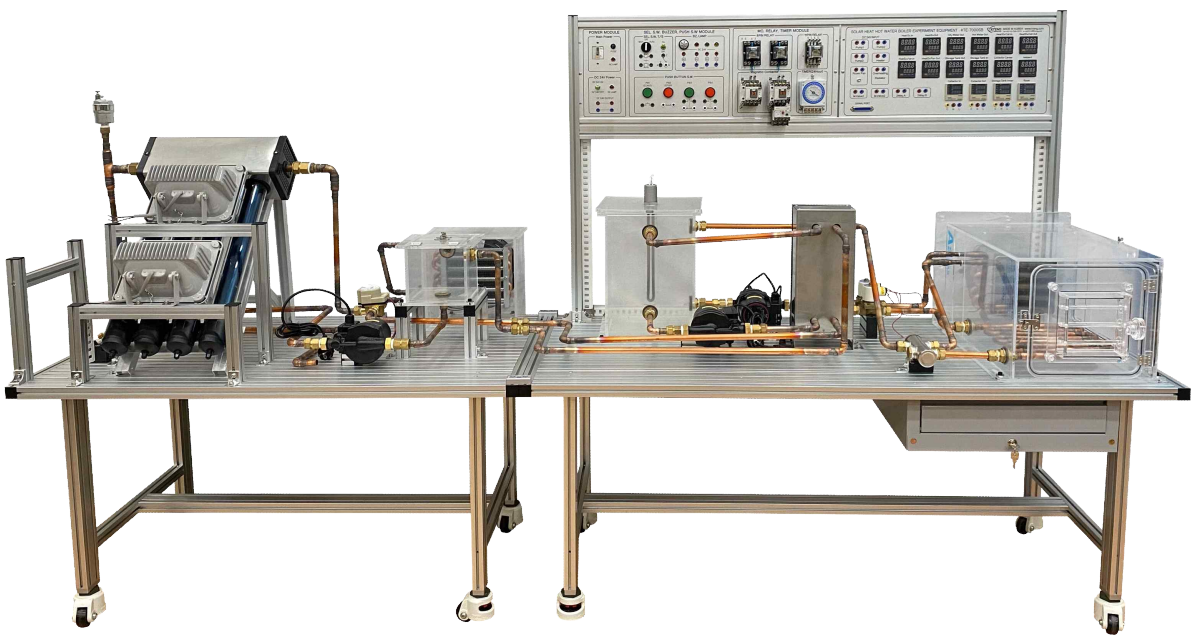
Assignment Title	4-3. Measuring and analysis on the performance of Solar heat hot water Boiler System	Time Required
		8 Hours
Objective	- To understand the operating of components and system - To understand pipe system among the heat collector, storage tank and process and test the operation thereof according to the management requirements - Organize the data from measured temperature and heat flux, draw the graph based on the data, analyze evaluate and draw a conclusion to create a lab report	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)			

Components of Solar Heat System

1. Diagrams of Equipment

- KTE-7000SB(Solar Heat Hot Water Boiler test equipment)



(1) Heat Collector : Collects the radiant energy from artificial solar. The collected heat energy is sent to the thermal storage tank through a circulating pump and stored.
(2) Thermal Storage Tank : Stores heat energy sent from the heat collector to the supply necessary amount of heat for hot water or heating for buildings. It consists of a storage tank, auxiliary heater and controller.
(3) Processing part : It is a simulator of the solar hot water boiler system. It consists of a power lamp, boiler controller, individual room controller and temperature indicator. It uses the heat energy collected from the sun for producing hot water or heating room.
(4) Artificial Solar heat : Consists of halogen lamps with total capacity 1 KW of radiant energy sent to the heat collector.

2. Selection of variables for the performance test

Incident angle	Thermal Medium	Rate of heat collection	Heating load condition	Flux load
90°	Water (A-2)	Small (A-3)	Fan type heat exchanger (Strong)	Small (A-5)
45°	Water+PG (B-2)	Normal (B-3)	Fan type heat exchanger (Weak)	Narmal(B-5)
15°	Water+EG (C-2)	Large (C-3)	Coil type heat exchanger (C-4)	Large (C-5)

(1) Selection of thermal medium for the solar heat collector

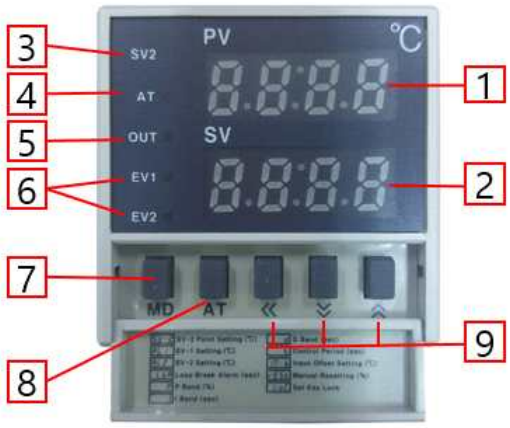
	Water	Ethylene Glycol	Propylene Glycol	Methanol
Molecular Weight	18.01	62.07	76.10	32.04
Specific Gravity 20/20	1.000	1.116	1.038	0.7917
Density at 20℃(kg/m3)	998.2	1113.0	1036.5	790.9
Freezing Point(℃)	0.0	-13.0		-97.7
Normal Boiling Point(℃)	100.0	197.2	187.8	64.4
Specific Heat at 20℃(kJ/kg℃)	4.18	2.347	2.481	2.47
Viscosity at 0℃(Centipoise)	1.79	57.4	243	
Viscosity at 20℃(Centipoise)	1.01	20.9	60.5	0.6
Viscosity at 40℃(Centipoise)	0.655	9.5	18.0	
Thermal Conductivity(W/m·K)	0.58	0.29		0.21
Flash Point(℃)		115.6	107.2	14.4

(2) Selection of rate of heat collection and flux load

Use a ball valve and area-based flow meter attached on the lower front of the heat collecting circulation pump to set the desired flux value.

Be careful with the conversion according to the weight of heat collecting medium when calculating the mass flux.

(3) Setting the operation conditions for heat collecting circulation pump



① PV: Measurement display (red)
Displays measured value.
Displays configuration subject in configuration mode.

② SV: Configuration value display (green)
Displays adjusting value.
Displays configuration subject in configuration mode.

③ SV2: SV2 on lamp

④ AT: auto-tuning on lamp

⑤ OUT: output on lamp

⑥ EV1,2: EVENT output display lamp

⑦ MD key: mode key
Press button for 3sec

⑧ AT key: Auto-tuning run key

⑨ ∧∨《: adjustment key

3. Composition of the operation circuit

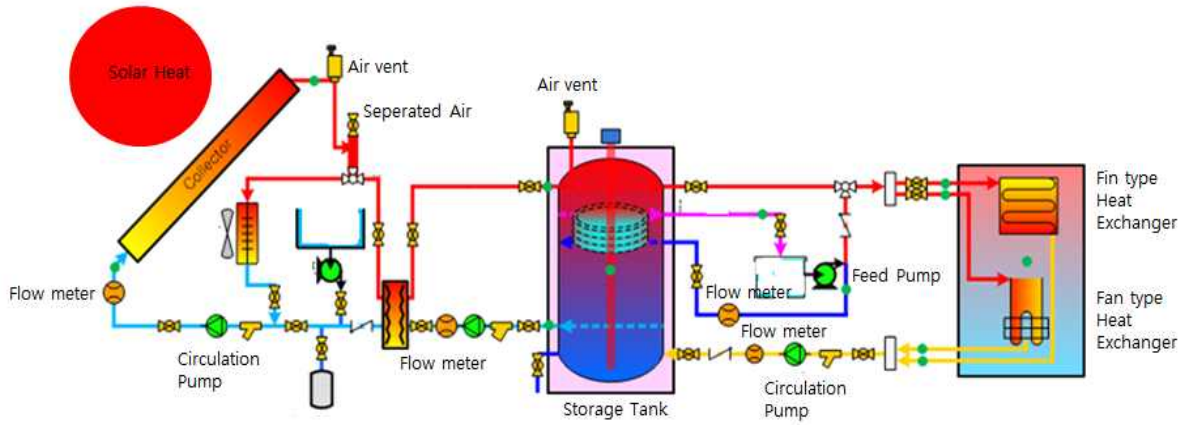
(1) When power is applied on the controller of solar boiler system, a red light on AC Lamp will turn on and the temperatures of each part will be indicated on the temperature indicator.

(2) When power is applied on the thermal storage tank, the controller on the tank will light up and show the temperature at the top of the tank.

(3) Apply power on the artificial lighting and use the toggle switch to chose a mode from 1, 2 and 3.

4. Measurement performance data

(1) System diagram and measuring points



(2) KTE-DA100 software operation

① Double click on "KTE-7000SB" from the background.

② A DA100 window will appear with a "Run" message. Here, enter the location and name of the file you desire to save and click on "OK" button to close the window. Then the data will start to be saved.

③ Once the experiment if over, press "Run" button at the top right corner

④ Data will be saved in excel file and you can find it in the folder you have designated at the beginning.

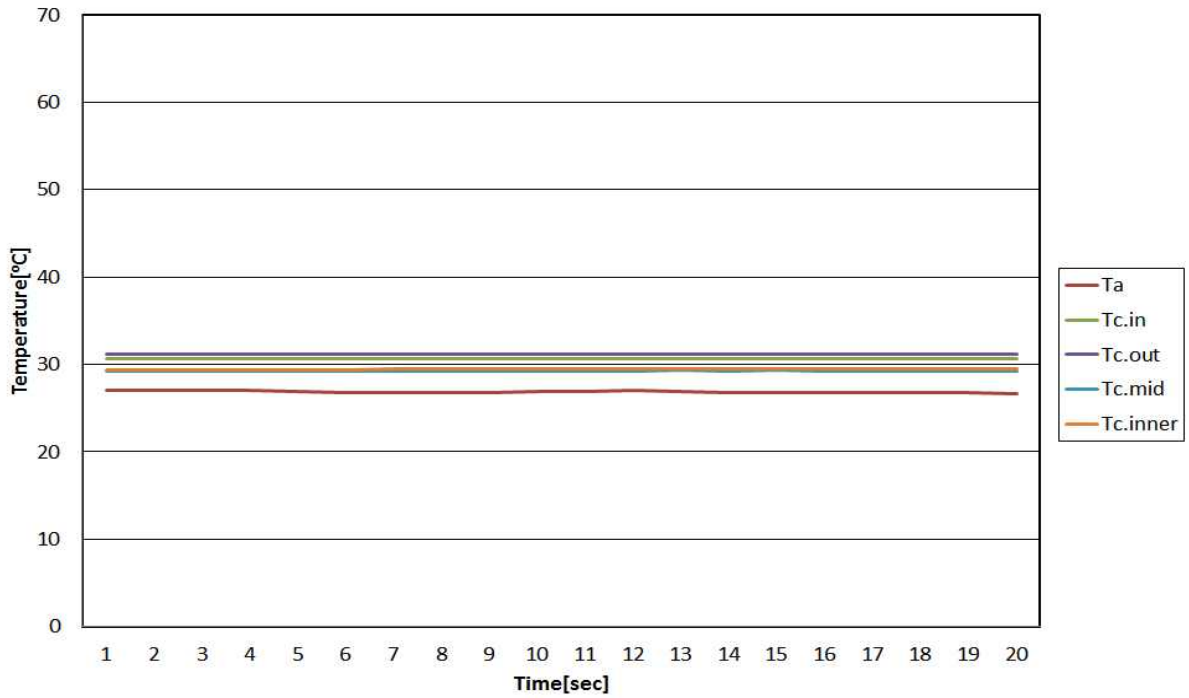
(3) Data

Time	T_a	$T_{c.i}$	$T_{c.o}$	$T_{s.i}$	$T_{s.o}$	$T_{H.W}$	$T_{C.W}$	$T_{H.o}$	$T_{H.i}$	$\dot{m}_c$	$\dot{m}_h$	$\dot{m}_{cw}$	P1	P2	P3	A_c	I_t
1																	
2																	
3																	
4																	
⋮																	
n																	

Time : Time measured(℃)
T_a : Temp. of external atmosphere(℃)
$T_{c.i}$: Temp. at input of collector(℃)
$T_{c.o}$: Temp. at output of collector(℃)
$T_{s.i}$: Temp. at input of storage(℃)
$T_{s.o}$: Temp. at output of storage(℃)
$\dot{m}_{cw}$: Flux of hot water (kg/s)
A_c : Area of collector
I_t : Insolation (W/m^2)

$T_{H.W}$: Temp. of hot water supply (℃)
$T_{C.W}$: Temp. of input water (℃)
$T_{H.o}$: Temp. of released heating water (℃)
$T_{H.i}$: Temp. at input of heating chamber (℃)
$\dot{m}_c$: Rate of heat collection (kg/s)
$\dot{m}_h$: Flux of heating water (kg/s)
P1 : Heat collecting circulation pump operation
P2 : Heating circulation pump operation
P3 : Water supplying Pressurizing Pump operation

(4) Graph of temperatures



(5) Analysis on the experiment

① Calculation of heat collected

$\dot{Q}_c = \dot{m} C_p (T_{c.o} - T_{c.i})\,[KJ/s]$

$\dot{m}$= Collected heat circulation rate[Kg/s]

C_p = Collected specific heat under constant pressure [KJ/Kg℃]

$T_{c,o}$= Collector Temp out [℃]

$T_{c,i}$ = Collector Temp In [℃]

② Calculation of heat stored

$\dot{Q}_c = \dot{m} C_p (T_{s.o} - T_{s.i})[kJ/s]$

$\dot{m}$ = Storage heat circulation rate[Kg/s]

C_p = Storage specific heat under constant pressure [KJ/Kg℃]

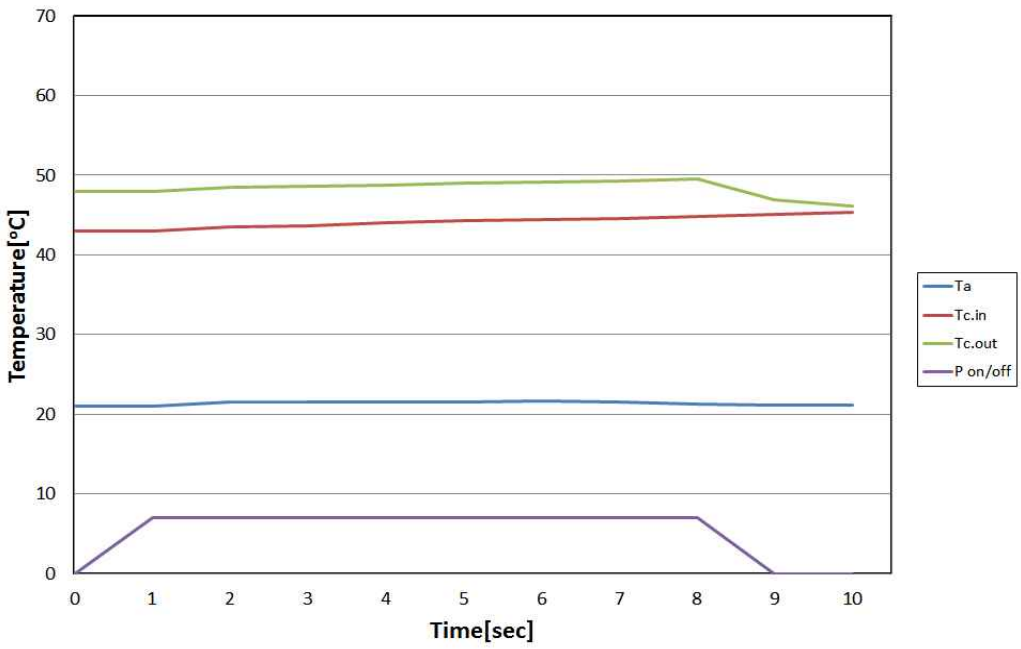
$T_{s,o}$ = Storage tank Temp Out [℃]

$T_{s,i}$ = Storage tank Temp In [℃]

