

Optimization of heating performance of the stretchable rib and its derivatives knitted wearable heating pad

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Abstract

Nowadays, conductive yarns or fabrics are utilized for the smart wearable electronic textile. Textile-based wearable heaters have drawn attention to the application of heat therapy for relieving joint and muscle pain. Herein, we are reporting rib and its derivatives knitted wearable heating pad with localized conductive yarn. A 14-gauge knitting machine is used to prepare a localized heating pad with a combination of knit (rib), float, and tuck loops at the active part. A knitted construction with a small modification is predicted to be used for both excellent stretchability and better heating performance.

Materials and Methods



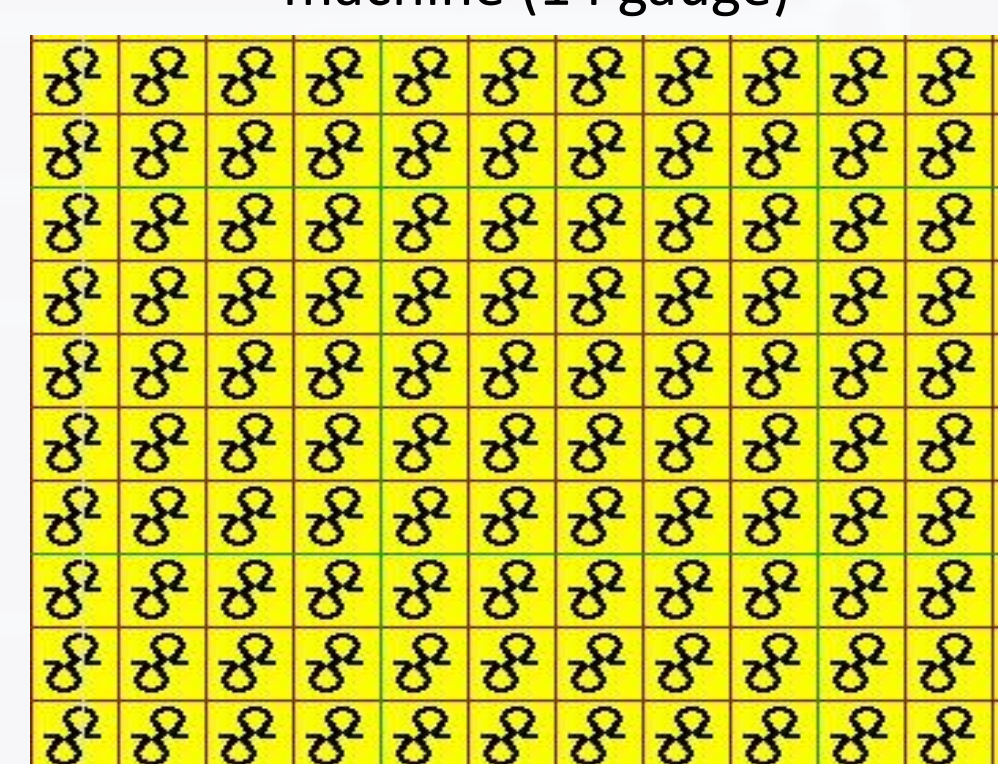
Shima Seiki V-bed knitting machine (14 gauge)



