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Temperature variations of microfiber textiles subject to DC voltage

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In recent years, thermal conductivity of micro and nano carbon textiles has been studies for possible manufacturing of cold weather protective clothing, window defrosting, road de-icing, medical instrumentation, and functional textiles [1-5]. The present paper sets out to investigate the thermal properties of a 30mmX130mm Carbone microfiber cloth.

1. Experimental setup

Figure 1 shows the experimental set up. A 30mm x130mm carbon micro fibre cloth is connected to a 1amp adaptor with 1.5 to 12V voltage. The temperature at the midspan of the strip is measured by a noncontact infrared thermometer.

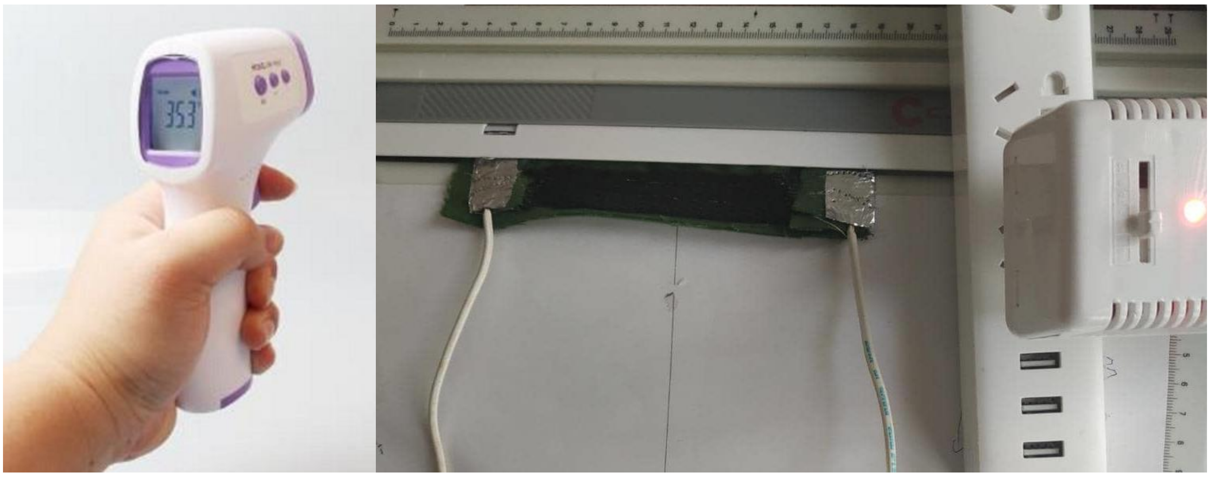

Fig. 1. Experimental set up

2. Results

Fig. 2 shows the temperature variations of the mid-point of the strip. For each voltage the temperature variant curve increases with high rate and then the rate decreases till the temperature reaches a plateau, T_{max}. Fig. 3 shows the variations of temperature at the mid-point of the strip under 12V voltage. The temperature increases from room temperature To and reaches a plateau, T_{max}. We turn off the voltage at t_{cr} denoting the measured temperature at this point of time t_{cr} with T_{cr}. It can be shown

$$T = (T_0 - T_{max})\, e^{-\alpha t} + T_{max}\,, \tag{1}$$

where

$$\alpha = \frac{1}{t_{cr}} \ln\left(\frac{T_{max} - T_0}{T_{max} - T_{cr}}\right)\,. \tag{2}$$