1) Result of saved data

Time	T_a	$T_{c.in}$	$T_{c.out}$	$\dot{m}$	P1	$\dot{Q}_c$
1	21	43	48	0.05	1	1.04
2	21.5	43.5	48.5	0.05	1	1.04
3	21.6	43.7	48.6	0.05	1	1.02
4	21.5	44	48.8	0.05	1	1.00
5	21.6	44.3	49	0.05	1	0.98
6	21.7	44.5	49.1	0.05	1	0.96
7	21.5	44.6	49.3	0.05	1	0.98
8	21.3	44.8	49.6	0.05	1	1.00
9	21.2	45.1	46.9	0	0	0
10	21.1	45.3	46.2	0	0	0

2) Graph of saved data



3) Calculation on the insolation and efficiency of heat collection

$\dot{Q}_i = I_t \times A_c [kJ/s]$

I_t : Insolation $[W/m^2]$

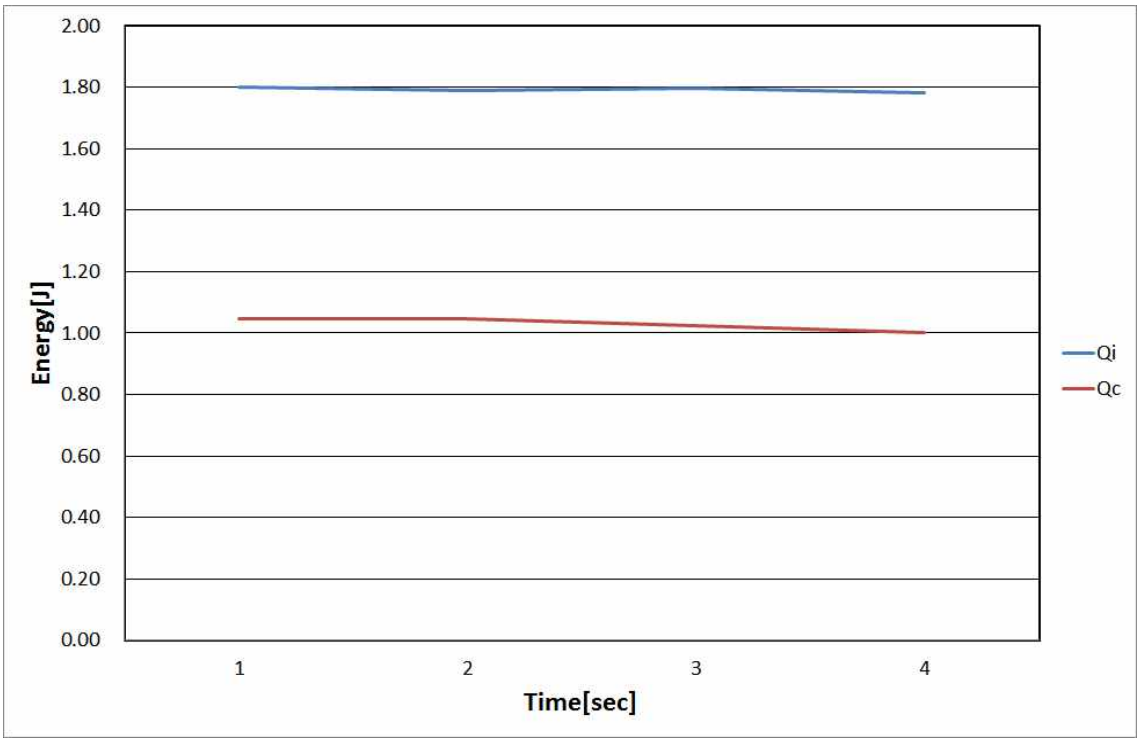
A_c : Area of heat collection $[m^2]$

$\eta = \frac{Q_c}{Q_i}$: Efficiency of heat collection

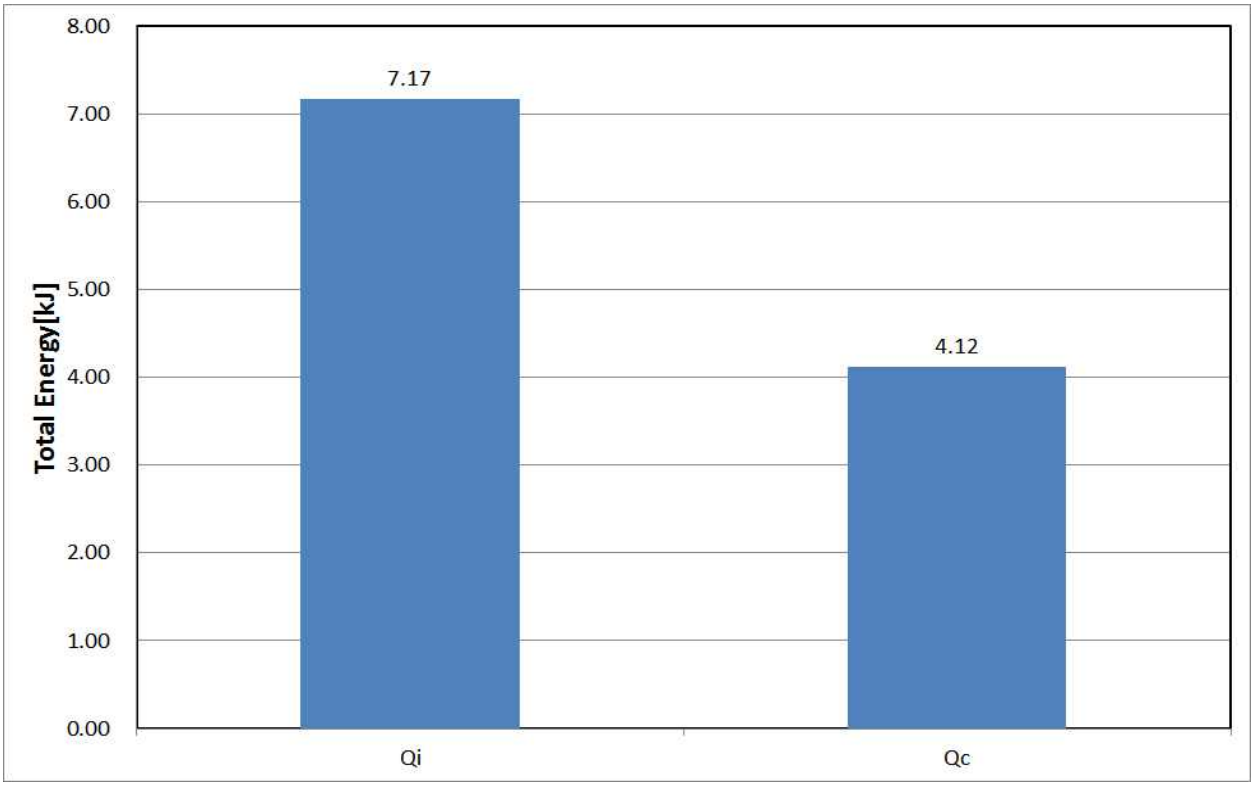
4) Result of saved data

Time	T_a	$T_{c.i}$	$T_{c.o}$	$\dot{m}_c$	$P1$	I_t	A_c	$\dot{Q}_i$	$\dot{Q}_c$	η
1	21	43	48	0.05	1	900	2	1.80	1.05	0.58
2	21.5	43.5	48.5	0.05	1	895	2	1.79	1.05	0.58
3	21.6	43.7	48.6	0.05	1	899	2	1.80	1.02	0.57
4	21.5	44	48.8	0.05	1	890	2	1.78	1.00	0.56
Total								7.17	4.12	0.57

5) Graph of saved data



6) Graph of total insolation and comparison of amount of heat collected



(6) Deriving a formula for efficiency of ehat collection

$$Q_c = F_R A_c [I_t \tau\alpha - U_L (T_{c.i} - T_a)]$$

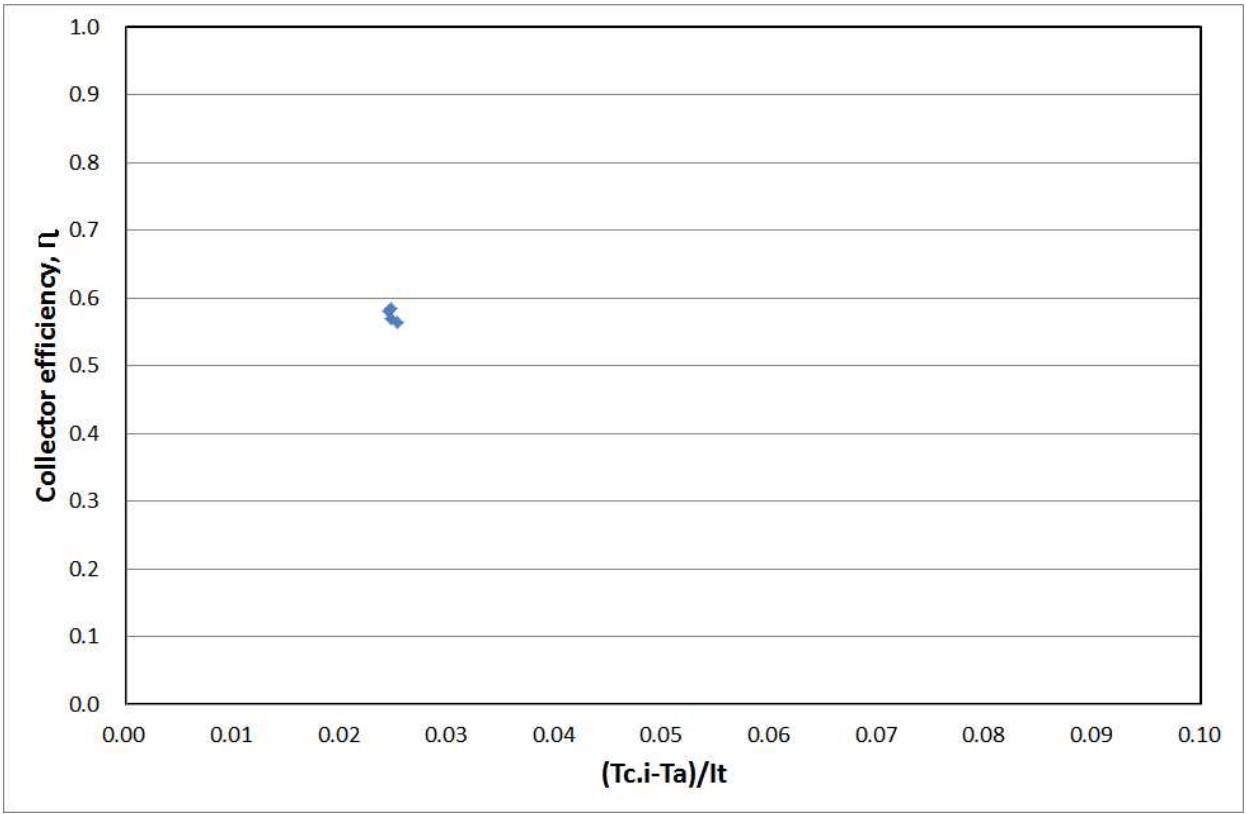
$$\eta = \frac{Q_c}{A_c I_t} = \frac{F_R A_c [I_t \tau\alpha - U_L (T_{c.i} - T_a)]}{A_c I_t} = F_R \tau\alpha - F_R U_L \left(\frac{T_{c.i} - T_a}{I_t} \right)$$

If the flux of heat collecting medium is constant, A_c, $F_R \tau\alpha$ and U_L can be considered to be constant, so η can be described in a linear equation with a variable $\left(\frac{T_{c.i} - T_a}{I_t} \right)$.

1) Result of saved data

Time	T_a	$T_{c.i}$	$I_t (W/m^2)$	$\dot{Q}_i$(kJ/s)	$\dot{Q}_c$(kJ/s)	η	$\frac{(T_{c.i} - T_a)}{I_t}$
1	21	43	900	1.80	1.05	0.58	0.024
2	21.5	43.5	895	1.79	1.05	0.58	0.025
3	21.6	43.7	899	1.80	1.02	0.57	0.025
4	21.5	44	890	1.78	1.00	0.56	0.025

2) Graph of efficiency graph for heat collection



3) Analysis on the efficiency of heat collection with change in temperature of external atmosphere

- Temp. of external atmosphere T_a = 21℃

Time	T_a	$T_{c.in}$	$I_t(W/m^2)$	$\dot{Q}_i$(kJ/s)	$\dot{Q}_c$(kJ/s)	η	$\frac{(T_{c.i}-T_a)}{I_t}$
1	21	43	900	1.80	1.05	0.58	0.024
2	21.5	43.5	895	1.79	1.05	0.58	0.025
3	21.6	43.7	899	1.80	1.02	0.57	0.025
4	21.5	44	890	1.78	1.00	0.56	0.025

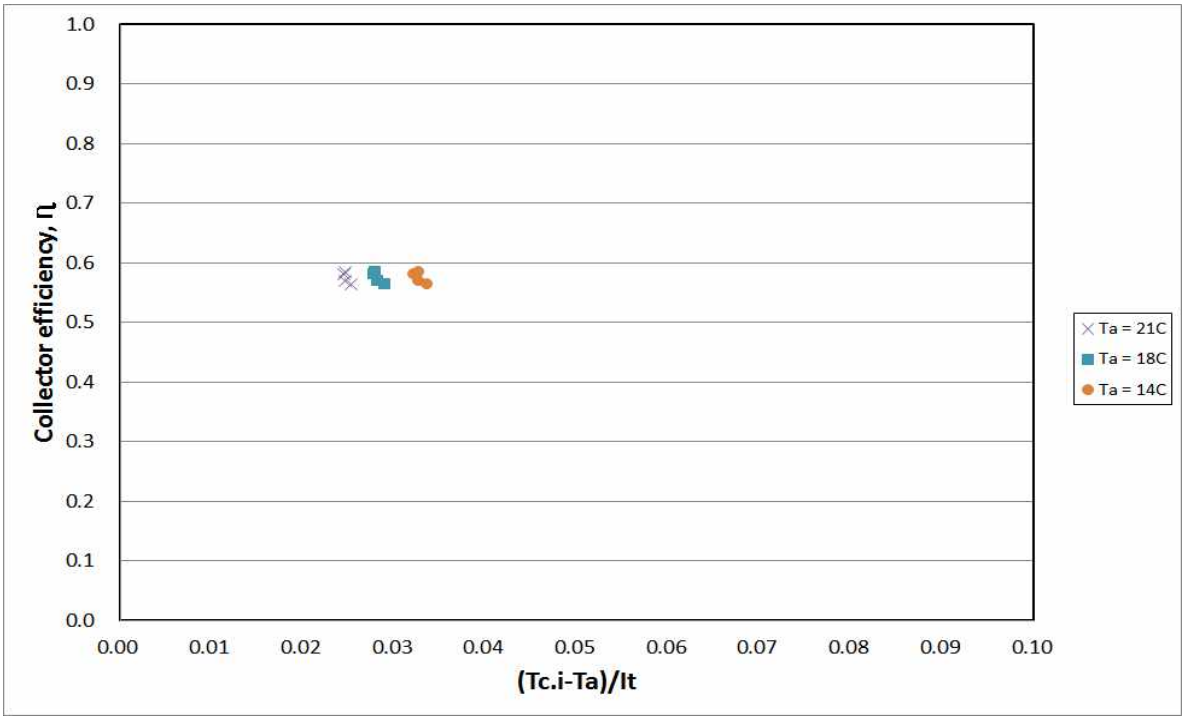
- Temp. of external atmosphere T_a = 18℃

Time	T_a	$T_{c.in}$	$I_t(W/m^2)$	$\dot{Q}_i$(kJ/s)	$\dot{Q}_c$(kJ/s)	η	$\frac{(T_{c.i}-T_a)}{I_t}$
1	18	43	900	1.80	1.05	0.58	0.028
2	18.5	43.5	895	1.79	1.05	0.58	0.028
3	18.3	43.7	899	1.80	1.02	0.57	0.028
4	18.2	44	890	1.78	1.00	0.56	0.029

