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Original Research Article

Saving energy with timers

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ABSTRACT

In this study, it is aimed to save energy by placing timers in public offices and private workplaces for heating residential units with geothermal energy outside working hours and on holidays. For this, proportional valve control system design and application has been carried out. Proportional valve is connected to the heat exchanger return. The control form of the floating type proportional valve is on-off, the control of the proportional valve with analog input is applied in the form of PI control. It is realized by programming smart relays in both controls. PT100 was used to measure the heat exchanger inlet, return and temperature values entering the building. As a result of this study, the heat exchanger return temperature was adjusted to the temperature at which the buildings would not cool completely on holidays and after working hours, allowing more buildings to be heated with the energy saved.

Keywords: Energy efficiency; Proportional valve; Timer

1. Introduction

Geothermal energy, which is one of the most important renewable energy sources, is a resource that can be used in many areas such as electricity generation, medicine, tourism, agriculture and industry [1]. Geothermal energy is an inexhaustible and renewable alternative energy source. Geothermal energy; Environmentally friendly, cheap, renewable and national energy. The most important uses of geothermal energy are heating of houses and greenhouses [2]. The geothermal source can be defined as hot water and steam, which is composed of accumulated heat at various depths of the earth's crust, whose temperatures are constantly above the regional atmospheric average temperature and may contain more molten minerals, various salts and gases than the normal underground and surface waters around it. Geothermal energy includes all kinds of direct or indirect benefits [3]. Geothermal energy plays an essential role in human progress and provides quality of life to us. Thermal energy that derives from the 1,800 miles below the crust of the Earth. It is heat deposited in the rock and fluid filling the pores as well as fissures of the Earth's crust. More than 20 countries are utilizing this natural energy today. Amongst them, the USA is the biggest generator of geothermal energy in the world with the most extensive geothermal field [4]. There are many considerations that come with geothermal power. Even as a renewable energy source, it is important to weigh the pros and cons of geothermal energy to better understand how it fits into the larger energy mix [5]. Geothermal energy is defined as the internal heat radiating from the hot regions deep into the earth towards the earth. In particular, groundwater reaches the earth's surface by heating more than other areas. Such areas are called geothermal areas. When we look at the main usage areas of geothermal energy, we see that electrical energy production, heating of houses and greenhouses, thermal facilities (health tourism) [6]. World energy consumption; In parallel with population

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growth, industrialization and technological developments, it is growing at a dizzying pace and as a result of the 21st century, there is a society that absorbs energy. Today, 84% of the world energy requirement is met by fossil fuels such as coal, oil and natural gas, and the remaining 16% is covered by resources such as animal and plant waste, wind, solar and geothermal energy. The global reserves of fossil fuels are estimated to be 68% coal, 18% petroleum, and 14% natural gas as the equivalent of oil [7]. It has been investigated whether the utilization of geothermal energy in heating of buildings is economical. As a result of the economic analysis, geothermal energy is more economical than other alternative energy sources [8]. The Aegean region has a rich potential for geothermal energy and ranks first in geothermal greenhouse cultivation [9]. Simav is 1568 km² and it is 143 km far from Kütahya city center. The population of the district center is 25831 [10]. Geothermal energy will be largely used locally and will play an integrative role. On the other hand, if solutions to regional and global energy problems are found, it is important that local energy sources participate in the national grid, where both local and imported energy is best used [11]. The economic development of countries rapidly increases the need for energy. For this reason, countries are exploring the ways in which they benefit more economically from conventional energy sources as well as from renewable energy sources [12]. Geothermal energy is an inexhaustible and renewable alternative energy source. Geothermal energy; It is an environmentally friendly, cheap, renewable and national energy. The most important usage areas of geothermal energy are the heating of houses and greenhouses [13]. Geothermal energy production cost is low compared to other energy sources. This cost is even lower when it comes to integrated uses. Geothermal energy is an inexhaustible and renewable alternative energy source [14].

2. Geothermal Energy Potential in Türkiye and in the World

As it is known, Geothermal Energy is a domestic underground resource that is renewable, clean, cheap and environmentally friendly. Since our country is located on an active tectonic belt due to its geological and geographical location, it is in a rich position among the countries of the world in terms of geothermal. There are many geothermal resources at different temperatures in the form of around 1000 natural outflows spread all over our country. The geothermal potential of our country is quite high, 78% of the potential areas are located in Western Anatolia, 9% in Central Anatolia, 7% in the Marmara Region, 5% in Eastern Anatolia and 1% in other regions. takes. 90% of our geothermal resources are low and medium temperature, suitable for direct applications (heating, thermal tourism, various industrial applications, etc.), while 10% is suitable for indirect applications (electric power generation).

