International Journal of Advanced Research in Engineering and Technology (IJARET)
Volume 11, Issue 6, June 2020, pp. 367-377, Article ID: IJARET_11_06_033
Available online athttp://www.iaeme.com/IJARET/issues.asp?JType=IJARET&VType=11&IType=6
ISSN Print: 0976-6480 and ISSN Online: 0976-6499
DOI: 10.34218/IJARET.11.6.2020.033

FOR MINIMUM ENERGY USE IN A AIR CONDITIONING ROOM INSTALLATION AND OPERATION OF THE OPTIMUM CONTROL SYSTEMS

Yılmaz Akgüney
Energy Systems Engineering Department,
Ereğli Faculty of Engineering and Natural Sciences, Konya, Turkey

ABSTRACT

For a specific operating system and clothing conditions it is very important to provide comfort conditions and minimize energy needs. To achieve this optimum control system equipment is required in air conditioning systems. In these systems as variables air temperature, humidity, velocity and mixing ratio should be checked. Regions that need to be controlled for air conditioning with minimum energy use residences, workplaces, greenhouses, submarine, aircraft etc. there may be places. An experiment intallation was set up to show that the desired conditions can be met with different energy expenditures in air conditioning systems. In the case of the least energy expenditure necessary control equipment was placed on the room to operate the system. At different values of the variables this system was run and tested. As a result of the experimental studies it was observed that the amount of air mixed by circulating back and again depending on the variables in the room did not cause any negativity Fresh air intake and exhaust air outlet rates are compatible between them. The control system was found to work well within the permitted limits. As a result control variables and control elements are compatible. The studies carried out here show that it is possible to control digitally in a climate room using a computer.

Key words: Air conditioning room, Control equipments, variables, systems, Mixing air

Cite this Article: Yılmaz Akgüney, For Minimum Energy Use in a Air Conditioning Room Installation and Operation of the Optimum Control Systems, *International Journal of Advanced Research in Engineering and Technology*, 11(6), 2020, pp. 367-377.
http://www.iaeme.com/IJARET/issues.asp?JType=IJARET&VType=11&IType=6

1. INTRODUCTION

Energy demand is increasing rapidly due to the rise of industrialization and living standards in all countries of the world. Keeping the temperature, humidity and air velocity at the most appropriate level for human health and comfort or industrial process together with energy saving is an expected feature in conditioning the air in an environmental space to be air-conditioned. It is imperative to provide suitable environmental conditions as required by a manufacturing or process, as well as in terms of human health increased work efficiency and comfort. Automation systems used in buildings built for both industrial purposes and human health and comfort are used to provide information functions such as monitoring equipment and ensuring its safety. Today, building automation systems are arranged and used to provide control functions along with information functions. In other words the designed building automation systems play a direct role in the operation and use of air conditioning systems. In order to apply the developed control algorithms to an environmental space to be air-conditioned, the control system and hardware must be selected and applied appropriately. Electronic and computer technologies that will help in this matter have developed, their prices have fallen and become available for multi-purpose applications that will enable more flexible applications. Thus, the processes; working conditions with more efficient, higher quality and less energy consumption, less waste and damaged product were made possible. Specially designed controllers and computers designed for special processes have increased their prices due to their inconvenience for mass production. In addition, the prices of multipurpose computers have dropped as a result of mass production, making it more convenient in practice to control many processes with the same computer and distribute the same type of controllers on a single serial production line. Today, control, regional control in a complex production line; it is widely based on data supply and information processing. That is, computers located locally; transmit data to the control computer in the center, whose parasite values are filtered, amplified, and sampled at appropriate intervals and adapted for use in digital or analog form. This computer performs control functions. There is a certain hierarchical order in communication between computers, and within this order, each computer functions in good harmony with its states. In this study; A climate chamber was set up and operated under the conditions of the experiment. Control equipment between the control variables and control elements of this air-conditioning chamber is introduced. Calculation of energy use was expressed, the system was run, some results were obtained and interpreted.