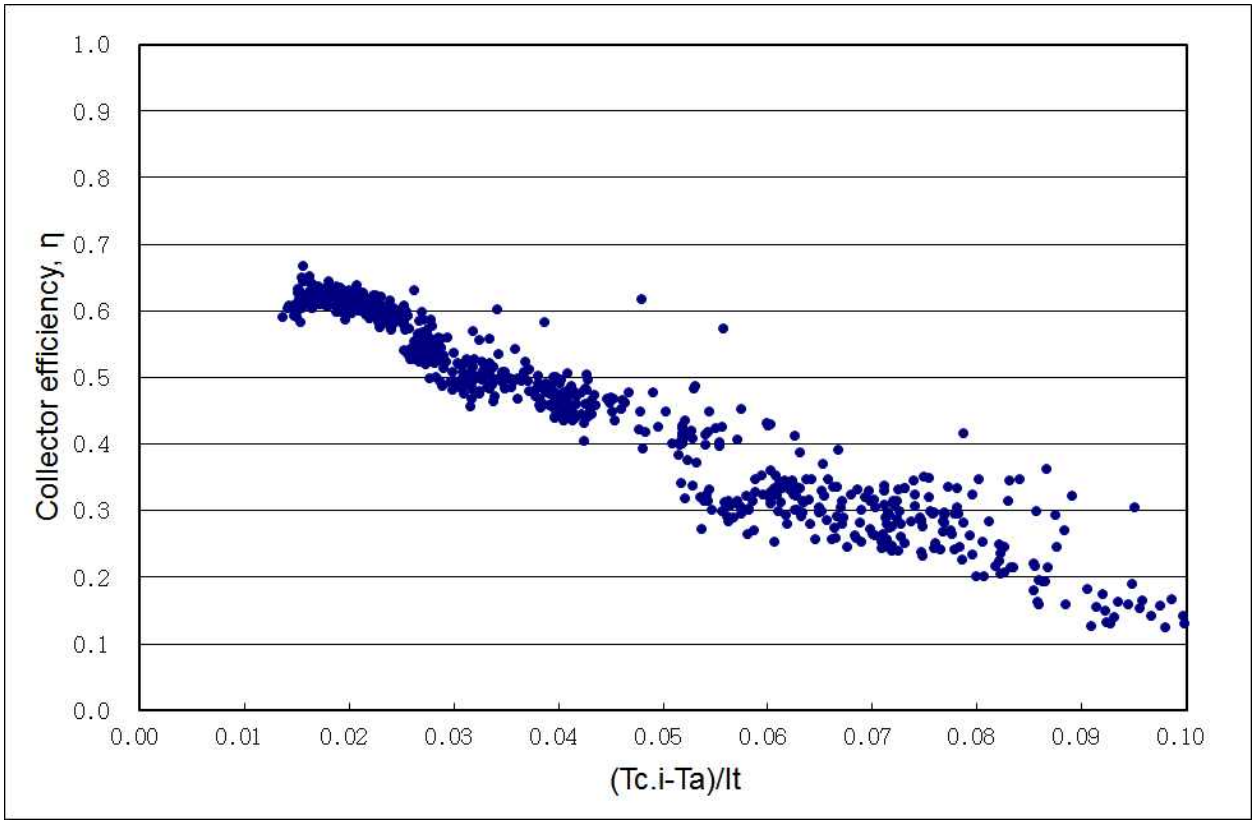
- Temp. of external atmosphere T_a = 14℃

Time	T_a	$T_{c.in}$	$I_t(W/m^2)$	$\dot{Q}_i$(kJ/s)	$\dot{Q}_c$(kJ/s)	η	$\frac{(T_{c.i}-T_a)}{I_t}$
1	14	43	900	1.80	1.05	0.58	0.032
2	14.2	43.5	895	1.79	1.05	0.58	0.033
3	14.3	43.7	899	1.80	1.02	0.57	0.033
4	14.1	44	890	1.78	1.00	0.56	0.034

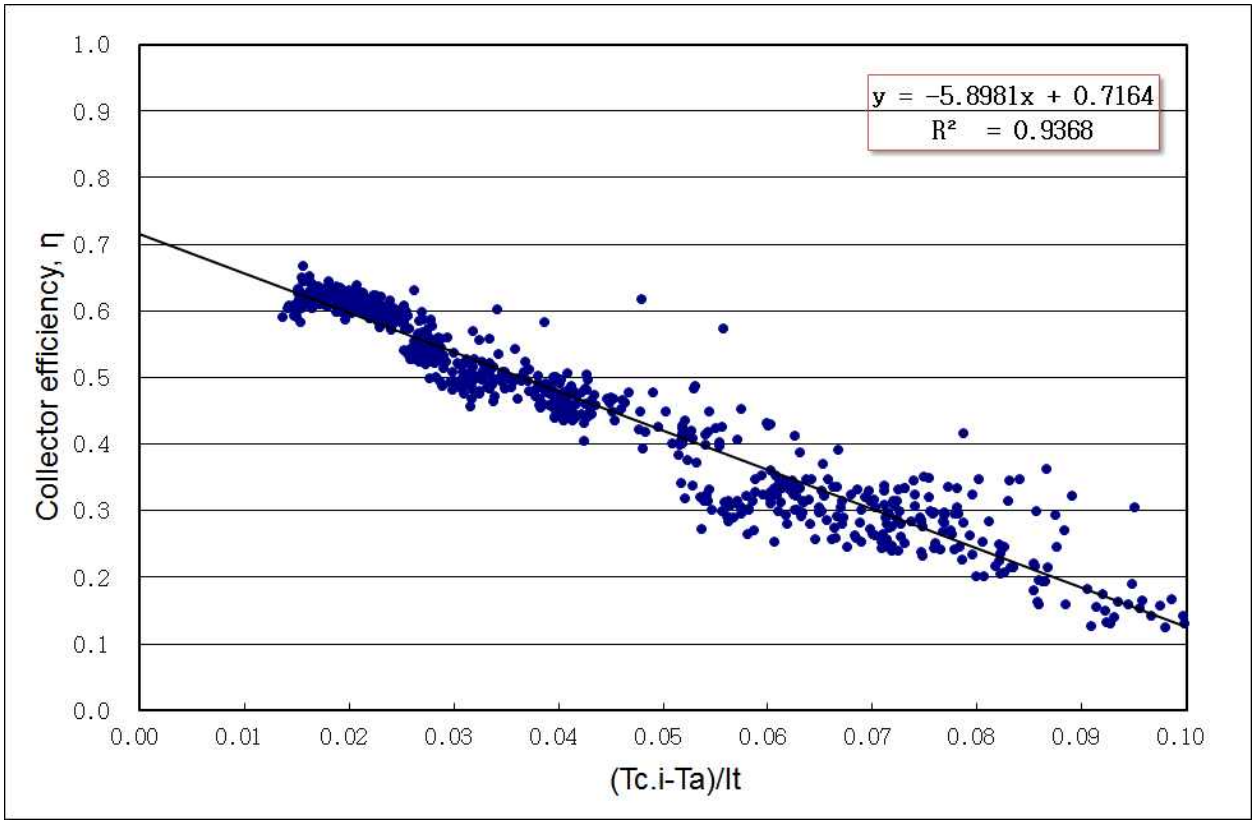
- Graph of the curve of heat collection efficiency



4) Graph of curve of the actual daily heat collection efficiency



5) Finding a formula for heat collection efficiency using the trend line on Excel



- Use add trend line function on Excel to find a linear equation for the values distributed on the graph. As a result the following equation was derived
y = -5.8981x + 0.7164.

- In the equation, y represents η, x represents $\frac{(T_{c.i} - T_a)}{I_t}$, -5.8981 indicates the loss of heat in solar heat collector ($F_R U_L$), and 0.7164 indicates the rate of absorbance ($F_R \tau\alpha$).

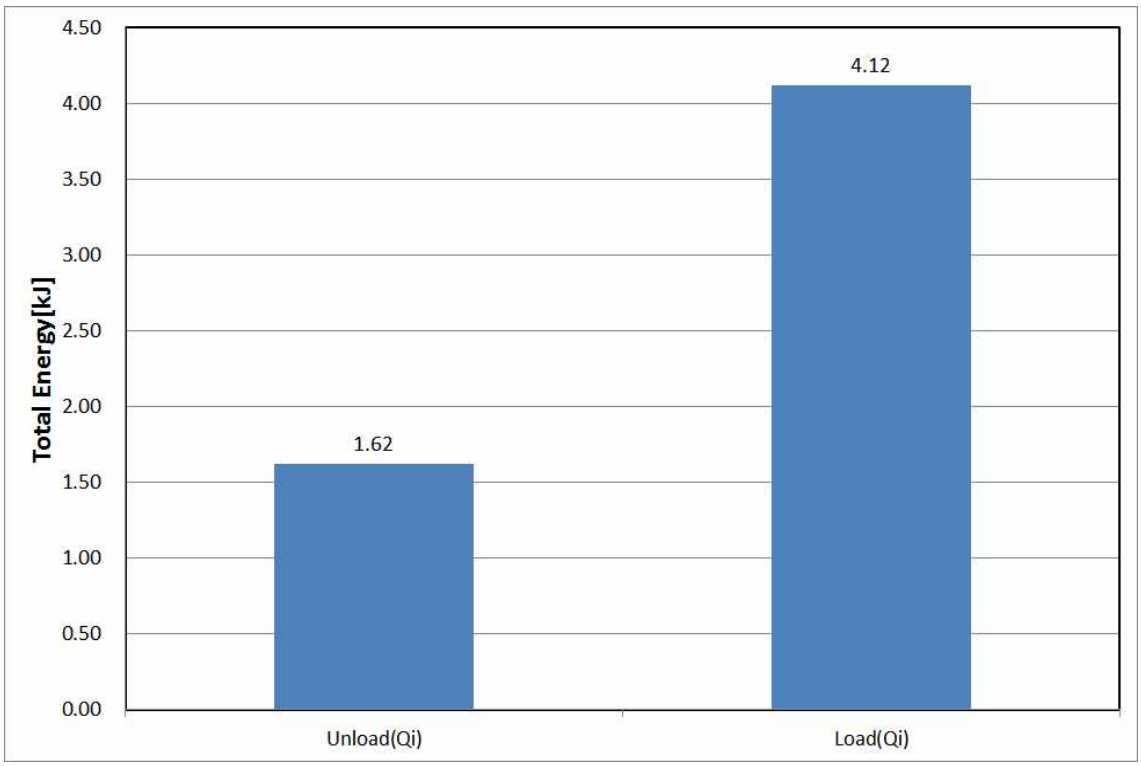
(7) Analysis on the energy amount with and without load

■ Energy analysis with fan-type heat exchanger

1) Presentation of collected data and energy calculation

	Unloaded test data (No fan operation)						Loaded test data (with fan operation)					
Time	T_a	$T_{H.o}$	$T_{H.i}$	$\dot{m}_h$	$P2$	$\dot{Q}_c$	T_a	$T_{H.o}$	$T_{H.i}$	$\dot{m}_h$	$P2$	$\dot{Q}_c$
1	21	43	45	0.05	1	0.42	21	43	48	0.05	1	1.05
2	21.5	43.5	45.5	0.05	1	0.42	21.5	43.5	48.5	0.05	1	1.05
3	21.6	43.7	45.6	0.05	1	0.40	21.6	43.7	48.6	0.05	1	1.02
4	21.5	44	45.8	0.05	1	0.38	21.5	44	48.8	0.05	1	1.00
Total						1.62						4.12

2) 열량 비교 그래프 작도



· Selecting the variables for performance test on the solar heat system

Incident Angle	Thermal Medium	Rate of Heat Collection	Heating Load Condition	Flux Load
90°	Water (A-2)	Small (A-3)	Fan-type heat exchanger (A-4)	Small (A-5)
45°	Water+PG (B-2)	Normal (B-3)	Fan-type heat exchanger (B-4)	Normal (B-5)
15°	Water+EG (C-2)	Large (C-3)	Coil-type heat exchanger (C-4)	Large (C-5)

· Performance Test and Requirements

1. Prepare the test equipment, tools and materials and inspect the functions of freezer, circulating pump and flow meter.
2. Use the test equipment to follow the test procedure and requirements provided in advance. Apply power for running the solar heat hot water boiler.
3. Set the variables for measuring the performance of solar boiler system and start the data measuring program.
4. Save the experimental data collected while the performance measuring device is operating as an excel file. Selectively save a reliable set of data from a specific range.
5. Separately save the final experiment data collected by the performance measuring device by dividing into temperature and energy data. Create graphs for each set of data.
6. Use the temperature and energy data collected by the performance measuring device to draw graphs and conduct calculations.
7. Based on the graphs created using excel file based on the data collected by the performance measuring device to analyze the causes and contents.
8. Refer to the analysis on the experimental data collected by the performance measuring device while solar boiler system was operating to write evaluation and conclusion.
9. Write report based on the analysis, evaluaion and conclusion on the data collected and give a presentation.

	Criteria		Marks	Scores	Notes
Experiment · Evaluation standards	Experiment (50)	Preparation for the experiment and safety measures	10		
		System operation condition	10		
		Appropriacy of test method and conditions	10		
		Organization of experiment data and drawing of graph	20		
	Analysis (30)	Contents of analysis and graph	10		
		Evaluation conclusion of experiment	20		
	Presentation (20)	· ( ) points off for every ( ) minutes over the required time limit			Total

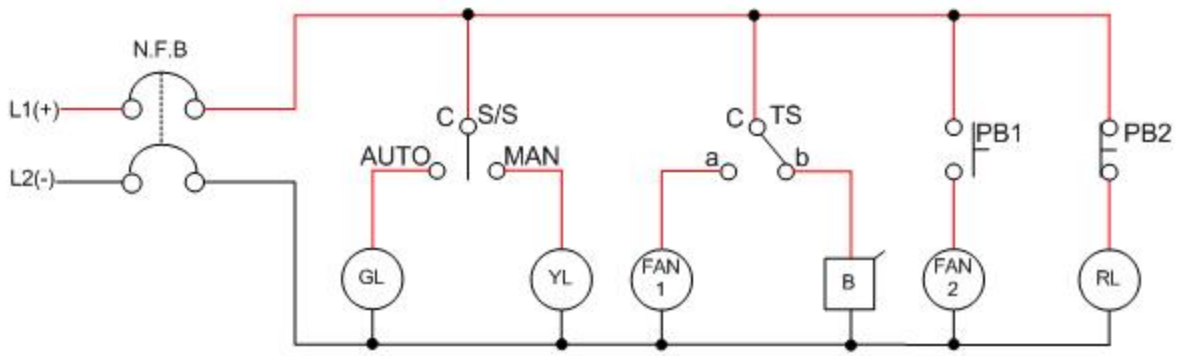
5. Practice to auto control solar heat boiler system

Assignment Title	5-1. Construction of Switch Circuit for Controlling the Operation of Solar Heat System (Push Button, Selector Switch)	Time Required
		8 Hours
Objective	① To understand the principles of push button switch and to construct a driving circuit ② To understand the principles of toggle button switch and to construct a driving circuit ③ To understand the principles of push selector switch and to construct a driving circuit	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wiper Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

Components of Solar Heat System

· Controller Circuit



L1, L2 : Line potential

N.F.B : Overcurrent breaker

TS : Toggle switch

FAN1 : Overheating prevention fan

S/S : Selector switch

B : Buzzer

PB1 : contact A push button switch

PB2 : contact B push button switch

RL, GL, YL : Lamp

FAN2 : Heating fan

2. Push button switch

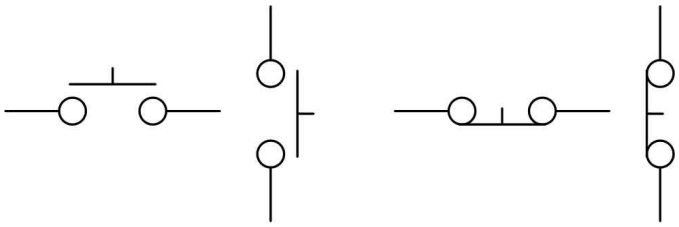
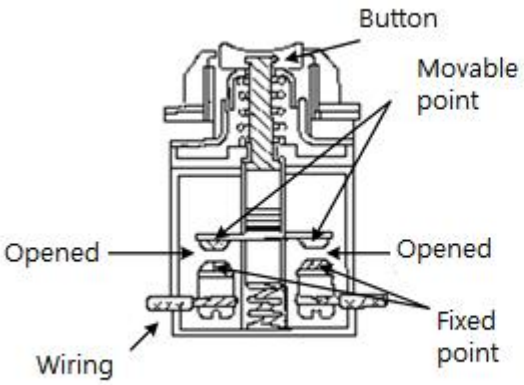


Diagram 2. Push button switch Diagram 3. contact A Diagram 4. contact B



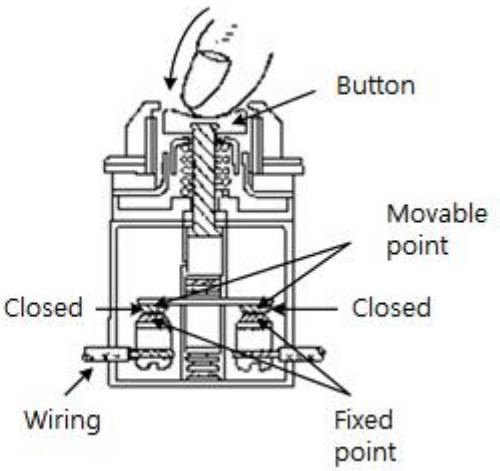
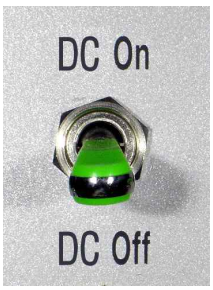


Diagram 5. Switch at original position Diagram 6. Switch opened

(1) Switches are used the most to make control orders. Above diagrams show operation of the push button switches. Switches(PB :Push Button switch) closes or opens the circuit across an contact when manually pressed down. Once you remove your hand from the switch, a spring will act to automatically return the switch to its original position.

