Journal of Engineering and Applied Sciences 14 (5): 1438-1442, 2019
ISSN: 1816-949X

A Study on the Heating Characteristic and Electromagnetic Wave Shielding Carbon Fiber Mat

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Abstract: The popular floor heating of Korea, ondol is a direct heating system for cold Winter. It mainly uses woods, briquettes and petroleum as fuel. With the increase of the income and economic development in the 21st century, health has become the keyword of the era. As people are aware of human health it arouses concern about the electromagnetic waves emitted from the Korean domestic heating mat products. Electricity consumption of residential zones is another aspect of the growth and development. Therefore, this study describes the heating system of electric heating mat for home use and the feature of its electromagnetic waves using carbon fiber to reduce waste and improve human health issue.

Key words: Carbon fiber, electromagnetic wave, electric power, human health, Korean living circumstance, heating mat

INTRODUCTION

Korean people still live in houses with poor insulation in Winter. Older houses are particularly prone to these problems. So, electric heating mat may be a good alternative to keep the heat running constantly. However, it arouses concern about the electromagnetic waves emitted from the Korean domestic heating mat products. Therefore, this study describes the heating system of electric heating mat for home use and the feature of its electromagnetic waves using carbon fiber to reduce waste and improve human health issue.

Literature review: A heating wire is a material which uses the property of an electric conductor that generates heat by resisting a current flow. The specification of heating wire must have a high inherent resistance with small of temperature coefficient of resistivity. In addition, heat resistance and corrosion resistance must be good and workability is required. The heating wire consists of Ni, Cr and Si components and is used in electric furnaces up to 1,100°C. Figure 1 is shows a cross-section of PVC hot wire embedded in a general electric heating mat (Choi, 2007).

Non woven fabric is a fabric made by mechanically treating fibers to be entangled with heat and resin and is excellent in thermal insulation and is generally used in

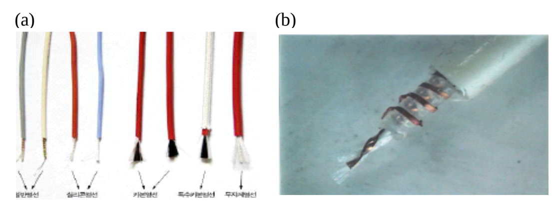

Fig. 1: a, b) Types of heating wires and PVC heat wire

electric mats. Carbon fiber offers technical properties that are popular in various applications where its high strength-to-weight ratio is of importance. In addition to its high strength-to-weight ratio, carbon fibers are thermally and electrically conductive. They have high tensile strength, low density, low weight, low thermal expansion and excellent fatigue resistance.

In some cases, the term carbon fiber is used interchangeably with graphite. However, carbon fibers structure and graphite fibers are made and treated for heat at different temperatures and have different carbon contents (Shin *et al*., 2010).

Because of this, graphene can move electrons 100 times more freely than silicon. It is also strong against impact thanks to honeycomb shape. This is because the shape of the net is changed by bending or pulling the net but the hollow space of the hexagonal structure serves as a buffer as well as the connection state of the net does not change. Strength is 100 times stronger than steel and

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the capacity for being stretched is good enough to increase even 20% of the area. The electric conductivity does not disappear even when bent or stretched. The thermal conductivity is more than 10 times that of copper metal and transparent enough to pass 98% of light (Lee *et al*., 2014). With the above characteristics, carbon fiber was used for insulation and shielding of electromagnetic wave.

MATERIALS AND METHODS

Proposed system: To measure electromagnetic waves we constructed a system as shown in Fig. 2. The inductive sensor is fabricated with the characteristics in Table 1. The frequency at which the magnetic field component is measured is limited to 30 Hz-400 kHz. Figure 3 shows the sensor is positioned in the middle of two runs of PVC heating cable. Electromagnetic field is formed as voltage is applied to the PVC heating cable and alternating current

Table 1: L&C of inductive sensor

Frequencies/Connection	L (mH)	C (uF)
120 Hz		
Serial	10.0	0.3
Parallel	1.2	0.5
1000 Hz		
Serial	0.5	1.5
Parallel	0.5	1.2