1.1. Application History

The side view of the established test chamber is shown in Figure 2.1 and the cross-section view is shown in Figure 2. Basic approaches to control of such systems were introduced in the 1960s [1, 2, 3]. A three-variable model has been developed that keeps volume variables constant within the comfort zone [4]. A model created without taking into account the air circulation and the stability of the model established in the past is also shown [5]. The energy use function and optimum control problem regarding comfort conditions have been developed and solved on the basis of an example [6]. Some experimental results are given for energy saving [7]. A mathematical model is created for the control variables of the air-conditioning room and simulation results are given [8]. In 1989, he installed the control equipment for the control system, which was set up by me, [10], with the on-off method [9]. Some of the errors and deficiencies seen here were taken into account and the necessary changes were made to the test system, it was re-installed and operated by me again [10]. A mathematical model of this room has been obtained by constructing an air conditioning room in suitable dimensions and under experimental conditions and the results have been interpreted, taking into account all the work and deficiencies performed in the past until now [10]. The experimental setup, which was installed and operated by me [10], was used by many researchers. Control principles of effective energy use are presented in a air-conditioning room [11]. Modeling of an experiment room with minimum energy is presented [12]. The behavior of a room was investigated by establishing a heat transfer correlation for energy modeling [13]. The performance of an experiment room operating with minimum energy use has been investigated [14]. Two optimization techniques have been described for optimum control of energy use in comfort conditions [15].

1.2. Features Required in a Control System

If the response of a system to each limited input is limited, this situation is defined as stable for that system. In control systems, the system's stable operation, rapid response and sensitivity are the most important minimum features that must be provided. In control systems operating under a fixed reference, the controlled size is equal to or equal to the reference value. Due to disruptive effects or change of reference value, system output may change and out of the desired tolerance. In this case, the system output should be brought back to the reference value and should regularly maintain this value. If the system in the control system deviates from the continuous regime value due to disruptive effects or reference changes, it must reach the continuous regime value again as soon as possible with a stable transition regime. In continuous regime operation, if the system output is equal to the reference value, that is still zero, its sensitivity is very high. In general, since zero increases the cost, it is acceptable to determine an optimum point between cost and precision and to keep the output between certain tolerances. Although stable, sensitive and fast control systems are desired, generally very stable systems may be slow, whereas very fast and very sensitive systems may also experience unstable operation.

1.3. An Environmental Room to Air Condition

In Chapter 2, necessary information is given about the experimental chamber and equipment established as a real system with multiple inputs and multiple outputs for an environmental space to be air conditioned. The classic and optimal controls described here are those defined in sources [6, 7].

1.4. Control Equipment

The sectional view of the room and the condition of the air ducts are shown in Figure 2.2. Standard air conditioning equipment is installed in this room. The system has a two-position damper that provides a mixture of outside air and return air. The circulation of the air is provided by fans. Pulverizers are installed in the ducts for heating resistances and humidification.

1.5. Classic Controls

A heating / cooling thermostat is placed in the room. A humidistat is placed in the return air duct and controls the humidity independently of the thermostat. In classical controls, the return air is completely re-activated. In winter conditions, the temperature is 21 °C and relative humidity is 40%, in summer conditions the temperature is 24 °C and relative humidity is 50%. The control of the air conditioning equipment is provided by the thermostat and humidistat by energizing the coils, which is a typical built-in system [6, 7].

1.6. Optimal Controls

The optimal control system uses the same hardware and control relays. Relay end connections are made by a microprocessor control not by conventional control hardware. In this case, the microprocessor takes control of the hardware. The output of the microprocessor is transmitted to the semiconductor relays through the inverters and energy is applied to the coils of the hardware relays there. Internal and external temperature and relative humidity should be measured for optimum control. Temperature sensitive diodes and operational amplifiers are used for temperature measurement. The output of the amplifier feeds the multiplexer. In the relative humidity detection, a separate sensor element is used for the outside and for the inside. With this sensitive element, the function of relative humidity is output in volts [6, 7].