3. Toggle Switch



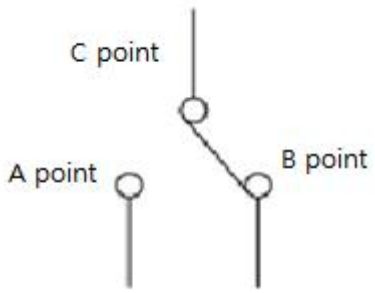


Diagram 7. Toggle Switch Diagram 8. Circuit Diagram

(1) Toggle switch is another type of switches used on a circuit. Above diagrams show the toggle switch (a.k.a. snap switch). Switches can be categorized into automatically and manually intersecting types depending on their operating method. Push button switch belongs to the former, whereas toggle switch belongs to the latter type of switches. The characteristics of their contact are noted using different symbols.

4. Selector switch

Diagram 9. Selector switch

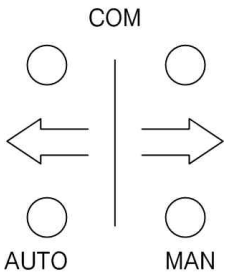
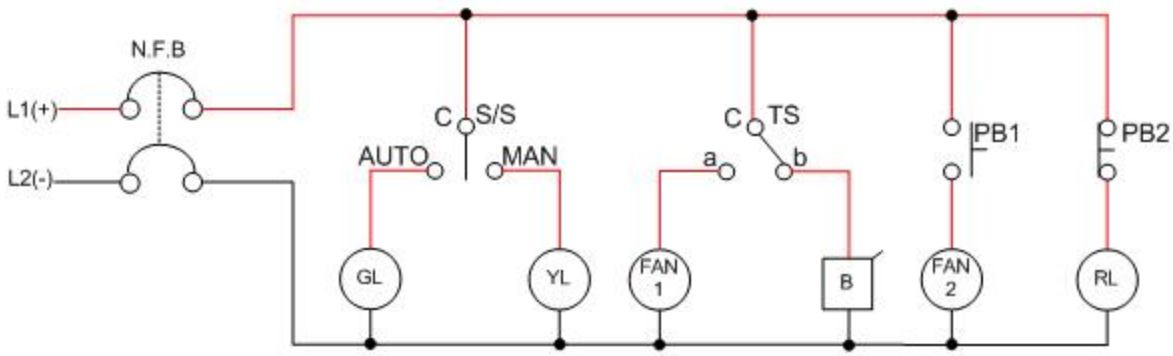


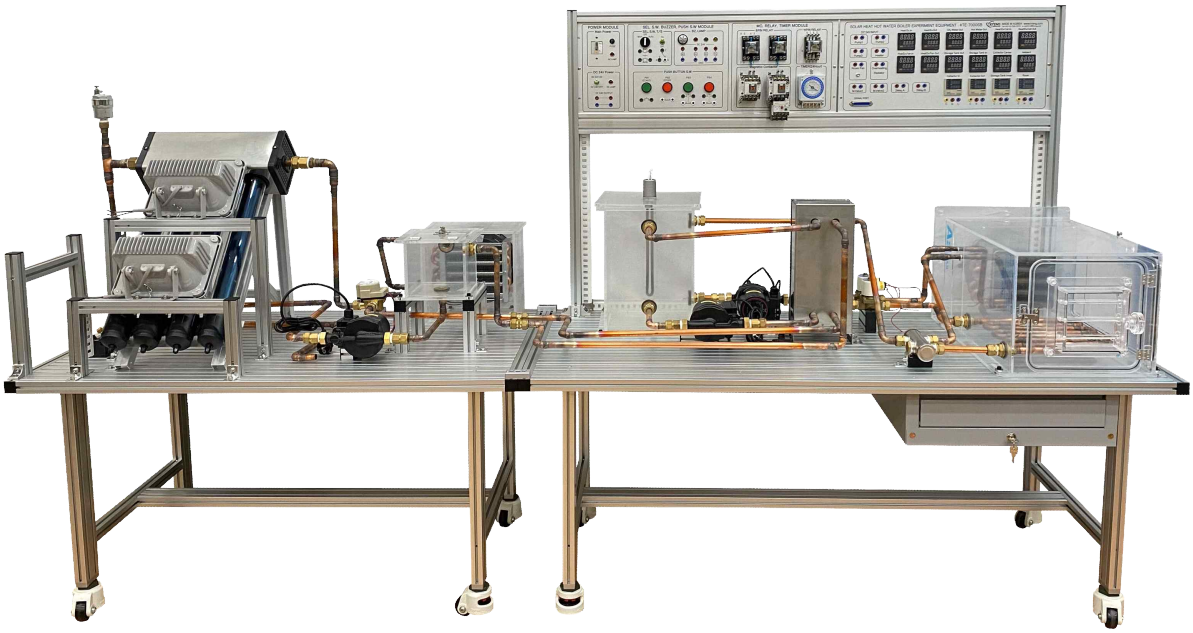
Diagram 10. Circuit Diagram

(1) Above diagrams show a selector switch (a.k.a. rotary switch). It maintains its last state of contact even after you take your hand off the switch. You may select between AUTO and MAN using the switch lever.

5. “A" and "B" contact circuit with different types of switch



(1) GL Lamp turns on when S/S is on AUTO.
YL Lamp turns on and GL Lamp turns off when S/S is on MAN.
(2) Buzzer sounds when TS is on b.
FAN1 runs and Buzzer turns off when TS is on a.
(3) FAN2 runs when PB1 at A contact is pressed.
FAN2 stops when hand is taken off from PB1.
(4) RL turns off when PB2 at B contact is pressed.
RL turns on when hand is taken off from PB2.



・Requirements

1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand how the circuit works.
   (1) Explain the actions that occur when Toggle switch turned on(a) and off(b).
   (2) Explain the actions that occur when push switch is pressed down.
   (3) Explain the actions that occur when Selector switch is on AUTO and MAN.
4. Use the test equipment, tools and materials to construct an actual circuit and run it.

Evaluation Standards	Criteria		Marks	Scores	Notes
	Works (70)	Operation of circuit with banana jack	20		
		Operation of the actually wired circuit	20		
		Real circuit and wiring condition	10		
		Understanding and description on the circuit	20		
	Attitudes (10)	Working attitudes and safety issues	5		
		Usage of materials/tools and clear-up works afterwards	5		
	Time (20)	( ) points off for every ( ) minutes over the required time limit			

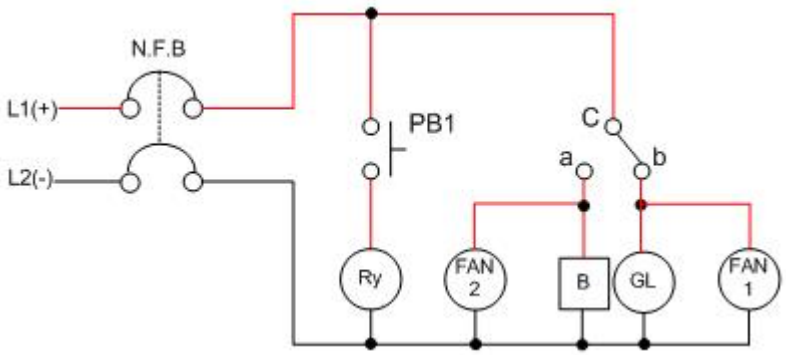
Works	Attitudes	Time	Total Score

Assignment Title	5-2. Experiment on “C” Contact Circuit using Relay	Time Required
		8 Hours
Objective	① To understand the structure of relay and operation principles thereof. ② To turn Lamp on and off using the contact of relay.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

Components of Solar Heat System

· Controller Circuit



L1, L2 : Line potential

N.F.B : Overcurrent breaker

Ry : Relay

B : Buzzer

GL : Green Lamp

FAN1: Heat emitting fan motor for heating

FAN2: Heat emitting fan motor for overheating

2. Relay

Diagram 2. Relay

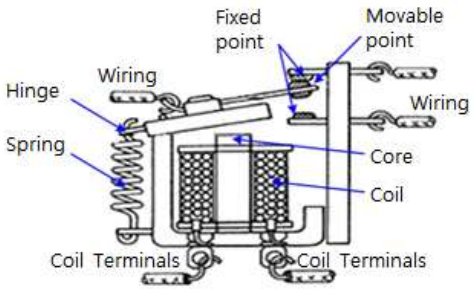
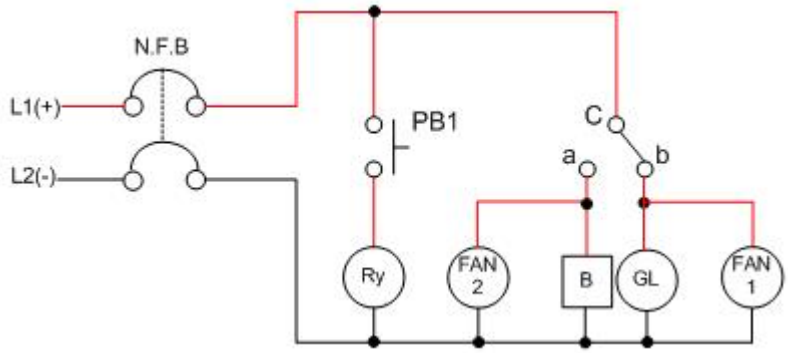


Diagram 3. Internal components of relay

(1) An electrical circuit is divided into two parts with one producing signals and another operating according to the signal, so the circuits need to be able to be opened and closed. Thus, an electrical component called relay, a type of electrical switch.

3. Relay at “C" contact on ”a" and "b" contact circuit

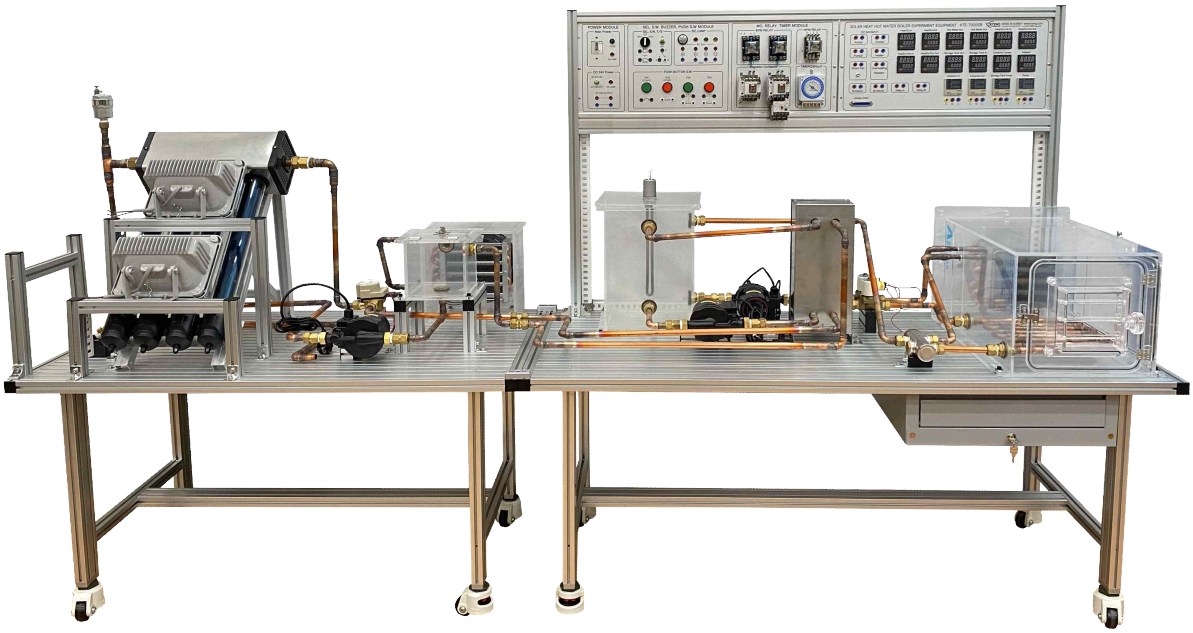


(1) When you turn N.F.B switch on GL and FAN1 turns on since RY-b contact is closed and FAN2 and Buzzer will turn off since RY-a contact is opened. (PB1 stays opened)

(2) When you press PB1 the coil on relay is energized and RY-a contact is closed so FAN2 and Buzzer turns ON, whereas FAN1 turns OFF.

(3) Arbeit contact means 『a working contact』 and is marked as “a”.

(4) Break contact means 『an opening contact』 and is marked as “b”.



・Requirements

1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand the relay circuit and its operation principles.

(1) Explain the actions that occur when PB1 is pressed.

(2) Explain the actions that occur when PB1 is released.

