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Authors: Mustafa ÇATAK, Tuncay AYDOĞAN Ramazan SELVER

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THERMAL BEHAVIOR OF DIFFERENT FLUIDS IN ELECTROMAGNETIC INDUCTION

Mustafa ÇATAK[1*], Tuncay AYDOĞAN [2] Ramazan SELVER [3]

[1]Mehmet Akif Ersoy University, Ağlasun Vocational School, Computer Programming, Burdur, Türkiye.
[2] Isparta University of Applied Sciences, Faculty of Technology, Computer Engineering, Isparta, Türkiye.
[3] Süleyman Demirel University, Engineering Faculty, Mechanical Engineering, Isparta, Türkiye.

[*]Corresponding Author: mustafacatak@mehmetakif.edu.tr
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ABSTRACT: In this study, the thermal behavior of different fluids in electromagnetic induction heating was investigated. For research, induction coil, heat exchanger and control circuit designs were made. An experimental setup was created by using a temperature gauge, tachometer, DC motor and circulation pump. The thermal behavior of 650 ml of boron oil, pure water, olive oil, sunflower oil, motor oil and boron–pure water composition fluids after their circulation at 700 rpm and 92 minutes from the experimental setup was investigated. The heat exchanger surface temperature, circulation channel temperature, beaker temperature and ambient temperature were recorded. The specific heat capacity values of the said fluids were also determined experimentally in another experimental setup. At the end of the research, it was observed that the temperature of 92 minutes showed values between 79 ^oC and 95 ^oC in the same electromagnetic induction experimental setup and ambient conditions. It has been determined that the most efficient fluid is the engine oil, which has a heating value of 37 ^oC at the 2^{nd} minute, 85 ^oC at the 42^{nd} minute and 95 ^oC at the 92^{nd} minute. It was observed that boron oil, olive oil, sunflower oil, boron–pure water composition and pure water followed, respectively. It has been observed that the specific heat capacity values are inversely proportional to the temperature increase of the fluids.

Keywords: Electromagnetic Induction, Boron Fluid, Boron–Pure Water Fluid, Olive-Oil Fluid, Sunflower Oil Fluid, Specific Heat Capacity, Heating.

1. INTRODUCTION

Electromagnetic induction systems are a technology that is being developed day by day, especially used for heating purposes. Its application areas are rapidly increasing and becoming widespread thanks to its advantages such as very short processing time, no heat dissipation to the environment, high efficiency as well as not allowing events such as combustion and explosion, being a more reliable system than conventional heating systems [1].

Michael Faraday was the first researcher to describe the basic principles of electromagnetic induction in the 1830s. Other well-known physicists have since contributed to this field of research, such as Emil Lenz, who introduced Lenz's law, and Joseph Henry, who discovered the principal inductance. James Clerk Maxwell summed up the finally discovered electromagnetic phenomenon in four differential equations. These early researchers formed the basis of today's common electromagnetic applications, including the ability to use control devices such as relays, to carry electrical energy without high losses using a transformer, and to transmit energy without the need for any other equipment. State-of-the-art design, also called electromagnetic induction, is a state-of-the-art method for heating, welding and annealing metallic structures [2].

Although predetermined for metals due to their electrical and magnetic properties, induction heating technology has also begun to be adapted to polymeric materials and composites in the last decade. This fitting provides a summary of the state-of-the-art inductive processing of composites and research is ongoing, covering mechanisms, key parameters, simulations, market-ready experimental applications and the latest developments in this field [2]

The electromagnetic induction heating temperature control method is studied against the background of Internet fusion. Electromagnetic induction heating is widely used because of its environmental friendliness, high efficiency and low heat dissipation characteristics, but the control of the heating process has been slowly developed. PID control and intelligent control together make it well suited to unstable systems. By combining these two, a more adaptable controller can be designed with a small data application, indicating broad application prospects. A mathematical model of electric, magnetic, thermal and force multi-domain two-way real-time coupling calculation is established, and a multi-domain two-way real-time coupling calculation method for electricity, magnetism, heat and force is created. The recommended Temperature accuracy is 96.7% and it has been proven in this study that the temperature control efficiency is increased by 10.1% [3].

In the induction heating system, heating is much more efficient than traditional heating elements, since the heat is only produced in the fluid. In other words, with induction heating, heat losses are reduced and thus the overall heating efficiency is increased.

That's why today's industrial world has to adapt quickly to rapidly changing technology and induction heating system creates many innovations and advantages over other traditional heating methods. For example, induction heating is more energy efficient than other heating methods and is naturally environmentally friendly and does not produce carbon dioxide emissions. It contributes to environmental friendliness by significantly reducing the overall heat exposure of the heat production line. With induction heating, businesses in the industry can maximize environmental, process flexibility and electrical efficiency, as well as offer continuous solutions for the production of higher quality products. These possibilities can be listed as: Safe / Reliable Use, High Efficiency and Energy Saving, Accurate and Easy Temperature Control, Long Service Life, Short Heating Time and High Work Efficiency [4].

