Modeling of a New Method for Metal Filaments Texturing

P. Peivandi[a]*, M. Latifi[b], J. Moghani[c]

[a] *Phd Student, Department of Textile Engineering, Amirkabir University of Technology*
[b] *Professor, Department of Textile Engineering, Amirkabir University of Technology*
[c] *Assistant Professor , Department of Electrical Engineering, Amirkabir University of Technology*

Abstract

In recent years, applications of conductive yarns in textile products are widely developed especially in electronic and smart clothing. Comfort of these products is very important. Metallic Filament yarns are generally required to be texturized to use in fabric structure and contribute in its comfort. In the present work a novel method, based on a rotational magnetic field, is introduced for texturizing metallic filament yarns. The electro-magnetical and mechanical operations of the method are modeled using different finite element techniques. The capability of the introduced method in displacing metallic filaments as much as required for interlacing them is successfully confirmed by models.

Keywords: Metallic Filament, Yarn, Texturizing, Modeling, Magnetic Field

Introduction

Electronic and smart clothing have attracted increasing attention in recent years [1]. The combinations of textile structures that are lightweight, flexible, conformable, and strong, with electronics have aroused keen interest from many disciplines. With technological innovations appearing in both textile and electronics, integration of these has started giving benefits. Innovations like electrical blankets and heating jacket [2], wearable electronics [2], textile based antennas [3], life-shirt [4], wearable music player [5], smart shirt [6-7], …

However, there are some general difficulties in creating conductive textiles for clothing. Textiles used for clothing have to be flexible and elastic in order to achieve a high comfort of wearing. Fabrics need to have a low resistance to bending and shearing so that they can be easily deformed and draped. These demands are inconsistent with the materials and geometries that are needed for an electrical conductivity. Metal, carbon and conductive polymers are quite rigid and brittle materials. Nevertheless, textile technologies have been developed to manufacture processable fibers and yarns out of these materials [8]. Methods of creating conductive threads are [9]:

- Filling of fibers with carbon or metal particles;
- Coating of fibers with conductive polymers or metal;
- Use of continuous fibers that are completely made of conductive material.

This work focuses on third way which is used to produce conductive filament fibers for electronic and smart textile applications. Texturizing is the common method to make filament yarn suitable for using in apparel. When filament yarns are texturized and woven or knitted into fabric, the finished fabric resembles a fabric made from spun yarns. However, all texturizing methods are to apply for polymeric filament yarns. Therefore, exploring a new method for texturizing conductive metallic filament yarns is considered.

2. Methodology

Regarding the conductivity of filaments and the effect of magnetic field on a wire with electrical current, it seems that the principle of an induction squirrel cage electro-machine can be used for interlacing metallic filaments.

2.1 Principle of induction squirrel cage electro-machine

Stator is the part of a motor that includes stationary portions of the magnetic circuit and associated windings and leads [10, 11]. Induction electromotor works by three phase power which makes rotational magnetic field in stator space. Three-phase power can be thought of as three different single-phase power supplies (A, B, and C Fig. 1). In the three-phase motor, each phase of the power supply is provided with its own set of poles, located directly across from each other on the stator, and offset equally from each of the other two phases' poles.

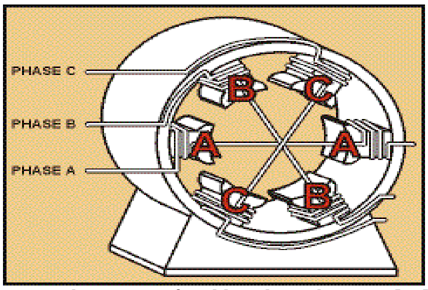

Fig. 1. Three Pairs of Field Coils on the Stator[12]

The three currents start at different times. Phase B starts 120° later than phase A and phase C starts 120° later than phase B. This is shown on the sine wave graph in Fig. 2, which indicates the way the magnetic field will point at various times in the cycle [12].

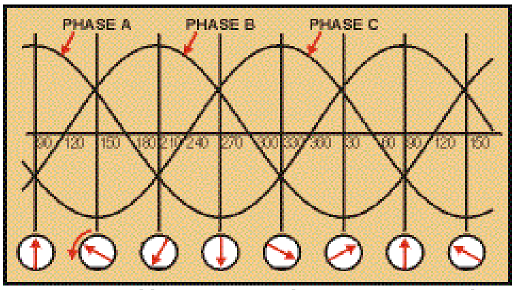

Fig. 2. Magnetic Field Rotation Providing Torque to Turn the Motor [12]

Introducing these different phase currents into three field coils 120° apart on the stator produces a rotating magnetic field (Fig. 2), and the magnetic poles are in constant rotation.

2.2 Applying the principle of induction squirrel cage electro-machine

In order to apply the same principle for interlacing metallic filaments, the squirrel cage rotor is replaced with a suggested filament feeding system (Fig. 3).