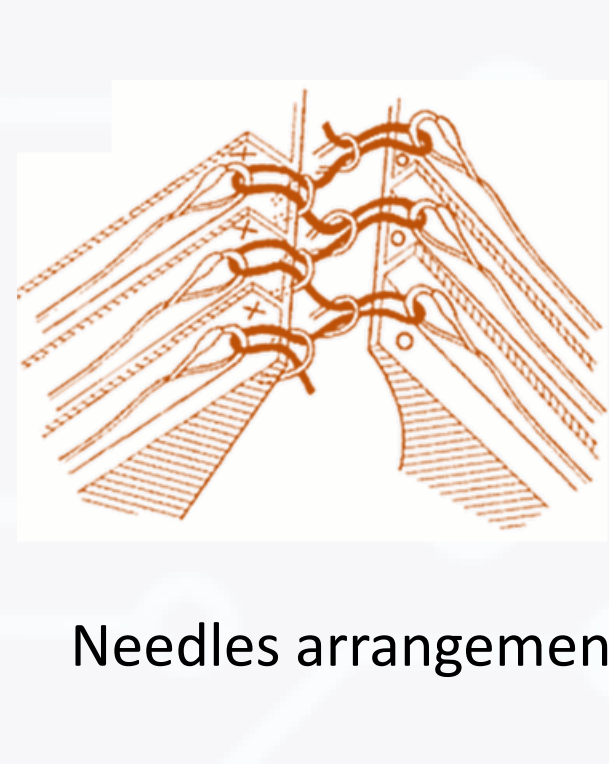
Silver coated nylon and cotton yarn



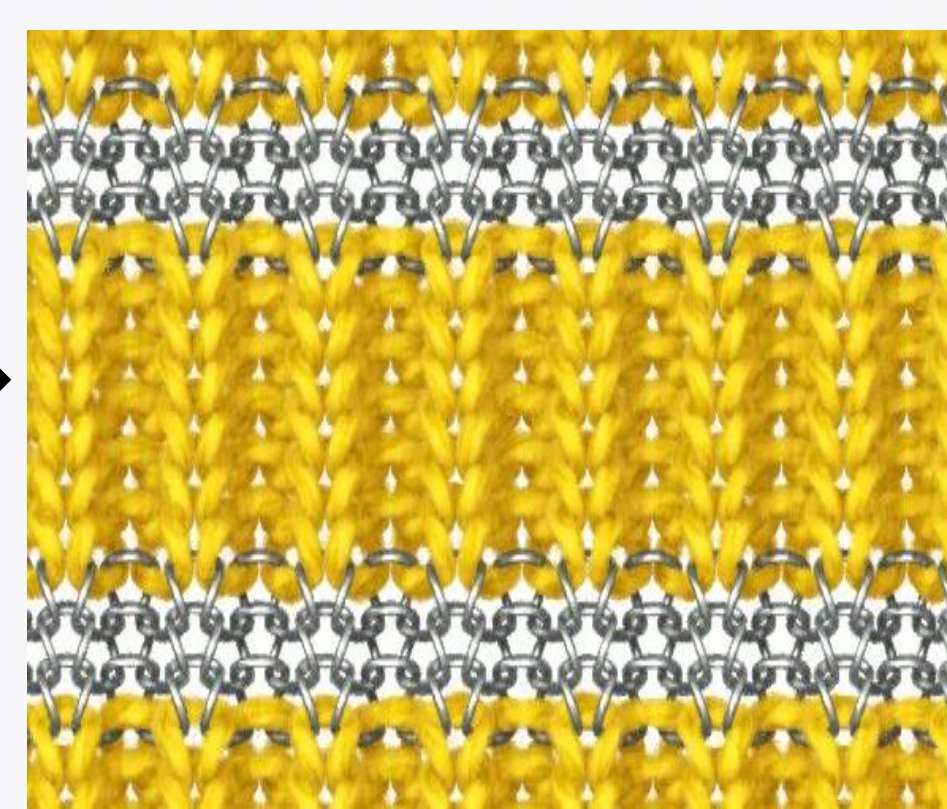
Prepared sample (Rib)



