(REFEREED RESEARCH)

PRODUCTION IN TWISTING MACHINE AND EXAMINING PHYSICAL AND THERMAL PROPERTIES OF TUNGSTEN WIRE REINFORCED COMPOSITE YARN

BÜKÜM MAKİNESİNDE TUNGSTEN TEL ÖZLÜ KOMPOZİT İPLİK ÜRETİMİ VE ÜRETİLEN KOMPOZİT İPLİĞİN FİZİKSEL VE ISIL ÖZELLİKLERİNİN İNCELENMESİ

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ABSTRACT

Production methods of metal wire reinforced composite yarn were investigated and tungsten wire reinforced composite yarn was produced in the twisting machine. In the literature, commonly copper, cromium/nickel, steel were used as core but tungsten wire was used in core of yarn differently in this study and nylon 6.6 yarns were used as sheath. Two 1400 dtex and one 2100 dtex %100 nylon 6.6 yarns were plied in the 'S' direction and produced plied yarn is wrapped around the tungsten wire in the 'Z' direction so especially voluminous sheath yarns were prefered to cover around the tungsten wire completely. Performance of produced tungsten wire reinforced composite yarn was tested by measuring yarn count, twist, and tensile properties. Also surface temperature of composite yarn was measured, depending on electrical current and compared with surface temperature of bare tungsten wire.

Keywords: Metal wire reinforced composite yarns, twisting machine, nylon 6.6, tungsten wire, thermal conductivity

ÖZET

Bu çalışmada; büküm makinesinde metal tel takviyeli kompozit iplik üretilmiştir. Merkezde literatürde sıklıkla kullanılan bakır, çelik, krom/nikel tellerin dışında tungsten teli kullanılmıştır. Manto lifi olarak Naylon 6.6 kullanılmıştır. Merkezde tungsten ve etrafına naylon 6.6 sarılmak suretiyle kompozit iplik elde edilmiştir. Isıtma amaçlı kullanılması hedeflendiği için telin maksimum seviyede kapatılması amacıyla ikisi 1400 dtex biri 2100 dtex olmak üzere üç ayrı Naylon 6.6 ipliği kullanılmıştır. Üretilen kompozit ipliğin performansı numara, büküm, kopma yükü ve kopma uzaması testleri yapılarak ölçülmüştür ve kademeli olarak akım verilerek elektriğe bağlı yüzey sıcaklık değerleri detaylı olarak incelenmiştir ve sonuçları analiz edilmiştir.

Anahtar Kelimeler: Metal tel takviyeli kompozit iplikler, Büküm makinesi, Naylon 6.6,Tungsten teli, Isıl iletkenlik

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1. INTRODUCTION

Today, used metal yarns that have low cost, are usually derived from pure soft metal and metal alloy. Copper, steel and aluminum are among the most commonly used metals. Metal fibers are used for decoration in home textiles. Stainless steel and copper, aluminum fibers were used in production of carpet and it was seen that static electricity and the risks of burns had reduced. It is also benefited from metal fibers in the automotive industry[1].

In the literature; there are two different metal yarn structures that are quite far from each other. First group of these yarns is produced in fancy yarn machine. These yarns are used in decorative and ornamental many different textile products [2,3]. Second group of metal yarns containing metal wire is used in electrically conductive textile structures for example; industry, military, space, and medicine for purposes of defense, protection, health, communication, or automation. Recently, these yarns are used for electromagnetic protection heating, antistatic applications and also they are utilized to fulfill different requirements in warning controllers, power transfer, sensors, transmitters and microcontrollers [4].