According to the end of 2018 data, the installed power of geothermal energy in the world is at the level of 14.9 GWe. Top 5 countries in electricity generation from geothermal energy; USA, Philippines, Indonesia, Turkey and New Zealand. Non-electrical use has exceeded 70,000 MWt, and the first 5 countries in direct use applications in the world are the USA, China, Sweden, Belarus and Norway [15].

3. Schematic Illustration of Proportional Valve Control System

A proportional valve must be used to control the return water temperature of the heat exchanger for each building. These valves can be controlled by mechanical or electronic devices. In this study, valve controls are provided with LOGO smart devices. Two different proportional valve systems, realized with "OPEN-CLOSE" and "PI CONTROLLED" proportional control software, were kept under control and necessary controls were made. Various operator panels were used to operate and monitor the implemented systems, and to make necessary adjustments and instant interventions. The system was operated by using 3 different operator panels at the same time in the proportional valve control, which works in the form of ON - OFF. These are the KTP 400 color key operator panel, the panel above the smart relay and the Logo TDE text operator panels belonging to this smart relay. Logo TDE text operator panel belonging to the smart relay and text panel on the smart relay are used in the proportional valve system operating with PI supervision control.

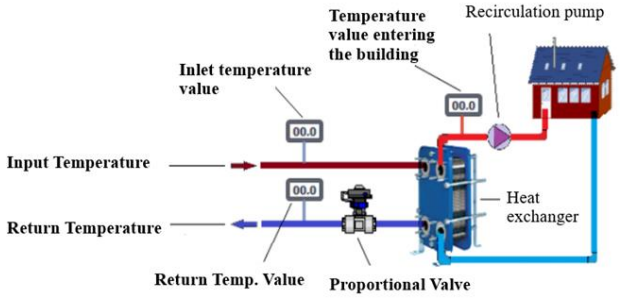

Fig. 1. Schematic illustration of proportional valve control system [16]

4. KTP 400 Operator Panel Screens in Proportional Valve System

We said that more than one operator panel is used in the proportional valve control system. Among these, Siemens brand KTP 400 Operator panel was used as a color touch key panel. In this panel, system operation, temperature value assignments, timing settings, error messages etc. Operations and observations related to the control of the entire system are made.

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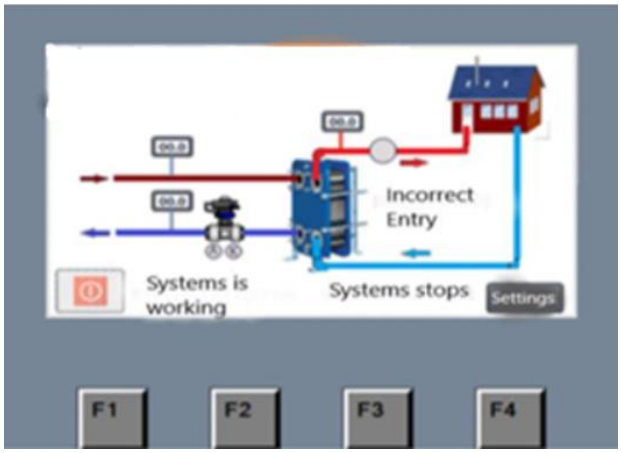

Fig. 2. Operator panel main screen

It is the main screen where we can observe that the system is running, the hot water values coming to and returning to the heat exchanger, the temperature value leaving the house, the set temperature value, and the circulation pump is active. If an incorrect value is entered at a set degree, the system will not work and the warning text warning that an incorrect entry is made is also available on the main screen. The system cannot be started or stopped from the main screen. Only the position of the system can be observed. In order to intervene in the system and make the necessary settings, the "Setting" button is pressed on the lower right part of the main screen and the second page is accessed.