Computerized design for sample

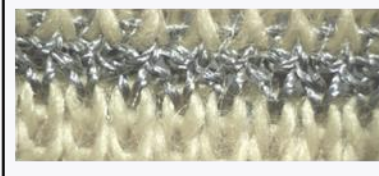


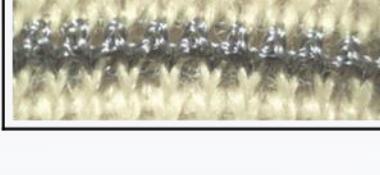


Needles arrangement

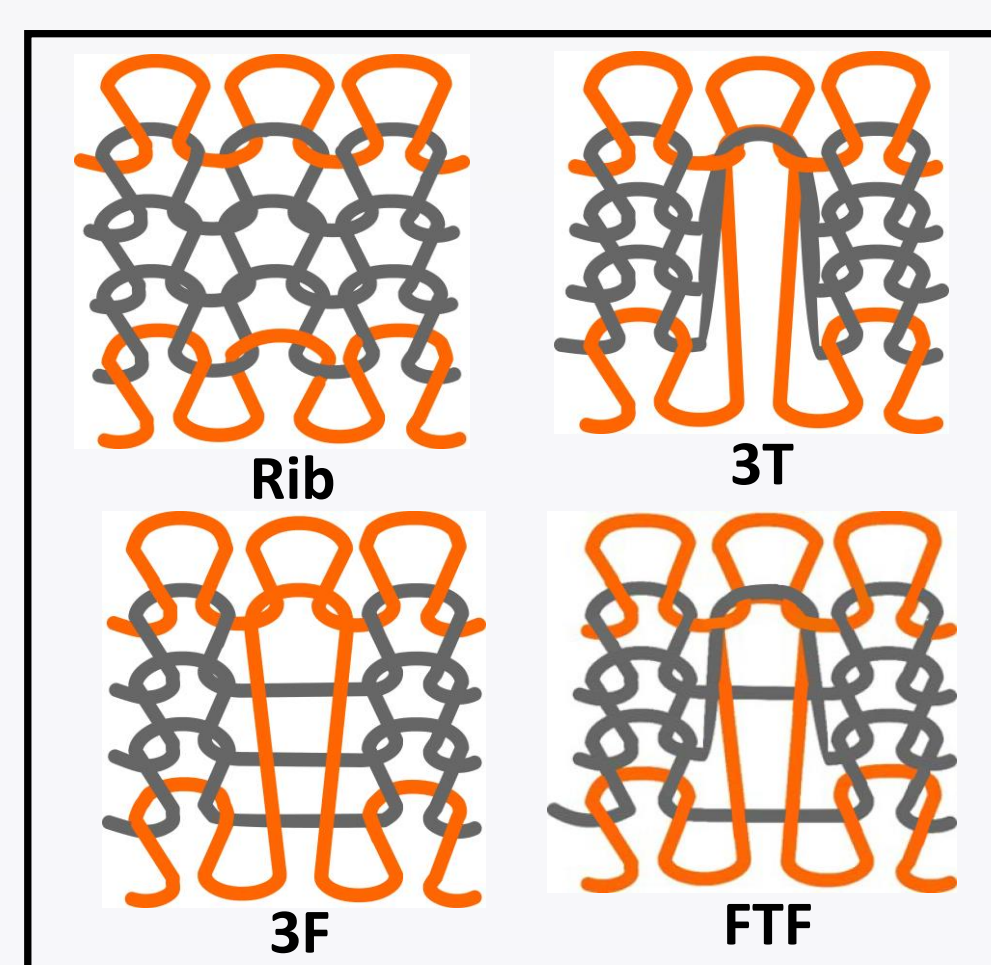


Mimetic view of sample (Rib)

Sample specifications

Fabric structures	Fabric structure	Structure of Textile substrate	Resistance (Ω)	Areal density (g/m^2)	Thickness (mm)
	3R	Rib	72 \pm 2	420	1.50
	3T	Rib	67 \pm 2	437	1.70
	3F	Rib	62 \pm 2	395	1.95
	FTF	Rib	51 \pm 2	436	1.87