4. Use the test equipment, tools and materials to construct an actual circuit and run it.

Evaluation Standards	Criteria		Marks	Scores	Notes
	Works (70)	Operation of circuit with banana jack	20		
		Operation of the actually wired circuit	20		
		Real circuit and wiring condition	10		
		Understanding and description on the circuit	20		
	Attitudes (10)	Working attitudes and safety issues	5		
		Usage of materials/tools and clear-up works afterwards	5		
	Time (20)	( ) points off for every ( ) minutes over the required time limit			

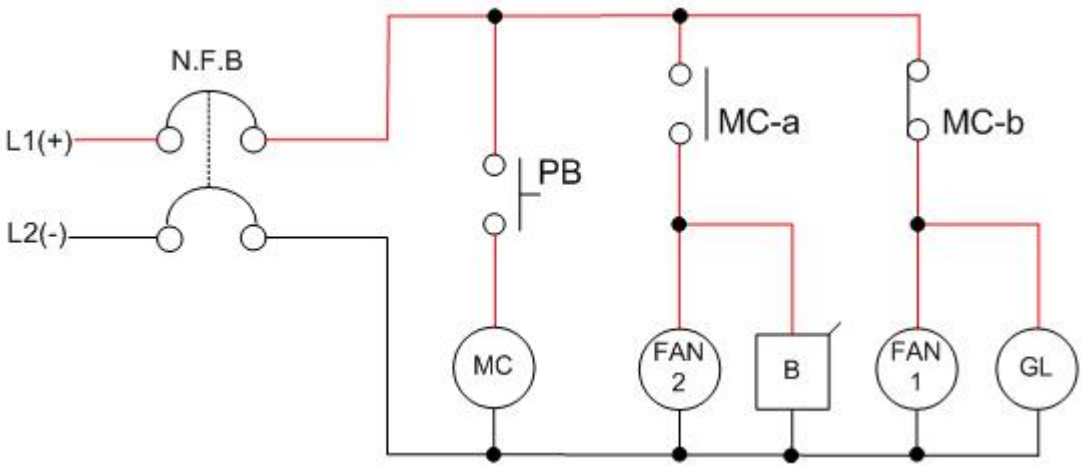
Works	Attitudes	Time	Total Score

Assignment Title	5-3. Experiment on "a" and "b" Contact Circuit using Magnetic Contactor (MC)	Time Required
		8 Hours
Objective	① To understand the structure and operation principles of magnetic contactor (MC). ② To use "a" and "b" contacts of MC to operate a loading device. ③ To explain operation of "a" and "b" contact circuit with MC.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	· Driver · Nipper · Wire Striper · Hook Meter	· #2× 6× 175㎜ · 150㎜ · .5~6㎟ · 300A 600V	1 1 1 1 per each group

Components of Solar Heat System

· **Controller Circuit**



L1, L2 : Line potential

N.F.B : Overcurrent breaker

FAN1 : Heat emitting fan motor for heating

FAN2 : Heat emitting fan motor for overheating

MC-a : Magnetic contactor "a"contact

MC-b : Magnetic contactor "b"contact

B : Buzzer

PB1 : Push button switch

GL : Green Lamp

MC : Magnetic contactor coil

2. Magnetic contactor(MC : Magnetic Contactor)

Diagram 2. Magnetic contactor

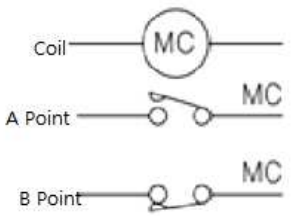


Diagram 3. Circuit Diagram

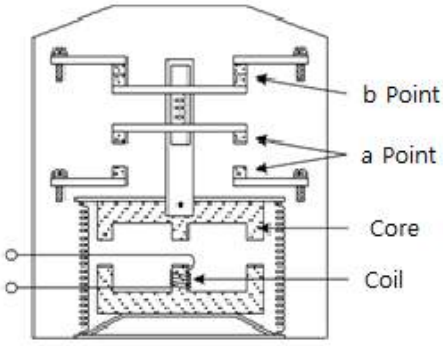
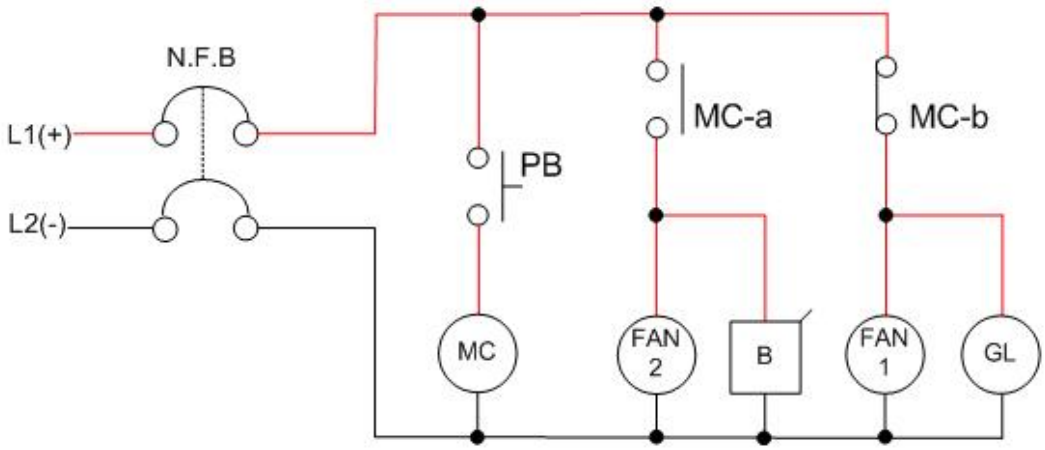


Diagram 4. Internal Structure

(1) The operation principle of MC is the same as that of an electrical contactor. In other words, it operates the contacting part using the absorption force of electromagnet and it is mostly used for closing/opening high currents or for frequent operating/stopping of motors. High-voltage MC is also used for opening/closing high-volatage circuits. MC can be divided into the main contact type for high current and auxiliary contact type for circuits (low currents).

3. “a" contact circuit and ”b" contact circuit

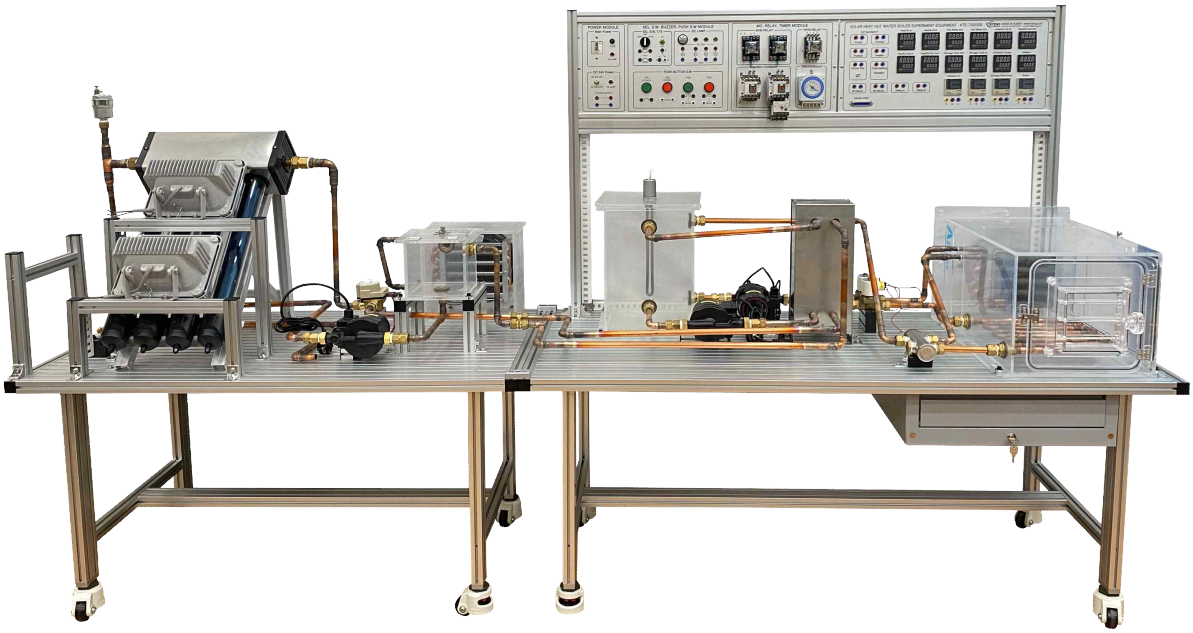


(1) When N.F.B switch is turned on, FAN1 and GL turns on since MC-b contact is closed and FAN2 and Buzzer turns off since MC-a contact is opened. (PB swtich is stays opened)

(2) When PB1 switch is closed, now the electrical coil on MC is energized with MC-a contact closed and MC-b contact opened, so FAN2a nd Buzzer turns on, whereas FAN1 and GL turns off.

(3) Arbeit contact means 『a working contact』 and is marked as “a”.

(4) Break contact means 『an opening contact』 and is marked as “b”.



・Requirements

1. Prepare and inspect test equipment, tools and materials.

2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.

3. Understand the MC circuit and its operation principles.

(1) Explain the actions that occur when PB1 is pressed.

(2) Explain the actions that occur when PB1 is released.

5. Explain “a” contact and “b” contact on a frozen electrical circuit.

6. Use the test equipment, tools and materials to construct an actual circuit.

Evaluation Standards	Criteria		Marks	Scores	Notes
	Works (70)	Operation of circuit with banana jack	20		
		Operation of the actually wired circuit	20		
		Real circuit and wiring condition	10		
		Understanding and description on the circuit	20		
	Attitudes (10)	Working attitudes and safety issues	5		
		Usage of materials/tools and clear-up works afterwards	5		
	Time (20)	( ) points off for every ( ) minutes over the required time limit			

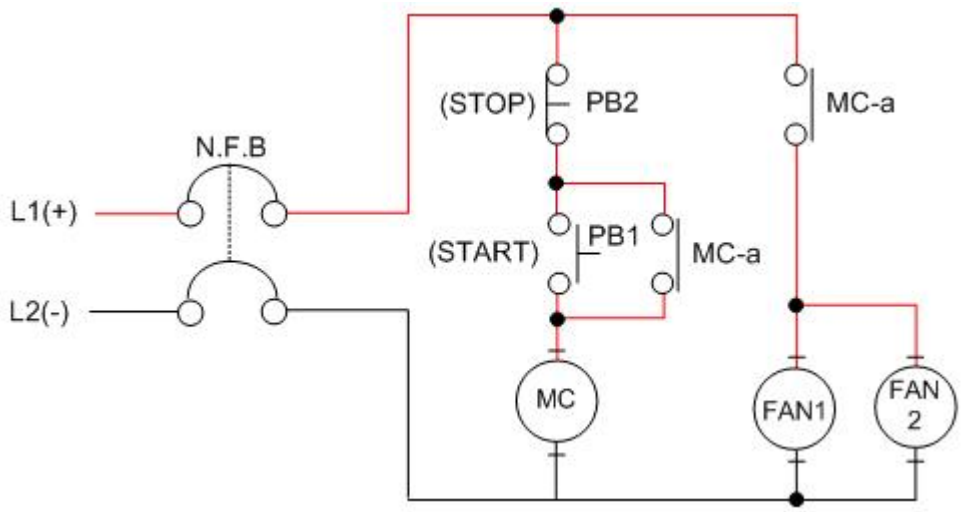
Works	Attitudes	Time	Total Score

Assignment Title	5-4. Construction and Operation of Reset Self-Holding Circuit	Time Required
		8 Hours
Objective	① To construct and operate a reset self-holding circuit and understand the operation principles thereof. ② To explain the reset process of the self-holding circuit based on a circuit diagram.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

Components of Solar Heat System

· Controller Circuit



L1, L2 : Line potential

N.F.B : Over current breaker

MC-a : Magnetic contactor "a"contact

MC : Magnetic contactor Coil

FAN1 : Heat emitting fan motor for heating

FAN2 : Heat emitting fan motor for overheating

PB1 : Push button switch

2. Magnetic contactor(MC : Magnetic Contactor)

Diagram 2. Magnetic contactor

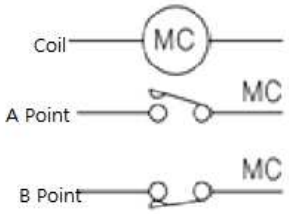


Diagram 3. Circuit Diagram

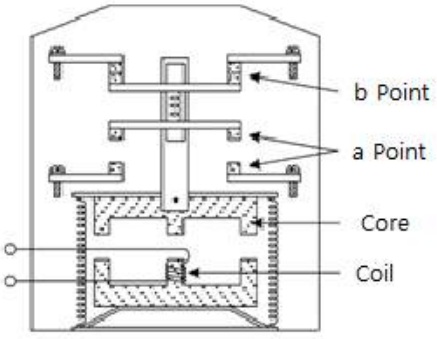
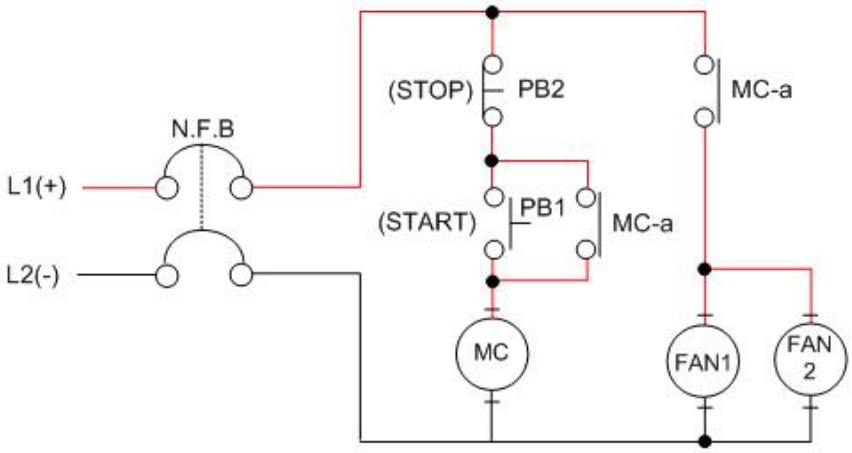


Diagram 4. Internal Structure

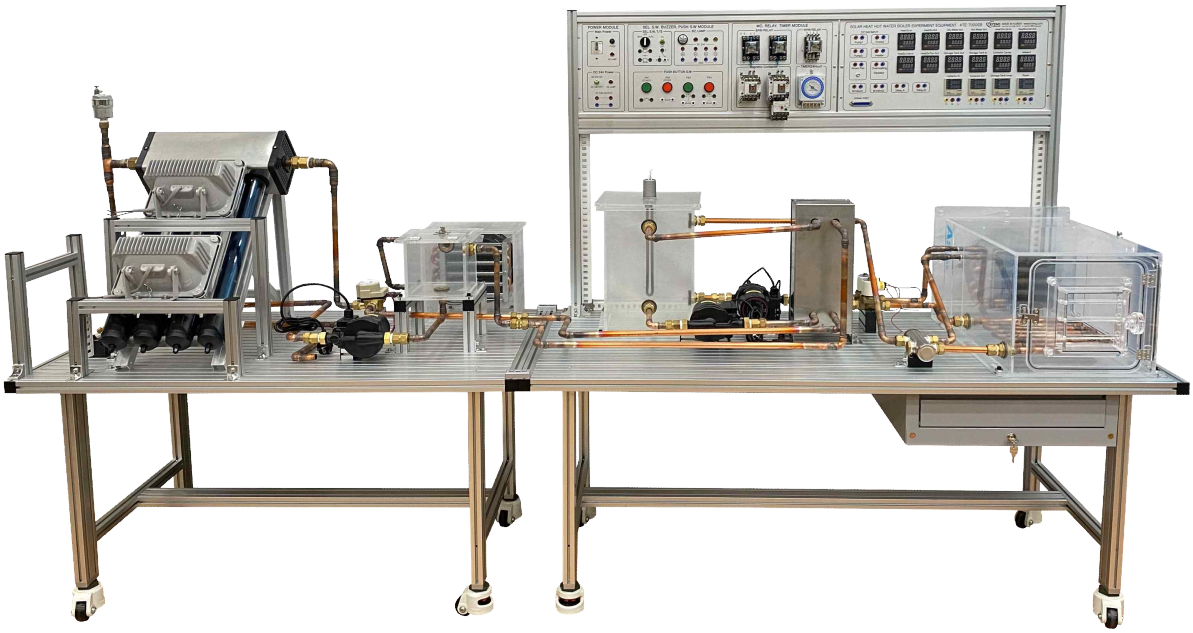
(1) The operation principle of MC is the same as that of an electrical contactor. In other words, it operates the contacting part using the absorption force of electromagnet and it is mostly used for closing/opening high currents or for frequent operating/stopping of motors. High-voltage MC is also used for opening/closing high-volatage circuits. MC can be divided into the main contact type for high current and auxiliary contact type for circuits (low currents).

3. “a" contact circuit and ”b" contact circuit



(1) When PB1 (START) button is turned ON while N.F.B switch is ON, the MC coil is energized and the main contact, an “a” contact circuit, is closed, so FAN1 and FAN2 starts to operate normally.

(2) When PB2 (START) button is turned OFF, the MC coil is demagnetized and “a”contact is opened, so FAN1 and FAN2 stops operating.



・Requirements

1. Prepare and inspect test equipment, tools and materials.

2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.