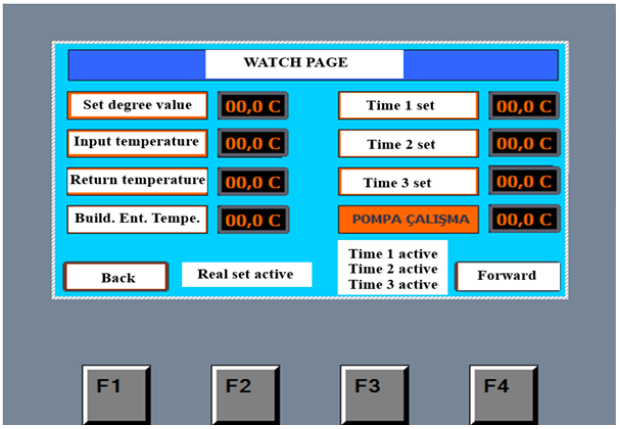

Fig. 3. Operator panel (Monitoring Page Screen)

No intervention is made to the system on this page either. It is a page created to get more detailed information about the status of the system. It is possible to see the set states and set values of the timings on this page. Press the "Back" button at the bottom to go to the HOME screen from this page, and the "Forward" button for settings.

“PASSWORD” soft key is pressed for operator authorization and password assignment. If you want to go to the previous page, press the "FOLLOW" button.

Operator authorization is done on the password change screen. Username and passwords are assigned from this screen. Password change and authorization are created only by ADMIN. If the password is written correctly, this screen can be entered and proceeded further. In this way, access of 2nd or 3rd parties to the system control is prevented.

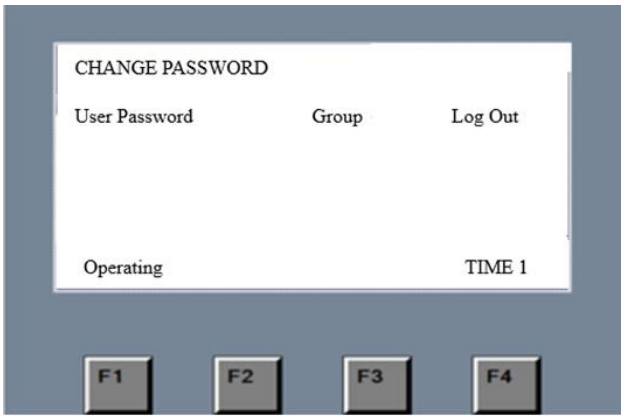

Fig. 5. Operator Panel (Password Change Screen)

Proportional valve is the most important part of the control program. Apart from the set value degree, it has the feature of giving set value in three different timing programs. The operator that will create the schedules of the timers is the highly authorized operator. “Days of the Week”, “Set Value”, “Start and End” times of the set temperature value are given on these pages in each timer. Incorrect entry warning of a set degree with an incorrect value can also be seen on this page.

For example; It is clear when education will take place in a school. Considering that there will be education at the school between 8.00 and 17.30 on weekdays, the proportional valve control system brings the set value to 40 degrees on Monday morning at 06.00. At an hour close to the departure of the students, such as 16.00, the set value is reduced to 35 degrees. If the school has training courses, courses within the scope of non-formal education or evening classes, the set value continues until 22.30 at 35 degrees. After 22.30, the system goes into sleep mode and reduces the set value to 27 degrees. Until Tuesday morning, this return temperature value is sufficient for the school. At 06:00 on Tuesday morning, the set value reaches 40 degrees again and all units of the school are sufficiently heated until the school opens. All weekdays can work this way. The system, which goes into sleep mode on Friday at the weekend, gradually rises to the set value on Monday and all units of the school are warmed up before the students arrive. This system, government buildings, governor's mansions, libraries, sports facilities, social facilities, mosques, etc. By applying it in places such as heating, the cost of heating is greatly reduced. Different set value system made with timings in the proportional valve system can be applied not only in public buildings, but also in all small-large workplaces, shopping malls, estates and even residences. Considering the official holidays and even the very long 9-day holidays, we will be paying for the heat