*R- Rib, T-Tuck, F-Float

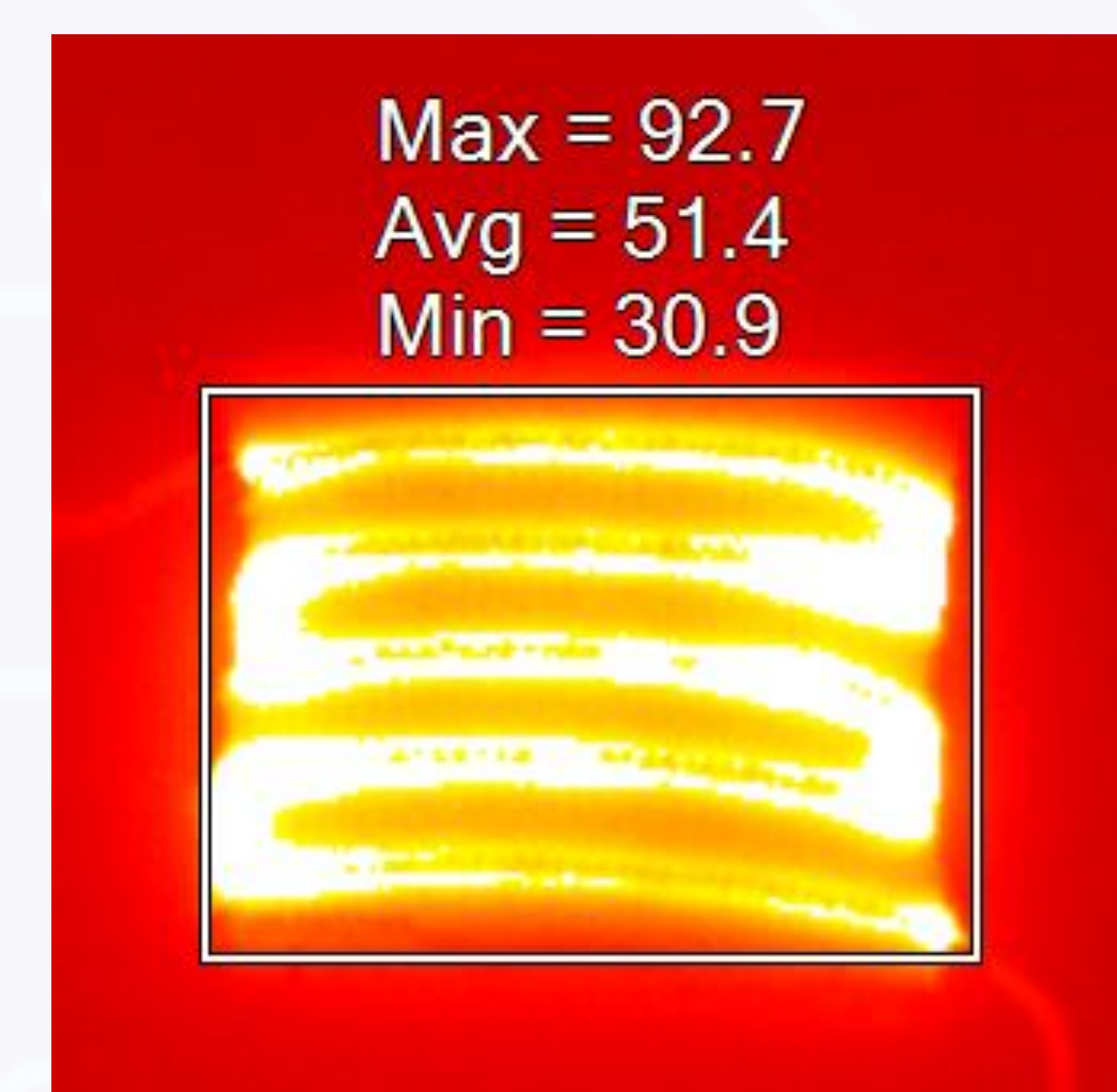


Results and Discussion

