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Electromagnetic Shielding Effectiveness and Manufacture Technique of Functional Metal Composite Knitted Fabrics

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Abstract. In order to fabricate fabrics with electromagnetic shielding effectiveness (EMSE) and other function, we fabricated Crisscross-section polyester /antibacterial nylon / stainless steel wires (CSP/AN/SSW) composite yarns with stainless wires as core yarn, antibacterial nylon and crisscross-section polyester as inner and out wrapped yarns, respectively. Knitted fabrics were fabricated with the metal composite yarns with wrap amount of 8 turns/cm on a circular knitted machine. Furthermore, the EMSE of the metal composite fabrics were evaluated by changing the lamination amounts and lamination angles. The results show that when the lamination amount was four, lamination angles were 0°/45°/90°/-45°, the EMSE of the fabrics reached to -10--20 dB in the frequency range of 300 KHz to 3 GHz.

Introduction

In recently years, the usage of electrical and electronic devices has grown rapidly. Many devices such as computer cellular phone and microwave oven will emit strong electromagnetic wave and result in electromagnetic inference (EMI) problem during their operation. The electromagnetic waves not only cause electrical devices malfunctions but also harm our health such as leukaemia, depression, stress sleep etc[1-2].

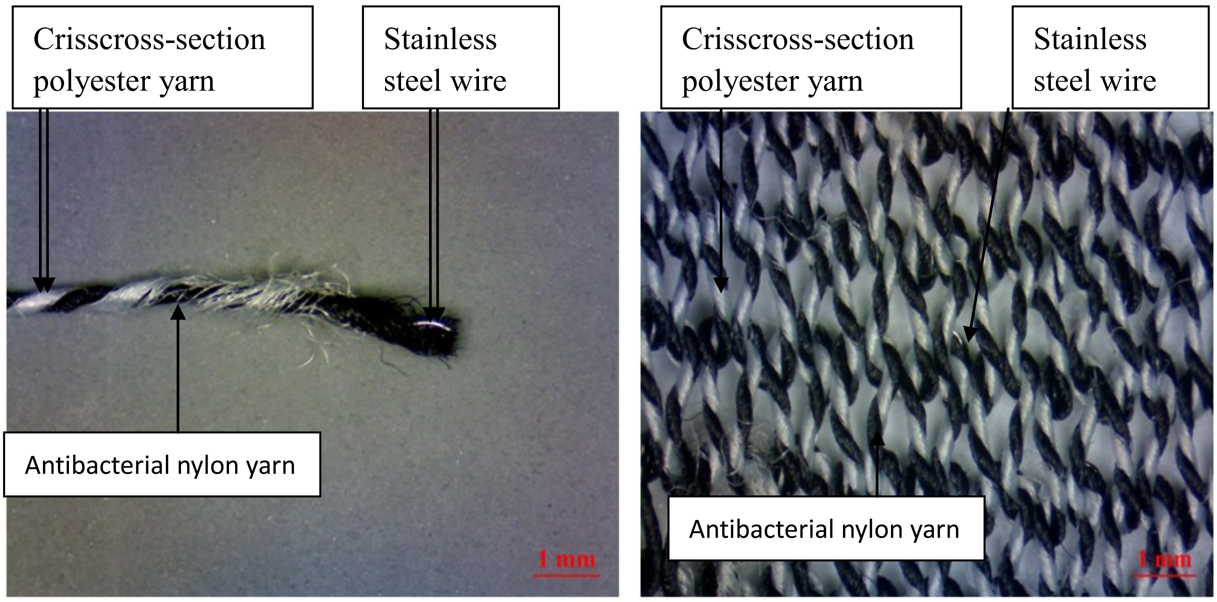
To overcome this problem, there is a growing need for suitable materials that will act as a shielding and limit against the electromagnetic energies. The fabrics made of the metal wires and common yarns were often used as EMSE fabrics. This is mainly due to their desirable properties of flexibility, electrostatic discharge, EMI, thermal expansion and weight. Lin et al. used a rotor twister machine to produce charcoal polyester/Stainless steel complex yarns [3].Although many metal composite fabrics were fabricated in previous study, theirs functions were too single and difficulty to simultaneously meet the other special requirement as protective clothing.

The aim of this study was to produce the functional composite knitted fabrics processing various functions, such as electromagnetic shielding, antistatic and good wicking properties. In this paper, crisscross-section polyester /antibacterial nylon / stainless steel wires (CSP/AN/SSW) composite yarns were manufactured with stainless wires as core yarn, antibacterial nylon and crisscross-section polyester as inner and out wrapped yarns, respectively. The EMSE of the metal composite fabrics were evaluated by changing the lamination amounts and lamination angles in this paper.