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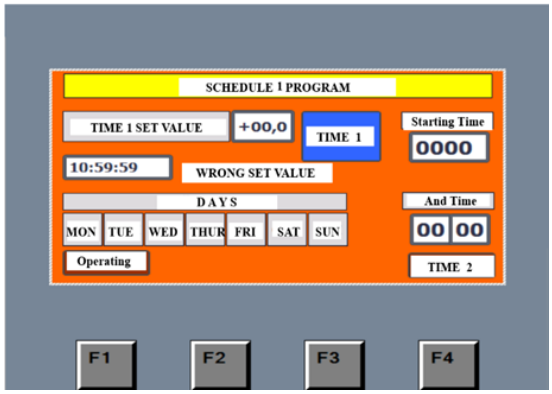
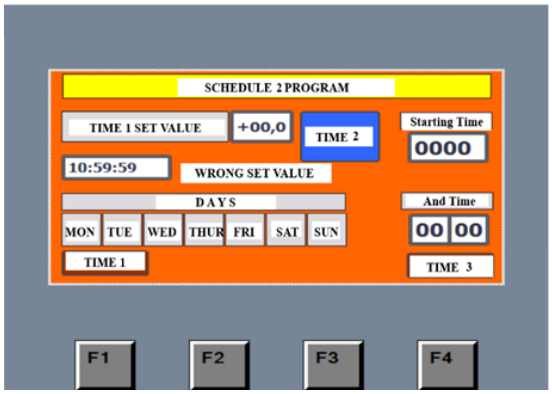
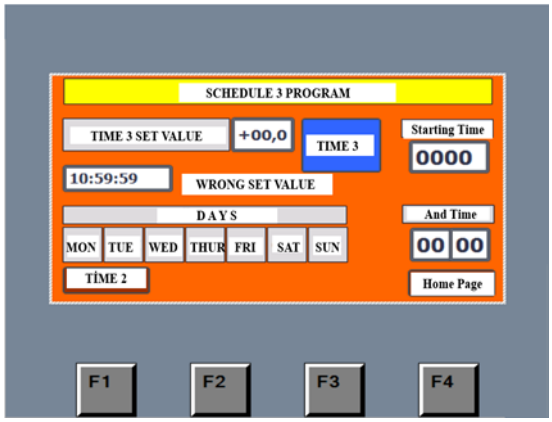
that we do not heat. If we consider all the institutions of the state, it turns out that we pay a large amount of extra cost to energy [16].



(a)



(b)



(c)

Fig. 6. Programming screen of operator panel time modes [16]

5. Logo TD text operator panel screens for on-off proportional valve control

Logo TD operator panel is a panel of smart relay. It can perform operations such as starting and stopping the system, assigning set values, seeing error messages, monitoring temperature values. There are 3 timing modes in this control system. These timing modes are set from these screens. If desired, one-time mode or three time modes can be programmed if desired. Above, the start time of Onset value determines the end time of OFF set value. If we examine the first screen, the return temperature will increase to 40.3°C between 23.00 and 23.50 on Monday. After 50 minutes, at 23.51, the system will come back to the real set value. Time 2 mode is programmed on the second screen. It is set to 35.6 degrees between 18:00 and 21:25 on Tuesday. On this set day and time, the set value will be 35.6°C.

Fig. 7. Screens with Time Settings in Logo TD

6. Panel screens on logo in PI controlled proportional valve control

When the system is started, it can monitor the temperature values set, coming from the center, returning from the center and leaving the building. These are the screens where the

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time modes are set in the Logo Display in the PI-controlled control system. Day/days are selected from the screen, start and end times are determined, and set value assignments are made. Which timing mode is active and temperature values are monitored on these screens on the PI-controlled Logo panel. In the PI-controlled control system, the mutual operation of the Logo TD operator panel and the Logo Display panel is envisaged and the program is designed in this way. Message screen that cannot be on one panel can be viewed on the other panel. The system control is prepared in the form of a dual panel.

