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Scientific Journal of Mehmet Akif Ersoy University

Year: 2019 Volume: 2 Issue: 1

Editor
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Indexes and Platforms

Our true mentor in life is science.

Mustafa Kemal Atatürk

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Secetariat Office
Burdur Mehmet Akif Ersoy Üniversitesi
Bucak Teknoloji Fakültesi Dekanlığı
15300 Bucak / Burdur /Türkiye

Phone and e-mail
+90 248 325 99 00
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Preface to Second Volume, First Issue

The first volume of our journal was completed successfully. Together with our journal team, we have organized Techno-Science 2018 (International Technology and Science Conference) with an intensive participation. We have already started preparations for Techno-Science 2019. We made a good start with this issue for our second year.

We would like to thank all the authors of their original papers for their efforts in the evaluation of these papers. It's about to meet the next issue.

January 30, 2019
Prof. Dr. Afşin GÜNGÖR
Executive Manager and Editor
On behalf of the Editorial Board

Techno-Science

Scientific Journal of Mehmet Akif Ersoy University

General Information

Scientific Journal of Mehmet Akif Ersoy University (Techno-Science) is a peer-reviewed, open access and refereed international journal published by Burdur Mehmet Akif Ersoy University. The first issue of the Techno-Science was published in 2018. Techno-Science accepts only English language manuscripts. Techno-Science publishes high quality original papers in the fields of engineering and sciences. The journal publishes research or review papers in the fields of applied science and technology such as Physics, Biology, Mathematics, Statistics, Chemistry and Chemical Engineering, Environmental Sciences and Engineering, Civil Engineering, Earth and Atmospheric Sciences, Electrical and Electronical Engineering, Computer Science and Informatics, Materials Sciences and Engineering, Mechanical Engineering, Mining Engineering, Industrial Engineering, Aeronautics and Astronautics, Architecture, Health Sciences, Pharmaceutical Sciences, and so on. It allows authors to submit articles online and track their progress via its web interface. The journal aims for a publication speed of 60 days from submission until final publication.

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2. The type of your paper: original scientific paper, review scientific paper, or short scientific paper.
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- 4-6 significant key words should follow the abstract to aid indexing.
- An Introduction, which should provide a review of recent literature and sufficient background information to allow the results of the article to be understood and evaluated.
- A Theory or experimental methods used.
- An Experimental section, which should provide details of the experimental set-up and the methods used for obtaining the results.
- A Results section, which should clearly and concisely present the data using figures and tables where appropriate.
- A Discussion section, which should describe the relationships and generalizations shown by the results and discuss the significance of the results making comparisons with previously published work. (It may be appropriate to combine the Results and Discussion sections into a single section to improve the clarity).
- Conclusions, which should present one or more conclusions that have been drawn from the results and subsequent discussion and do not duplicate the Abstract.
- References, which must be cited consecutively in the text using square brackets [1] and collected together in a reference list at the end of the manuscript.

Units standard SI symbols and abbreviations should be used. Symbols for physical quantities in the text should be written in italics (e.g. *v*, *T*, *n*, etc.). Symbols for units that consist of letters should be inplain text (e.g. ms^{-1}, K, min, mm, etc.).

Abbreviations should be spelt out in full on first appearance, e.g., variable time geometry (VTG). Meaning of symbols and units belonging to symbols should be explained in each case or quoted in a special table at the end of the manuscript before References

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References must be numbered and ordered according to where they are first mentioned in the paper, not alphabetically. All references must be complete and accurate. All non-English or. non-German titles must be translated into English with the added note (in language) at the end of reference. Examples follow.

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[1]. Gungor, A. (2010). Simulation of emission performance and combustion efficiency in biomass fired circulating fluidized bed combustors. *Biomass and Bioenergy* vol. 34, no. 4 p. 506-514, DOI: 10.1016/j.biombioe.2009.12.016.

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[2]. Groover, M.P. (2007). *Fundamentals of Modern Manufacturing.* John Wiley & Sons, Hoboken.

Chapters in Books:

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[3]. Carbone, G., Ceccarelli, M. (2005). Legged robotic systems. Kordić, V., Lazinica, A., Merdan, M. (eds.), *Cutting Edge Robotics*. Pro literatur Verlag, Mammendorf, p. 553-576.

Proceedings Papers:

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[4]. Li R.T.H., Chung S.H. (2008). Digital boundary controller for single-phase grid-connected CSI. *IEEE 2008 Power Electronics Specialists Conference,* p. 4562-4568.

Standards:

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[5]. BS EN 14214:2012+A1:2014. *Liquid petroleum products - Fatty acid methyl esters (FAME) for use in diesel engines and heating applications - Requirements and test methods.* The British Standards Institution. London.

Patents

Standard-Code (year). Title. Organisation. Place. Note that the *Title of the Standard* is italicized.

Surname 1, Initials, Surname 2, Initials (year). *Patent No.* Place of publication: Publisher. Note that *Patent no.* is set in italics.

[6]. Tsukahara, E., Takurou, K. (2015). *U.S. Patent No. 9010288*. Shizuoka: U.S. Patent and Trademark Office.

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[7]. Mehmet Akif Ersoy University, from *http://www.mehmetakif.edu.tr*, accessed on 2018-05-01.

Reports:

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[8]. Yager, J. (2000). *Practice guidelines for the treatment of patients with eating disorders* (2nd ed.). Washington, DC: American Psychiatric Association.

EXTENDED ABSTRACT (SHORT SCIENTIFIC PAPER)

By the time the paper is accepted for publishing, the authors are requested to send the extended abstract (approx. one A4 page or 3.500 to 4.000 characters).

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Address : Techno-Science (Scientific Journal of Mehmet Akif Ersoy University)
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Bucak Teknoloji Fakültesi Dekanlığı
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Phone : +90 248 325 99 00
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Original Research Article

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Utilization of waste heat from exhaust gases of gasoline generator for water heating

Nicholas Akhaze Musa[1*], Olawale James Okegbile[1], Adeola Owojaiye[1]

[1] *Department of Mechanical Engineering, Federal University of Technology, Minna, Niger State, Nigeria*

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ABSTRACT

This work presents the application of waste heat from exhaust gases of gasoline generator through a heat exchanger for household water heating. Two cases were experimented. First, was when water was supplied and filled the heat exchanger without discharging through the tap (retained). Second, was when water was continuously supplied to the heat exchanger and continuously discharged through the tap. In both cases, the temperatures of water and exhaust gases were measured. Measurement showed that during one hour of operation, the water temperature increased from 30^{0}C to 63^{0}C in the first case and from 28^{0}C to 49^{0}C in the second case. The average mass flow rate of water in the first case, average mass heating rate of water in the second case and average mass flow rate of exhaust gas in the first and second cases were determined to be 0.01 kg/s, 0.044 kg/s, 0.02 kg/s and 0.09 kg/s respectively. The heat gain rate of water in first and second cases were determined to be 1.28 kW and 22.58 kW respectively.

1. INTRODUCTION

Conservation of energy is paramount as a result of the need to mitigate the wide gap that prevails between the demand and supply of energy [1]. With the perpetual need of energy by humans, it has become imperative to have an increase in energy production and reduction in its consumption in order to forstall its unsupportable longstanding balance [2]. The various types of internal combustion engine used as prime movers or for electricity generation give out heat along with their exhaust gases [3] and this heat is undoubtedly wasted [4]. The waste heat is in the range of 55-75% of its total energy contained in the fuel [2] and more than 30% of combustion heat is carried away by the exhaust gases [1, 5-7]. If a fraction of the waste energy is reclaimed by the system, it will result in an inrease in efficiency and reduction in emissions of the engine [7-8].

In most cases, this waste heat is not used. However there are great investments in the technology of waste heat use so as to promote reduction in cost of use of energy [9]. Waste heat recovery system is simply the reclaiming of heat contained in fluids of systems like internal combustion engines; heat that can be converted to other forms of energy that would have been lost[10]. Although waste heat has been used for electricity generation [11-15], mechanical work [16] and vapour absorption refrigeration system, it can be employed for heating water for domestic use. The reason is that the main area where energy is highly consumed in living homes is water heating [10]. Forty percent of electricity used in homes is for water heating [17]. Cooking, processing and domestic appliance cleaning requires the use of hot water [17]. To meet with these reqirements, hot water is produced by the use of electricity which is expensive or burning fossil fuels which have adverse effects on the environment. Waste heat from the condensing unit of refrigerating systems have been used to heat water to temperatures in the range of 40^{0}C–70^{0}C for domestic use with reasonable energy savings and cost [18-21].

In developing countries like Nigeria, there is a dwindling availability of fossil fuel and erratic power supply. So meeting up with water heating requirement for domestic purposes is a herculean task. It has now become imperative to find another energy source to mitigate the challenges. To this end, this research work embarks on the use of waste heat from the exhaust gases of a gasoline generator. Generators are used in Nigeria to provide electricity in homes, offices and industries

* Corresponding Author: madonick1@yahoo.com / Tel: +2348058717209

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for lighting, powering devices, appliances and machines, because of the aforementioned problems. Generator is a thermal system where a mixture of fuel and air is burnt to produce power to drive an alternator and thereby produces electricity. The burnt gases are expelled through the exhaust into the atmosphere. This work is geared towards using the generator exhaust gases to provide hot water by allowing the exhaust gases to flow through shell and tube parallel flow heat exchanger that was designed and constructed by Owojaiye(2017) in [22] shown in Figure 1.

Fig. 1. *Shell and tube parallel flow heat exchanger*

It comprises of three pipes through which the exhaust gases flow and running through a water tank which is the shell. The specifications of the heat exchanger are shown in Table 1.