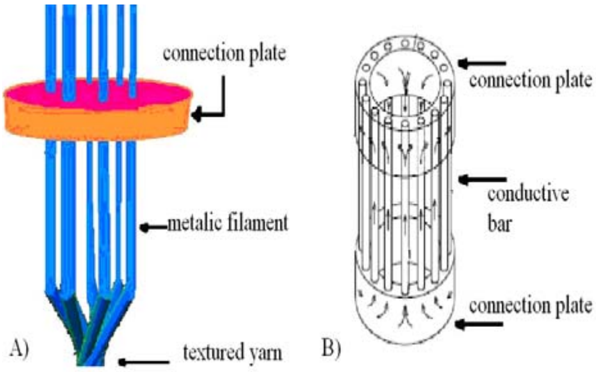

Fig. 3. A) Suggested filament feeding system B) Squirrel cage rotor

The texturing box contains the stator of the induction squirrel cage motor and the suggested filament feeding system (Fig. 4). The rotating magnetic field in the stator induces electric currents in the metallic filaments which are in texturing box space. Then, the induced currents set up their own magnetic fields in opposite to the magnetic field that caused the currents. The resulted attractions and repulsions provide torque to the metallic filaments. If the torque is strong enough, the overfed filaments will be moved and entangled with each other.

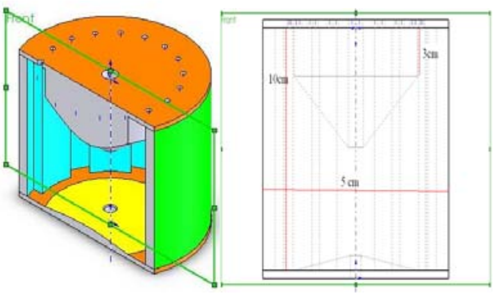
Fig. 4. Designed texturing box

3. Modeling

The mechanical and electrical properties of metallic filaments are illustrated in Table 1.

Table 1 metallic filaments properties

properties	
material	iron
permeability	2500
diameter	0.1mm
density	7.86 gr/cm^3
modules	200Gpa
Cross section	circular

3.1 Electro-magnetic modeling

The Opera 8.7 software is used for simulating the force of rotating magnetic field. As it is shown in Fig. 4 the space between filament and stator's inner wall and between filaments and the iron core are 0.1 mm. It is supposed that the stator has four poles and the current density in stator windings is equal to 3A/cm^2.

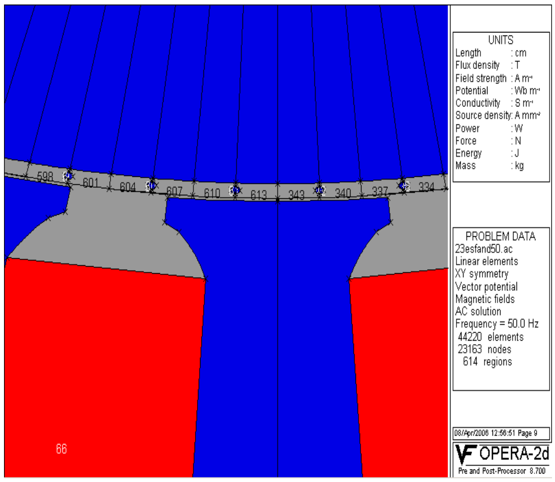

Fig. 4. Top view of texturing box

Fig. 5. shows that the flux density in metallic filament is up to 1.1 T which exerts 1.653 N.cm torque.

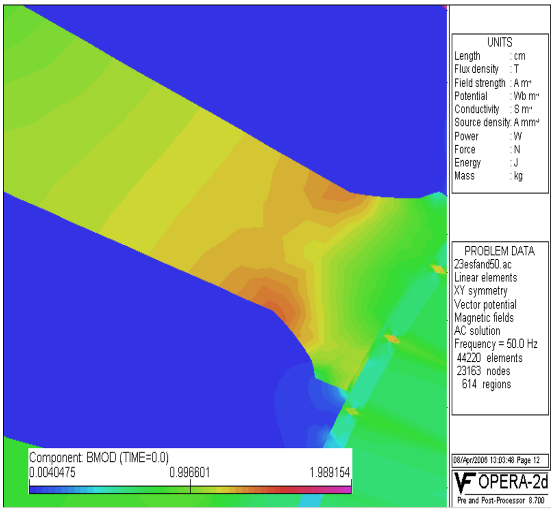

Fig. 5. Flux density caused by rotational magnetic field

3.2 mechanical modeling

The effect of magnetic field power on filaments is investigated by the mechanical model which is illustrated in Fig. 6.