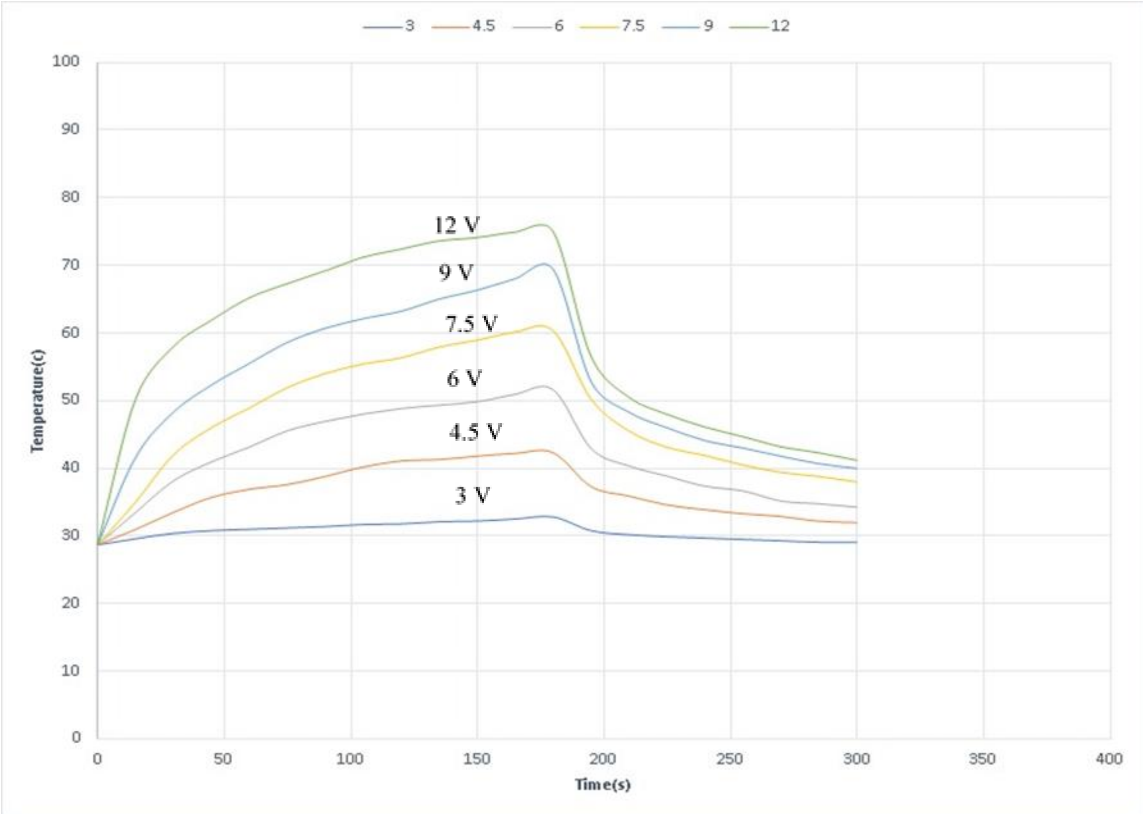

Fig. 2. Temperature variations of the mid-point of the strip for each voltage

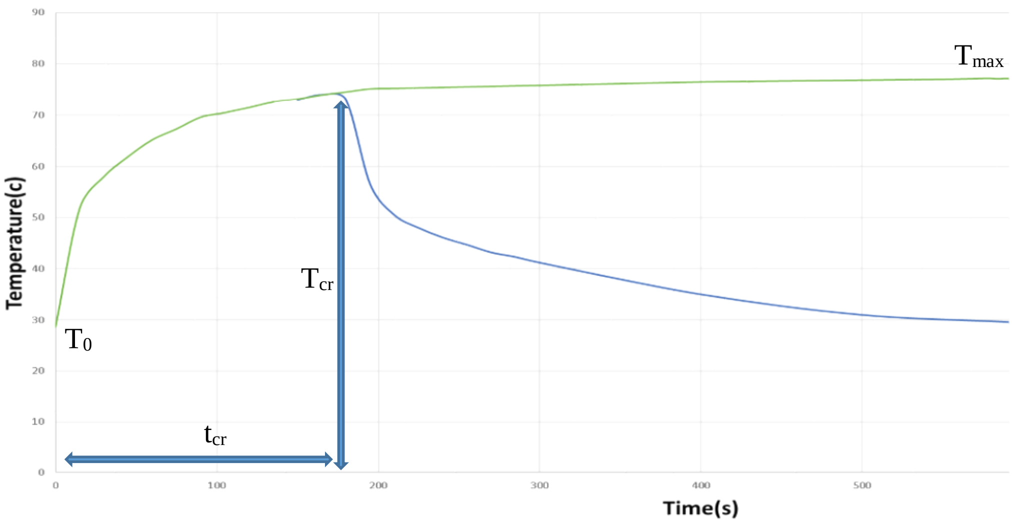

Fig. 3. Shows the variations of temperature at the the mid-point of the strip under 12 V voltage

Fig. 4 shows the maximum possible temperature as a function of the voltage of two ends of the strip. Table 1 shows the time series of the temperature for 15 second time step.

3. Conclusions

From the foregoing discussions and results we conclude there is an electrical and a mechanical analogy with the thermal system investigated in this paper. The variations of the temperature at the midspan of the strip is exactly the same way as the voltage across a capacitor in an electrical circuit with a capacitor and resistor or the velocity across the spring in a mechanical vibrator with a damper and a spring.