Experimental

Materials

Crisscross-section polyester /antibacterial nylon / stainless steel wires (CSP/AN/SSW) composite yarns were manufactured on a hollow spindle spinning machine. The metal composite yarns using stainless steel wires as core yarn, antibacterial nylon and crisscross-section polyester as inner and out wrapped yarns, respectively. For the metal composite yarns, the wrapped amount is 8 turns/cm for both AN and CSP filaments. The metal composite knitted fabrics were fabricated n a 20-gauge circular knitting machine using the CSP/AN/SSW composite yarns. Figure 1 shows the metal composite yarn and knitted fabric. The 75D/144 f crisscross-section polyester filaments were offered by Everest Textile Co., Ltd. 0.05 mm stainless steel wires were provided by King's Metal Fiber Technology Co., Ltd.



(a) Metal composite yarn (b)Metal composite knitted fabrics

Figure 2. The metal composite yarn and knitted fabric

EMSE measurement

A coaxial transmission line method specified in ASTM D4935-99 was used to test the EMSE of the metal composite knitted fabrics. Figure 3 shows the schematic of the testing device used for assessing the EM behavior of the metal composite knitted fabrics [4]. Before the measurements and tests, all fabrics samples were conditioned in standard atmospheric conditions (20±2 ℃，65±5 % relative humidity) for 48 h. All tests were performed under standard ambient conditions.

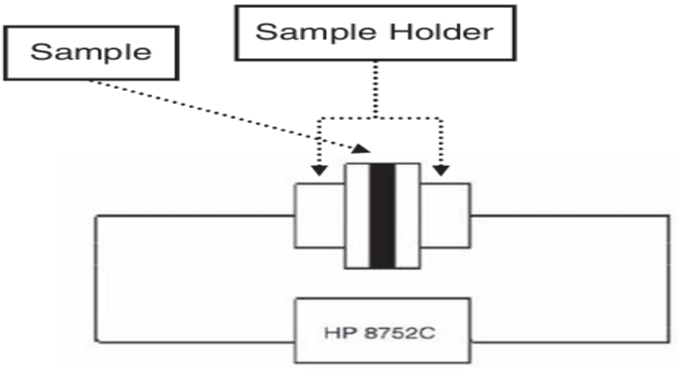


Figure 3.The schematic of the test holder

Results and discussion

EMSE of the various knitted fabrics

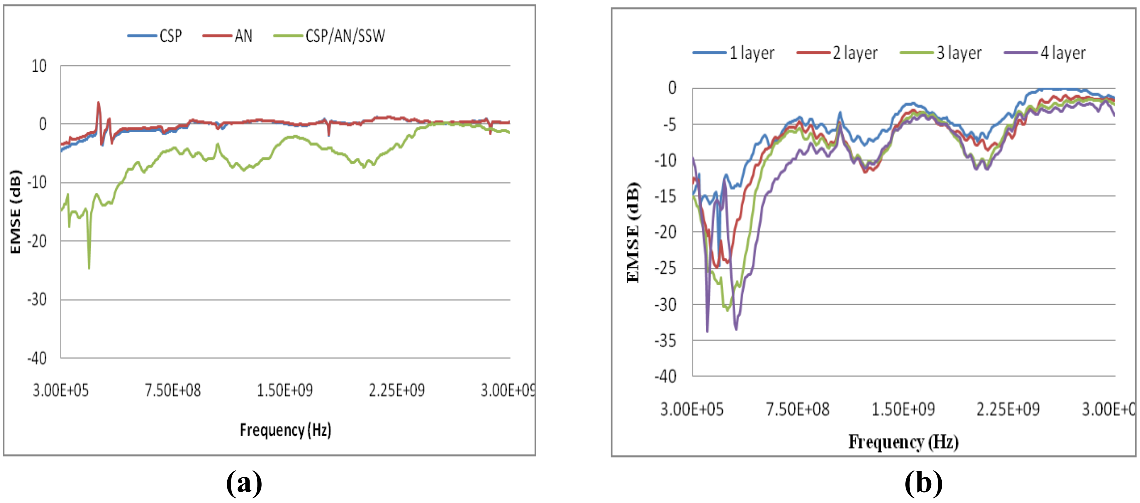
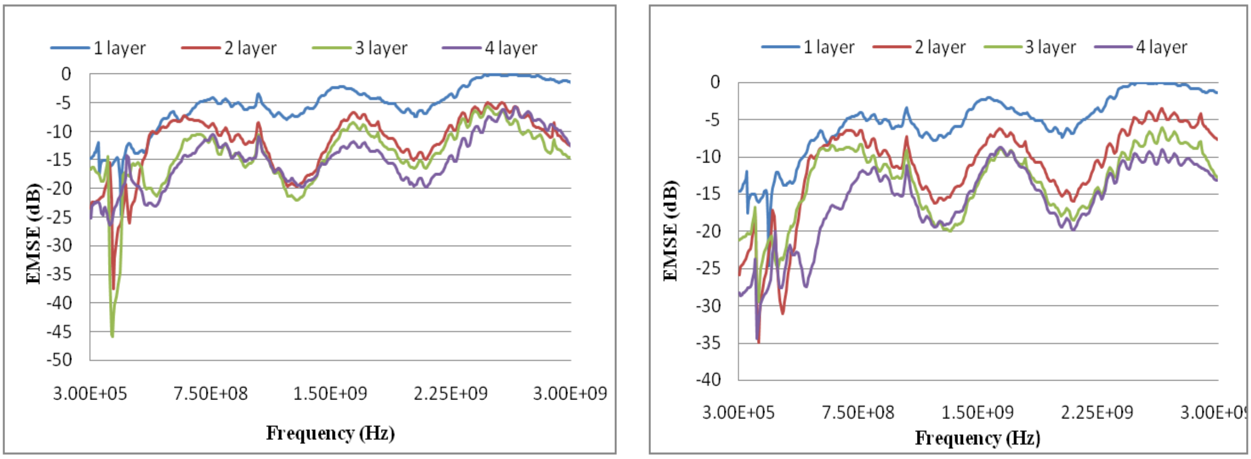