Basically an induction heating system; consists of power supply, rectifier circuit, inverter and coil [5]. Electrical energy as a heat source; Indirect Heating is by Direct Heating, Induction Heating, Electric Field Heating, Laser and Ultra-Violet Heating, Conduction Heating, Infrared Radiation Heating, and Electron Beam Heating[6]. The most widely used of these systems is the heating method with resistance [7]. This system is based on the relationship between resistance current and voltage in Joule's Law [8].

In this research, it is aimed to examine the heat generation behaviors by revealing the thermal characteristics of different fluids consisting of boron, pure water, olive oil, sunflower oil, metallic motor oil and boron-water mixture in electromagnetic induction. This research is of great importance in terms of energy use and obtaining the best efficiency with this energy.

2. METHODS

Electromagnetic induction was discovered by Michael Faraday in 1831 and this invention formed the basis of induction heating [9]. Michael Faraday, the founder of modern induction heating, put forward the principle that a voltage can be induced in the secondary circuit with a current change in the primary circuit [10].

The electromagnetic induction system experimental setup designed in figure 1 is seen.

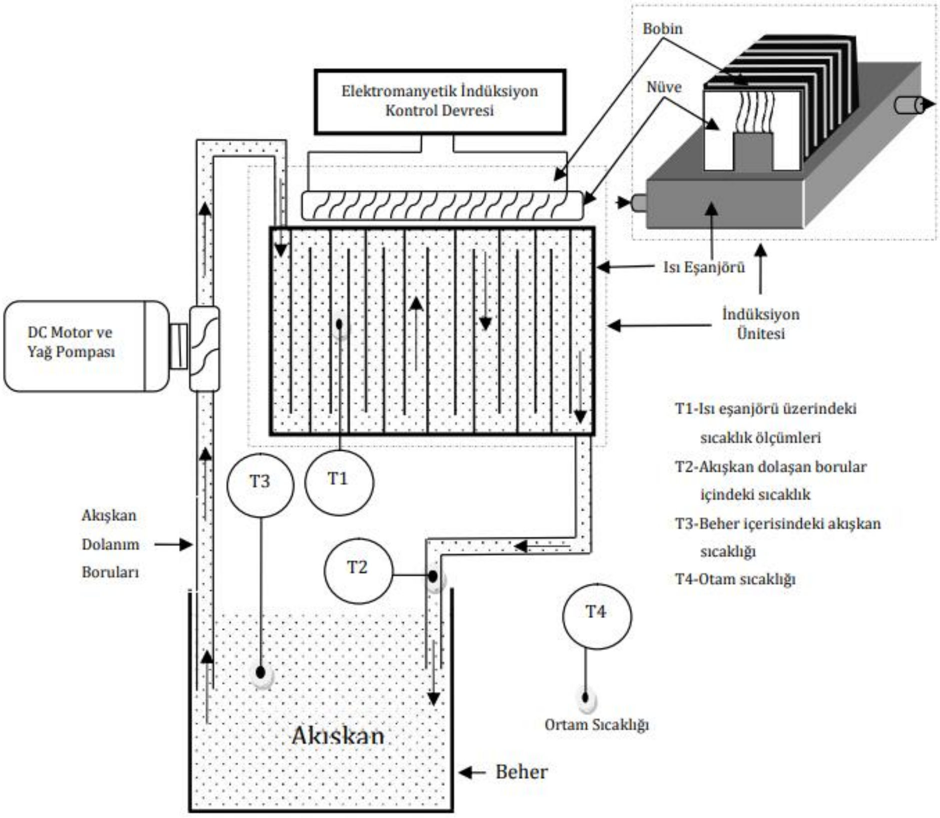

Figure 1. General Structure of Electromagnetic Induction Heating Experiment Equipment.

Figure 1 shows the general structure of the electromagnetic induction heating system designed for this research. The system consists of electromagnetic induction control circuit, induction unit, heat exchanger, DC motor, tachometer, oil pump, temperature measuring unit, thermocouples and fluids.

The induction unit seen in Figure 2 consists of ferrite cores, a coil of 0.25 mm diameter copper wire wrapped around ferrite cores, and a heat exchanger in the form of an iron-based planar plate affected by magnetic induction. Iron-based materials have a higher magnetic induction absorption value than other materials (copper, aluminum, etc.). Therefore, the heat exchanger material was chosen from iron-based material. The magnetic induction absorption of this material also depends on parameters such as the thickness, permeability and volumetric resistance of the material. The calculations of these parameters were calculated with the formula of magnetic flux resistance "Edyy Current" emanations [11].

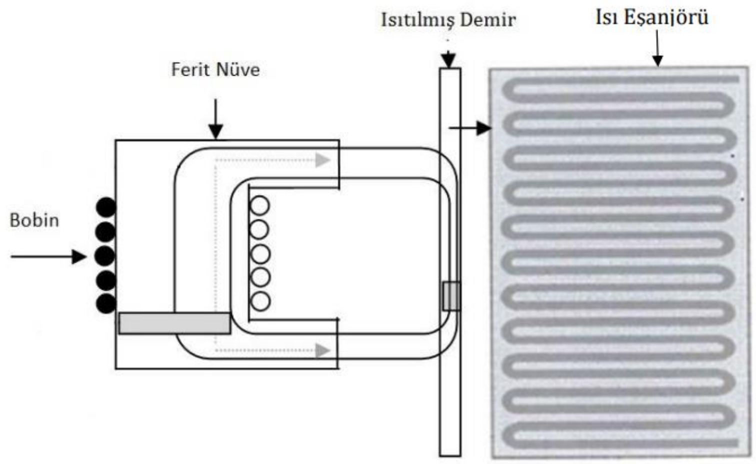

Figure 2. Induction Unit.