1.7. Determination of Energy Efficiency

Energy efficiency is found by dividing the actual energy used by the energy charge in volume (heat and cooling). Energy load is the amount of energy load and heat loss in the building if the temperature and relative humidity in the room are equal to the values of classical controls. In other words, the energy load is calculated if the room temperature is 21 ^{0}C and relative humidity is 40% during heating, the room temperature is 24 ^{0}C and relative humidity is 50% during heating. The energy charge is calculated by taking the average of a time period (preferably a day or more). In the total values of this load, kJ can also be used instead of kW. Energy efficiency is calculated as follows. n_e = Energy Used / Energy Load, (%). Energy use is calculated based on the currently used equipment and the energy rate used by that equipment. In this equation, it compensates for changes in energy load and thus forms a common basis for comparison. If the room is kept correctly at the values of the classical control scheme, energy use must be equal to the energy load. Also, if there is any doubt about whether it is being kept right, it is sufficient to compare the values of energy load and energy use. Energy use is often calculated correctly but cannot be used as a basis. Because, opening the door and the like can change the energy usage but does not affect the energy load calculations. Energy cost efficiency is calculated as follows. n_c = Energy Cost / Energy Load, (Price / kJ). Here, the energy cost is found using the formula. Energy cost = Σ (Energy used, kJ) (Unit Energy cost, Price / kJ), (Price). Since changes in energy and costs are possible, both efficiency criteria are used. However, when comparing between classic and optimum controls, data are calculated based on the same fuel type and cost [6, 7].

1.8. Calculation of Energy Load

Heat loss (energy load) is calculated as follows by measuring the relative humidity and temperature in the room and the temperature on the outer wall of the room. $Q = \sum_{\mathrm{i}=1}^{\infty} \mathrm{K_i}\, \mathrm{S_i}\, (\mathrm{T} - \mathrm{T_i}) + \mathrm{k}\, \mathrm{g}\, (\mathrm{v_a})\, \mathrm{h}$. Some of the parameter values in this equation are directly entered into the memory of the computer. Others are measured by sensitive instruments and uploaded to the computer. The values entered in the memory of the computer were calculated. T and T_i values are measured, h is calculated from measurements or known. Other parameters k, g and v_a are known [6, 7].

1.9. Calculation of Energy Use

Energy use is found by calculating the average values of the energy used within a time period (one day or more). This value can be obtained from the currently used equipment and the energy rate (in kW) used by this equipment. For an electric heater, this value is found on the basis of unit power. For others (dampers, fans and humidifiers) nominal power ratings are used. This information is sufficient to calculate energy use [6, 7].

2. MATERIAL AND METHOD

In this part of the study, the structure of the controlled volume, measurement and measurement method, control organs and test results will be mentioned. The controlled volume is [6, 7], as seen in Figure l and Figure 2, was designed and built in accordance with the model used by Kaya in his studies on this subject [10]. In the system, the outlet air is given back to the inlet to ensure that the volume contains clean air. By determining the pollution criteria in the volume under comfort conditions, that is, the required fresh air ratio, a mixture containing that amount of fresh air was provided to enter the room.

Figure 1 Picture of the test chamber is [10].

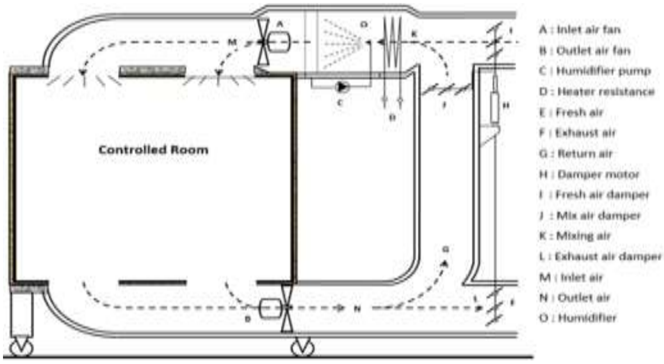

Figure 2 Construction of the test chamber [10].

2.1. System Operation

Digital computer was used in the experiment of the installation. The data exchange between the system and the computer is ensured by the interface profitable. A/D inputs and digital analog outputs are calibrated before the card is used. The block diagram of the test facility is as in Figure 4. Sensors are placed in the most suitable place in the installation. The temperature and humidity sensor is integrated and the output ends are connected to the amplifier. Output of air velocity sensor only. 0-10 V D.C. It is not dependent on the amplifier. Voltages with sensor information at temperature and humidity amplifier outputs are based on A/D inputs. In addition, two analog measuring instruments showing temperature and humidity are connected parallel to the amplifier outputs.