Table 1. *Specifications of the shell and tube parallel flow heat exchanger*

S/N	Specifications	Quantities/Dimensions
1	Number of tubes	3
2	length of each tube	0.3 m
3	Internal diameter of tube	0.0127 m
4	External diameter of tube	0.00147 m
5	Internal shell diameter	0.18 m
6	External shell diameter	0.183 m
7	Length of heat exchanger	0.5 m
8	Capacity of the heat exchanger	0.012 m^3

2. EXPERIMENTAL SETUP

The engine used in this study was a 4-stroke, 1-cylinders, air cooled LUTIAN gasoline generator. The detailed specifications of the gasoline generator are shown in Table 2.

Table 2. *Specifications of the LUTIAN gasoline generator*

S/N	Specifications	Quantities/Dimensions
1	Model	LT3990E
2	Make	LUTIAN
3	Type	Air cooled One cylinder Four-stroke
4	Fuel capacity	15 litres
5	Rated output	3.3 Kva
6	Maximum output	3.5 Kva

The generator exhaust was coupled with the heat exchanger as shown in Figure 2. The schematic or line diagram of the experimental setup is shown in Figure 3.

Fig. 2. *The gasoline generator coupled with heat exchanger*

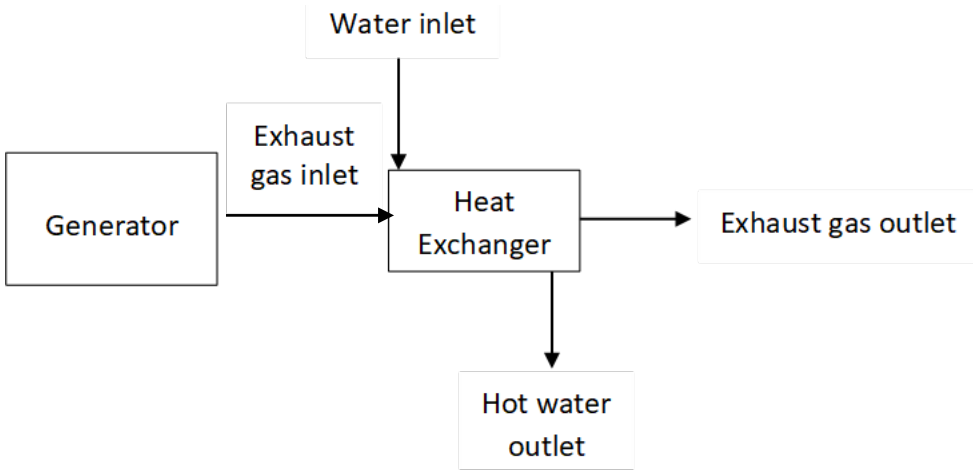

Fig. 3*. The schematic or line diagram of the experimental setup*

2.1. Experimental Run

Two cases were experimented. First, water was supplied and filled the heat exchanger (tank) without discharging through the tap. Second, water was continuously supplied to the heat exchanger and continuously discharged through the tap.

2.1.1. Test with the heat exchanger filled up and water is retained by closing the tap

The heat exchanger (tank) was filled with water and the tap was closed. The generator was put on and the inlet and outlet temperatures of exhaust gas and the temperature of water in the tank were measured with *K* type thermocouples after every 5 minutes. This test allowed the knowledge of the maximum period taken to heat the known quantity of water in the heat exchanger to its maximum temperature. More so, to estimate the quantity of heat required from the exhaust gases to heat the water. In order to estimate the rate at which mass of water was heated and mass flow rate of the exhaust gas, the following relations were used.

$$\dot{M}_w = \frac{\rho v_c}{t} \tag{1}$$

Where $\dot{M}_w$ is mass of water heating rate, v_c is the capacity of the heat exchanger (water tank). ρ is the density of water, t is the period of heating.

In order to estimate the mass flow rate of the exhaust gases, the energy balance equation was used, neglecting losses. That is, "heat given out by the exhaust gases = Heat gained by the water in the heat exchanger".

$$\dot{M}_e C_e (\Delta T)_e = \dot{M}_w C_w (\Delta T)_w \tag{2}$$

Where $\dot{M}_e$ is the mass flow rate of exhaust gases, C_e is the specific heat capacity of the exhaust gases. $(\Delta T)_e$ is the change in temperature of the exhaust gases, C_w is the specific heat capacity of water and $(\Delta T)_w$ is the change in temperature of water.

2.1.2. Test with water continuously supplied to the heat exchanger and water being discharged from the exchanger by opening the tap

The heat exchanger (tank) was continuously filled with water and the tap was opened. The generator was put on. The inlet temperatures of the exhaust gases and water as well as the outlet temperatures of exhaust gases and water were also measured after every five minutes with thermocouples. This allowed the estimation of the quantity of heat required from the exhaust heat to heat the water neglecting losses. In order to estimate the mass flow rate of water, after every five minutes of the experiment, the mass of water collected in the tap was weighed and divided by the time (five minutes). In order to estimate the mass flow rate of the exhaust gases, the energy balance stated in equation 2 was used. In this case $\dot{M}_w$ stated in equation 2 is called the mass flow rate of water.

3. RESULTS AND DISCUSSION

The variations of water temperature with time for filled up tank with retained water and filling up tank with discharging water are shown in figure 4 .

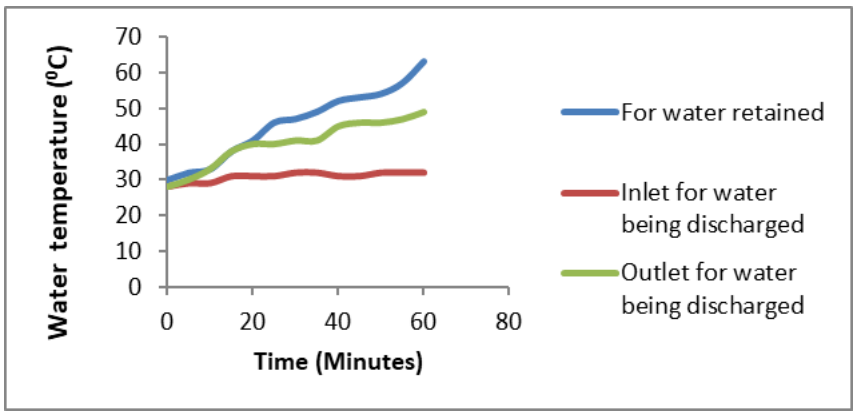

Fig. 4*. Variations of water temperature with time for filled up tank with retained water and filling up tank with water being discharged from the tank*

It can be seen from figure 4 that the temperature of the retained water in the tank, the inlet and outlet temperatures of water being discharged increased with time. However, the temperature increased more with the case of water being retained in the tank. This higher increase can be attributed to the long residence time of water to gain heat from the exhaust gases, which is the whole period of heating in the tank. During one hour of operation, the water temperature increased from 30⁰C to 63⁰C when the water was retained in the tank and from 28⁰C to 49⁰C when the water was being discharged from the tank. Figure 5 shows the variation of inlet and outlet exhaust gas temperature with time for filled up tank with retained water and filling up tank with water being discharged from the tank .

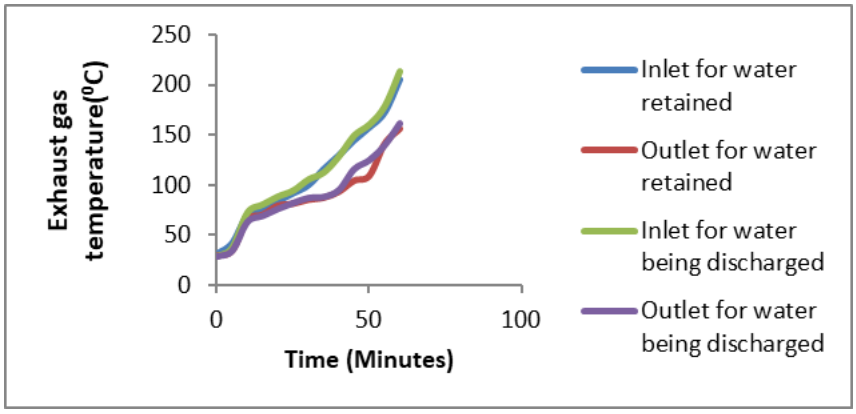

Fig. 5*. Variations of inlet and outlet exhaust gas temperature with time for filled up tank with retained water and filling up tank with water being discharged from the tank*

After five minutes of generator engine warm up and the start of the of the experiment, the inlet and outlet temperatures of the exhaust gases rose from 42⁰C and 35⁰C for water being retained, 37⁰ Cand 34⁰C for water being discharged to 206⁰C

and 157^{0}C for water being retained and 213^{0}C and 162^{0}C for water being discharged respectively. As it is evident in figure 5, the exhaust gas temperatures increased with increase in time of operation of the generator. The variation of mass flow rate of exhaust gases and water with time for filled up tank with retained water and filling up tank with water being discharged from the tank are shown in figure 6.