In the research, the effect of the specific heat capacities of the fluids whose properties were examined in the electromagnetic induction heating system was also desired to be determined. Specific heat is the energy required to raise the temperature of one gram of a substance by one °C. Each substance has a separate specific heat value [12]. For this, the specific heat is the thermal distinguishing feature of the substance. The unit of specific heat is (J/g °C) [13].

When calculating the specific heat capacities of fluids, the energy changes per unit time are calculated. In the experimental system designed to measure the specific heat capacities of fluids, a new setup was created in which a heating(hot) plate, digital temperature measurement unit, temperature measuring thermocouples and glass beakers were used.

3. EXPERIMENTAL

In this section, the temperature measurement values of the fluids formed by boron oil, pure water, olive oil, sunflower oil, motor oil and boron-water composition and the specific heat capacity measurement values of the fluids are given. The test process for all fluids was considered as follows;

Before electromagnetic induction is given to the system, DC power supply was started and the speed of the fluid was kept constant by adjusting the DC motor speed at 700 rpm. The measurement of the system was controlled with a continuous tachometer in order to keep it at a constant speed. By keeping the speed constant, it is ensured that the fluid circulating in the system is exposed to an equal (constant) amount of electromagnetic induction by keeping the flow rate constant. The temperature values at different points were measured analogously by means of thermocouples placed in the middle of the beaker containing 650 ml of fluid, inside the return pipe coming back from the system and in the middle of the magnetic field surface. Temperatures were obtained in 92 minutes at one-minute intervals. The temperature data obtained were recorded in ^{o}C (Celsius).

In the charts below;
T1: Surface temperature value on the heat exchanger,
T2: The hot value of the fluid circulating in the system and at the end of the outlet pipe,
T3: The hot value of the fluid that will enter the system and at the end of the inlet pipe,
T4: It shows the temperature value of the environment where the test is performed.

3.1. Boron Oil Findings

In our experimental study, boron oil was used first in the electromagnetic induction field according to the above order. The temperature measuring device used in the experiment measures the temperature in Fahrenheit (F) units. The measured values were converted to the C value and used in our research. In the experimental study, in the measurements made before applying electromagnetic induction to the fluid circulating in the system, the heat exchanger surface temperature was recorded as 20 ^{o}C, the fluid temperature in the pipe was 20 ^{o}C, and the fluid temperature in the beaker was 20 ^{o}C. The temperature value of the environment where the experiment was carried out was measured as 16 ^{o}C.

Then, electromagnetic induction started to be applied on the experimental system and the temperature of the fluids circulating in the system increased. As a result of the measurements, the temperature value reached 93 ^{o}C at the 92nd minute on the heat exchanger from the value of the fluid at 20 ^{o}C circulated over the magnetic field. The temperature value did not change in the following times. After this value, the temperature remained constant. The temperature value of the fluid in the pipe has reached from 20 ^{o}C to 79 ^{o}C and the temperature value of the fluid in the beaker has reached from 20 ^{o}C to 78 ^{o}C.

3.2. Pure Water Findings

In the experimental study, experiments were carried out by circulating pure water, which is another fluid after boron oil from the electromagnetic induction field, in the experimental system on a different day. Initially, the temperature values, which were equal as at the beginning of the boron fluid, separated from each other during the test period and showed an increase. At the 10th minute, the temperature value obtained from the thermocouple on the heat exchanger surface was measured as 55 ^{o}C, the measurement values obtained inside the pipe and inside the beaker were measured as 40 ^{o}C. At the 30th minute, the measurement on the heat exchanger surface shows 68 ^{o}C, and the measurement results inside the beaker and pipe show 57 ^{o}C.

Looking at the measurement results at the 90th minute, the temperature on the surface of the heat exchanger was 79 ^{o}C, the temperature inside the pipe was 72 ^{o}C and the temperature inside the beaker was 71 ^{o}C. As mentioned in this explanation, decreases in temperature values are observed in the parts that come into contact with the atmosphere.

3.3. Olive Oil Findings

As a result of the experiment, the temperature values that were equal at the beginning separated from each other over time and showed an increase in temperature. At the 12th minute, the temperature value obtained from the thermocouple on the magnetic field was measured as 64 °C, the measurement values obtained inside the pipe and inside the beaker were measured as 47 °C. At the 52nd minute, the measurement on the magnetic field shows 85 °C, and the measurement results in the beaker and pipe show 71 °C.