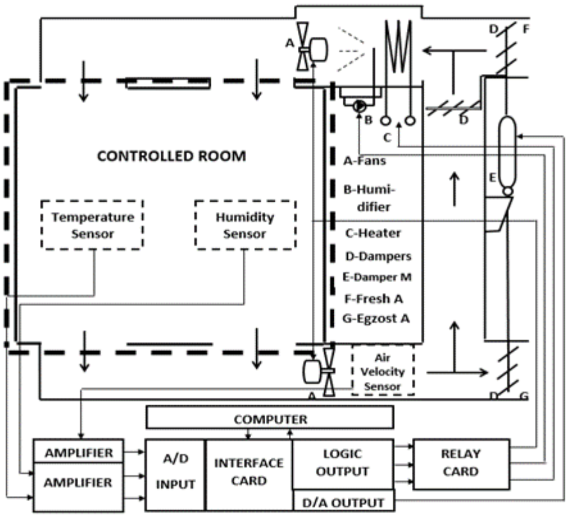

Figure 3 Test chamber control diagram [10]

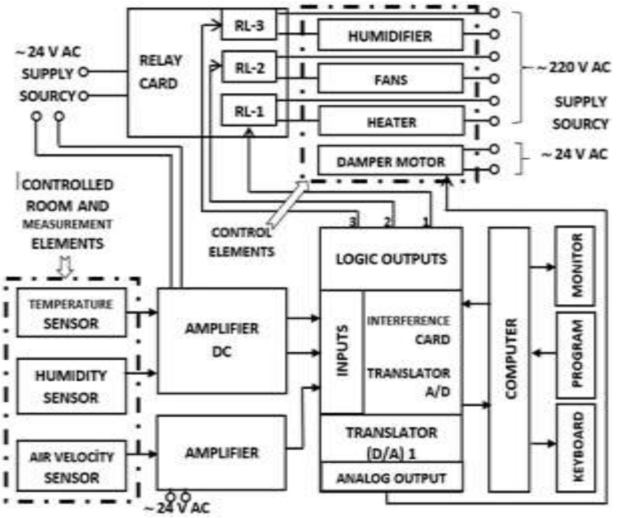

Figure 4 Block diagram of the test chamber [10]

Fans (ventilator, aspirator), heaters, pump and computer are fed with 220 Volt mains voltage. All other electrical and electronic components work with low voltage. A good grounding was made in the installation and the connection cables that provided data exchange were kept very short.

2.2. Multifunctional Data Input-Output Interface Card

High performance card, general purpose and multi-functional (A/D, D/A, D/I, D/O, timer, counter etc.) and software-controlled interface card in the experimental installation installed, generating control signal depending on the computer's data exchange and control program in the computer used as.

2.3. Measuring Elements

Variable sizes in the control environment with the help of transducers are obtained for monitoring and control purposes. Our control sizes here are temperature, humidity, air velocity and air mixing ratio.

Temperature Measurement: The sensor used in this study is a temperature sensor that has the feature of changing resistance with temperature change. A Nickel resistance element of 1000 Ω at 0 °C was used in the test installation. The temperature coefficient of the nickel conductor type used here is 0.5 % (1°C). In small resistance changes, amplifier is needed. Temperature range is given for 0-50 °C. The time constant is 3.5 minutes depending on air movement and thermal coupling. Also called passive temperature detector.

Moisture Measurement: Moisture is the amount of water vapor in the air, and the most common measure used for water vapor is called relative humidity. It is a humidity sensor with resistance change used in control volume. In these types of sensors, which are used most in air conditioning systems, the resistance value of the sensor changes as the amount of humidity in the air changes. It is a potentiometer whose value varies according to humidity. This value ranges from 1000 - 2000 Ω for 30% - 90% relative humidity. The bridge method also measures the change in relative humidity due to the change in resistance.