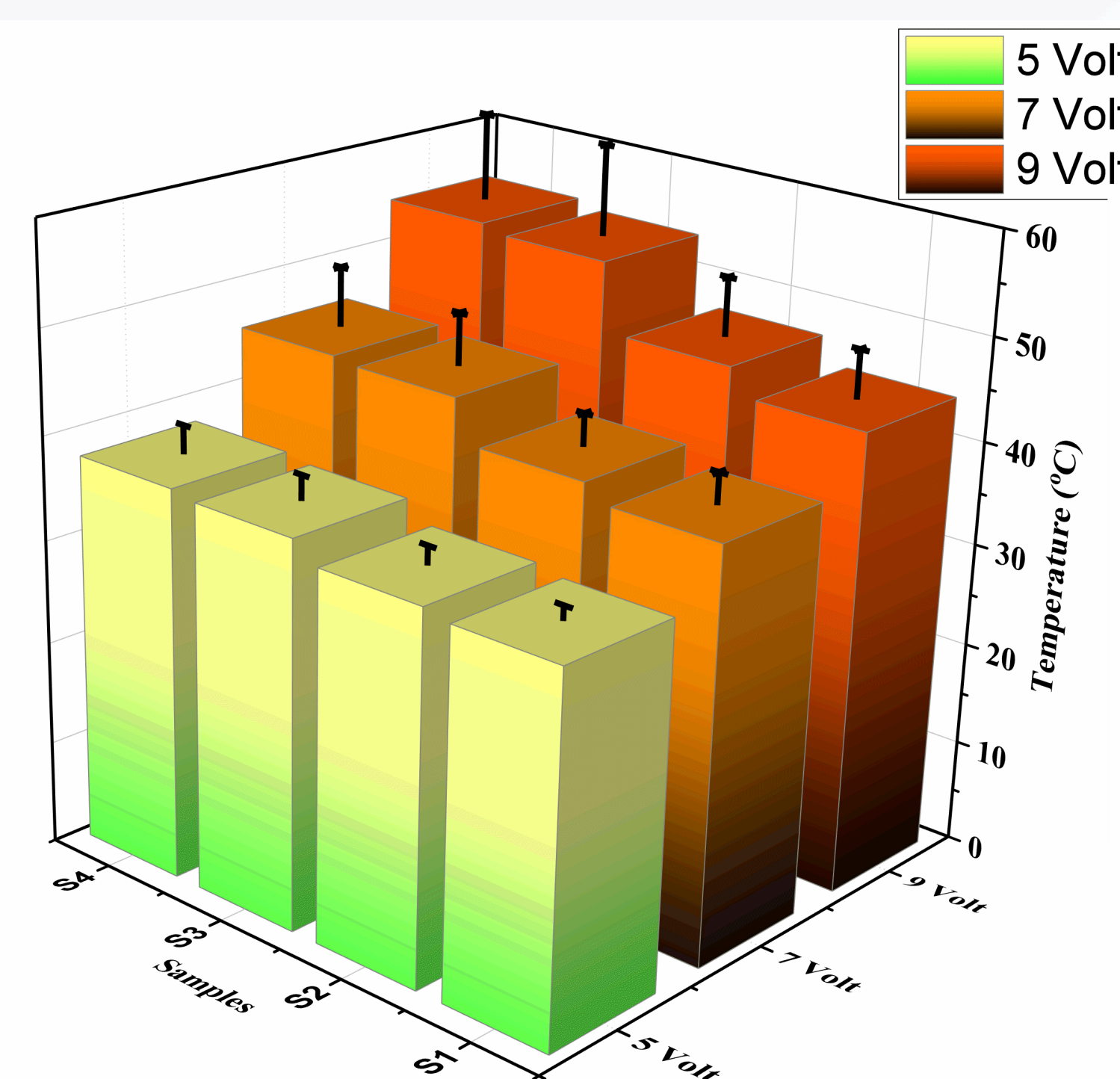
Temperature measurement



DC Power source



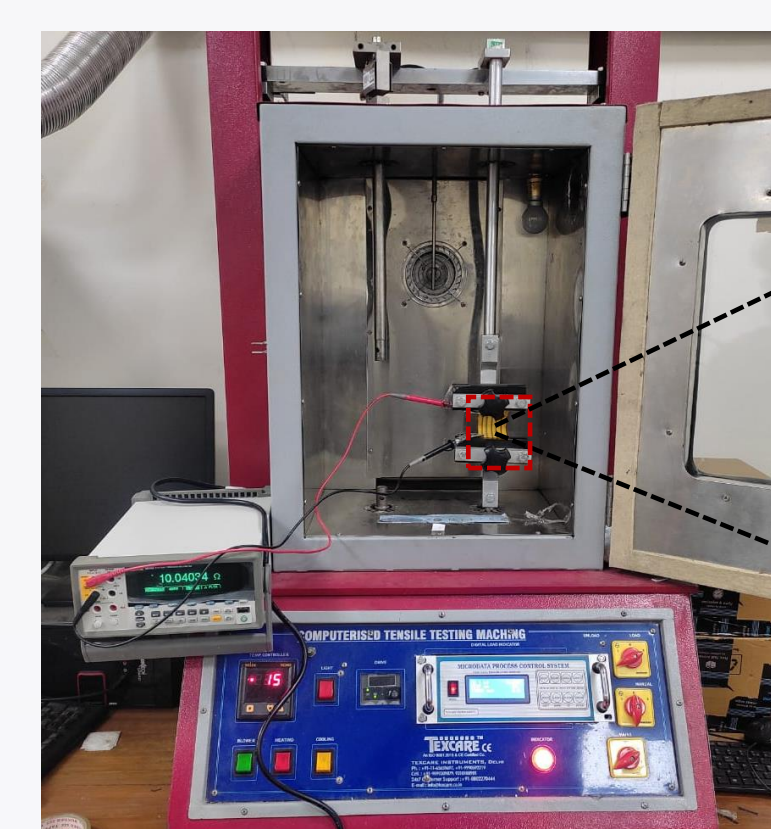