As in the previous experiments, in this experiment, all temperature values were equal at 20 ^{o}C, and they showed an increase in temperature by separating from each other over time. At the 12th minute, the temperature value obtained from the thermocouple on the heat exchanger surface was measured as 64 ^{o}C, the temperature values obtained inside the pipe and inside the beaker were measured as 47 ^{o}C. At the 52nd minute, the temperature on the surface of the heat exchanger was 85 ^{0}C, and the temperature values inside the beaker and pipe were measured as 71 ^{0}C.

Looking at the measurement results at the 92^{nd} minute, the temperature on the surface of the heat exchanger was 91 ^{o}C, the temperature inside the pipe was 78 ^{o}C, and the temperature inside the beaker was 77 ^{o}C. It can be seen from here that the temperature values in the parts in contact with the atmosphere differ due to heat loss.

3.4. Sunflower Oil Findings

In our experimental study, sunflower oil belonging to the company "Orkide", which was produced commercially from the electromagnetic induction system, was used as the experimental fluid. The temperature increase that sunflower oil is exposed to in the electromagnetic induction field was measured analogously by means of thermocouples placed in the pipe coming right in the middle of the beaker and in the middle of the heat exchanger surface. The temperature values, which were equal at the beginning, showed an increase by separating from each other over time. At the 12^{th} minute, the temperature value obtained from the thermocouple on the heat exchanger surface was measured as 40 ^{o}C, the temperature values obtained inside the pipe and inside the beaker were measured as 23 ^{o}C.

At the 62^{nd} minute, the temperature on the heat exchanger surface was measured as 85 ^{o}C, and the temperature values in the beaker and pipe were measured as 73 ^{o}C. Looking at the measurement results at the 90^{th} minute, the temperature on the surface of the heat exchanger was 89 ^{o}C, the temperature inside the pipe was 77 ^{o}C and the temperature inside the beaker was 76 ^{o}C.

3.5. Engine Oil Findings

In these measurements we made, 10/40 Metallic Engine oil used in engines was added to the beaker. When the flow rate of the fluid circulated in the experimental system setup is fixed, the electromagnetic induction unit is turned on and a magnetic field is given to the system. The temperature values, which were equal at the beginning, showed an increase by separating from each other over time. At the 12^{th} minute, the temperature value obtained from the thermocouple on the heat exchanger surface was measured as 66 ^{o}C, the temperature values obtained inside the pipe and inside the beaker were measured as 49 ^{o}C. At the 62^{nd} minute, the temperature on the surface of the heat exchanger was 91 ^{o}C, and the temperature values inside the beaker and pipe were measured as 77 ^{o}C. Looking at the temperature results at the 90^{th} minute, the temperature on the surface of the heat exchanger was 95 ^{o}C, the temperature inside the pipe was 77 ^{o}C and the temperature inside the beaker was 77 ^{o}C.

3.6. Boron-Pure Water Findings

In our experimental study, a compound fluid was obtained by mixing boron oil and pure water at the rate of 50% from the electromagnetic induction field. This compound fluid obtained was used as the final fluid in our experiment system. They are fluids that do not have electrical conductivity of both pure boron oil and pure water; It has been determined that the electrical conductivity of the mixture fluid formed when distilled water, which has no electrical conductivity, is dropped into the boron oil. Pure water and boron oil were placed in a beaker of 325 ml each, and a homogeneous composition fluid with a total volume of 650 ml was obtained.

Thermocouples placed in the middle of the beaker, inside the incoming pipe and in the middle of the heat exchanger surface, analogously, the temperature values that the composition was exposed to in the electromagnetic induction field were measured. While making the measurements, the flow rate of the fluid was determined as 700 rpm and the fluid was circulated through the magnetic field with a constant flow rate.

The temperature value of the fluid in the beaker in the resulting composition fluid is very different from other fluids and the temperature values inside the pipe. While the temperature value inside the beaker was measured as 30 ^{o}C at the 32nd minute, it was measured as 68 ^{o}C inside the pipe and 73 ^{o}C on the heat exchanger surface. It is understood that the composition obtained here also exhibits a different heating characteristic in the atmospheric environment. At the end of the 92nd minute, the temperature value measured on the heat exchanger surface was 88 ^{o}C, while it was 81 ^{o}C inside the pipe and 63 ^{o}C inside the beaker.

3.7. Specific Heat Capacity Values Findings

In the experimental system prepared for the research, the heat changes of the fluids in the electromagnetic induction prepared experimentally were investigated. Boron oil, pure water, olive oil, sunflower oil, metallic motor oil and boron-pure water mixed fluids were used as test fluids in the experiment set prepared under electromagnetic induction in the research, and the values in each fluid were plotted by measuring the temperature values. Table and graphically measured temperature values were compared.

The compared temperature values were found different for each fluid. It has been revealed that the differences in these temperatures are related to the specific heat capacities, which are the physical properties of the fluids. Therefore, the specific heat capacities of each fluid must be known. However, since the specific heat capacities of the fluids we used in the research are not found in the literature, additional research is needed in our research. Due to this requirement, the specific heat capacities of each fluid were experimentally measured by creating an experimental set.