Air Velocity Measurement: Hot wire anemometer is used to measure the air velocity. The measurement with this method is based on the cooling of two very thin wires, one of which is heated, with the air flow passing through the sensor. The change in energy amount with the measuring transformer in the circuit is regulated as air velocity and transferred to the output as 0-10 V DC. This output value is always the same in the measurement areas 0-5, 0-10 and 0-15 m / s and the connections on the sensor and the measuring areas are selected. The measuring area of the sensor is 0-10 m / s for the test installation. It has no moving parts and the immersion length is important for the actual measurement of air velocity. The sensor is powered by 24 V ± 20%, 50/60 HZ AC and consumes 2 VA power.

Measuring Amplifier Unit: Temperature and humidity amplifiers actively convert resistance changes in these passive sensors to 0-10 V DC voltage. Measuring amplifiers inside the unit are designed using opamp. The unit is powered by 24 V, 50 Hz ± 20% tolerance AC. There is a + 15 V DC power supply inside and amplifiers are fed with it. The output voltage is at normal 0-10 V DC output value and has a tolerance of ± 20%.

2.4. Control Elements

The effective value of the voltage is changed with the signals coming from the computer and the controls are made. The power of the heaters is given in Table 2.1.

Humidifier and Control: Water compressed with 220 V AC pump is adiabatically moistened by two sprinklers. The maximum capacity of the humidifier is 4 kg/h. Control of the humidifier pump is done with a computer, such as a heater control.

Fan and Control: To change the air movement within the control volume, two fans are used for the blowing and intake air operated with 220 AC and they are controlled by a computer. Table 2.2 gives the necessary information about the fans. When the fans work together, the maximum flow is 2160 m^3/h.

Table 2.1 Maximum power of heaters

HEATER I		HEATER II		HEATER I+II	
Ampere	Watt	Ampere	Watt	Ampere	Watt
6	1440	11	2600	17.8	3920

Table 2.2 Power of axial fans according to air velocity

ROOM AIR VELOCITY (m/s)	AMPERE	VOLT	WATT
0.30	1.7	216	270
0.25	2.2	216	280
0.20	2.9	216	290
0.15	3.3	216	320
0.10	3.2	216	300
0.05	2.9	216	220

Damper motor and its control: The movement amount (position) of the cylinder is provided by the control electronics of the damper motor. Positions vary proportionally according to the control signal. In other words, the position of the damper varies proportionally between the angles of 0^0-90^0, w hile the motor cylinder changes between 0-60 mm and the damper drive power between 0-10 V DC. The duty of the electronic circuit in the damper motor is to provide control of the damper motor according to 0-10 V (0.1 mA) DC input voltage and 0-1000 Ω input resistance (by connecting a potentiometer ranging from 0-1000 Ω). There is also an analog gauge connection to show the control signal applied to the damper motor of the circuit. The velocity and calculated flow values in the air ducts at the air circulation of the air leaving the volume with the air circulation of the air leaving the volume, at the rate of 0.1 m / s in Table 2.1, 0.2 m/s in Table 2.2 and 0.3 m/s in Table 2.3 are given. In the chart in Figure 5 the status of three separate damper characteristics is shown according to the results of the experiment on the flow-angle coordinates. Comparing the damper characteristics can be easily made from these graphics according to the speed, flow and mixing ratio (damper angle). In Figure 6, the stiffness of the return air flow rate is given according to the damper control signal and therefore the mixture provided by the damper angle at room air velocities of 0.1, 0.2 and 0.3 m/s.