Thermal image of FTF at 9 Volt



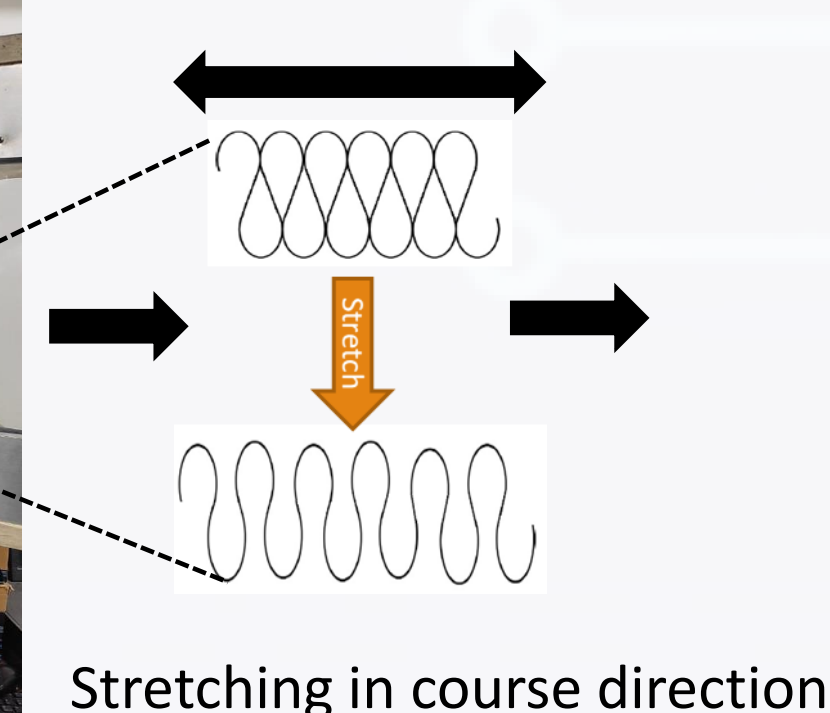
Samples:

*S1-Rib, S2-3T, S3-3F, S4-FTF

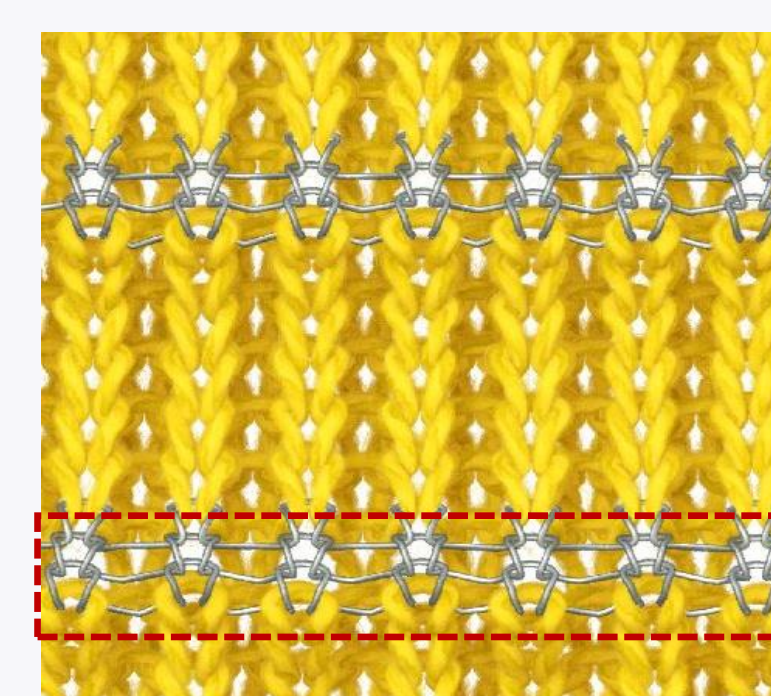
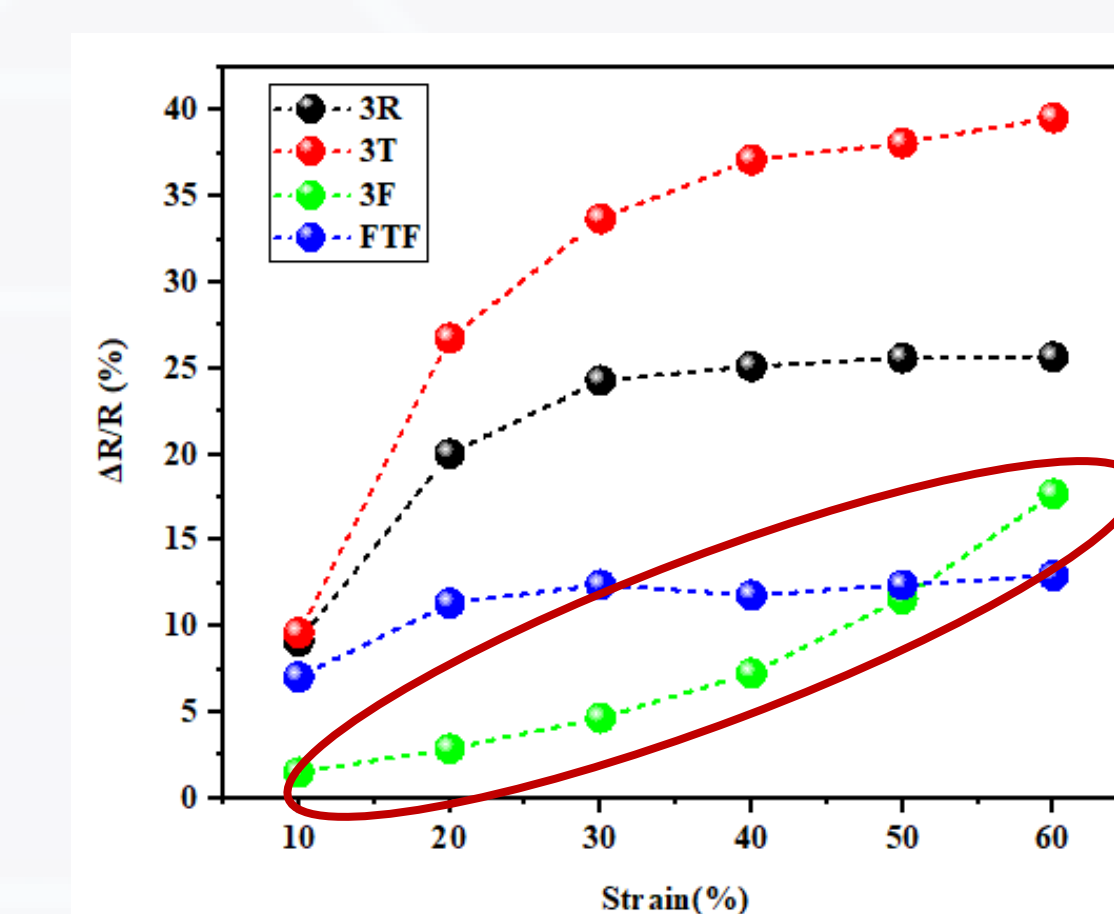
Effect of strain on resistance behavior