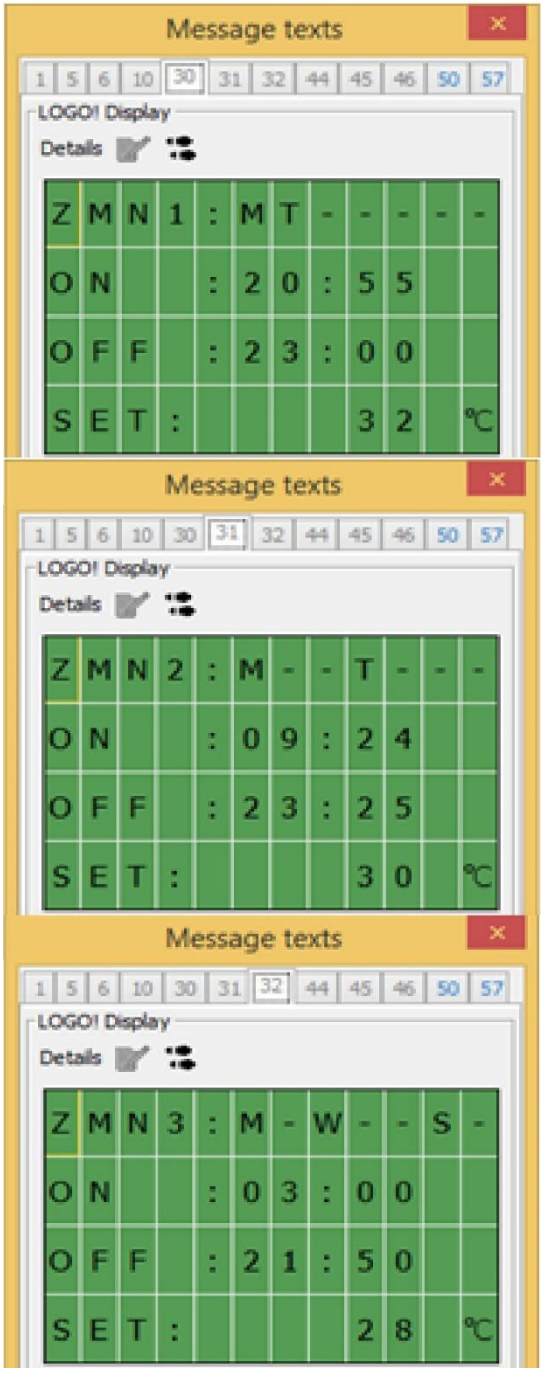

Fig. 8. Screens with time settings in logo display

7. Conclusion and Recommendations

Control of the heat exchanger return temperature was made with smart relays, keeping the system under control and operating the smart relays were provided by different operator panels and devices with android operating system. Public buildings, schools, mosques, etc. Considering the places where the set values will change according to time, it is certain that the size of the savings will be much larger when it is considered that the set value will go down to the lowest position (sleep mode) outside of working hours or on weekends. With the efficient use of energy, there will be no need to increase the number of geothermal wells, thus, less wells will be drilled in these regions and the earthquake risk will be reduced.

In the table below, the energy consumed in a day is calculated by using the geothermal energy of a house and the proportional valve and the timings are activated (Table 1). In the last column, there is the calculation made without proportional valve. The savings difference is set below.

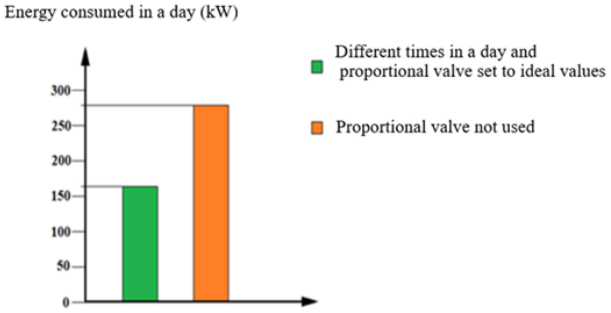

Fig. 9. Saving indicator of the proportional valve set to ideal temperatures according to the time modes throughout the day

When proportional valves and timers are used, 162.2 kW of energy is consumed, while when proportional valves and timers are not used, 279.12 kW of energy is used. Thus, 58% energy savings were achieved. This situation is shown in Figure 9.

Authorship contribution statement for Contributor Roles Taxonomy

Rüştü Güntürkün: Writing - original draft, Supervision, Investigation,.

Erhan Güngör: Methodology, Visualization, Writing – review & editing.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1. The energy consumed throughout the day by setting the proportional valve according to the time modes

	Hours of Proportional Valve Set					All Day
Set Value Times / Heat, Flow and Energy Spent	10:00 18:00	18:00 00:00	00:00 06:00	06:00 08:00	08:00 10:00	
Thermal Input Temp. (°C)	60	60	60	60	60	60
Thermal Output Temp. (°C)	48	50	45	54	50	56
Building Return Temp. (°C)	45	48	40	50	48	54
Average indoor temp. (°C)	22	24	20	26	24	27
Flow (m^3/h)	0.48	0.65	0.30	1.20	0.65	2.50
Energy Spent (Time kW)	**6.70**	**7.56**	**5.23**	**8.37**	**7.56**	**11.63**
Time	8	6	6	2	2	24
Energy consumed per hour (kW)	53.6	45.36	31.38	16.74	15.12	279.12 kW
All Day spent energy (kW)	162.2 kW					

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