It will be explained that the temperature values of all fluids circulated in the electromagnetic induction experiment set and the differences in time are related to the specific heat capacities, which are the physical properties of the fluids. Each substance has its own specific heat capacity value. For this, the specific heat capacity is a physical property that distinguishes the thermal performance of the material. The specific heat capacity unit is kcal/kg °C.

In the experimental measurements obtained on the experimental set prepared to measure the experimental specific heat capacity values, the compound fluids with known specific heat capacity and unknown specific heat capacity on the same experiment set were placed in the same glass beakers with the same mass weights on a single hot plate. they are heated. These beakers, containing different fluids, were exposed on the Hot plate to increased temperature values over time. The graphs of the specific heat capacity values of the fluid with known and unknown specific heat capacity values were drawn in a graphic program. From this graph, the specific heat capacity values of each fluid were found graphically.

In addition, in the experimental study, the specific heat capacity is calculated analytically as follows, starting from the total amount of heat given to the fluid in a beaker whose specific heat capacity is known.

$$\underbrace{m_{water} x C_{p\ water} x (\Delta T)_{water}}_{\substack{Heat\ Value\ of\ Fluid\ with \\ Known\ Spesific \\ Heat\ Capacity}} = \underbrace{m_{boron} x C_{p\ boron} x (\Delta T)_{boron}}_{\substack{Heat\ Value\ of\ Fluids\ with \\ unknown\ Specific \\ Heat\ Capacity}} \quad (1)$$

In formula 1, the masses are taken as 75 g for all fluids. The values in Table 1 are the values obtained when the values obtained from the measurements are applied to the 1st formula with water with known specific heat capacity. 75 g of water and 75 g of boron fluid in the beakers placed on the experimental set are placed on the hot plate with the same temperature value at room temperature.

Then, the temperature of the hot plate is gradually increased and the temperature values created by the heat transmitted to the fluids gradually increase the temperature of the fluids in the beaker depending on time.

These temperature values are taken with a datalogger and recorded in a digital environment. When these temperature values reach the desired point in the experiment, the experiment set is stopped.

The specific heat capacity values of all fluids were calculated separately with the help of the above formula (1) by showing the collected data under a graph. In the calculation, the masses (m) are equal and the temperature starting points are the same for each fluid; When the hot plate temperature value was increased gradually, differences were observed in the temperature values in the fluids. These differences are due to the difference in the specific heat capacities of each fluid.

Each different fluid is calculated individually with this method. Calculated specific heat capacity values are given in Table 1.

Table 1. Calculated specific heat capacity values of fluids

Material	Specific Heat [Kcal/kg °C]
Boron	0,53
Water	1
Olive oil	0,860211
Sunflower oil	0,94056
Engine oil	0,5
Boron-Pure water	1,097198

Comparisons of the specific heat capacity values of the fluids we used in our research are shown in Figure 3. The specific heat capacity of the fluids is inversely proportional to the heat values in the heating of the fluids by electromagnetic induction. The temperature value of metallic engine oil with a low specific heat capacity value is obtained at a higher temperature difference value compared to other oils. The lowest temperature difference value belongs to the boron-pure water mixture.

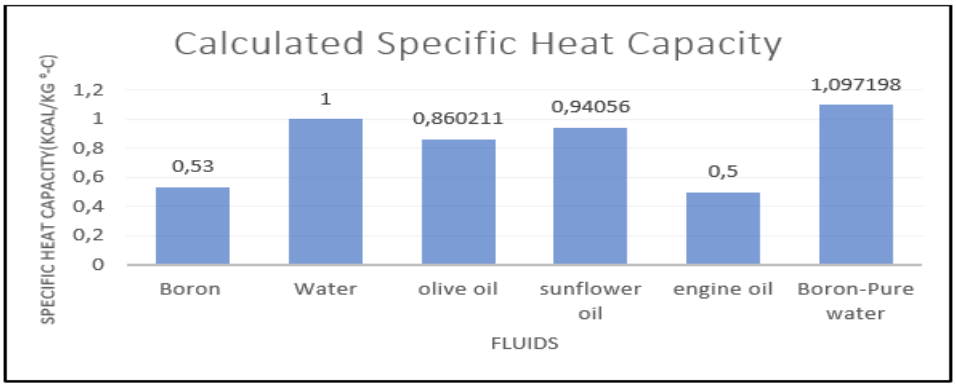

Figure 3. Comparison of specific heats of fluids

For example, in experimental studies with electromagnetic induction, provided that the initial conditions are the same for different fluids; When the above magnetic field temperature values of boron oil and pure water fluids given in Figure 4 are compared, it is seen that the specific heat capacities are inversely proportional.

Considering the numerical values calculated experimentally, the amount of energy required per unit mass is lower in boron fluid, because the amount of heat (heat flux) given to the unit area in our experiment for boron fluid remains the same, so the temperature difference of the boron fluid is high according to the energy balance in the boron fluid.