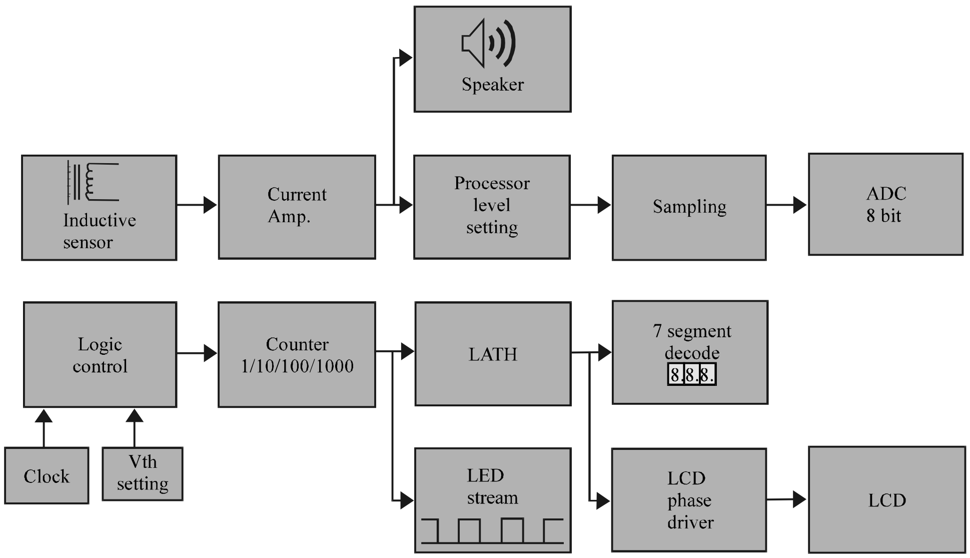

Fig. 2: Block diagram of the detecting electromagnetics

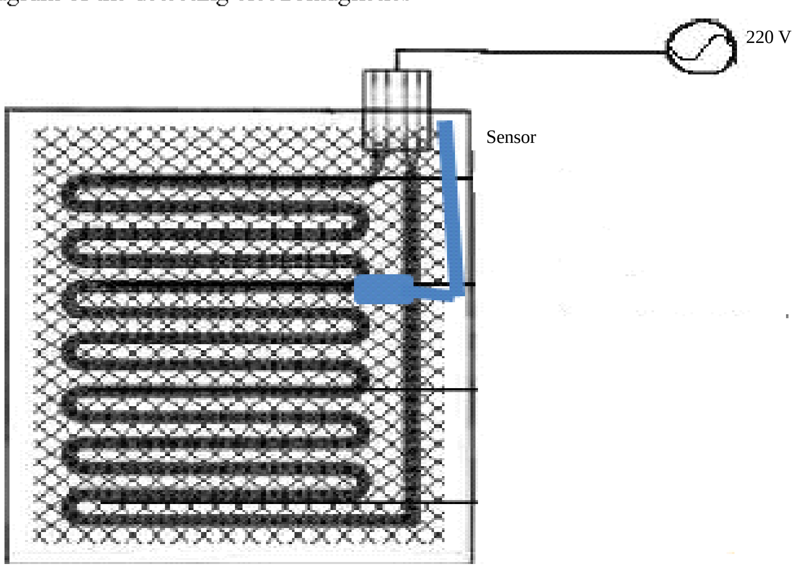

Fig. 3: Induction and carbon fiber non-woven fabric

flows. In this state, the electromagnetic field generated from the carbon fiber nonwoven fabric is all extinguished. And the temperature is maintained by the carbon fiber nonwoven fabrics.

By amplifying the current derived from the induction sensor, the sound of the electromagnetic wave can be confirmed by the sound. At the same time, the level(sensitivity) is set in the processor and converted into an 8-bit digital signal through sampling. The digital signal is set to the clock frequency and the threshold value is set and sent to the counter circuit to display the electromagnetic wave value through the LED or LCD display through the latch circuit. The signal from the counter can be used to display the intensity of the electromagnetic wave by LED display. Processor programs are written in assembler.

RESULTS AND DISCUSSION

Simulation: Figure 4 shows the connection of the connector (③) to connect the PVC heating wire on the electric mat and apply the power 220 (V). Connect the power switch (④) and measure the minimum temperature and the maximum temperature of the power control unit (④).

The temperature is measured by ①, ②. The upper and lower 10 points were set on the basis of temperature. The temperature of the electric mat using the general nonwoven fabric and the electric mat using the carbon fiber was measured with a thermal imaging camera.

Then, the electromagnetic waves were measured by the same method and the carbon non woven fabric was connected to the rolling terminal for grounding to absorb electromagnetic waves as shown in Fig. 5.

Figure 6 displays the temperature heating time of general nonwoven fabric and carbon non woven fabric. Each electric mat was heated 20 times (600 sec) at intervals of 30 sec and measured three times in the same procedure. The weight of general nonwoven fabric and carbon nonwoven fabric was measured as 150 g as shown in Fig. 6.

In comparison of the temperature between the general non woven fabric and the carbon non woven fabric, it can be confirmed that the temperature of the carbon non woven fabric increases with time. The results showed that the temperature difference between general non woven fabric and carbon non woven fabric had a high difference of 8.2°C.