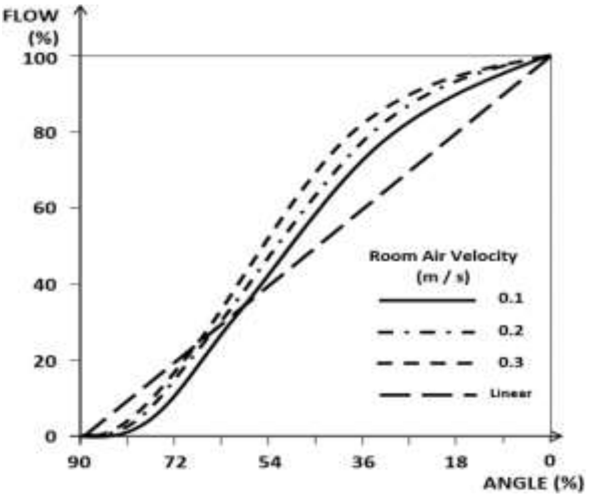

Figure 5 Damper characteristic

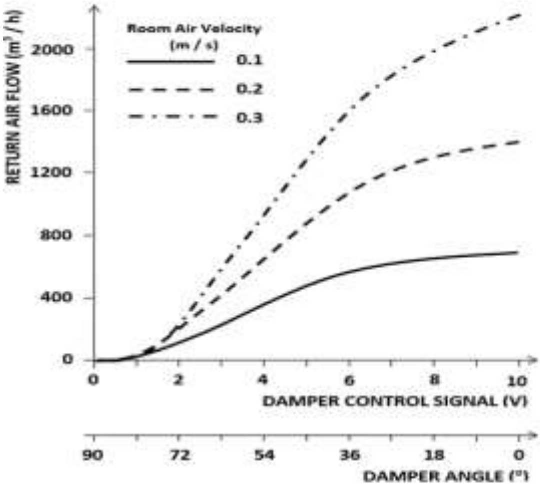

Figure 6 Air flow according to the damper angle

3. RESULTS AND DISCUSSION

Since the high reliability, speed and control process in the computer is performed with software, it provides convenience in the renewal of the system according to new conditions. It is also possible to transfer my system control algorithm. With the use of personal computers in transactions, real-time control takes place in high reach. At the same time, it provides great opportunities for the user to evaluate the collected data later. The control and data collection systems to be installed with personal computers, together with the data collection, easily carry out the control and display operations.

3.1. Results

Necessary experiments were carried out in the test room, which was established as a real system with multiple inlets and multiple outlets, taking into account the back circulation of air. A computer was used for data collection in the experimental room. The multifunctional data input-output card is located inside the computer. Experiments are provided with a software support. Card, it also includes powerful, easy-to-use and accessible software driver operations. When it is desired to use some features such as complex data transfer that is possible with the card, software driver operations are easier to implement. While creating the air conditioning experiment room data collection program, the function programs that provide the software of the interface card were used. Each function program is numbered and used. When the program starts, the software and hardware related settings (I/O Port Address Selection, driver loading, A/D input cards, A/D input gain and internal trigger speed) are made on the card for A/D dialing. In the next section, analog temperature, relative humidity and air velocity data inside the room detected by the sensors are converted into digital data by the A/D converter. At the same time, these numerical sizes are monitored on the computer screen. Then, with a subprogram, temperature, relative humidity and air velocity data are recorded in a specific log depending on time and registration number. A mixture of 0-10 V DC is applied to the motor for the mixture of fresh air and recirculating air recirculating, and the air mixture is adjusted in the dampers. A/D converter on the interface card is used as control signal.

3.2. Discussion

Numerous experiments were carried out in the control room, at actual parameters, at room air velocities of 0.1, 0.2 and 0.3 m/s, in six different mixing conditions and in different climatic conditions. Tables 3, 4 and 5 provide the values in the experimental conditions. The experiments were carried out for one hour and it was accepted that the environmental conditions did not change during the experiment. Generally, it is allowed to change the average temperature set values ± 1 ^{o}C and the relative humidity set value up to ± 5% in the places used by people. While it is under the effect of temperature distortion, it does not exceed 3% at most. In the absence of a disturbing effect, this value is approximately 1.5%. While the relative humidity defect has no disruptive effect, this decreased to approximately 2.6% and 1.2% due to the decrease in humidity when the disruptive effect occurs. At the same time, measurement error deviations in the air velocity do not exceed 5%. In all cases, with or without a disruptive effect, experiments in the system were carried out within the permitted limits. Providing mixture with the back circulation of air in the system did not cause unstable operation of the system. It was observed that the test results were in good agreement with the general conditions of the test room. The following presentations of the system described and studied are reached. a- It can be used easily wherever it is undesirable to exceed temperature error ± 1 ^{o}C, relative humidity error 2% and air velocity measurement error 5%. b- It can be applied simultaneously under the control of multi-region places from a separate or central location. d- It can be used with other control elements and systems by making necessary hardware and software changes. e- Microprocessor can also be used instead of a computer. f- Setting values can be changed continuously with the support of the software. Based on the results studied and presented here, the system shows stable operation and is highly promising.