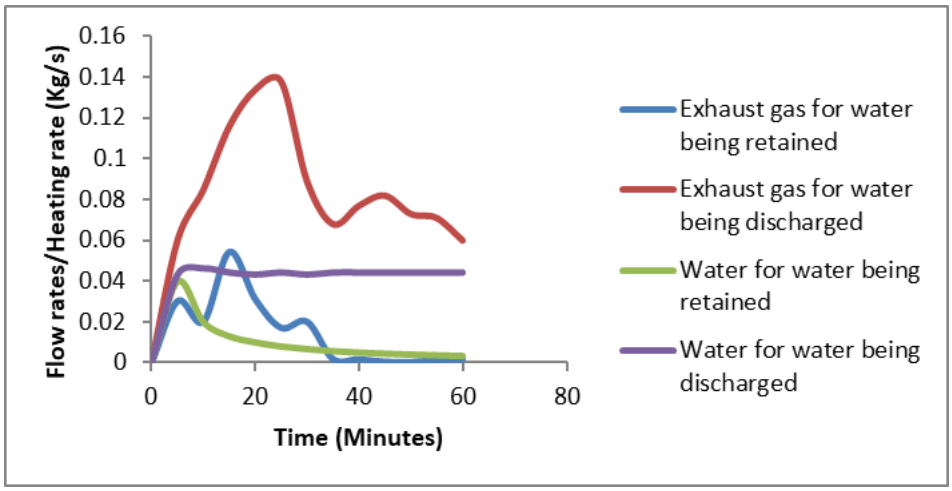

Fig. 6. Variation of mass flow rate of exhaust gases and water heating rate with time for filled up tank with retained water and filling up tank with water being discharged

The mass flow rate of the exhaust gases and water heating rate when water was retained in the tank and the mass flow rate of the exhaust gases and water when water was discharged from the tank varied considerably with time. The mass flow rate of exhaust gases and water heating rate varied around an average of 0.02 kg/s and 0.01 kg/s respectively when the tank was filled up and hot water was retained. The mass flow rate of exhaust gases and water varied around an average of 0.09kg/s and 0.044kg/s respectively. Figure 7 depicts the variation of heat gain rate with time for filled up tank with retained water and filling up tank with water being discharged from the tank.

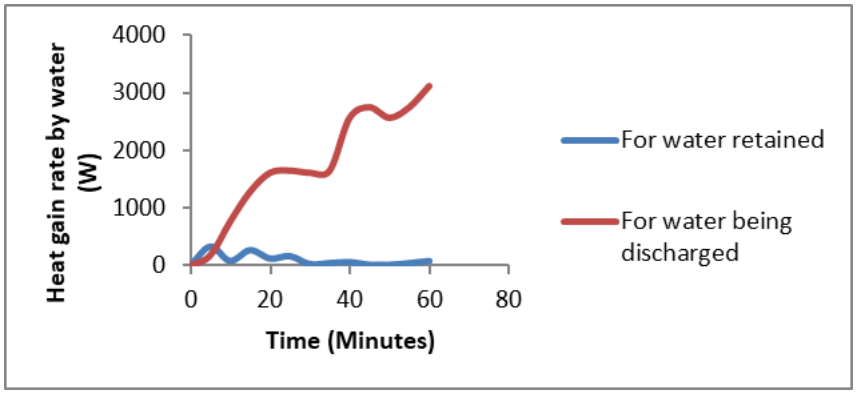

Fig. 7. Variation of water heat gain rate with time for filled up tank with retained water and filling up tank with water being discharged

The heat gain rate by water varied remarkably with time but more remarkably when the tank was filled up and water was retained than when the tank was filling up and water was being discharged, as seen from figure 7. During one hour of operation and neglecting losses the total heat gain rate for the tank being filled up and retained water and the tank filling up and water being discharged are 1.28 kW and 22.58 kW respectively

4. CONCLUSION

The use of waste heat from the exhaust of a gasoline generator through heat exchanger to heat water for household use was experimented in this research work. From the obtained results, it can be concluded that recovered waste heat from the exhaust gases of gasoline generator can heat water and raise its temperature from 30^{0}C to 63^{0}C and 28^{0}C to 49^{0}C within an hour when the heat exchanger (tank) is filled up with water, heated and the hot water is retained in the heat exchanger and when the heat exchanger is being filled up with water and the water being discharged from the heat exchanger as it is heated respectively.

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Original Research Article

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Real-Time Communication between S7-1200 PLC and Matlab/Simulink and a Fuzzy Logic Temperature Humidity Control Application

Yavuz User[1*], Cumali Kara[1]

[1] *Department of Electrical and Electronics Engineering, Akdeniz University, Antalya, Turkey*

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ABSTRACT

It is not much possible for controllers such as PLC (Programmable Logic Controller) and DCS (Distributed Control System) used in the industry to solve complex systems. On the contrary, Matlab/Simulink provides advantages with the solutions it offers in the complex systems. It is highly significant that PLCs have a real-time communication with Matlab to solve this kind of complex systems. For industrial automation, interoperability standard OPC (OLE for process control) plays the role of a bridge between Matlab/Simulink and PLC and enables data exchange between them. On the other hand, Fuzzy Logic provides advantage in solving complex systems. There are two inputs in this research. Temperature and relative humidity data is transferred to Matlab/Simulink via OPC by PLCs. Based on the temperature and relative humidity felt depending on the temperature, the percentage of fan speed is calculated by using Fuzzy controller in Matlab/Simulink and transferred to PLC via OPC and the required physical output connected to PLC is activated. This system shows how fast the processes which are complex in PLC can be solved with Matlab/Simulink. A complex system developed in Matlab/ Simulink can be automatically converted to any microcontroller code. The PLC used in industry can communicate with this microcontroller as well and obtain the desired output in the best way possible. Nowadays, Artificial Intelligence develops day by day and such a system gains even more importance.

1. INTRODUCTION

Generally, industrial controllers that can perform simple operations in a factory environment are used. However, these controllers cannot evaluate complex processes at the desired performance. For this reason, complex processes can be calculated by using a PC and the result can be transferred to the controller. Complex processes can be calculated in Matlab through an artificial intelligence algorithm.

MATLAB is a programming language that is capable of performing multi-paradigm numerical computation. And, it is a powerful tool that enables the development of operations such as process control, fuzzy logic, artificial neural networks, image processing, genetic algorithms in their own environment. Also, it is easier to prepare and run programs with Matlab/ Simulink solution.

PLC (Programmable Logic Controller) is a processor unit which is generally used in the industry for process controls. It is in great demand in the industry as it provides easy programming possibility, the flexibility it provides in including into the process, and it can operate under severe conditions. The Siemens product S7-1200 used in this study can be programmed with the TIA PORTAL editor via its Ethernet port.

Before OPC, producers offered special software and drivers to enable different products communicate with each other, and as a result, data exchange was ensured by complying with specific protocols.
The wide product range and the protocols varying from brand to brand made it necessary to proceed with a specific standard in this respect.

* Corresponding Author: yuser@akdeniz.edu.tr / Tel: +905053762675

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OPC technology, which is based on server-client architecture, was developed to enable seamless interoperability of different products with a single standard [1].

Figure 1 shows the structure where the systems using different communication protocols offered product-specific driver before the OPC.

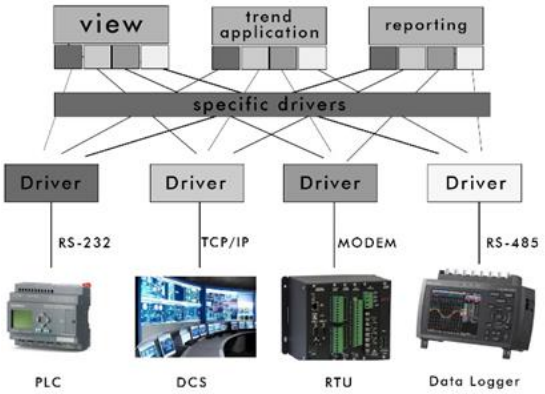


Fig. 1. *Connection diagram before OPC*

Different devices included in the system with different software applications enable communication with a single standard as long as they have the OPC driver. The communication structure after OPC is shown in Figure 2 [3] [7].

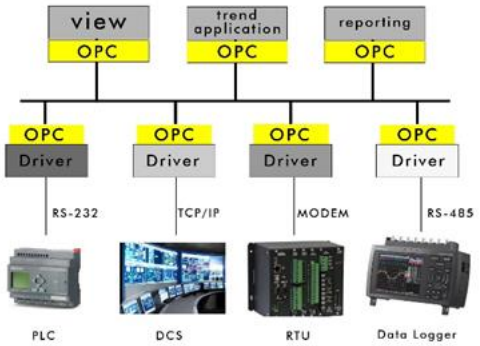


Fig. 2. *Connection diagram after OPC*

2. METHOD

2.1. Communication Between Matlab/Simulink and S7-1200 PLC Over OPC

In the OPC structure where the server and the client reside, the server carries out data transfer in line with the requests of the client. OPC client is supposed to be used on the application side to communicate with an appropriate OPC server. Also, it functions as the data receiver as clients control the communication with the servers. Figure 3 shows the structure of OPC Server.

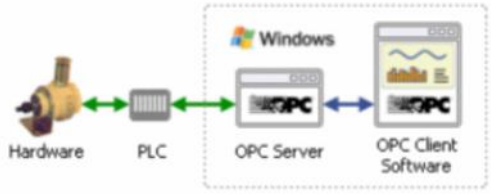


Fig. 3. *OPC Server Structure*

OPC DA (OPC Data Access) standard was established for the interaction between server and client. OPC Toolbox in Matlab is an OPC DA client application. With this application, it is possible to connect to a server that is in compliance with OPC DA from Matlab environment and to read/write data through the server. The connection between Matlab/Simulink, PLC and OPC is shown in Figure 4.

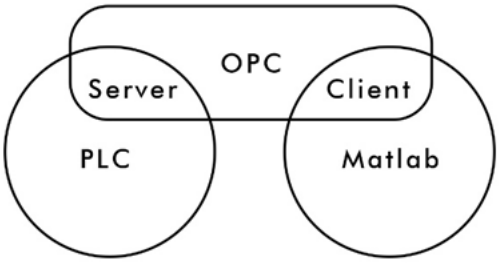


Fig. 4. *Matlab, PLC and OPC connection structure*

In Matlab / Simulink, first of all, OPC Server object is created within the OPC client program and information about the OPCItems stored on the server is obtained. Considering the information obtained, OPCGroup objects are created for OPCItems and then they are grouped. This enables the configuration of group, item and all client objects via the OPC Toolbox.