4. RESULTS

In the curves shown in Figure 4, the heat exchanger surface temperature values obtained by rotating the fluids consisting of boron oil, pure water, olive oil, sunflower oil and motor oils and boron pure water at 700 rpm in the electromagnetic induction system are given comparatively. It is seen in Figure 4 that the heat exchanger surface temperature value in the obtained boron-pure water composition is higher than the heat exchanger surface temperature increase of the pure water forming the composition, and lower than the temperature increase of the boron oil. The boron-pure water composition obtained showed a different feature.

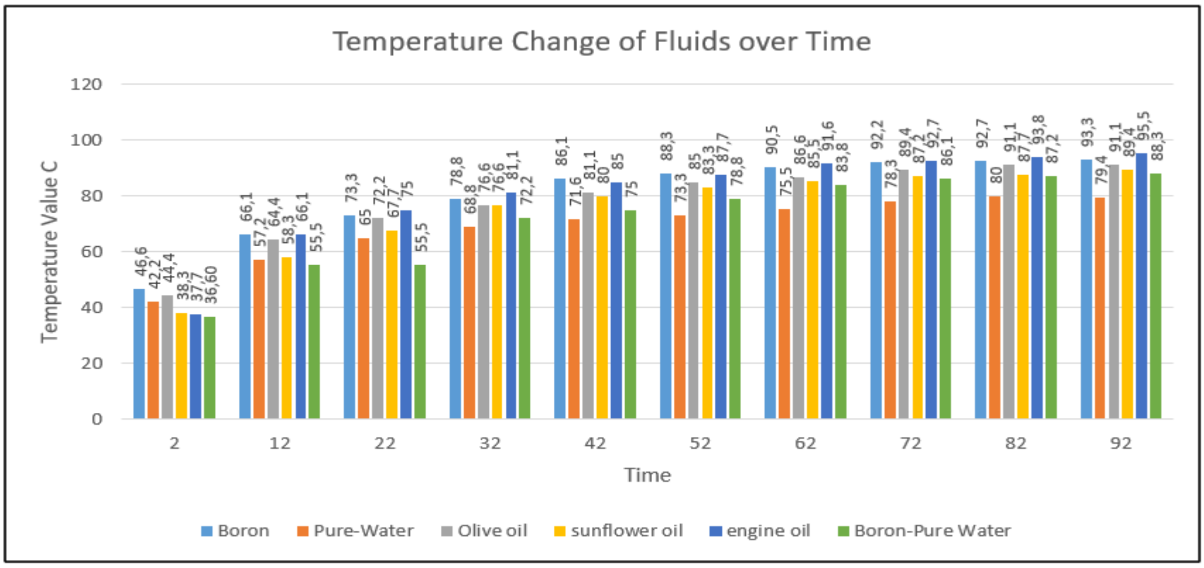

Figure 4. Comparison of the heat exchanger surface temperature values of different fluids.

In Figure 5, the comparison of the inside pipe temperature values returning from the electromagnetic induction system of all fluids including boron oil, pure water, olive oil, sunflower oil, motor oil and boron-pure water composition is shown. Although the boron-pure water composition was lower than the temperature value of other fluids in the 2nd minute time frame, the temperature value reached the temperature values of olive oil and sunflower oil over time and had a value close to them.

If we look at the temperature values of the boron oil and pure water that make up the composition, the temperature value of the boron oil in the 92nd minute was 79 °C, the temperature value of the pure water was 72 °C and the temperature value of the boron-pure water combination obtained was 79 °C.

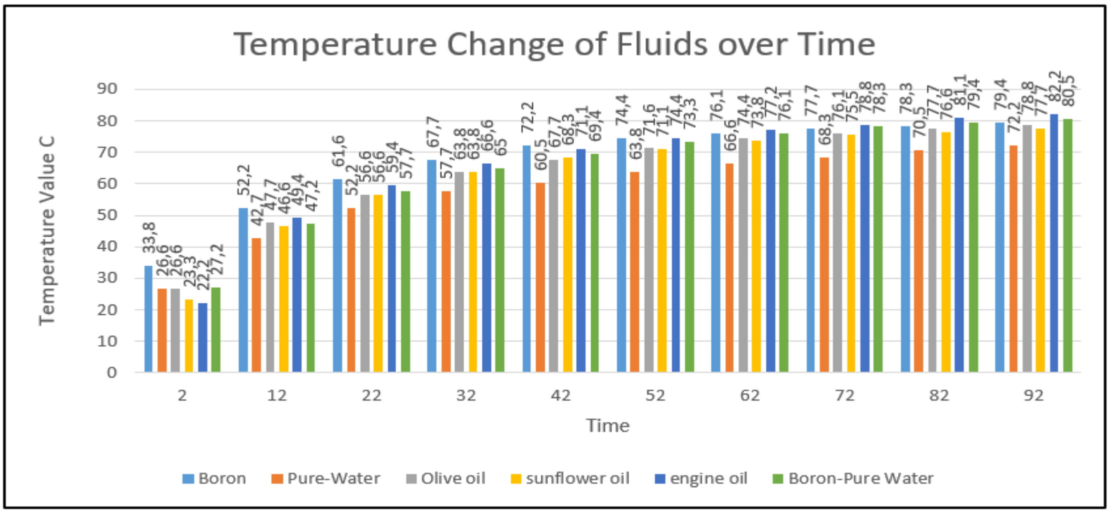

Figure 5. Comparison of in-pipe temperature values of different fluids returning from the electromagnetic induction system