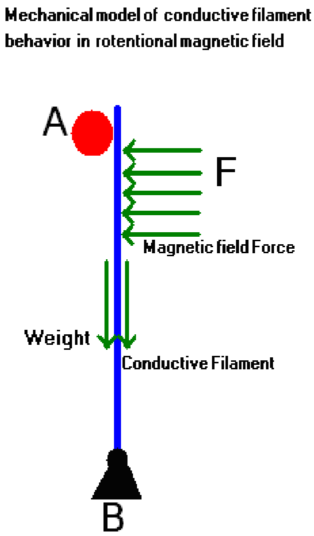

Fig. 6. Mechanical model of conductive filament in texturing box

The connection plate through which the filaments are feeding are modeled to work as a roller bearing in yarn forming zone.

Mechanical simulation is performed by Abacus 6.4 software (Fig. 7) to define the displacement of each filament.

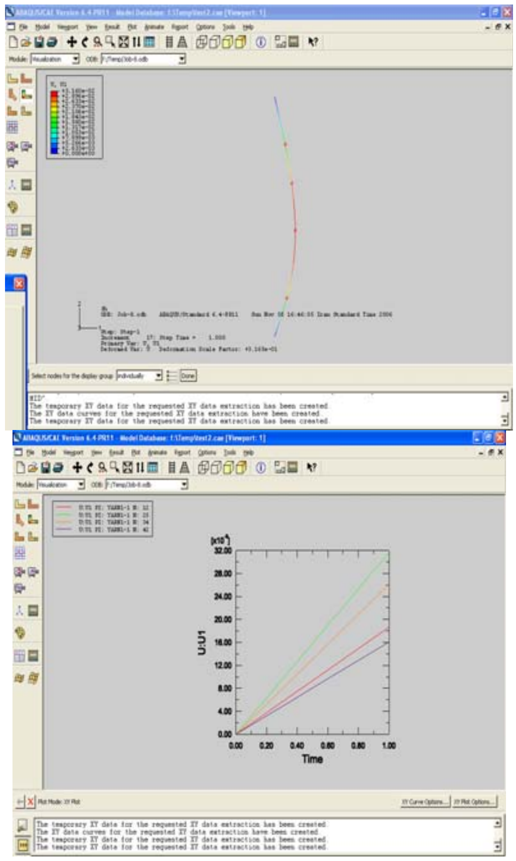

Fig. 7. The result of filament displacement cause of magnetic force

The model shows that 1.653 N.cm torque derived from rotational magnetic field displaces each metallic filament more than 3cm which seems to be enough for filaments entangling.

4. Conclusion

The mechanical and electrical modeling of the proposed method shows that it can be possible to apply it for metallic filament texturizing. The experimental work is being carried out to verify the result of the modeling part.

Reference:

[1] E. Ethridge, D. Urban, ElectroTextiles - Technology to Applications, Mat. Res. Soc. Symp. Proc. Vol. 736 © 2003 Materials Research Society

[2] K.Natarajan, A.Dhawan, A.M. Seyam, Electrotextiles – Present and Future, Mat. Res. Soc. Symp. Proc. Vol. 736 © 2003 Materials Research Society.

[3] J. Slade, J. Teverovsky, B. Farrell, J. Bowman, M. Agpaoa-Kraus, P. Wilson, Textile Based Antennas, Mat. Res. Soc. Symp. Proc. Vol. 736 © 2003 Materials Research Society

[4] F. Carpi, D. De Rossi, Electroactive Polymer-Based Devices for e-Textiles in Biomedicine, IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE, vol. 9, no. 3, September2005

[5] D. MARCULESCU, N. ZAMORA, Electronic Textiles: A Platform for Pervasive Computing, Preceding of the IEEE, vol. 91, No. 12, December 2003
[6] S. PARK, S. JAYARAMAN, Enhancing the Quality of Life Through Wearable Technology, IEEE ENGINEERING IN MEDICINE AND BIOLOGY MAGAZINE 0739-5175/03,2003IEEE May/June 2003
[7] F. Axisa, P. Schmitt, C. Gehin, Flexible Technologies and Smart Clothing for Citizen Medicine, Home Healthcare and Disease Prevention, IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE, vol. 9, No. 3, September 2005
[8] T.A. Skotheim, Handbook of Conducting Polymers,Publisher CRC; 2 edition (November 24, 1997) pp. 993–1013.
[9] D. Cottet, J. Grzyb, T. Kirstein, Electrical Characterization of Textile Transmission Lines, IEEE TRANSACTIONS ON ADVANCED PACKAGING, vol. 26, No. 2, May 2003
[10] A. Chiba, T. Fukao, O. Ichikawa, M. Oshima, M. Takemoto and G. Dorrell, Magnetic Bearings and Bearingless Drives, publisher: Elsevier, First published 2005,ISBN: 0 7506 5727 8
[11] Ed. Phillip A. Laplante, Electrical Engineering Dictionary, Boca Raton: CRC Press LLC, 2000
[12] http://www.eatonelectrical.com