Table 3 While the room air velocity is 0.1 m/s the velocity and calculated flow values in the air ducts at various mixing ratios

v_r (m/s)	f_r (m^3/h)	Y (V)	D_a (^{0})	r (%)	v_{eg} (m/s)	f_{eg} (m^3/h)	v_{ex} (m/s)	f (m^3/h)	v (m/s)
0.00	0	0	90	0	2.00	1440	1.0	720	0.1
0.05	36	1	81	5	1.90	1368	1.0	720	0.1
0.15	108	2	72	15	1.60	1152	1.0	720	0.1
0.30	216	3	63	30	1.25	900	1.0	720	0.1
0.45	324	4	54	45	0.90	648	1.0	720	0.1
0.60	432	5	45	60	0.60	632	1.0	720	0.1
0.73	525	6	36	73	0.40	288	1.0	720	0.1
0.83	597	7	27	83	0.25	180	1.0	720	0.1
0.90	648	8	18	90	0.15	108	1.0	720	0.1
0.95	684	9	9	95	0.05	36	1.0	720	0.1
1.00	720	10	0	100	0.00	0	1.0	720	0.1

Table 4 While the room air velocity is 0.2 m/s the velocity and calculated flow values in the air ducts at various mixing ratios.

v_r (m/s)	f_r (m^3/h)	Y (V)	D_a (^{0})	r (%)	v_{eg} (m/s)	f_{eg} (m^3/h)	v_{ex} (m/s)	f (m^3/h)	v (m/s)
0.00	0	0	90	0	2.00	1440	2.0	1440	0.2
0.10	72	1	81	5	1.90	1368	2.0	1440	0.2
0.40	288	2	72	15	1.60	1152	2.0	1440	0.2
0.75	540	3	63	30	1.25	900	2.0	1440	0.2
1.10	792	4	54	45	0.90	648	2.0	1440	0.2
1.40	1008	5	45	60	0.60	632	2.0	1440	0.2
1.60	1152	6	36	73	0.40	288	2.0	1440	0.2
1.75	1260	7	27	83	0.25	180	2.0	1440	0.2
1.85	1332	8	18	90	0.15	108	2.0	1440	0.2
1.95	1404	9	9	95	0.05	36	2.0	1440	0.2
2.00	1440	10	0	100	0.00	0	2.0	1440	0.2

Table 5 While the room air velocity is 0.3 m/s the velocity and calculated flow values in the air ducts at various mixing ratios.

v_r (m/s)	f_r (m^3/h)	Y (V)	D_a (^{0})	r (%)	v_{eg} (m/s)	f_{eg} (m^3/h)	v_{ex} (m/s)	f (m^3/h)	v (m/s)
0.00	0	0	90	0	3.00	2160	3.0	2160	0.3
0.15	108	1	81	5	2.85	2052	3.0	2160	0.3
0.55	396	2	72	15	2.45	1764	3.0	2160	0.3
1.10	792	3	63	30	1.90	1368	3.0	2160	0.3
1.60	1152	4	54	45	1.40	1008	3.0	2160	0.3
2.00	1440	5	45	60	1.00	720	3.0	2160	0.3
2.35	1692	6	36	73	0.65	468	3.0	2160	0.3
2.63	1893	7	27	83	0.37	266	3.0	2160	0.3
2.80	2016	8	18	90	0.20	144	3.0	2160	0.3
2.92	2102	9	9	95	0.08	57	3.0	2160	0.3
3.00	2160	10	0	100	0.00	0	3.0	2160	0.3