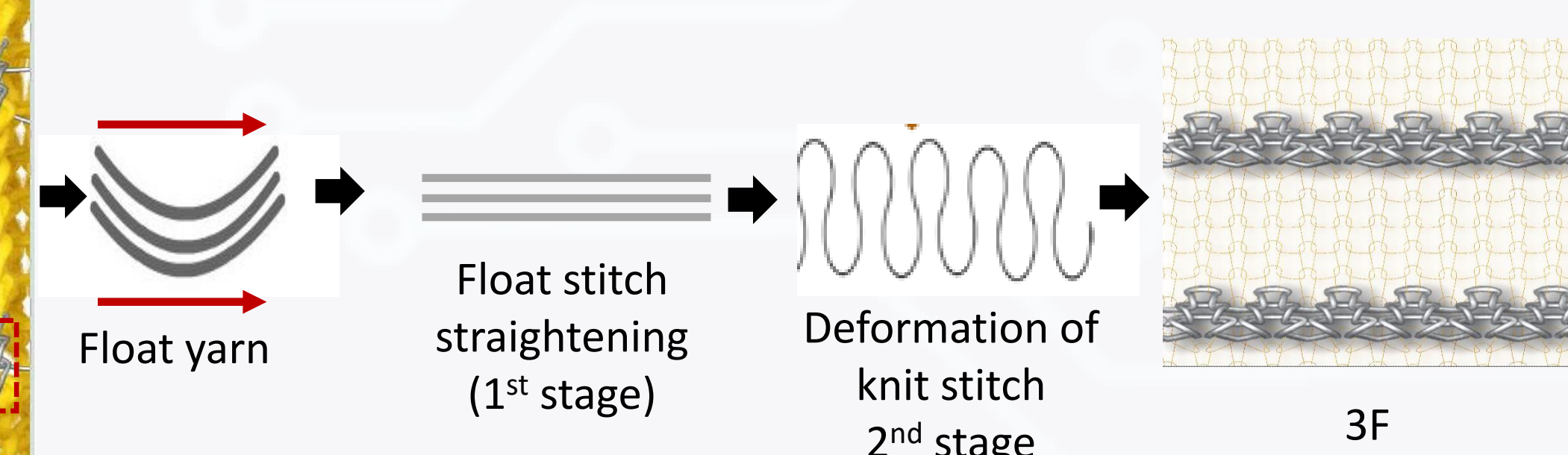
Instron tensile testing machine



Stretching in course direction



3F



3F

Conclusions

- Heating pad with float and tuck in rib structures at the conducting region demonstrated superior heating performance. combination of tuck and float loops (FTF) showed a 22% better heating performance, i.e., 51.4 °C than the 100% knit loop at 9 volts.
- It is observed that the change in resistance caused by fabric stretching is linearly proportional up to a 20% strain level. Afterwards, the resistance is nearly constant with strain.

References

- Wang, F., Gao, C., Kuklane, K., & Holmér, I. (2010). A review of technology of personal heating garments. International journal of occupational safety and ergonomics, 16(3), 387-404.
- Hamdani, S. T. A., Potluri, P., & Fernando, A. (2013). Thermo-mechanical behavior of textile heating fabric based on silver coated polymeric yarn. Materials, 6(3), 1072-1089.
- Pragya, A., Singh, H., Kumar, B., Gupta, H., & Shankar, P. (2020). Designing and investigation of braided-cum-woven structure for wearable heating textile. Engineering Research Express, 2(1), 015003.
- Sun, Kexia, Su Liu, and Hairu Long, Structural parameters affecting electrothermal properties of woolen knitted fabrics integrated with silvercoated yarns, Polymers, 11 (10) (2019), pp. 1709.

Acknowledgement

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