When the above heat exchanger surface temperature values of boron oil, pure water and olive oil fluids given in Figure 6 are compared, it is seen that the physical properties of these fluids are inversely proportional to their specific heat capacities. The specific heat capacity values we found in the experiments are $C_{p\ water}$ = 1.004 kcal/kg K, $C_{p\ boron}$ = 0.53 kcal/kg K and $C_{p\ olive\ oil}$ =0.8607 kcal/kg K. When these values are examined, it is seen that they are ordered according to the amount of energy required per unit mass, according to the specific heat capacity value, which is one of the physical properties of the fluids.

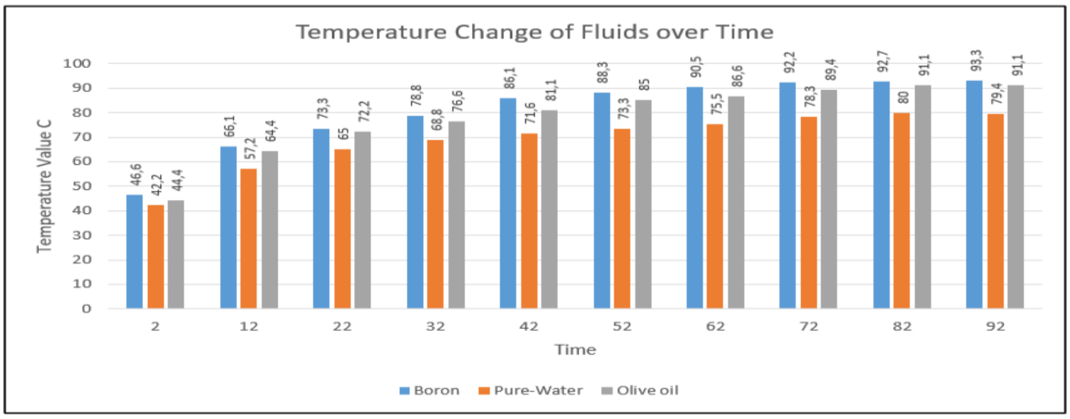

Figure 6. Comparison of the heat exchanger surface temperature values of boron oil, distilled water and olive oil fluids.

When the heat exchanger surface temperature values of boron oil, pure water, olive oil and sunflower oil fluids given in Figure 7 are compared, since the physical properties of water and sunflower oil, which are their specific heat capacities, are higher than other fluids, the temperature values of these fluids are lower than other fluids.

The specific heat capacity values we found in the experiments are $C_{p\ water}$ = 1.004 kcal/kg K, $C_{p\ boron}$ = 0.53 kcal/kg K, $C_{p\ olive\ oil}$ =0.8607 kcal/kg K and $C_{p\ sunflower}$=0.94 kcal/kg K. When these values are examined, the effect of ordering the amount of energy required per unit mass according to the specific heat capacity value is seen.

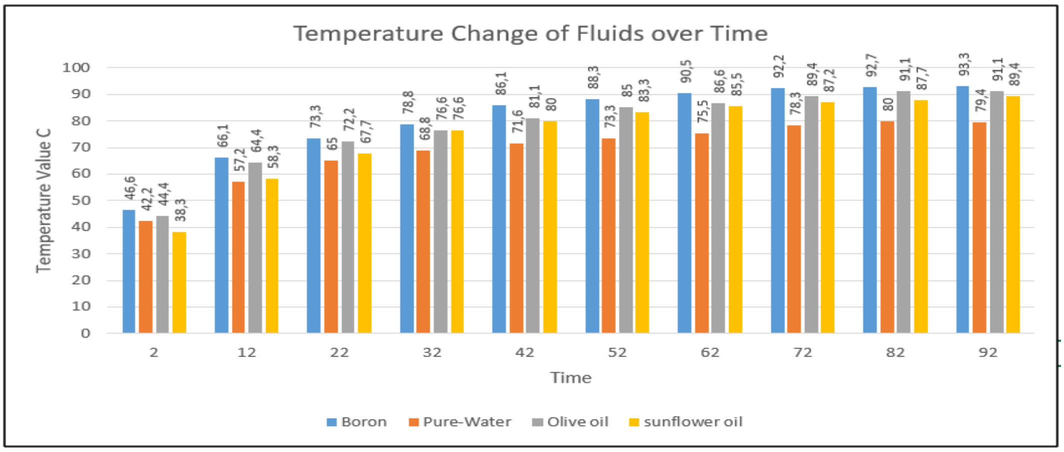

Figure 7. Comparison of the heat exchanger surface temperature values of boron oil, distilled water, olive oil and sunflower oil fluids. (Boron, Pure-Water-Olive Oil-Sunflower Oil)

When the heat exchanger surface temperature values of boron oil, pure water, olive oil, sunflower oil and motor oil fluids given in Figure 8 are examined, it is seen that the specific heat capacities of the fluids are inversely proportional. The specific heat capacity values we found in the experiments are $C_{p\ water}$ = 1.004 kcal/kg K, $C_{p\ boron}$ = 0.53 kcal/kg K, $Cp_{\ olive\ oil}$ =0.8607 kcal/kg K, $C_{p\ sunflower}$=0.94 kcal/kg K and $C_{p\ engine\ oil}$=0.5 kcal/kg K. When Figure 8 is examined, since the specific heat capacity of engine oil is low in the specific heat capacity of other fluids, the temperature increase has occurred due to the energy equality given to this fluid.