Also, it can be confirmed that the temperature difference between the nonwoven fabric (a, b) and the carbon nonwoven fabric (c, d) which are taken for 100 sec

(a)

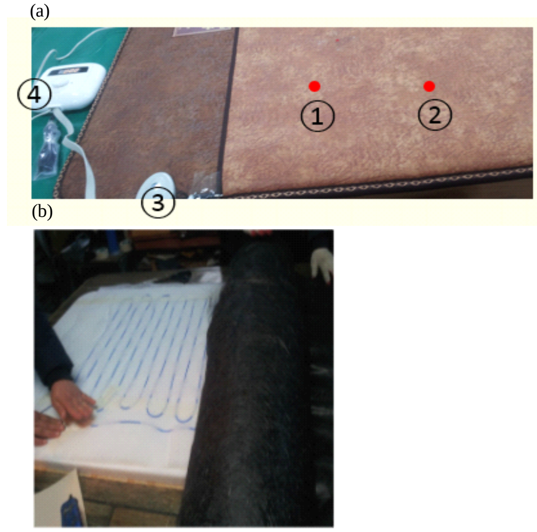

Fig. 4: a, b) Connection of thermal control and electromagnetic measurement of electric heating mats used carbon fiber non woven fabric

Table 2: Influence field on ordinary mat and carbon mat

Mat (mG)/ Test device	Carbon fiber heating mat	--General electric heating mat--					Average
PULSE HCP03	0	8	8.0	8.9	9.0	10.3	8.84
Protoype	0	6	8.5	8.8	9.0	11.0	8.66

by the thermal imaging camera is significantly different and the thermal diffusion rate is high by the carbon fiber as shown in Fig. 7.

Also, Fig. 8 displays the cooling time of general non woven fabric and carbon nonwoven fabric. Each electric mat was cooled 10 times (600 sec) at intervals of 60 sec and measured three times in the same procedure. As shown in Fig. 8, the cooling rate is decreasing at the same rate. However, it can be confirmed that the retaining ability of the carbon fiber is large.

From the results of Table 2 and Fig. 9, it can be confirmed that there is a small error (0.18) in the measurement of the electromagnetic wave of the carbon mat and the general mat. When compared with PULSE's product it can be confirmed that the electromagnetic wave generation indicator has a similar value.

As a result, the heat retention ratio of carbon nonwoven fabric is 7~8°C. Also, the heat diffusion is good and the magnetic field component of the electromagnetic wave is not affected at all.

The system used in the implementation is a block diagram of Fig. 2. The manufactured system is shown in Fig. 10. The magnetic field measurement of the electromagnetic wave is a prototype designed by the constitution diagram of Fig. 2. It was confirmed that the

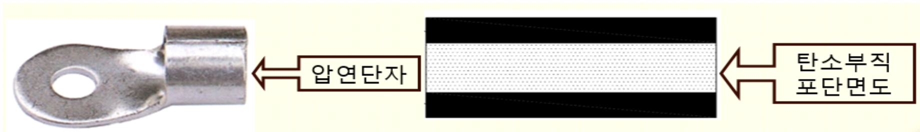

Fig. 5: Grounding method of carbon fiber non-woven fabric to block electromagnetic waves

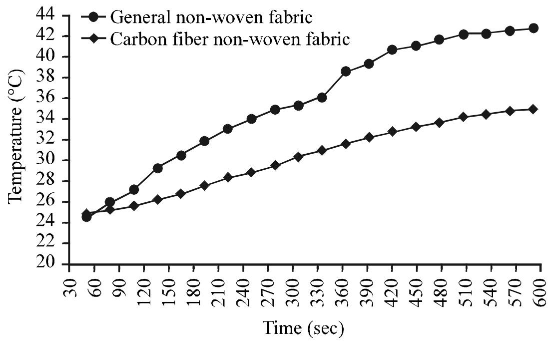

Fig. 6: Comparison of heating time (30 sec) interval) between general non-woven fabric and carbon fiber non-woven fabric

Fig. 9: Prototype and PULSE (HCP03) magnetic field measurement

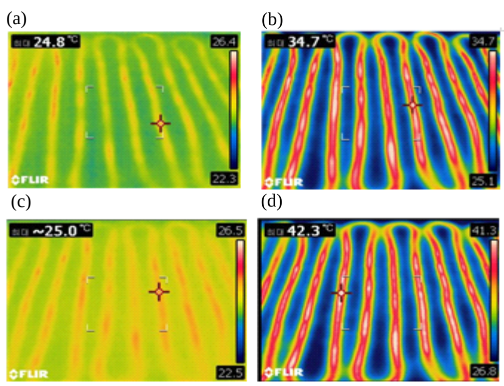

Fig. 7: Comparison of heating time between general non-woven fabric: a, b) Carbon fiber non-woven fabric (min and max time) and c, d) Thermal camera (min and max time)