3. Understand the reset self-holding circuit and its operation principles.

(1) Explain the actions that occur when PB1 is pressed.

(2) Explain the actions that occur when PB1 is released.

5. Explain “a” contact and “b” contact on the circuit.

6. Use the test equipment, tools and materials to construct an actual circuit.

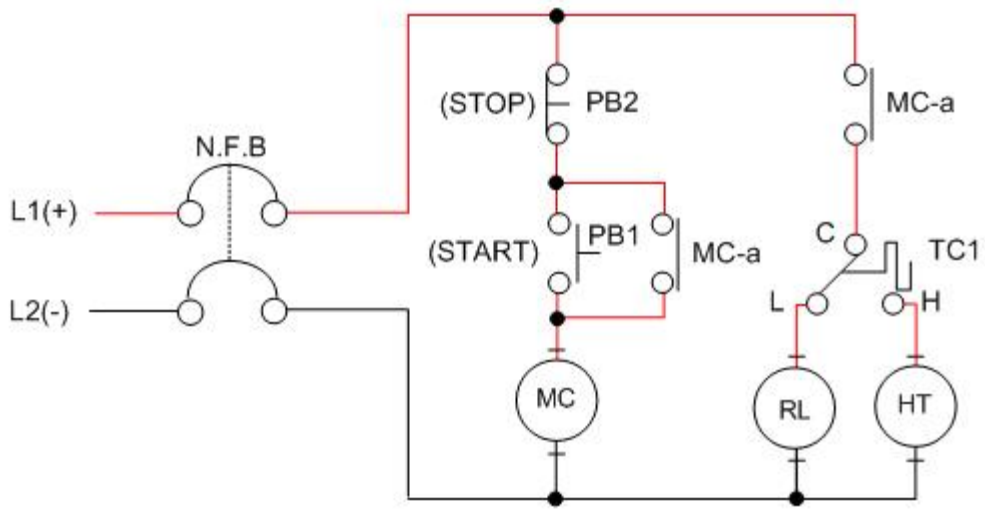
<table>
<tr><td rowspan="8">Evaluation Standards</td><td colspan="2">Criteria</td><td>Marks</td><td>Scores</td><td colspan="4">Notes</td></tr>
<tr><td rowspan="4">Works (70)</td><td>Operation of circuit with banana jack</td><td>20</td><td></td><td colspan="4" rowspan="5"></td></tr>
<tr><td>Operation of the actually wired circuit</td><td>20</td><td></td></tr>
<tr><td>Real circuit and wiring condition</td><td>10</td><td></td></tr>
<tr><td>Understanding and description on the circuit</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Attitudes (10)</td><td>Working attitudes and safety issues</td><td>5</td><td></td></tr>
<tr><td>Usage of materials/tools and clear-up works afterwards</td><td>5</td><td></td></tr>
<tr><td>Time (20)</td><td colspan="3">( ) points off for every ( ) minutes over the required time limit</td><td>Works</td><td>Attitudes</td><td>Time</td><td>Total Score</td></tr>
<tr><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Assignment Title	5-5. Construction and Operation of Temperature Switch Heater Controller Circuit	Time Required
		8 Hours
Objective	① To handle the temperature switch controller and understand the principles thereof. ② To use a circuit diagram to connect the temperature switch controller with a device to drive.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

Components of Solar Heat System

· Controller Circuit



L1, L2 : Line potential

N.F.B : Over current breaker

HT : Thermal Storage Tank Aux. Heater

MC-a : Magnetic contactor "a"contact

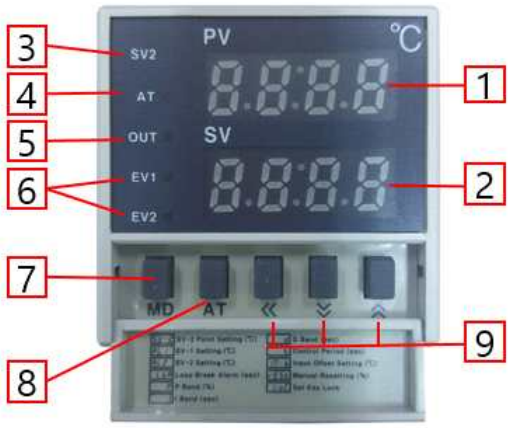
MC-b : Magnetic contactor "b"contact

PB1 : Push button switch

RL : Red Lamp

MC : Magnetic contactor Coil

2. Temperature Controller (TC)



① PV: Measurement display (red)
Displays measured value.
Displays configuration subject in configuration mode.

② SV: Configuration value display (gree
Displays adjusting value.
Displays configuration subject in configuration mode.

③ SV2: SV2 on lamp

④ AT: auto-tuning on lamp

⑤ OUT: output on lamp

⑥ EV1,2: EVENT output display lamp

⑦ MD key: mode key
Press button for 3sec

⑧ AT key: Auto-tuning run key

⑨ ∧∨《: adjustment key

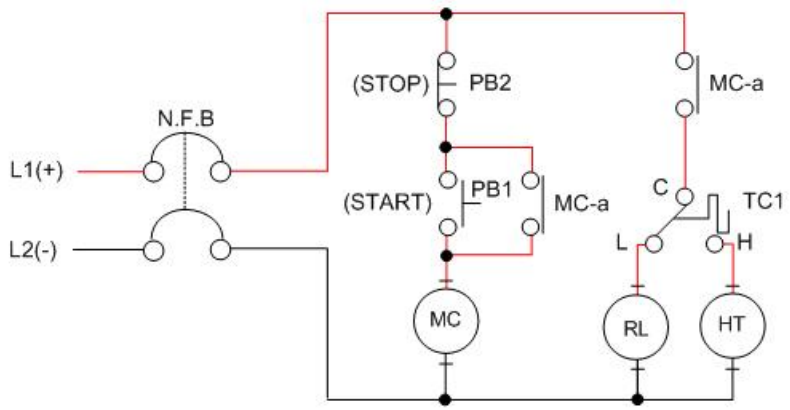
Temperature Controller

It is a part used for turning an equipment on or off by setting temperature values.

① Press enter temperature button to set desired value.
② Press increase and decrease temperature buttons to enter values.
③ Press enter deviation to set deviation value.
④ Apply + power on com.
⑤ Apply + end of power on H or L according to the connected device.

(1) The temperature switches controls otuput device by changing the “a” and “b” contacts according to the temperature setting.

3. “a" contact circuit and ”b" contact circuit



(2) When PB2 (START) button is turned OFF, the MC coil is demagnetized and “a”contact is opened, so TC1 stops.

(1) When PB1 (START) button is turned ON while N.F.B switch is ON, the MC coil is energized and the main contact, an “a” contact circuit, is closed, so power is applied on TC1. If the temperature is higher than the setting, RL turns on and otherwise heater starts to operate.
(2) When PB2 (START) button is turned OFF, the MC coil is demagnetized and “a”contact is opened, so TC1 stops.

・Requirements
1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand the principles of temperature switches and be able to set the values according to the setting values for automatic control.
4. Understand the circuit and its operation principles.
(1) Explain the actions that occur when PB1 is pressed.
(2) Explain how opening the temperature switch while the solar heat system operates stops the heater from operating.
(3) Explain how closing the temperature switch while the solar heat system operates starts the heater to operate.
(4) Explain the actions that occur when PB2 is pressed.
5. Use the test equipment, tools and materials to construct an actual circuit.

Evaluation Standards	Criteria		Marks	Scores	Notes
	Works (70)	Operation of circuit with banana jack	20		
		Operation of the actually wired circuit	20		
		Real circuit and wiring condition	10		
		Understanding and description on the circuit	20		
	Attitudes (10)	Working attitudes and safety issues	5		
		Usage of materials/tools and clear-up works afterwards	5		
	Time (20)	( ) points off for every ( ) minutes over the required time limit			

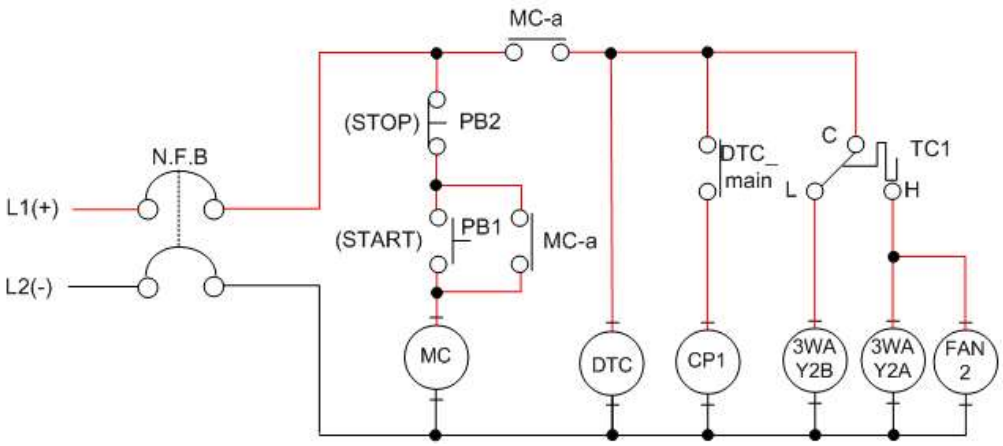
Works	Attitudes	Time	Total Score

Assignment Title	5-6. Construction of Heat Storage/Emission Convertible Circuit using 3-Way Valve	Time Required
		8 Hours
Objective	① To handle 3-Way Valve and understand the operation principles thereof. ② Use a circuit diagram to construct a heat storage/emission convertible circuit according to the operation requirements.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

Components of Solar Heat System

· Controller Circuit

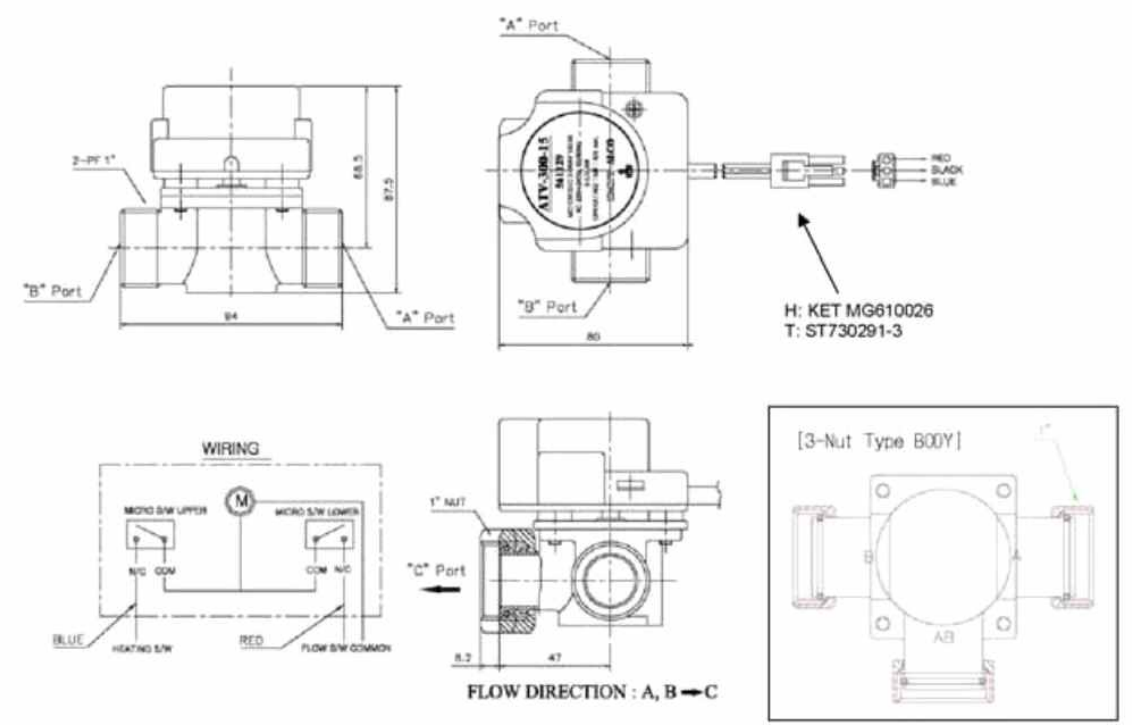


- L1, L2 : Line potential
- N.F.B : Over current breaker
- MC : Magnetic contactor Coil
- CP : Circulating Pump
- MC-a : Magnetic contactor "a"contact
- PB1 : Push button switch
- FAN2 : Heat emitting fan motor for overheating
- 3WAY2_A : 3-Way Valve Direction A
- 3WAY2_B : 3-Way Valve Direction B

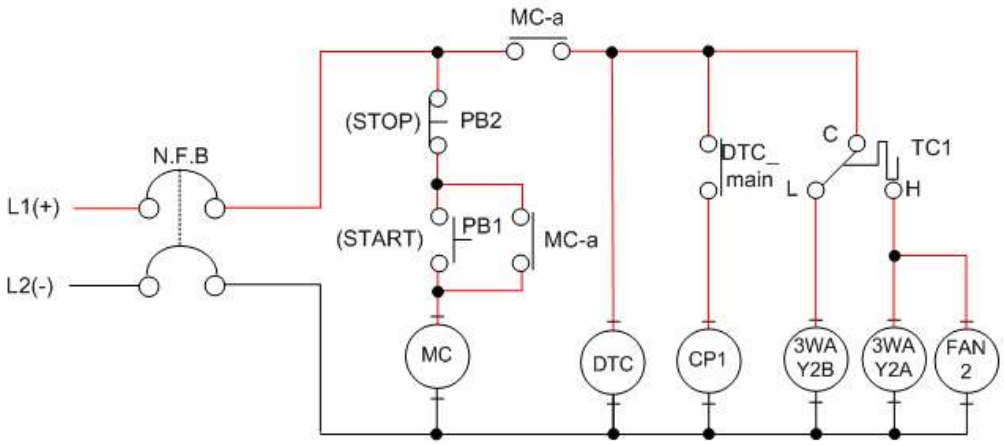
2. 3-Way Valve

3-Way Valve

(1) It is used to tightly close or open the flow ways in two directions and it converts heating water inside thermal storage tank or boiler.



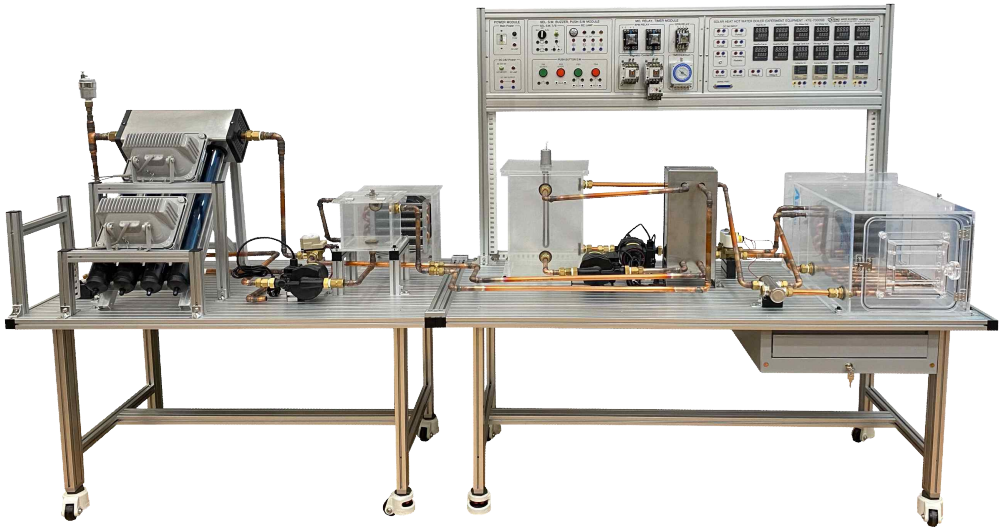
3. "a" contact circuit and "b" contact circuit



(1) When PB1 (START) button is turned ON while N.F.B switch is ON, the MC coil is energized and the main contact, an “a” contact circuit, is closed, so power is applied on DTC. If the temperature difference is greater than the setting, CP1 starts operating and otherwise CP1 stops.