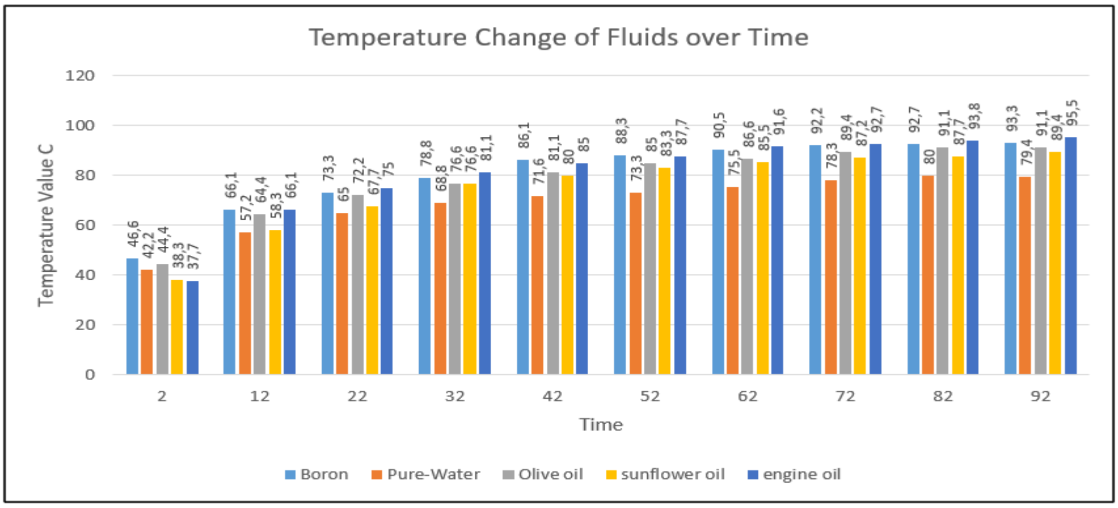

Figure 8. Comparison of the heat exchanger surface temperature values obtained as a result of the measurements of the fluids (Boron, Pure-Water-Olive Oil-Sunflower Oil-Engine Oil)

When the fluids in question are circulated in the electromagnetic induction system at 700 rpm in the heat exchanger system, when their temperature values are measured and examined, it is seen that the fluids are ranked according to the amount of energy required per unit mass, according to the specific heat capacity value, which is one of the physical properties of the fluids.

5. DISCUSSION

In line with the results obtained, a research was conducted to determine the appropriate fluid to be used in order to convert the energy obtained by using electromagnetic induction technology into heat energy. In addition, the relationship between the specific heat capacity values of the fluids and the thermal behavior of the fluids was investigated.

Within the scope of the study, an experimental system was created by using electromagnetic induction circuit, thermocouples, DC motor and circulation pump. The experiments consist of 92 minutes of thermal measurements for each fluid. For fluids passing through the heat exchanger; The heat exchanger surface temperature (T1), the fluid temperature of the pipe end connected to the fluid system leaving the electromagnetic induction system (T2), the beaker temperature (T3) and the ambient temperature (T4) were measured.

In the research, composite fluids consisting of boron oil, pure water, olive oil, sunflower oil, motor oil and boron-pure water mixture were investigated. In the research, the boron oil temperature values were 46.6 °C in the second minute, 86.1 °C in the 42nd minute and 93.3 °C in the 92nd minute, which is the shortest time. The temperature values of pure water are 42.2 °C in the 2nd minute, 71.6 °C in the 42nd minute and 79.4 °C in the 92nd minute. Olive oil temperature values are 44.4 °C at the 2nd minute, 81.1 °C at the 42nd minute and 91.1 °C at the 92nd minute, Sunflower oil temperature values are 38.3 °C at the 2nd minute, 80 °C at the 42nd minute and 89 °C at the 92nd minute. The temperature values of the engine oil composite mixture are 37.7 °C at the 2nd minute, 85 °C at the 42nd minute and 95.5 °C at the 92nd minute. The fluid forming the boron-pure water composition is 36.7 °C at the 2nd minute, 75 °C at the 42nd minute and 88.3 °C at the 92nd minute.

From these data, it has been seen that engine oil and boron oil are the most suitable fluids for heating with electromagnetic induction technology.

In the experimental system we prepared using fluids consisting of boron oil, pure water, olive oil, sunflower oil, motor oil and boron-pure water, the heat flux formed by the electromagnetic field effect; When T1, T2, T3, T4 are compared, it is seen that the differences are related to the specific heat capacities, which are the physical properties of these six fluids.

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