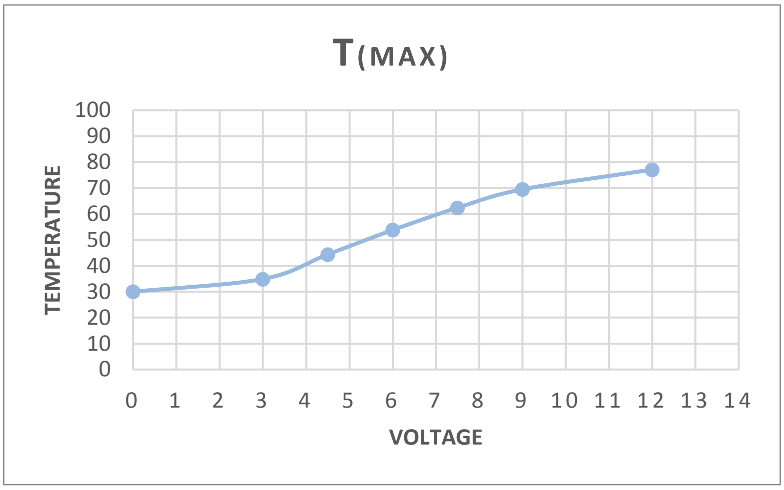

Fig. 4. Variations of T_{max} as a function of the difference in voltages of the two ends of the strip

Table 1. Time series of the temperature

Time(s)	V=3	V=4.5	V=6	V=7.5	V=9	V=12
0	28.7	28.7	28.7	28.7	28.7	28.7
15	29.6	31	32.5	35	41.6	51.8
30	30.3	33.5	36.2	42	48.3	58
45	30.7	35.7	40	46	52.3	61.9
60	31	37.2	42.2	48.9	55.5	65.2
75	31.2	38.6	44.6	51.9	58.6	67.3
90	31.4	39.8	46	54	60.7	69.6
105	31.7	40.4	47.5	55.4	62.1	70.5
120	31.8	41.1	48.9	56.9	64.2	71.5
135	32.1	41.3	49.4	57.9	65	72.6
150	32.2	41.8	50.5	58.9	66.3	73.1
165	32.5	42.2	51	60.1	67	73.9
180	32.8	42.3	51.7	60.3	67.4	74.5
195	32.9	42.4	51.8	60.4	67.5	75.1
210	33	42.5	51.9	60.5	67.6	75.2
225	33.1	42.6	52	60.6	67.7	75.3
240	33.2	42.7	52.1	60.7	67.8	75.4
255	33.3	42.8	52.2	60.8	67.9	75.5
270	33.4	42.9	52.3	60.9	68	75.6
285	33.5	43	52.4	61	68.1	75.7
300	33.6	43.1	52.5	61.1	68.2	75.8
315	33.7	43.2	52.6	61.2	68.3	75.9
330	33.8	43.3	52.7	61.3	68.4	76
345	33.9	43.4	52.8	61.4	68.5	76.1
360	34	43.5	52.9	61.5	68.6	76.2
375	34.1	43.6	53	61.6	68.7	76.3
390	34.2	43.7	53.1	61.7	68.8	76.4
405	34.3	43.8	53.2	61.8	68.9	76.5
420	34.35	43.85	53.25	61.85	68.95	76.55
435	34.4	43.9	53.3	61.9	69	76.6
450	34.45	43.95	53.35	61.95	69.05	76.65
465	34.5	44	53.4	62	69.1	76.7
480	34.55	44.05	53.45	62.05	69.15	76.75
495	34.6	44.1	53.5	62.1	69.2	76.8
510	34.65	44.15	53.55	62.15	69.25	76.85
525	34.7	44.2	53.6	62.2	69.3	76.9
540	34.75	44.25	53.65	62.25	69.35	76.95
555	34.8	44.3	53.7	62.3	69.4	77
570	34.85	44.35	53.75	62.35	69.45	77.1
585	34.9	44.4	53.8	62.4	69.5	77.1
600	33.95	43.45	52.85	61.45	68.55	76.1

References

[1] Guran, A., Yousefghahari, B., Invited speakers, I-9: Modal analysis of carbon nano tubes (Cnt) by means of finite element technique, Cell Journal (Yakhteh) 13 (2) (2011) 7-7.

[2] Guran, A., Yousefghahari, B., Bayranvand, M., Vahidi-Shams, A., Feasibility of using nanotextiles for hypothermia or applied to a part of the body for warmth, Cell Journal (Yakhteh) 13 (2) (2011) 7-7.

[3] Hao, Y., Tian, M., Zhao, H., Qu, L., Zhu, S., Zhang, X., Chen, S., Wang, K., Ran, J., High efficiency electrothermal graphene/tourmaline composite fabric joule heater with durable abrasion resistance via a spray coating route, Industrial & Engineering Chemistry Research 57 (40) (2018) 13437-13448.

[4] Wen-Jin, S., Ling, X., Li-Chuan, J., Chang-Ge, Z., Yang, X., Ru-Hua, Y., Ding-Xiang, Y., Jian-Hua, T., Zhong-Ming, L., Highly conductive and stretchable carbon nanotube/thermoplastic polyurethane composite for wearable heater, Composites Science and Technology 181 (2019) 107695.

[5] Yan, J., Jeong, Y., Synergistic effect of hybrid carbon fillers on electric heating behavior of flexible polydimethylsiloxane-based composite films, Composites Science and Technology 106 (2015) 134-140.