The Influence of Fabric Structures of the Woven Fabrics on Electromagnetic Shielding Effectiveness

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Abstract

Stainless steel (SS) blended yarns with electromagnetic interference (EMI) were made into woven fabrics, after which the fabrics were evaluated with electromagnetic shielding effectiveness (EMSE). Parameters of laminated angle and the lamination number layers affected the fabrics' EMSE differently. In addition, density of unidirectional SS yarns affected EMSE in frequency range of 200 to 500 MHz , so as the density of cross SS yarns on a frequency over 1000 MHz.

Introduction

Electromagnetic waves contain lower radiation energy, keeping materials from ionization without jeopardizing the environment directly. However, EMI generated by electronic necessities might affect or damage the electronic products. At present, the casings for electronic products are made of engineering plastic. Thouhg with insulation, casings cannot prevent the interference by electromagnetic and static discharge electricity. In addition, after using computer for a long time, people would have eyestrain, tired eyes, irritation, redness, blurred vision, double vision or even dry eye [1] due to electromagnetic waves. People, exposing to radiofrequency electromagnetic radiation (EMR), are likely contract hypertensive and dyslipidemic [2].

Industrial-grade functional textiles are the one of the major productive goals for textile industry in the application fields [11,14]. SS is pervasive EMSE materials used frequently, ascribing to its lower conductivity and higher permeability. For example, SS fibers (SSF) can be used as conductive filler to fabricate into thermoplastic or thermosetting composites due to the functions of EMI shielding, anti-electrostatic properties and electric conduction [1][4~6]. SS fibers were made into mats, and then bounded by sintering, forming heat-resistant filters [7, 8]. With the evolution of the technology, the fineness and softness of stainless steel fiber blended yarns are improved, creating different SS weaves[9]. Furthermore, SS knitted fabrics [10] or woven fabrics [12] could further form the composites by hot pressing [13]. In this research, chief value CVC/ SSF blended yarn were made into woven fabric with EMSE by changing the fabric density and fabric layers. Then the influences of the woven fabric components on EMSE were discussed.

Experimental

Using a water jet loom (TSUDAKOMA ZW303), 3/1 S twill woven fabrics were with warp floats on one side, and weft floats on the other. Warp was made of polyester filaments (PET 75 D/72 F

DTY SD) offered by SHINKONG, Taiwan. Two types of wefts offered by Tah Tong Textile Co., Ltd., Taiwan were 13.1 tex CVC staple blended yarn (C60 %/T40 %) and CVC 13.1 tex SS blended yarn (C60 %/T35 %/SSF5 %). We fabricated woven fabrics with different SS content by changing the weft density, and then evaluated EMSE of the specimen according to ASTM-D4935. Table 1 summarizes the codes for specimens.

Table 1. The codes for specimens.

fabric	warp threads per cm (ends/cm)	weft threads per cm (picks/cm)	warp material	weft material	weight % (SSF/fabric)
A	71	39	PET 75D/72F DTY	CVC 13.1 tex/SSF	2.4
B	71	43	PET 75D/72F DTY	CVC 13.1 tex/SSF	2.5
C	71	43	PET 75D/72F DTY	CVC 13.1 tex	0.0
D	67	43	CVC 13.1 tex/SSF	CVC 13.1 tex/SSF	5.0

Results and Discussion

As far as fabric A and B are concerned, the warp yarns were polyester filaments and weft yarns were CVC 13.1 tex/SSF blended yarn. The weft density were 39 picks/ cm for fabric A and 43 picks/ cm for fabric B; meanwhile, the SSF which the woven fabrics contained were 2.4 % for fabric A and 2.5 % for fabric B. Fabric C served as controlled group, and both of its warp and weft yarns were polyester filaments. Fabric D, the warp and weft yarns were CVC 13.1 tex/SSF blended yarn, and the SS content was 5.0%.

Fabric A, B and C all contain SS content and are with EMSE, exemplified in Figure 1. Fabric A and B both had an EMSE of 16 dB on frequencies between1200 and1300 MHz regardless A had more SS content. However, EMSE of fabric B slightly surpassed that of fabric A on a low frequency. Fabric C exhibits an EMSE over 20 dB in two ranges (1200-1500 MHz and 1800-2400 MHz). Figure 2 illustrates EMSE level of fabric B with lamination number of 1, 2, or 4 layers of 0° laminating. EMSE of fabrics B increased with lamination number on low frequencies instead of high frequencies. Figure 3 compares EMSE of 2-layer fabric B with 0° or 90° laminating while Figure 4 compares EMSE of 4-layer fabric B with the same two laminating angles. On the frequencies 2000MHz to 2200MHz, 2-layer fabric B with 90° had EMSE of 23 dB to 26 dB while 2-layer fabric B with 0° laminating 8 dB to 11 dB. Similiarly, in Figure 4, with the same frequencies, 4-layer fabric B with 90° laminating demonstrated EMSE of 29 dB to 32 dB, surpassing that with 0° laminating which varied from 9 dB to 12 dB.