Figure 4.The effect of the lamination amount on EMSE of the metal composite knitted fabrics. (a) Single-layer metal composite knitted fabric, CSP and AN knitted fabrics, (b) The lamination amount varies from 1 to 4 layer, lamination angles is 0°/0°/0°/0° for the metal composite knitted fabrics.

Figure 4 (a) shows the EMSE of the metal composite fabric,fabric AN and fabric CSP with the incident frequency in the range of 300KHz to 3G Hz. CSP means the Crisscross-section polyester knitted fabrics, AN refers to antibacterial nylon knitted fabrics, and CSP/AN/SSW stands for Crisscross-section polyester /antibacterial nylon / stainless steel wires metal composite knitted fabrics. Among all fabrics, the metal composite knitted fabric displayed the highest EMSE, whereas fabric AN and CSP displayed zero EMSE. This phenomenon could be due to synthetic fiber inherent electrically insulating and transparent to electromagnetic radiation. For the metal composite knitted fabrics, stainless steel wires in the knitted fabrics could prevent passage of electric field and magnetic wave which were produced by electromagnetic waves. The optimum EMSE of 25 dB was obtained for the single-layer metal composite knitted fabrics in the frequency range of 0.53 GHz.

In order to further increase EMSE of the fabrics, the lamination method was used in this research. Figure 4 (b) shows that EMSE of the metal composite knitted fabric increased slightly with the lamination amount and the difference between all EMSE of the fabrics was less than 5 dB. This was due to with the same lamination angles (0°/0°/0°/0°), the stainless steel wires failed to reduced the electric web holes to prevent the EM waves penetrate the fabrics.



(a) (b)

Figure 5. The effect of the lamination amount, lamination angles on EMSE for the metal composite knitted fabrics. (a) lamination angles of 0°/90°/0°/90°, (b) lamination angles of 0°/45°/90°/-45°

Figure 5 show a dramatic range of the EMSE levels for the lamination fabrics with different lamination amounts and angles. It should be noted that the fabrics had four lamination amounts with 0°/45°/90°/-45° lamination angles had the better EMSE level than with 0°/90°/0°/90° lamination angles in this research. These results may be due to change the lamination angles, the holes size of electric web became smaller so that EMSE increased. The EMSE nearly reached to -10 dB and resulting in 99 % EM waves were intercepted by the metal composite knitted fabrics in the wide frequency range of 300 KHz to 3 GHz.

Summary

In this research, we successfully manufactured the Crisscross-section polyester /antibacterial nylon / stainless steel wires (CSP/AN/SSW) composite yarns and knitted fabric using a hollow spindle spinning machine and a 20-gauge circular knitting machine. EMSE of the metal composite knitted fabrics increased with the lamination numbers. In particular, the four-layer metal composite knitted fabrics with 0°/45°/90°/-45° lamination angles had an EMSE of -10 dB in the frequency range of 300 KHz to 3 GHz. Such functional metal composite knitted fabrics can be applied in EMSE protective clothes, microwave oven shielding and so on.

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