Fig. 10: Prototype system for measuring electromagnetic waves

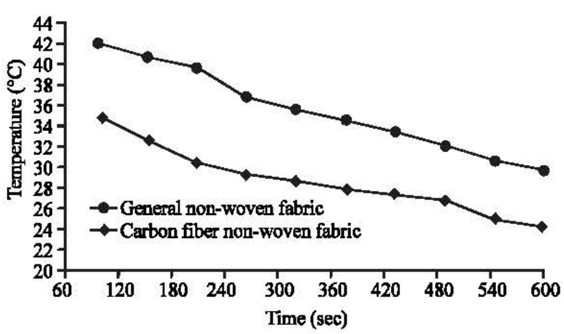

Fig. 8: Comparison of cooling time (60 sec) interval) between general non-woven fabric and carbon fiber non-woven fabric

diffusion of the heat of the heating wire (Fig. 7) was clearly distinguished by the carbon fiber according to the configuration and arrangement of the PVC non woven fabric and the carbon fiber non woven fabric.

Especially, it was confirmed that the electromagnetic wave completely disappears by the grounding method when using carbon non woven fabric (Fig. 5).

From the experimental results, it was confirmed that the heat diffusion was good and the magnetic field component of electromagnetic wave was not affected by 0 (mG).

However, in terms of economy, the price of carbon fiber non woven fabric is much higher than that of general non woven fabric. We think that it is necessary to compare the temperature change and power consumption according to the quantity and the material of carbon fiber In the era of well-being, it is considered necessary to develop an electric mat that can be used safely and economically in order to raise the index of human's most basic health and happiness (Bae, 2010; Jeon *et al*., 2009; Jung *et al*., 2004; Kim and Kim, 1995; Kim and Na, 2004; Kin, 2014; Seong, 1973).

CONCLUSION

It was confirmed that the heat diffusion was good and the magnetic field component of electromagnetic wave was not affected by 0(mG). From a practical point of view it is not economical. Therefore, for practical use of carbon fiber, carbon fiber composite materials composed of a plastic system (CFRP, Carbon Fiber Reinforced Plastic) and thermosetting resin system (TS, Thermosetting Resin) should be considered for further study.

ACKNOWLEDGEMENT

This research was supported by Howon University of academic research funding.

REFERENCES

Bae, H.S., 2010. Changes in mechanical properties of sanitary nonwoven fabrics by Chitosan-nanosilver mixed solution treatment. Text. Sci. Eng., 22: 163-172.

Choi, J.M., 2007. An experiment study on ignition characteristics of electric mat. Master Thesis, Graduate School of Industrial Technology & Information, Kyonggi University, Suwon, South Korea.

Jeon, H.Y., H.B. Kong, S.G. Kang, J.H. Kim and S.H. Jeong, 2009. Tensile property evaluation of nonwoven geotextile in simulated sea water solution. Text. Sci. Eng., 46: 342-347.

Jung, Y.H., K.S. Kim, H.Y. Kim and H.J. Kim, 2004. A study on characterization of nonwoven mats via. electrospinning under vacuum. Text. Sci. Eng., 41: 424-432.

Kim, H.S. and W.A. Kim, 1995. Effect of fiber component on the heat transfer characteristics of nonwoven insulating materials. Yonsei Educ. Sci., 44: 117-135.

Kim, S.L. and C.K. Na, 2004. Preparation and characteristics of polypropylene nonwoven fabric grafted by styrene. Fashion Text. Res. J., 6: 377-383.

Kin, H.K., 2014. Study on the thermal property of covalently networked carbon nanotube mats. Master Thesis, Seoul National University, Seoul, South Korea.

Lee, J.H., S.J. Cho, K.Y. Park, J.H. Song and C.H. Lee, 2014. A study on a heating and electromagnetic characteristics of electric heating mat using the carbon fiber. IEEE. Honam Sect., 1: 27-31.

Seong, H.K., 1973. Studies on adhesive nonwoven fabrics for padding Cloths-the effect of the ironing temperature and time on the adhesion of the adhesive nonwoven fabrics. Family Environ. Res., 11: 276-284.

Shin, H.S., J.H. Yu and L. Kim, 2010. A study on oil absorption rate and oil absorbency of Melt-blown nonwoven. Text. Color. Finish., 22: 257-263.

Shin, Y.S., J.E. Lee, I.K. Yeon, J.D. Cheung and S.Y. Choi *et al*., 2009. Effect of nonwoven fabrics materials on the growth and yield of korea melon (Cucumis melo L. var. Makuwa Mak.). Protected Hortic. Plant Factory, 18: 101-106.