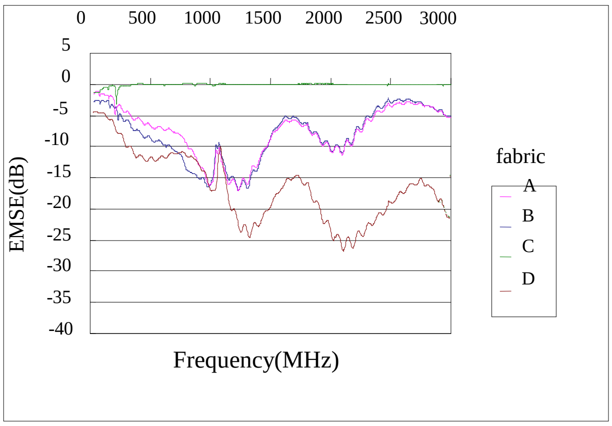

Figure 1. EMSE of woven fabrics with various content of SS blended yarns

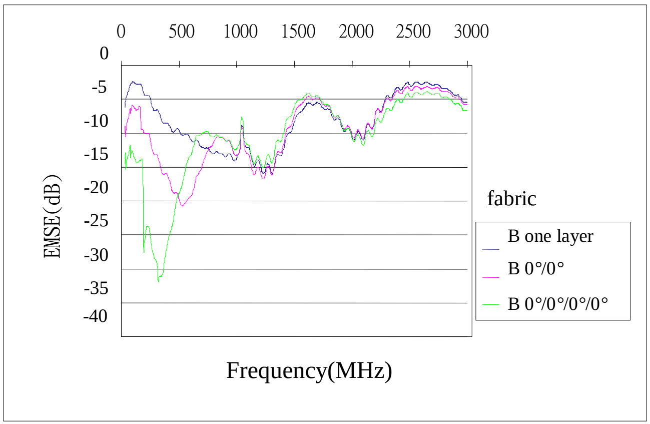

Figure 2. The influence of lamination number on the EMSE of the woven fabrics made of CVC 13.1 tex/SSF staple blended weft yarns. (Fabric B)

To sum up, Fabric B was CVC 13.1 tex woven fabrics of SS blended weft yarns, and stainless steel fibers arrayed unidirectionally inside the fabrics. When layers with the same lamination angle increased, the weft density increased. Because the wave length had an inverse ratio against frequency, the higher the bandwidth of electromagnetic wave was, the shorter its corresponding wave length was. Electromagnetic wave of high frequency can easily penetrate the slit of the EMSE materials. For Fabric D, which was woven by CVC/ SSF blended weft yarns and CVC/ SSF blended warp yarns. Fabric B, laminated crosswise, was woven by SS fibers, giving the resulting fabrics with holes between SS fibers. The more lamination number, the smaller the holes disturbed over the fabrics, resulting in higher EMSE on high frequencies.

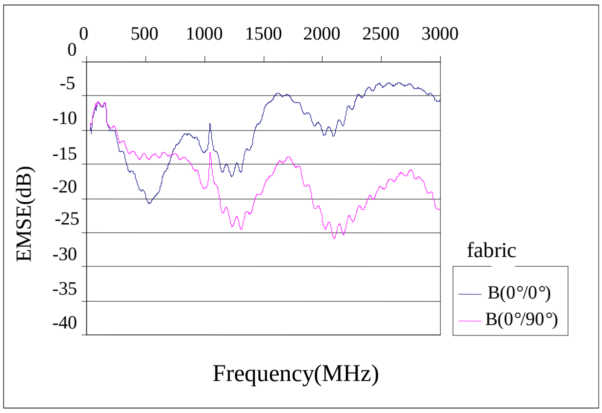

Figure 3. The comparison of the EMSE on two-layer fabric B with 0° and 90° laminating.

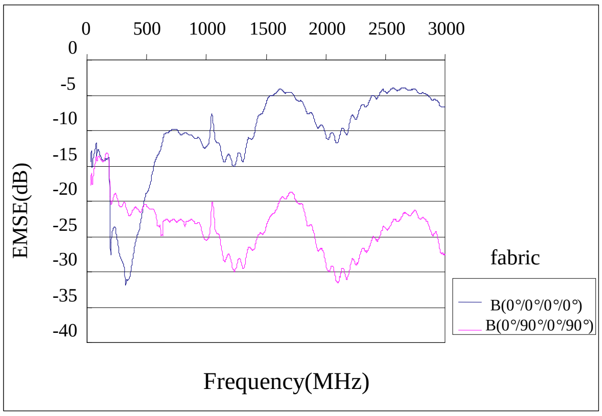

Figure 4. The comparison of the EMSE on four-layer fabric B with 0° and 90° laminating.

Conclusion

In this study, we fabricate the woven fabrics containing electromagnetic shielding effectiveness successfully. The fabrics contain different SS content by changing the weft density. When at 200 MHz to 500 MHz, woven fabrics demonstrated optimum EMSE which was also evidently interfered by lamination number, ie., the amount of SS fibers had an influence on EMSE. Meanwhile, the optimum EMSE of 32 dB was obtained from the 4-layer woven fabrics.

For woven fabrics, made of CVC/SSF blended warp and weft yarns, and woven fabrics, which was crossed with CVC/SSF blended weft yarns, obtained the optimum EMSE when the frequency was over 1000 MHz. However, Fabric D and Fabric B (0°/90°) had similar amount of SS blended yarns thus their EMSE performance were also similar. Finally, when lamination number of fabric B was increased from two layers to four layers, the EMSE increased 6 dB.

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