2.2. Fuzzy Logic

Classical logic is based on strict judgments. According to 0 and 1 logic, whether an object belongs to a cluster is specified with definitive expressions. In Fuzzy Logic, there is no definitive expression like 0 and 1, and instead, there are flexible expressions that we use in our daily life.

According to the classical logic, the weather is either hot or cold. In Fuzzy Logic, it is possible to have classifications such as the weather is "slightly warm", "warm", "very hot", "somewhat cold", and this gives flexibility to the fuzzy logic. The fuzzy logic stages are shown in Figure 5.

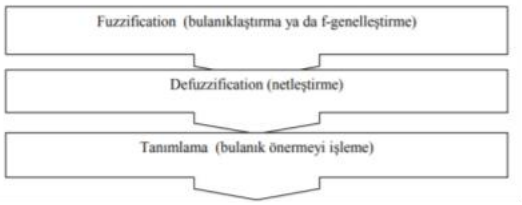


Fig. 5. *Fuzzy Logic stages*

The first and second phases refer to cluster formation and identification processes. Fuzzification is the generalization of fuzzy clusters, and at this stage, we get the correct degree of the line in question. The membership functions stored at this stage are used to obtain fuzzy input values. The information is converted into fuzzy sets and defuzzification refers to a process that transforms a fuzzy number into an integer [2].

The Methods section details the theoretical or experimental methods used. What justifies using a given method? What is special, unexpected, or different in your approach? If you use a standard or usual procedure, mention that upfront, too.

3. CREATION OF THE SYSTEM

It is ensured that the server is ready with the channel setting, system settings, PLC model, Ethernet address and tag entries to be used for OPC server configuration. The addresses and data types of the data to be transferred from Matlab to PLC and from PLC to Matlab are shown in Figure-6.

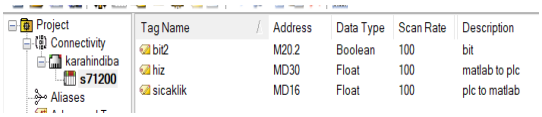


Fig. 6. *The data created in the OPC*

S7-1200 was programmed via Tia Portal editor. Analog temperature information was scaled between 0-100 (Figure-7). The scaled 'temperature' data was transferred to Matlab via OPC.

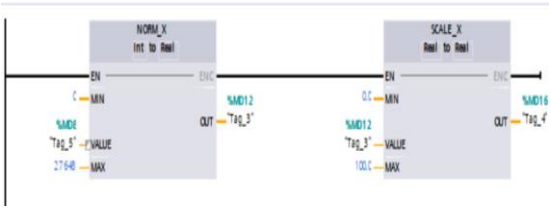


Fig. 7. *Scaled analog value*

The temperature and relative humidity information obtained from DHT22 connected to PLC were inserted into the fuzzy logic block in Matlab / Simulink through PLC, and the resulting fan speed analog value were transferred from Matlab to the PLC as a percentage. For the physical representation of the results, it was ensured that the physical outputs were activated/deactivated by using the speed information comparison commands from Matlab in TiaPortal as shown Figure 8.

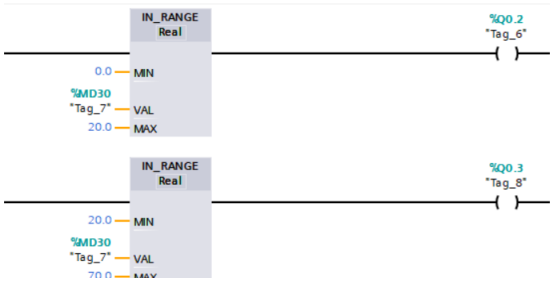


Fig. 8. *Activated physical output*

Fuzzy logic clusters were created by considering the apparent temperature table depending on the temperature and relative humidity as shown Figure 9 [4].

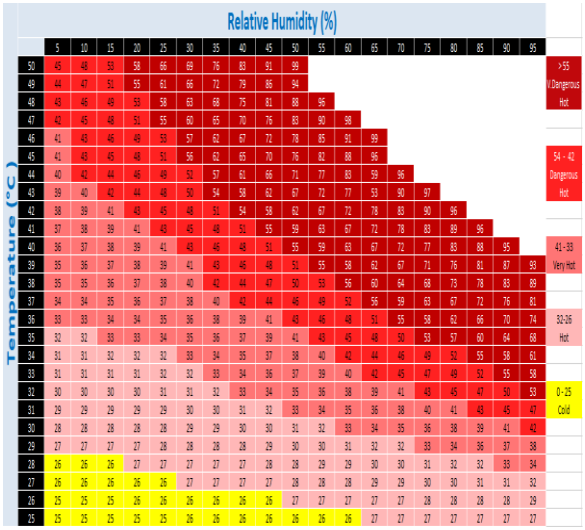


Fig. 9. *Apparent temperature table*

Figure 10 shows the parameters of the fuzzy model consisting of two input and one output parameters, and the system's modeling in MATLAB program.

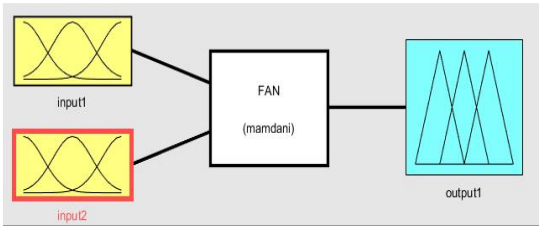


Fig. 10. *(input1=temperature , input2=humidity, output=speed)*

The graphical representation of the Input 1 "temperature" parameter in Matlab environment is given in Figure 11.

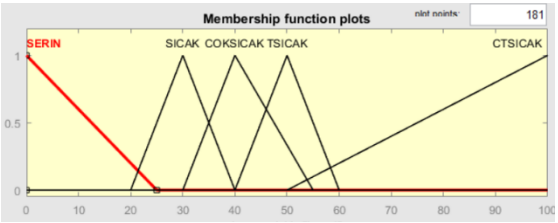


Fig. 11. *Temperature parameter*

The graphical representation of the Input 2 “humidity” parameter in Matlab environment is given in Figure 12.

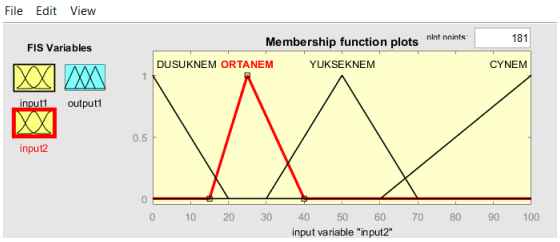


Fig. 12. *Humidity parameter*

The graphical representation of fan speed variable in Matlab environment is given in Figure 13.

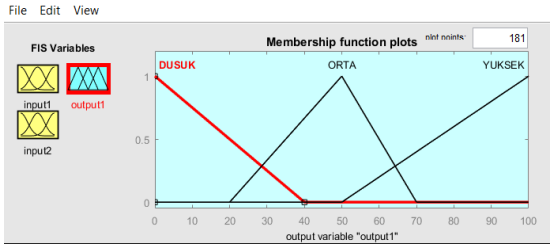


Fig. 13. *Fan parameter*

Rules were set to understand the relation between input and output parameters. The resulting database contains all the possibilities and some rules of the fuzzy model are shown in Figure 14.

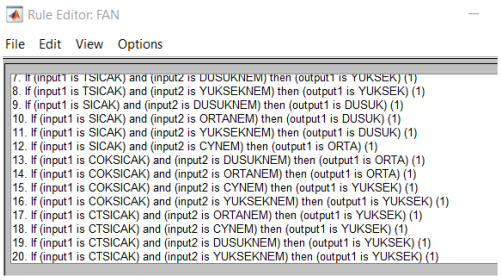


Fig. 14. Fuzzy Model rule

The impact of input variables on the output variables are given in Figure 15 based on the fuzzy rule base.

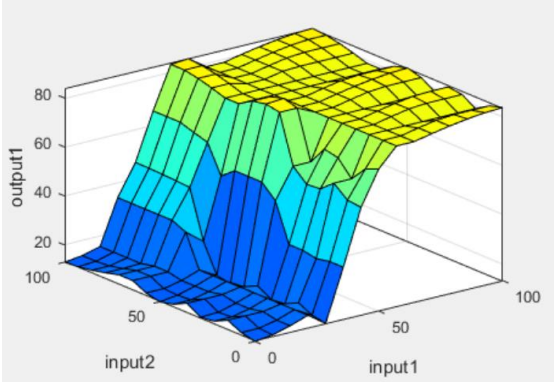


Fig. 15. *The impact of input variable on output variable*

Matlab/Simulink Block diagram is shown in Figure 16. Block descriptions are given in the following items and Figure 17 shows Matlab/Simulink OPC Configuration [5, 6].

1. In section 1, Matlab -OPC settings are made.
2. In section 2, address settings that will be read from PLC through OPC are performed.
3. The fan speed value resulting from fuzzy logic operations of the values entered in section 3 is transferred to the address associated with PLC from Matlab via OPC.
4. In section 4, the relative humidity and temperature information obtained from PLC are actively read via DHT22 with Matlab.