Symbols used in this study: Da- Damper angle (^{o}), f-A function, total air flow (m3/h), f_{eg}- Inlet air flow (m3/h), f_r- Return air flow (m^3/h), h-Entalpy (kJ/kg-dry air), k-Konstant for infiltration, n_e- Energy efficiency (%), n_c- Energy cost efficiency (%), Q-Heat loss (kW), r-Return air ratio (%), S_i-Wall area (m^2), T-Room temperature (^{o}C), T_i-Outside surface temperature (^{o}C), U_i-Overal heat transfer coefficient (kJ/s-m^{2o}C), v- Room air velocity (m/s), v_a-Outside wind velocity (m/s^2), v_{eg}- Inlet air velocity (m/s), v_{ex}- Outlet air velocity (m/s), v_r-Reference air velocity (m/s), Y- Damper control voltage (V).

REFERENCES

[1] Severns, W. H., Fellows, J, R., (1958) “Air Conditioning and Refrigeration”, Jonhn Wiley, New York.

[2] Threlkeld, J. L., (1962) “Thermal Environmental Engineering”, Prentice - Hall, Englewood Cliffs, New Jersey.

[3] Haines, R. W., (1971) “Control Systems for Heating, Ventilating and Air Conditioning”, Van Nostrand Rainhold, New York.

[4] Kaya. A., (1978) “Modeling of an Environmental Space for Optimum Control of Energy Use”, *Proceedings of VII th IFAC World Congress*, Helsinki, Finland, pp. 327-334, June.

[5] Parmaksızoğlu, C., Batur. C., (1979) “Introduction to Optimum Control in Ai Conditioning”, *II. National Heat Science Congress*, pp. 106-120.

[6] Kaya. A., (1981) “Optimum Control of HVAC System to Save Energy”, *Proceedings of 8th IFAC Triennial World Congress*, pp. XXII-A1 to XXIII-150, Kyoto, Japan.

[7] Kaya. A., et al., (1982) “Optimum Control Policies to Minimize Energy Use in HVAC Systems”, *ASHRAE Transactions*, Vol. 88, No. 2-2714, pp. 235-248.

[8] Öznergiz, E., (1988) “The Optimal Control of a HVAC System By Microcomputer”, University of İstanbul Technic, Science Institute, Ms Thessis.

[9] Öztürk, M., (1991) “Control of Air Conditioning Experiment Installation by Computer Aided On-Off Method”, University of Marmara, Science Institute, Ms Thessis.

[10] Akgüney, Y., (1994) “Modeling and Simulation its for Control Changes in to Air Conditioning an Environmental Space”, University of Marmara, Science Institute, PhD. Thessis.

[11] Akgüney, Y., (2016) “Principles of Control for Efficiency of the Energy Used in a Room”, *Energy: Regional Problems and Development Opportunities, 4th International Scientific Conference*, Akaki Tsereteli State University, Technical Engineering Faculty, Energy and Telecommunications Department, Proceedings, ISBN 978-9941-453-03-8, pp.76-81, 29-30 October, Kutaisi, Georgia.

[12] Akgüney, Y., (2016) “Modeling of an Experimental Room to Work With Minimum Use of Energy”, *Energy: Regional Problems and Development Opportunities, 4th International Scientific Conference*, Akaki Tsereteli State University, Technical Engineering Faculty, Energy and Telecommunications Department, Proceedings, ISBN 978-9941-453-03-8, pp.120-126, 29-30 October, Kutaisi, Georgia.

[13] Akgüney, Y., (2017) “Development of Heat Transfer Relationship for Modeling Energy Use in a Room”, *Journal of Energy Technologies and Policy, International Institute for Science*, Vol.7, No. 1, pp. 12-18.

[14] Akgüney, Y., (2017) “Investigation of Design and Performance of an Air Conditioning Experiment Room to Work with Minimum Energy Consumption”, *Journal of Energy Technologies and Policy,* International Institute for Science, Vol.7, No. 3, pp. 55-64.

[15] Akgüney, Y., (2017) “Two Optimzation Techniques for Optimum Control of Energy Use in Comfort Conditions in an Air Conditioning Room”, *Journal of Energy Technologies and Policy,* International Institute for Science, Vol.7, No. 5, pp. 1-13.