(2) If power is applied on TC1, value 2 on 3-way valve is fixed in “B” direction so hot water can circulate. If temperature of thermal storage tank exceeds the TC1 setting value, the value changes direction to “A” and a heat emitting fan motor for overheating starts to operate.

(2) When PB2 (START) button is turned OFF, the MC coil is demagnetized and “a”contact is opened, so TC1 stops.



・Requirements

1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand the principles of temperature switches and be able to set the values according to the setting values for automatic control.
4. Understand the circuit and its operation principles.

(1) Explain the actions that occur when PB1 is pressed.

(2) Explain how 3-way value works while the solar heat system operates.

(3) Explain how the 3-way valve changes trajectories and how the heat emitting fan motor for overheating works while the solar heat system operates.

(4) Explain the actions that occur when PB2 is pressed.

5. Use the test equipment, tools and materials to construct an actual circuit.

<table>
<tr><th rowspan="8">Evaluation Standards</th><th colspan="2">Criteria</th><th>Marks</th><th>Scores</th><th colspan="4">Notes</th></tr>
<tr><td rowspan="4">Works (70)</td><td>Operation of circuit with banana jack</td><td>20</td><td></td><td colspan="4" rowspan="5"></td></tr>
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<tr><td>Real circuit and wiring condition</td><td>10</td><td></td></tr>
<tr><td>Understanding and description on the circuit</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Attitudes (10)</td><td>Working attitudes and safety issues</td><td>5</td><td></td></tr>
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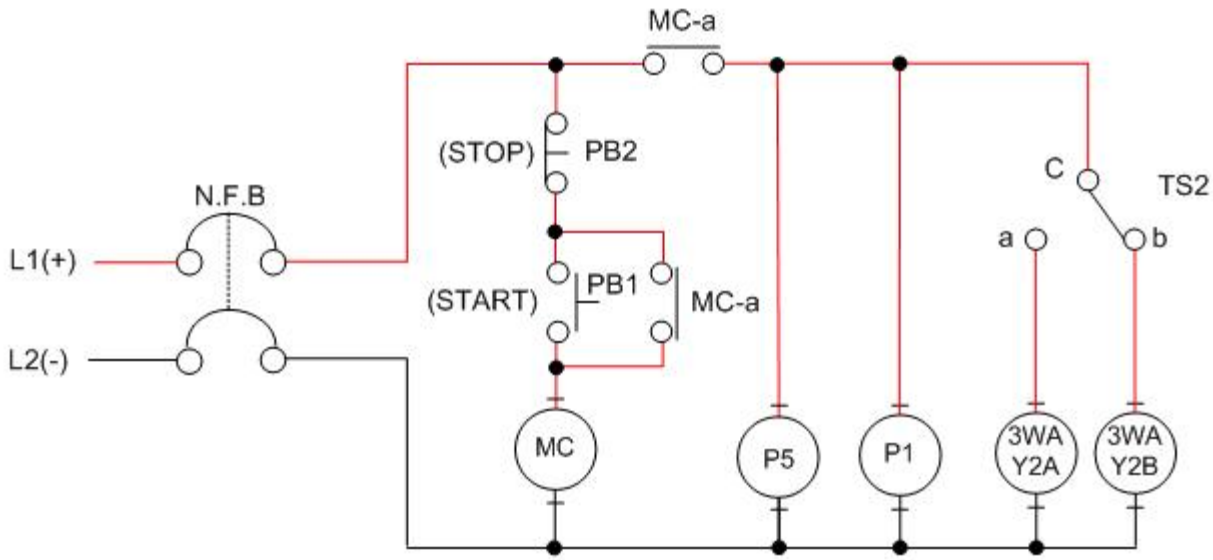
<tr><td>Time (20)</td><td colspan="3">( ) points off for every ( ) minutes over the required time limit</td><td>Works</td><td>Attitudes</td><td>Time</td><td>Total Score</td></tr>
<tr><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Assignment Title	5-7. Experiment on the Charging Circuit for Solar Heat Collector	Time Required
		8 Hours
Objective	① To construct the desired circuit and charge heat collecting medium in an order.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

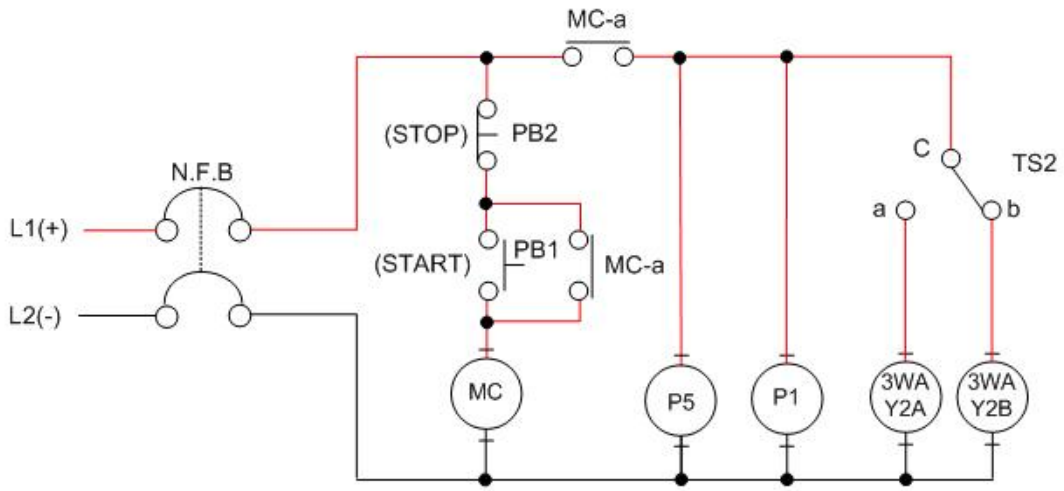
Components of Solar Heat System

· Controller Circuit



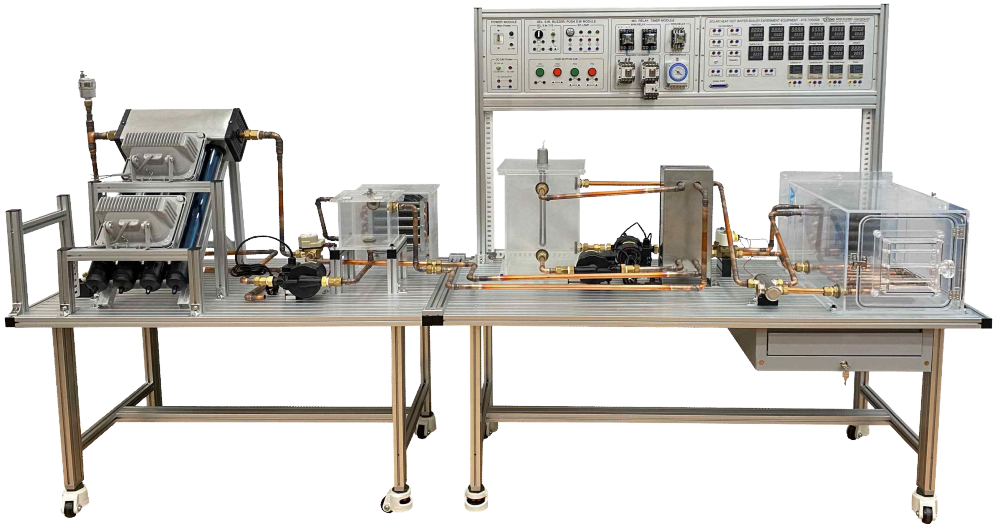
· L1, L2 : Line potential
· N.F.B : Over current breaker
· TS : Temperature Switch
· P1 : Circulating Pump
· 3WAY2_B : 3-Way Valve Direction B
· MC-a : Magnetic contactor "a"contact
· PB1 : Push button switch
· MC : Magnetic contactor Coil
· P5 : Pressurizing Pump
· 3WAY2_A : 3-Way Valve Direction A

3. "a" contact circuit and "b" contact circuit



(1) Construct the circuit and oepn the manual valve on circulating line of heat collector so the thermal medium can easily move through.
(2) Open the air valve at the top of heat collector as much as possible.
(3) Fill the make-up heat medium tank with clean water.
(4) Press PB1 button to operate P5 and P1 and check the pressure gauze at the top of the heat collector. If 1 bar is reached, change TS to a contact to supply thermal medium to overheat protecting line.
(5) If no air bubbles show in small-area flowmeter, press PB2 to stop.

1. Close drain valve on water tank→fill water(6kg)
2. Construct circuit and open the manual valve on heat collecting line
3. DC24V Power on
4. Press PB1(START)→P1 and P5 operates
5. See the pressure gauze and area-based flowmeter at the top of the heat collector to check water inside (1bar)
6. Turn T·S ON to charge water in pippes of overheat protector



・Requirements

1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand the principles of temperature switches and be able to set the values according to the setting values for automatic control.
4. Understand the circuit and its operation principles.
(1) Explain the actions that occur when PB1 is pressed.
(2) Explain how 3-way value works while the solar heat system operates.
(3) Explain how the 3-way valve changes trajectories and how the heat emitting fan motor for overheating works while the solar heat system operates.
(4) Explain the actions that occur when PB2 is pressed.
5. Use the test equipment, tools and materials to construct an actual circuit.

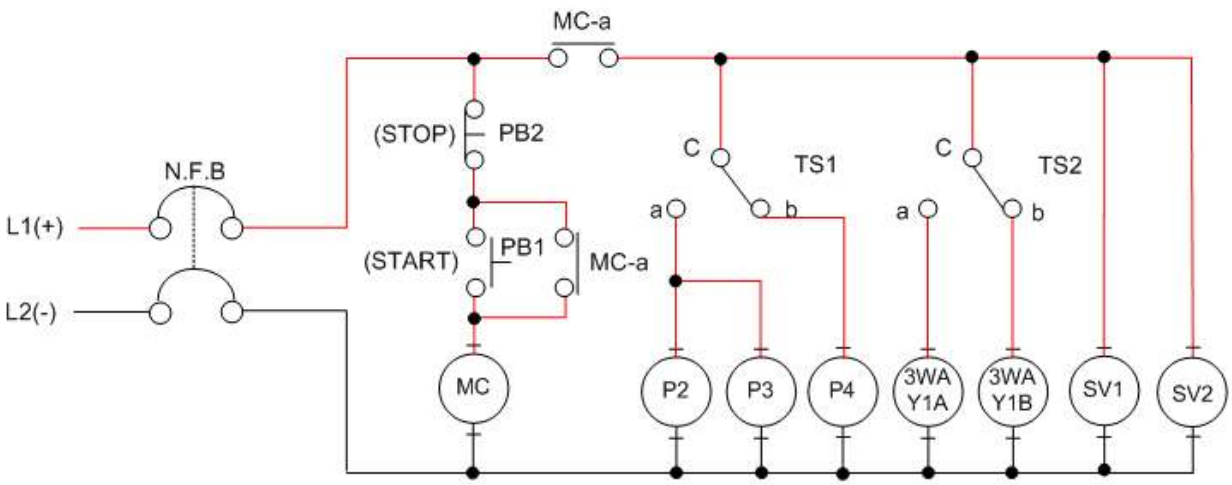
Evaluation Standards	Criteria		Marks	Scores	Notes			
	Works (70)	Operation of circuit with banana jack	20					
		Operation of the actually wired circuit	20					
		Real circuit and wiring condition	10					
		Understanding and description on the circuit	20					
	Attitudes (10)	Working attitudes and safety issues	5					
		Usage of materials/tools and clear-up works afterwards	5					
	Time (20)	( ) points off for every ( ) minutes over the required time limit			Works	Attitudes	Time	Total Score

Assignment Title	5-8. Experiment on the Charging Circuit for Solar Heat Storage Tank	Time Required
		8 Hours
Objective	① To construct the circuit and perform inspection to check the thermal medium is fully charged.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

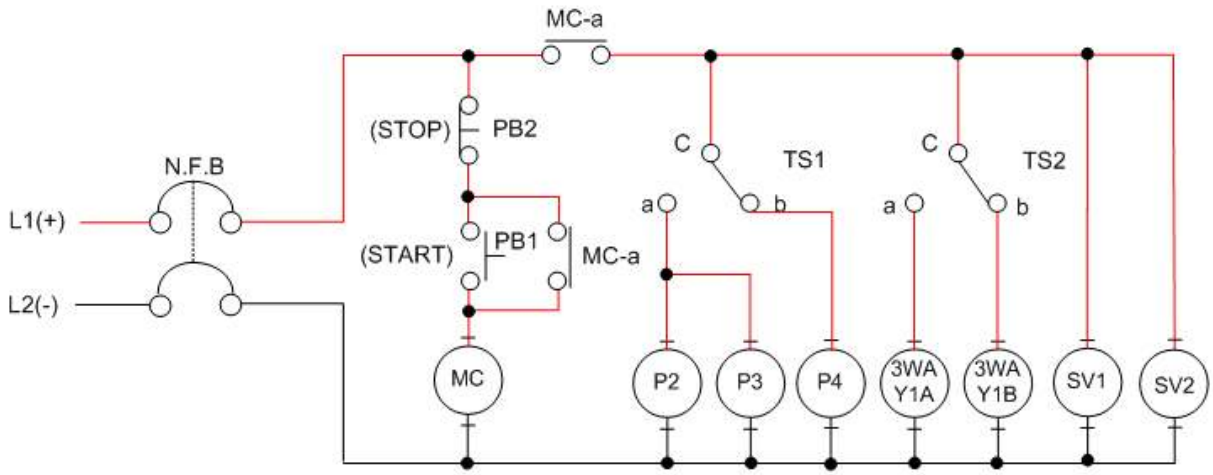
Components of Solar Heat System

· Controller Circuit



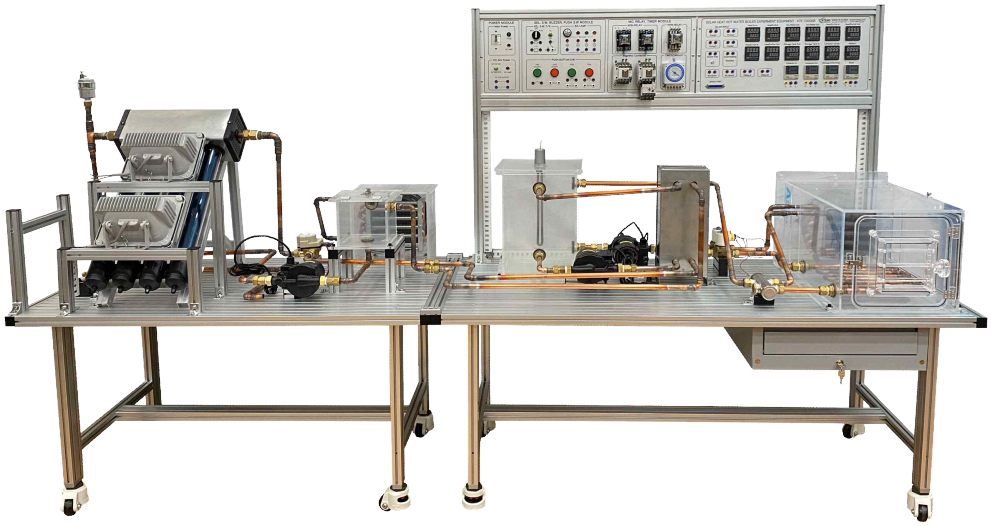
- L1, L2 : Line potential
- N.F.B : Overcurrent breaker
- TS : Toggle switch
- P2,3 : Circulating Pump
- 3WAY2_B : 3-Way Valve Direction B
- SV : Solenoid Valve
- MC-a : Magnetic contactor "a"contact
- PB1 : Push button switch
- MC : Magnetic contactor Coil
- P4 : Pressurizing Pump
- 3WAY2_A : 3-Way Valve Direction A

3. "a" contact circuit and "b" contact circuit



(1) Construct the circuit
(2) Open the manual valve on heating water supply lines
(3) Since the water pressure may cause overflow of water from the tank, make sure to keep the valve in “A” direction
(4) Fill the water tank with clean water
(5) Press PB1 to P4, open the 3WAY valve in B direction, and open both SV1 and SV2
(6) Once the thermal storage tank is fully supplied with water, change TS1 and TS2 to a contact to operate P2 and P3. Then change the line to thermal storage tank and heat exchanger for heating to supply heating water to the thermal storage lines and heating water pipes.
(7) Once the thermal storage tank and the pipes are fully supplied with water, press PB2 while Toggle2 is turned ON to stop PB2. (When turned OFF, water inside the thermal storage tank may flow backwards into water tank, causing overflow)

1. Close drain valve of water tank
2. Open the cover of the water tank to refill water
3. Create a circuit diagram (Keep toggle 1 and 2 off)
4. Press PB1 Start button



・Requirements

1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand the principles of temperature switches and be able to set the values according to the setting values for automatic control.
4. Understand the circuit and its operation principles.
(1) Explain the actions that occur when PB1 is pressed.
(2) Explain how 3-way value works while the solar heat system operates.
(3) Explain how the 3-way valve changes trajectories and how the heat emitting fan motor for overheating works while the solar heat system operates.
(4) Explain the actions that occur when PB2 is pressed.
5. Use the test equipment, tools and materials to construct an actual circuit.