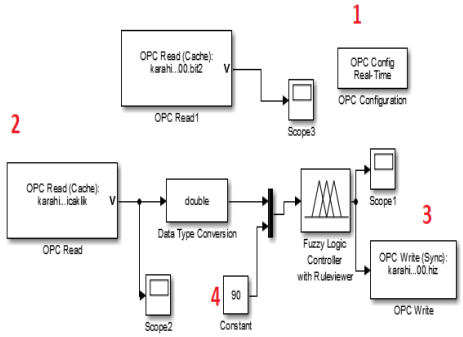


Fig. 16. *Matlab/Simulink Block Diagram*

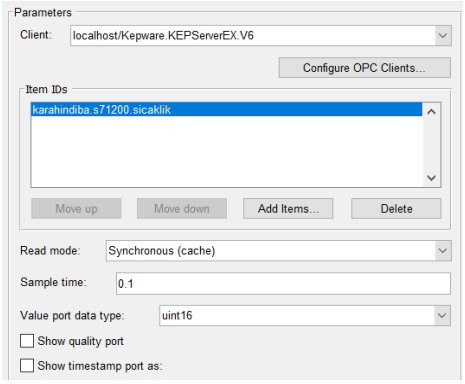


Fig. 17. *Matlab/Simulink OPC Configuration*

3.1. System Operation

The system gives the fan speed as percentage after the Fuzzy process on analog temperature value from PLC and relative humidity ratio entered through Matlab, and sends it to PLC. The real-time communication and control of the system are shown below. TIA PORTAL part of the system input is shown in Figure 18. OPC part of the system input is given in Figure 19.

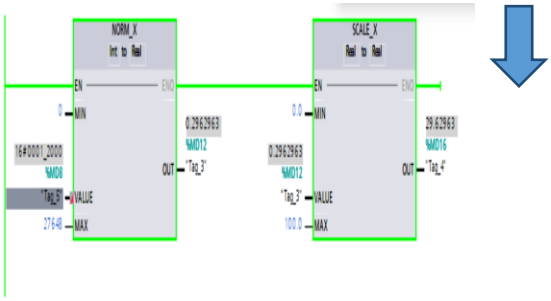
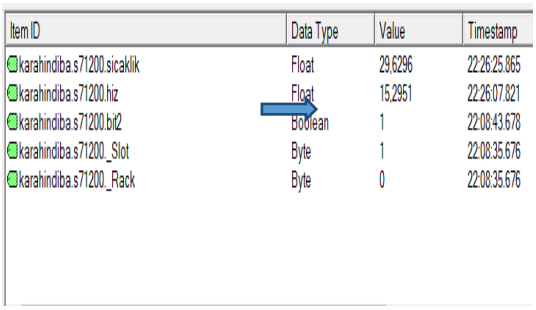


Fig. 18. *System input in TIA PORTAL*



Item ID	Data Type	Value	Timestamp
karahindiba.s71200.sicaklik	Float	29,6296	22:26:25.865
karahindiba.s71200.hiz	Float	15,2951	22:26:07.821
karahindiba.s71200.bit2	Boolean	1	22:08:43.678
karahindiba.s71200_Slot	Byte	1	22:08:35.676
karahindiba.s71200_Rack	Byte	0	22:08:35.676

Fig.19. *OPC View of system input*

System input is given in Figure 20 and system output is given in Figure 21.

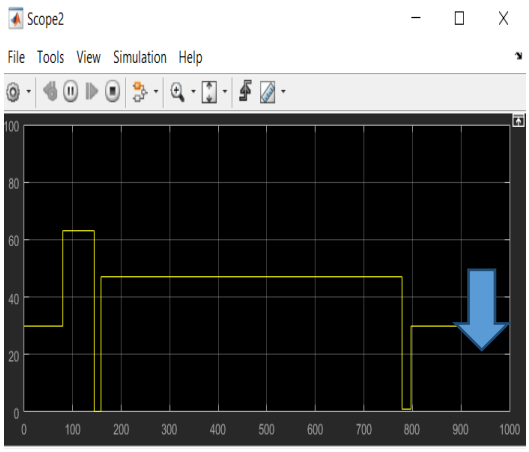


Fig. 20. *System input MATLAB view*

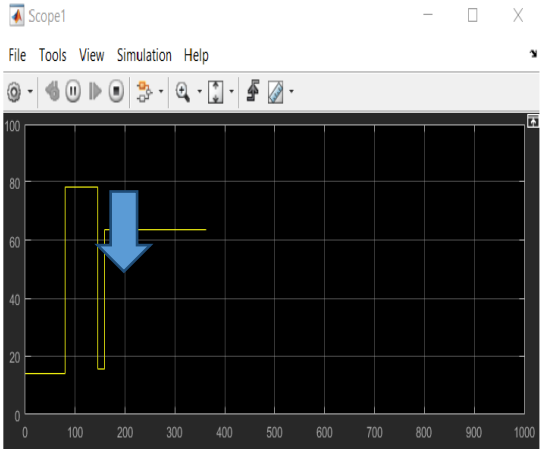


Fig. 21*. MATLAB output view*

OPC part of the system output is given in Figure 22. TIA PORTAL portion of the system output is given in Figure 23. Snapshot of the system's Fuzzy input/output is given in Figure 24.

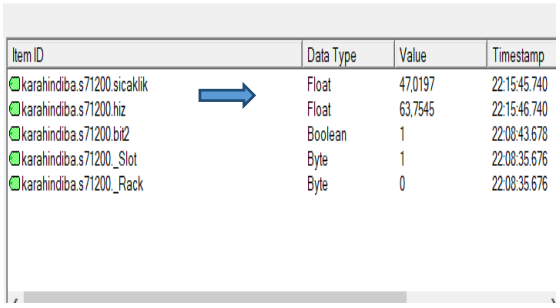


Fig. 22. *OPC View of system output*

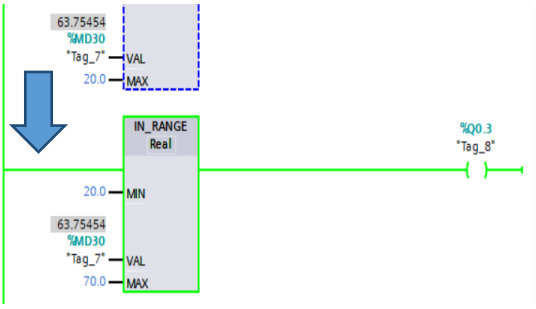


Fig. 23. *System output TIA PORTAL*

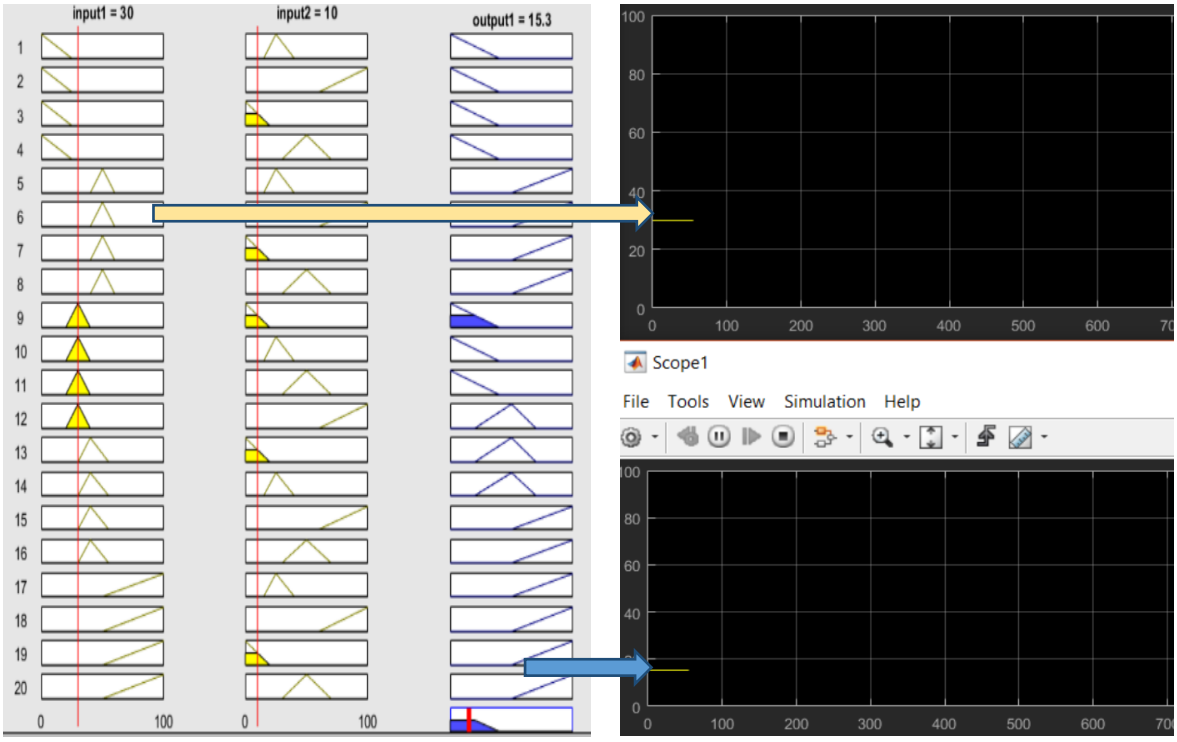


Fig. 24. *Snapshot of the inputs/outputs in Fuzzy controller*

4. CONCLUSIONS

Real-time data exchange between S7-1200 and Matlab / Simulink was ensured through OPC Server. System inputs were processed in in Fuzzy controller in Matlab / Sımulınk and then system output is obtained. The resulting system output was transferred to S7-1200 and the desired physical output is set. This study shows that a complex system is resolved in an equally strong platform in real time.

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Original Research Article

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Energy potential from gasification of agricultural residues in Burdur, Turkey

Zuhal Akyürek[1*], Afşin Güngör[2,3], Ali Akyüz[4]

[1] *Faculty of Engineering and Architecture, Burdur Mehmet Akif Ersoy ;University, Istiklal Campus, 15030, Burdur, Turkey*
[2] *Faculty of Engineering, Akdeniz University, 07058, Antalya, Turkey*
[3] *Bucak Faculty of Technology, Burdur Mehmet Akif Ersoy ;University, 15300, Bucak, Burdur, Turkey*
[4] *Bucak Emin Gülmez Vocational School of Technical Sciences, Burdur Mehmet Akif Ersoy ;University, 15300, Bucak, Burdur, Turkey*

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ABSTRACT

Gasification is one of the major waste to energy technologies for renewable energy production. Agricultural residues have high potential to be used as significant source of renewable energy in Turkey. In this study, different gasification systems are compared to estimate the bioenergy potential of agricultural residues in Burdur province. Syngas produced from gasification process can be used as renewable fuel in internal combustion engines, turbines and boilers. Syngas energy potential of agricultural residues from air gasification of agricultural residues are evaluated in up-draft fixed bed, down-draft fixed bed and circulating fluidized bed systems. The results revealed that down-draft gasifier has shown the highest annual energy production potential of 402 MW in Burdur province.

1. INTRODUCTION

The demand for energy has been steadily increasing in the last decades due to rapid growth in population and industrialization. Energy security is one of the main drivers of national energy policies in any country of the world today. Greenhouse gas emissions from fossil fuels have resulted in environmental pollution and global warming [1]. To reduce the negative impact of fossil fuel combustion, biomass is considered as one of the most promising routes for renewable energy production and for alleviating the environmental hazards [2-4].

Biomass resources are carbonaceous materials derived from agricultural crops, forestry, agro-industrial and urban waste. Biomass energy has advantage of being stored and transformed into heat and electricity, unlike the other renewables. Utilization of agricultural residues have several advantages such as recovering energy from waste materials, using local renewable energy source, providing environmental protection, etc. In the view of these issues, using the energy potential of these residues gain more importance in terms of sustainable development.

Gasification is an attractive energy production alternative from organic waste materials [5-7]. It is an environmentally friendly way of using bio-wastes for energy purposes [8]. Gasification results in higher energy recovery and heat capacity with respect to combustion and pyrolysis of biomass due to the optimum utilization of available biomass feedstock [9]. In gasification process biomass is converted into syngas by the partial oxidation of the solid fuel at high temperature, in the range of 800-1000 °C [10].

The gasification efficiency strongly depends on the operational parameters such as moisture content of biomass, gasifying agent, equivalence ratio, gasifier temperature, particle size of biomass, etc. [11]. Gasification can be carried out by using air, oxygen and/or steam as a gasifying agents. Product gas from gasification is the syngas which contains hydrogen, carbon monoxide, carbon dioxide, methane and nitrogen [12, 13]. Vast literature is available on the investigations of biomass gasification by using different gasifying agents, temperatures and gasifiers [14-18]. Air is widely used as gasifying

* Corresponding Author: drzuhalakyurek@gmail.com / Tel: -

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agent and among the alternatives such as steam, air/steam, oxygen, air gasification is the most economical and operationally advantageous option [19].

High economic contribution of agricultural activities in Turkey signify the availability of agro residues for energy production. Burdur province which is located in the West Mediterranean Region of Turkey. The economy of the city strongly depends on agricultural activities and livestock farming. Hence, there is high bio-waste potential. In this study, gasification energy potential of agricultural residue inventory in Burdur province has been evaluated with different types of gasifiers by using the previously published syngas composition data [11, 18].

2. MATERIALS AND METHODS

In this study, agricultural residue based gasification performance and syngas energy production potential is estimated for Burdur province by using different air-gasification technologies. The agricultural production data provided from Turkish Statistical Institute is given in Table 1 [20]. Variety of gasifiers have been developed for partial oxidation of the solid fuels such as fixed bed downdraft, fixed bed updraft, fluidized bed. Schematic description of the gasifier types used in this study is demonstrated in Fig. 1. As can be seen from the figure, in the updraft gasifiers, the gasifying agent enters the system from the bottom part of the gasifier and leaves from the top. Biomass on the other hand, enters the system from the top of gasifier and move toward the bottom where it gets oxidized and generate flue gases. In downdraft gasifiers both biomass enters the system from the top and biomass and air move in the downward direction of the gasifier unit. Fluidized bed gasifiers are known by their fuel flexibility characteristics. In circulating fluidized beds, biomass circulates within the gasifier and the cyclone separator. Table 2 reports indicative variation of syngas composition for different air-gasifiers.

Table 1. *Agricultural production in Burdur [20].*

Agricultural Products	Production Rate (ton/year)
Wheat	135661
Corn	369643
Barley	70435
Rye	7131
Oat	20023
Sugar Cane	186801
Tomato	1449623
Olive	271
Walnut	2511

Table 2. *Experimental results of woody biomass gasification using different types of gasifiers [18].*

Gas composition (% vol, dry basis)	Updraft	Downdraft	CFB
H_2	11	17	14.1
CO	24	21	18.7
CO_2	9	13	14.7
CH_4	3	1	3.5
N_2	53	48	47.7

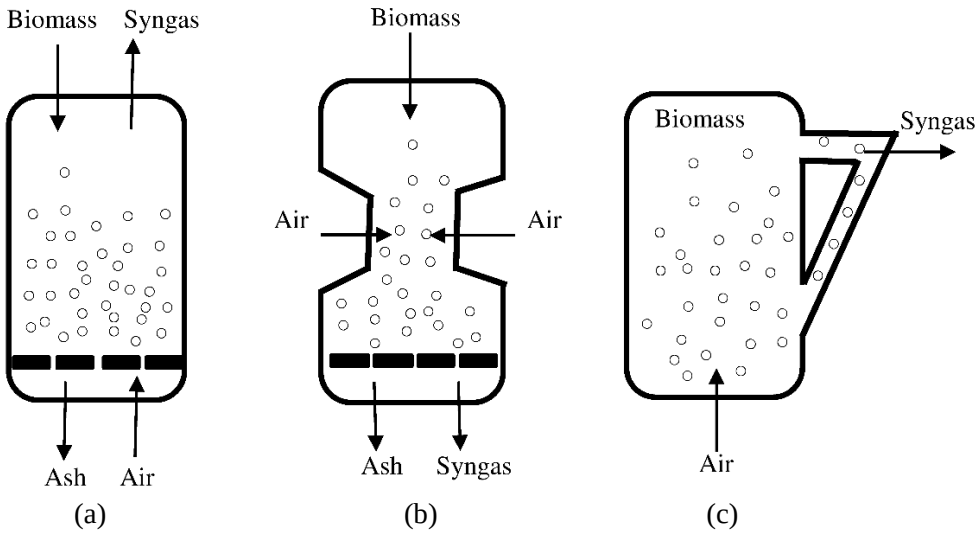

Fig.1. *Different gasification technologies (a) updraft, (b) downdraft, (c) circulating fluidized bed (CFB)*

3. RESULTS AND DISCUSSION

Biomass gasifiers convert solid biomass into gaseous products to be used for energy production. Gasification performance and syngas composition of biomass strongly depend on the operating parameters and type of the gasifier system. Energy content of the produced syngas is generally expressed by its heating value (MJ) generated from 1 Nm^3 of syngas [11]. Agro residue energy potential of Burdur province has calculated by using the previously published experimental data. Estimated syngas composition of the biomass residues are shown in Fig. 2. As can be seen from the figure downdraft gasifier has shown to have higher hydrogen, carbon monoxide, carbon dioxide and nitrogen emission indicating higher energy production performance compared to updraft and circulating fluidized bed systems.

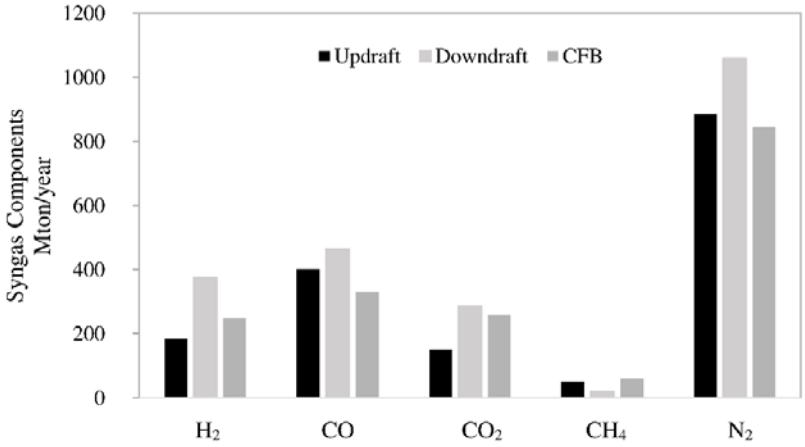

Fig.2. *Production rate of different syngas components from updraft, downdraft and CFB systems*

Influence of the reactor type (updraft, downdraft and circulating fluidized bed gasification systems) on energy production are presented in Table 3. The results revealed that downdraft gasifier system can provide higher potential of energy generation from agricultural residues in Burdur province with respect to updraft and fluidized bed technologies.

Table 3. *Energy production from different air-gasification systems estimated for agricultural residue potential of Burdur province*

	kWh
Updraft	293,788
Downdraft	401,902
CFB	254,795

4. CONCLUSION

Biomass gasification is a well-known technology pathway to convert biomass to hydrogen and other products, without combustion. The influence of various gasification systems in the final composition of syngas was evaluated for Burdur province based on the previously published experimental data. Conlusions can be drawn that there is significant potential

of agricultural residue in the Burdur province. Comparisons have shown that downdraft gasifier has higher energy production capacity than those of updraft and circulating fluidized bed systems. Burdur province has shown to have 402 MW annual thermal energy production potential from downdraft air-gasification of agricultural residues.