Evaluation Standards	Criteria		Marks	Scores	Notes
	Works (70)	Operation of circuit with banana jack	20		
		Operation of the actually wired circuit	20		
		Real circuit and wiring condition	10		
		Understanding and description on the circuit	20		
	Attitudes (10)	Working attitudes and safety issues	5		
		Usage of materials/tools and clear-up works afterwards	5		
	Time (20)	( ) points off for every ( ) minutes over the required time limit			

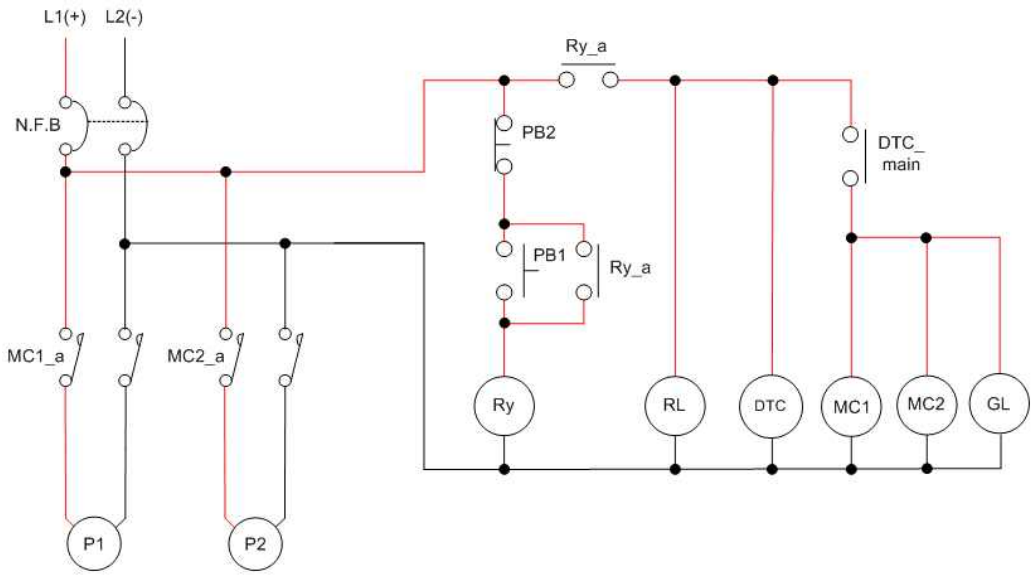
Works	Attitudes	Time	Total Score

Assignment Title	5-9. Construction of Driving Circuit for Heat Collection and Storage using Temperature Difference Control	Time Required
		8 Hours
Objective	① To find out the functions of Temperature Difference Controller. ② To understand the principles of Temperature Difference Control and set the temperature difference value. ③ To use a circuit diagram to describe the operation principle.	

Equipment	Tools and Materials	Specification	Quantity
- Solar Heat Hot Water Boiler test equipment (KTE-7000SB)	• Driver • Nipper • Wire Striper • Hook Meter	• #2× 6× 175㎜ • 150㎜ • .5~6㎟ • 300A 600V	1 1 1 1 per each group

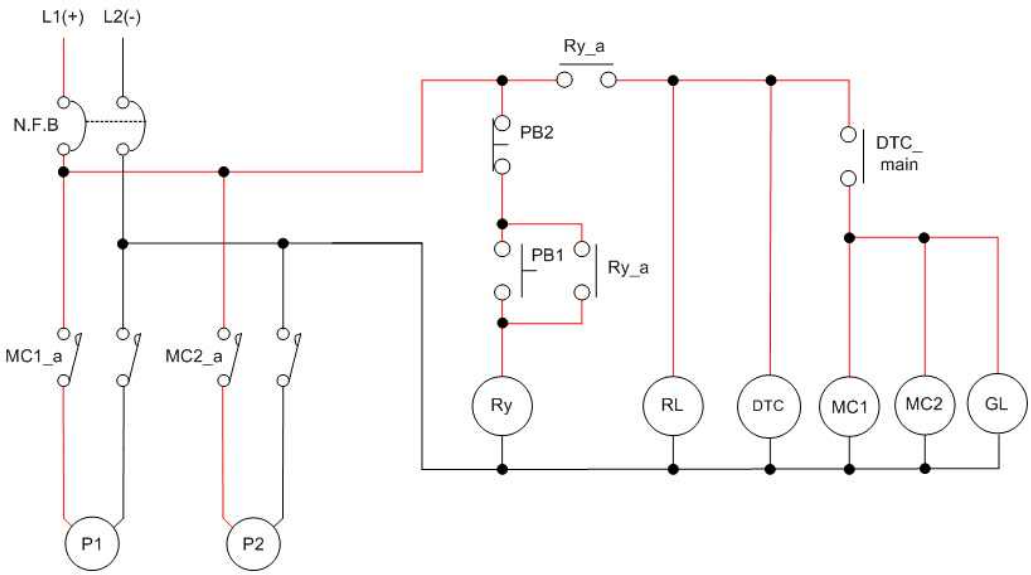
Components of Solar Heat System

· Controller Circuit



- L1, L2 : Line potential
- N.F.B : Over current breaker
- MC : Magnetic contactor Coil
- P1 : Circulating Pump
- Ry_a : Relay a contact
- GL : Green Lamp
- MC-a : Magnetic contactor "a"contact
- PB1 : Push button switch
- Ry : Relay
- P2 : 3-Way Valve Direction A
- Ry_b : Relay b contact
- RL : Red Lamp

3. "a" contact circuit and "b" contact circuit

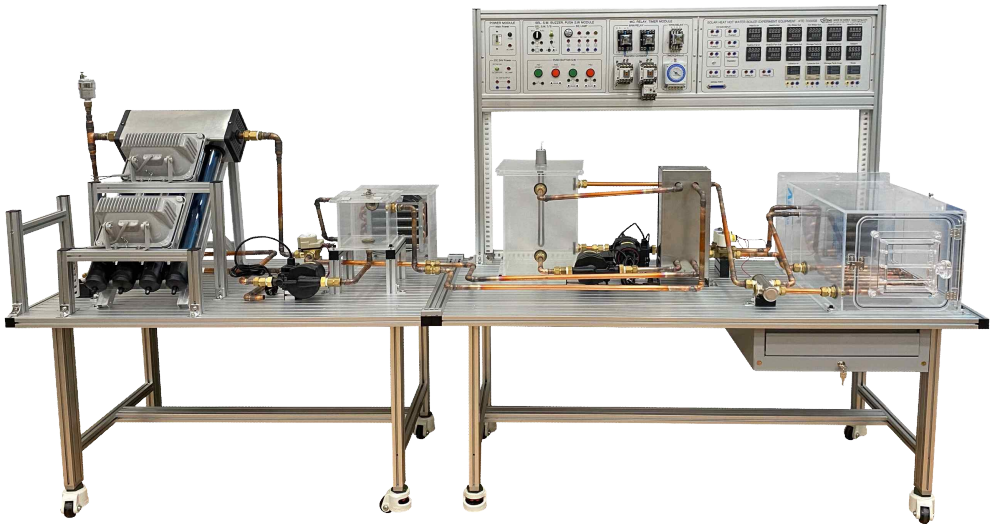


(1) Create the Controller Circuit.

(2) If you press PB2 button, self-holding circuit will be completed and power will be supplied to Temperature Difference Controller (DTC).

(3) According to the temperature difference value set on the controller, power is applied to or cut from MC1 and MC2. If power is applied, GL will turn on and heat collection/storage pump will start operating.

1. Construct the circuit diagram using banana jack.
2. Use Temperature Difference Controller (DTC) to set the desired values for operation and stop.
3. Put an artificial lighting in front of the heat collector and turn the light on.
4. Press PB1 (START) button to run the self-holding circuit
   (1) As the radiant energy from the artificial lighting is transferred, the PV value (temperature at the output of the collector) of DTC will increase.
   (2) According to the temperature difference value of DTC, P1(heat collecting circulation pump) or P2(heat storage circulation pump) will start operating to increase temperature of the thermal storage tank.
5. Once all experiment is over, press PB2 (STOP) button to turn the circuit to reset state.



・Requirements

1. Prepare and inspect test equipment, tools and materials.
2. Use the test equipment, tools and materials to make and run a circuit with a banana jack.
3. Understand the principles of temperature switches and be able to set the values according to the setting values for automatic control.
4. Understand the circuit and its operation principles.
(1) Explain the actions that occur when PB1 is pressed.
(2) Explain how 3-way value works while the solar heat system operates.
(3) Explain how the 3-way valve changes trajectories and how the heat emitting fan motor for overheating works while the solar heat system operates.
(4) Explain the actions that occur when PB2 is pressed.
5. Use the test equipment, tools and materials to construct an actual circuit.

Evaluation Standards	Criteria		Marks	Scores	Notes
	Works (70)	Operation of circuit with banana jack	20		
		Operation of the actually wired circuit	20		
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	Attitudes (10)	Working attitudes and safety issues	5		
		Usage of materials/tools and clear-up works afterwards	5		
	Time (20)	( ) points off for every ( ) minutes over the required time limit			

Works	Attitudes	Time	Total Score

6. Cautions in Handling the Equipment

6-1. Power Supply

(1) This test equipment requires main power of AC220V to operate.
(2) Fill the make-up water tank with water. (Since the equipment runs electrically, make sure no electrical parts other than the water tank is immersed in water.)
(3) The order to operating the equipment is as follows. Turn on N.F.B while the power cord is plugged in.

6-2. Equipment Device

(1) The solar energy collector is made of glass with a vacuum state inside, so be careful not to damage it.
(2) All functions of machinery equipment operates only with organized electrical circuits.
(3) The test equipment is shipped from the factory after completely welded. Random dissembling and reassembling of the equipment may cause malfunctioning or failure of the equipment. In such cases, you may be charged for repair works when you request for an A/S.

6-3. Overall Conditions

(1) Make sure to fully understand the manual and ways of handling the equipment before working with it.
(2) If the equipment malfunctions because of dissembling or modification, you may be charged for repair works, even during the free A/S period.
(3) For more inquiries on the malfunctioning and operation of the equipment, feel free to contact the head office.

6-4. Operation and Control

(1) Before Education
① Check that the drain valve on water storage tank is closed (leakage of water during water supply may cause malfunctioning of the controller or the equipment)
② Check that the pipe valves on the energy collector and energy storage tank are opened (drain valves remain closed)
③ Check that the pipe valves on the energy collector and load are opened (drain

valve and motor-valves on each load remain closed)

④ Check the amount of water inside the make-up water tank (About 2/3 point from the bottom)

⑤ Switch the main power of controller ON (Check the red light on AC lamp and the temperature indicator)

(2) After Education

① Once all parts of the equipment are checked to be operating normally, clear up all the banana jack.

② Remove water from the pipes and water storage tank.

③ Put the artificial lighting to its original position and remove the main power cord. (display powered off)

◎ Warrantee and A/S application sheet

Product Warrantee Certification

Fill out this sheet, and send by Fax or E-mail..

MODEL		
WARRENTEE TERM	1 YEAR	
PURCHASING DATE	(M/D/Y)	
ORGANIZATION	**SCHOOL**	
	DEPARTMENT	

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Factory : 133-1 Shinhyen-ri opo-eup, gwangju-si, geonggi-do, KOREA 464-895

Educational lab equipment training programs

KTE-101 : Standard Refrigeration System Experiment Practical Course
KTE-102 : Refrigerant Parallel Valve Automatic Control Experiment Practical Course
KTE-103 : E.P.R(Evaporation Pressure Parallel Control) Refrigeration Experiment Practical Course
KTE-104 : Heat Pump System Performance Experiment Practical Course
KTE-105 : Cryogenic Cold & Heat(Dual Refrigeration) System Performance Experiment Practical Course
KTE-106 : Brine Refrigeration(Ice-storage Refrigeration) System Performance Experiment Practical Course
KTE-107 : Vehicular Heating and Cooling Performance Experiment Practical Course
KTE-108 : Air-conditioning System Performance Experiment Practical Course
KTE-109 : Chiller Method Air-conditioning System Performance Experiment Practical Course
KTE-201 : Solar • Wind Power Control Basic Circuit Configuration Practice
KTE-202 : Solar Generation Test Practice
KTE-203 : Solar System Equipment Configuration Practice
KTE-204 : Wind Power Generation Test Practice
KTE-205 : Solar • Wind Power Hybrid Generation Practice
KTE-206 : Hydrogen Fuel Cell Generation Practice
KTE-301 : Solar Radiant Energy Measurement Practical Experiment
KTE-302 : Solar Hot water boiler Performance Practical Experiment
KTE-303 : Geothermal Heat Pump Cooling & Heating Practical Experiment
KTE-304 : Solar-Thermal Combined Geothermal System Practical Experiment
KTE-401 : LED Basic Theory & Performance Assessment Practice
KTE-402 : LED Application System Configuration Practice
KTE-403 : LED Lighting Equipment Practice
KTE-404 : LED Media Facade Lighting Practice
KTE-405 : LED Luminescent property analysis Experiment
KTE-406 : OLED Unit Element Characteristic Evaluation Experiment
KTE-501 : PLC Automation Control Practice Basic
KTE-502 : PLC Automation Control Practice Intermediate
KTE-503 : PLC Automation Control Basic Advanced
KTE-601 : Sequence Control Practical Basic Course
KTE-602 : Sequence Control Practical Intermediate Course
KTE-603 : Sequence Control Practical Advanced Course
KTE-701 : Power Equipment Basic Course
KTE-702 : Power Equipment Intensive Course
KTE-901 : Water-based Fire Extinguishing Equipment
KTE-902 : Gas Fire Extinguishing Equipment
KTE-903 : Alarm Equipment
KTE-904 : Fire Extinguisher
KTE-905 : Evacuation Equipment
KTE-1101 : Robot Control Practical Basic Course
KTE-1102 : Robot Control Practical Intermediate Course
KTE-1103 : Robot Control Practical Advanced Course
KTE-1201 : Welding Machine Practical Basic Course
KTE-1202 : Welding Machine Practical Intermediate Course
KTE-1203 : Welding Machine Practical Advanced Course
KTE-1301 : Basic Pneumatic Practice
KTE-1302 : Electro-pneumatic Basic Practice
KTE-1303 : Electro-pneumatic Intermediate Practice
KTE-1401 : Automatic Control Mechatronics Basic Practice
KTE-1402 : Automatic Control Mechatronics Intermediate Practice
KTE-1403 : Automatic Control Mechatronics Advanced Practice

Renewable Energy / Refrigeration & Air-conditioning & Welding
Automation controls(PLC) / Robot controls / Electric & Electronics(LED lighting)
Firefighting & safety / Big data & ICT / Automobile & ship / Nano chemical

3E EDUCATION
ENGINEERING
ENVIRONMENT

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