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Deep Learning in Marble Slabs Classification

İhsan Pençe[1], Melike Şişeci Çeşmeli[1*]

[1] *Zeliha Tolunay Applied Technology and Business School, Burdur Mehmet Akif Ersoy ;University, 15300, Bucak, Burdur, Turkey*

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ABSTRACT

The process of classification of marble slabs has an important place in terms of construction sector and demands. Despite the advanced mines and construction equipment in Turkey and the world, the separation of cut marble process is a problem that has not been solved yet. The lack of a standard for the classification of marbles and the use of human factors for this process lead to erroneous and inefficient determinations. In this study, for the first time the Deep Learning method has been tried on marbles, and the components obtained from Deep Learning layers have been examined and the success of classification has measured. Thanks to the successful results, the basics of the Deep Learning network have been laid for future marble databases.

1. INTRODUCTION

Artificial intelligence has become popular in industry, medicine, defence, agriculture, and informatics nowadays and the developed countries have been trying to improve their producing systems expeditiously by using artificial intelligence technologies. These systems which have an important place in terms of improving the product quality, productivity and added-value are supported by the governmental incentives and universities and they are the most important issues that have to be put emphasis on within the scope of Industry 4.0. Many systems or problems can be modelled and then solved with machine learning algorithms after determining their appropriate features. For instance, person's gender can be learnt from the wave length of the sound data and according to the blood values, it can be designated whether the person is ill or not. However, today to determine the features of the related problem is a challenging process that takes too much time and requires a specialist in the related field. Furthermore even if the systems are modelled theoretically, they reveal different impacts under the real life conditions and due to the factors such that sun light and temperature may change the colour values of the item, the systems are improved with difficulty. Alternatively, determination and variability of the complex features obtained to develop a model can be solved by using more basic presentations. Deep Learning, a popular method today, enables computers to create more complex concepts from simple concepts. Basic concepts such as edge, contour, and corner can be formed with the help of a Deep Learning system and then human figures can be obtained by combining these concepts. Basic presentations provide information to Deep Learning Program that tries to make sense out of the data and is one of the artificial intelligence approaches; each concept is defined with the relations to the concepts more simple than itself [1].

Due to the improvements in building industry and increasing demands in terms of aesthetics throughout the world, interest and demand in marble varieties such as travertine, onyx, and granite increase simultaneously. Turkey holds various and plenty of marble reserves and is one of the leader stone manufacturer countries in the world. Besides utilisation demands, technological improvements and industry have also effect on. Turkey has important business organizations and construction equipment in terms of extracting the natural stones from mines and first processing. However, there is a deficiency in fine cut and classification of stones obtained. Especially in terms of classification, nearly all marble businesses carry out man-made identification and human eye and skill are not competent enough to specify which classes marble stones belong to since there are various types and homogeneity of marble stones. When a human eye looks at objects that have the same colour and type, it gets tired and its selectivity decreases biologically. Therefore, classification failure due to the man skills is usually faced at the businesses and thereby production and productivity

* Corresponding Author: melikesiseci@mehmetakif.edu.tr / Tel: -

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decline. The most important criterion for the marbles to be selected in accordance with the requirements is colour harmony. Besides, there are some areas on the surface having different textures and colour with different dimensions. A human eye expects fluidity when looking at the natural stones and these areas spoil aesthetics of the stones. Even though the classifications are tried to be formed according to the stone's variety and demand for the marbles used for surface coating at the businesses, classification standards are not stated. Besides, when the differences in marble vein and user defects are added, stones are not able to be classified properly [2].

Image processing and artificial intelligence based autonomous systems are generally presented as solution method in order to designate the classes of marble slabs. When the studies carried out are analysed, it is seen that although there is a great demand for the marble throughout the world, there are few studies in this field. It is observed that mostly classifications and texture analysis of the stones such as marble, granite have been executed in the studies carried out. Martinez-Alajarin et al. [3] studied on various statistical features of marble surfaces and used the features on different colour spaces for classification. Selver and Akay [4] utilized histogram features of the marbles for classification. In their studies Benavente and Pina [5] carried out classification and segmentation processes of the marbles by using morphological operations. In their studies López et al. [6] used spectral features to classify granite stones in marble type. In their studies Şişeci and Cetişli [2] suggested a new class description for clustering algorithm that is one of the unsupervised learning methods as well as travertine plates. They used both colour and homogeneity analysis as features for algorithms. In their studies Şişeci et al. [7] developed a new rapid clustering method and used this method for separation of marbles. In their studies Turhal et al. [8] detected fringe areas and cavities on marble images by using digital image processing. They calculated marble surface unevenness by utilizing these features. Moghaddam et al. [9] tried to classify the marble slabs using image processing methods. In their studies Kemaloglu et al. [10] developed an automatic system that can classify marbles by utilizing controlled and uncontrolled learning algorithms.

When the studies carried out on marbles are examined, it is seen that to determine the colour and texture features of marbles and to use these features for classification generally come into prominence. Although there are also autonomous systems formed by using these methods, since the related systems are mostly affected by the real life conditions, they do not work at the desired productivity and accuracy depending on the sun light, temperature and working hours. Furthermore, the developed systems use features that are very selective and last too long to detect and these parameters differ in real life practice. Therefore to benefit from the interaction of more basic information enables the marbles to be classified better and to be affected by the external effects less. Deriving from these basic features, Deep Learning is suggested as the best method required to be used for the classification of marbles that are more complex.

When the studies carried out on deep learning are examined, even though the first algorithms emerged in 1980s, the most significant step for training the deep networks was taken in 2006. In their studies, Hinton et al. [11] suggested deep belief networks. These networks are composed of various hidden variables and all units on each layer are linked to all units of the neighbour layers. Layer training is conducted by using an uncontrolled avid pre-cultivation method. After that Bengio et al. [12] and Ranzato et al. [13] used the uncontrolled avid pre-cultivation method to train the other deep networks. In their studies Bengio and LeCun [14] showed that many nonparametric learning-directed popular approaches are limited in learning skills of large-scale complex functions. Delalleau and Bengio [15] compared deep and shallow architecture of neural networks and emphasized the importance of Deep Learning. Pascanu et al. [16] tried to expand recurrent neural networks to the deep recurrent neural networks. Montufar et al. [17] examined the complexity of functions calculated by deep feed-forward neural networks.

Unlike the former studies, Deep Learning was used on marbles in this study for the first time and results of the layers were examined and then achievement of classification was tried to be tested. Thereby, it is leaded up to develop a Deep Learning Network that is able to learn a database formed for marbles throughout the world and then estimate the marble classes such as AlexNet [18] and GoogleNet [19] which can generally estimate ImageNet [20] properly consisting of 1.2 million images in total at 1000 different classes and ones of the convolutional neural networks.

This study is organized such that: This section gives information about marble and Deep Learning, and literature research. In Section 2, Deep Learning and its layers are explained; furthermore, data set is also examined. Experimental studies about convolutional neural network and their results are given in Section 3. The conclusion is given in Section 4.

2. MATERIALS AND METHODS

In this study 80 marble samples that Ref. [2] used to suggest a new class definition for travertine slabs taken from Başarırlar Marble Company in 45x45 cm dimensions were used. These marbles belong to travertine slabs class and they are suggested as 9 classes such as first qualities (D1A, D1D, D, M, S), second qualities (D1A_2K, D1D_2K, D_2K) and non-homogenous ones. Although non-homogenous samples cover few samples that do not fit in both classes well, when it is required to classify as first and second quality, it will be better to include them to the second quality. Therefore, 80 marble

samples are tried to be classified as first quality and second quality class in this study. For classification achievement, an accuracy criterion is used.

Convolutional neural network, one of the Deep Learning Algorithms, is used as a method. With Deep Learning it is tried to calculate simple main components such as line, contour, corner, colour, and texture that enable an object to be distinguished from another and also to calculate the connection of these components to the more complex components of the next layers. An image can be reconstituted by using the components the best values of which are found through training; it can be determined to which class the image belongs; the locations and type of the objects in the image can be found and an object or film stars played on a video or a TV channel momently can be detected with their locations. In Deep Learning, stochastic gradient descent with momentum (Sgdm), Rmsprop and Adam methods whose name is taken from an adaptive moment estimation are often used as the best optimization algorithms [1]. Sgdm method enables gradient to be estimated unprejudicedly by using mini piles of a certain amount of samples obtained from data distribution. Learning rate can be accelerated by increasing momentum. Momentum method has been developed to speed up learning process that is small but consistent in a high gradient problem. Rmsprop algorithm eliminates distant past points by using average approach decreasing exponentially. After the convex structure is detected with this method, AdaGrad algorithm that is another method is initiated. Adam algorithm is formed by increasing momentum of Rmsprop method [1]

When the layers of Deep Learning are examined, some important image processing techniques and convolution features are raised. The most important layers are convolution layer, non-linear operator (ReLU), pooling, fully connected layer, and softmax layer.

When convolution layer is applied to an image, specific features from the image can be obtained. This operation is carried out by treating mathematical operation on the image with a filter [21]. A mathematical operation of convolution layer is given in Figure 1.

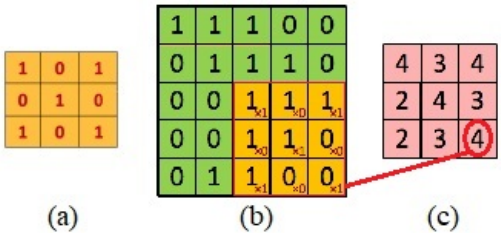

Fig. 1. *Convolution operation (a) filter, (b) matrix of the image, (c) convolution result [22]*

ReLU layer applies a transfer function to the data as seen in Equation (1) and produces the positive values as same while making the negative values 0

$$f(x) = \max(0, x) \tag{1}$$

The features the number of which has been increased greatly with pooling layers can be decreased using a simple operation. Max pooling operation selects the biggest element with a specific dimension in the filter and does not select the others. Thereby, only the elements with the highest values are selected by the specific window size with specific steps and the others are elected.

Fully connected layer covers the structure of classic artificial neural networks, collects and transfers the data incoming. Generally the next layer is softmax layer and classification layer which designates class label according to the highest-value outcome is added. A classical Deep Learning network is given in Figure 2.

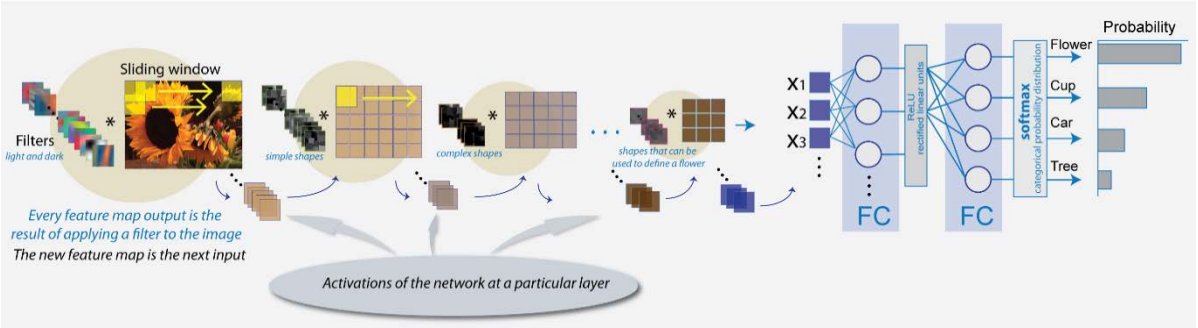

Fig. 2. *Deep Learning Network [23]*

In this study, on the input layer of the Deep Learning network suggested for marbles 'imageinput' that accepts the coloured image as an input is seen and in order to simplify the calculation, it takes the pixel values of marble images sized as [100,100,3] before. Then, 'convolution2dLayer' is seen which conducts two-dimensional convolution process; the output values are inserted into 'ReLU' layer. Then, 'max pooling' layer is used to decrease the number of feature and its output leads to new layers consisting of convolution-ReLU-max pooling layers. After that, the output features are inserted into full-connected layer. Then, softmax and classification layers are used for determine the class labels. The proposed Deep Learning network is constructed as in Figure 3.

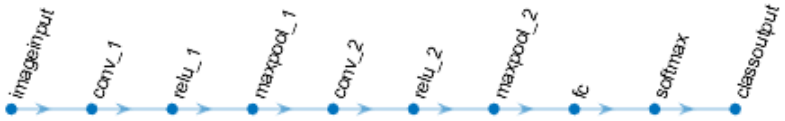

Fig. 3. *Deep Learning network formed for marble*

As seen in Figure 3, the recommended deep learning network consists of 10 layers.

3. EXPERIMENTAL STUDIES

In this study, 80 marble images which were used by Şişeci and Cetişli [2] for their studies are utilized to show the applicability of Deep Learning method to the marbles. Among these samples which are classified as first and second quality, non-homogenous marbles are accepted as second quality. It is tried to find out the classification achievement tested by 5-fold cross validation. Furthermore, while components at the fully connected layer outputs of the related deep network are determined, fully connected layer (fc) and softmax outputs of any marbles are also obtained. Classification achievement is tested with Sgdm, Rmsprop and Adam training algorithms. In the study where different iteration numbers are used, filter dimension is specified as 2x2 for the first of the convolution layers as a result of various tests and then units are stride by twos and 50 different filters are formed; dimension of the filter of the second convolution layer is specified again as 2x2 and then units are stride by twos and this time 10 different filters are formed. Filter at both max pooling layer is designated as 3x3 and then units are stride by threes. The beginning learning rate is determined as 0.0001.

According to different iteration and training algorithms, classification accuracy values of the test set are given in Table 1.

According to the Table 1 for the developed deep network, while the components on the fully connected 'fc' layer outputs of the network holding the best parameter results are seen in Figure 4, 'fc' and 'softmax' layer outputs for any marble from the first class are seen in Figure 5.

Table 1. *Classification accuracy values of the marble slabs with Deep Learning*

Iteration	Sgdm (%)	Rmsprop (%)	Adam (%)
100	62.50	62.50	62.50
300	62.50	68.75	75.00
500	66.25	62.50	75.00

When Table 1 is analysed, it is seen that achievement values obtained by Adam algorithm gives good results in marble classification and Deep Learning method can be used for marbles. Thus, instead of classical systems that last too long and tens of features are tired to be designated one by one, Deep Learning method enables the appropriate decomposition process to be completed in a very short span of time by training the filters.

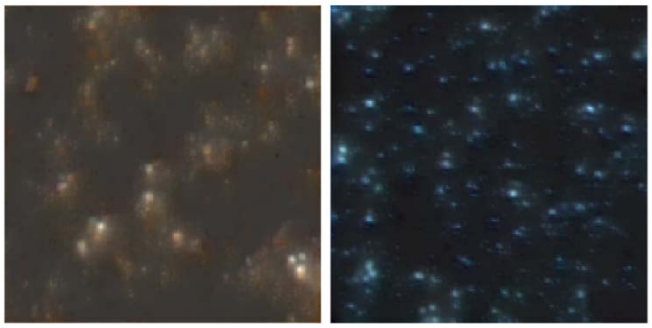

Fig. 4. *Fully connected layer (fc) output on deep network*

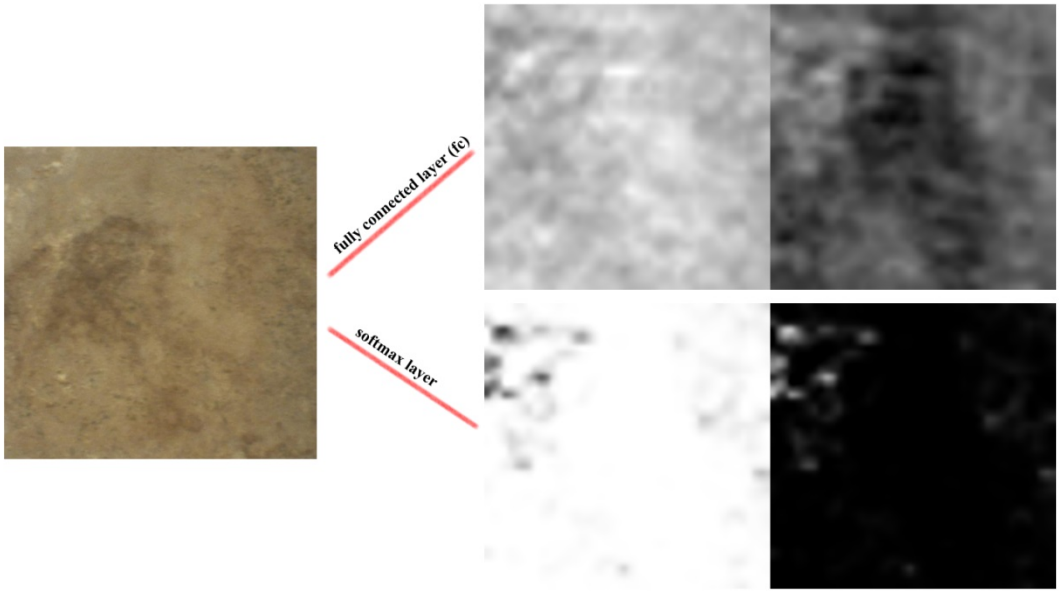

Fig. 5. *Fully connected layer (fc) and softmax layer outputs for marble on deep network*

When Figure 4 and Figure 5 are analysed, it is seen that as a result of convolution the relevant filters can determine the features that can distinguish the marbles holding different classes from each other. Furthermore, as also seen in Figure 5 'softmax' layer output of marble sample selected from the first class is classified properly after being assigned to the first class with a higher value (white coloured first layer).

4. CONCLUSION

Natural stones that are one of the import and export products for the countries are used in many fields and preferred in terms of aesthetics and also necessity. Marble and its derivatives are used for many materials such as building sector, historical ruins and souvenir. To determine the marble veins and then to cut marble blocks is carried out in a short or long period of time. However, to make the cut marble blocks thinner as plates and then to classify them is still a complicated problem. When the classification of marble slabs is examined, it is seen that there are few studies in this field and current methods are not applied even in the literature. For this reason, information flow has not reached to the mining enterprises yet and marbles are still tried to be classified by the workers with the naked eye at the workplaces. It is regarded as necessity to make the manual selection process automatic and to carry out by using popular methods within the scope of Industry 4.0.

In this study Deep Learning method, one of the today's successful and popular artificial intelligence methods, was applied on the marbles for the first time and then component outputs of the network layers were able to be examined. Successful classification results obtained reveals the practicability of Deep Learning to the marble industry and it is shown that the method can be used for marble cutting and selection processes. Furthermore, a basis of Deep Learning network for a potential marble database that can be standardized in the future has been established.

In the future studies a detail parameter and achievement analysis of Deep Learning network to be suggested for the classification of marble slabs with more labels will be carried out. Moreover, the relevant components will be obtained before output layer of deep network and will be used as features for k-nearest neighbour algorithm and classic artificial neural networks. Thereby it is estimated to achieve to increase the success of classification. The best learning method and parameters planned to be obtained will be tested by using cross verification method and then Deep Learning network that can classify the marbles successfully will be constituted.

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