Many methods are used for the production of metal wire reinforced core spun yarn. These are productions of core spun yarn in modificated ring spinning machine, DREF III machine, Open-End rotor spinning machine, air-jet texturing machine, hollow spindle spinning machine and twisting machine. Bedeloglu et al. produced composite yarns by using rovings with different counts and different metal wires (stainless steel and copper wires) and measured yarn count, hairiness, and tensile properties. They focused on the easier yarn manufacturing technique by adding a small apparatus to the existing spinning machines in spinning mills. Effect of roving counts and types and thickness of metal wires were investigated in yarn structure[4]. Ramachandran et. al. produced copper reinforced composite yarms using copper wire as core and cotton fiber as sheath material in Dref-3 friction spinning system [5]. Ortlek et. al. investigated production of metal wire reinforced composite yarns using diffrent ring spinning methods. Ring, siro and compact spinning methods are used for production of yarns containing stainless steel as core [6].

Production of metal wire reinforced composite yarn in twisting machine is a relatively new method.

In this study; two methods as twisting and coating are used for production of tungsten reinforced composite yarn in twisting machine. In the twisting method; two or more yarns are plied together to obtain a new thread. In the coating method; one or more yarns are wrapped around one or more yarns in the center to obtain a new composite yarn.

In the literature, several studies related to production of metal wire reinforced yarns were investigated and copper, steel, aluminum were mostly used. In this study, differently , the tungsten wire is used in the core of yarn and also nylon 6,6 yarns are used as sheath yarn due to having a higher heat transmission coefficient than other textile fibers.

Tungsten flament is used in electrical heaters and lamps and melting point of tungsten is approximately 3000 ^{0}C [7]. It is also highly preferred in heater systems because of having a high heat transmission coefficient.

2. EXPERIMENTAL

Respectively thinness and electrical resistance of tungsten wire which was used in the core of composite yarn are 30 micron and 96 ohm (obtained from Cagdas Otomasyon ve Mühendislik Ltd).

Two different methods are used as twisting and coating for production of composite yarn in twisting machine [Figure 1]. Coating method is used to produce tungsten wire reinforced composite yarn.

Two 1400 dtex and one 2100 dtex %100 nylon 6.6 yarns were plied in the 'S' direction and produced plied yarn is wrapped around the tungsten wire in the 'Z' direction so especially voluminous sheath yarns were prefered to cover around the tungsten wire completely.

2.1. Plying of sheath yarns in the 'S' direction

Two 1400 dtex and one 2100 dtex %100 nylon 6.6 yarns were plied in the 'S' direction using Agteks 2C-10'' twisting machine (Figure 2). It is showed features of machine and production conditions in Table 1.

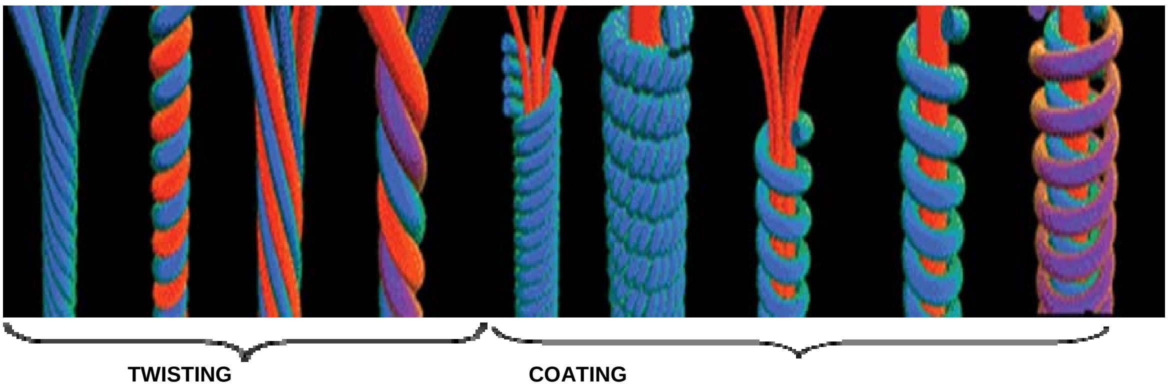

Figure 1. Produced yarns using twisting and coating methods [8]

Table 1. Features of machine and production conditions for combining of sheath yarns

Model of machine	Agteks 2C-10''
Direction of twist	S
Twist	150 T/m
Speed of machine	33.33 m/min.

Figure 2. Plying process of sheath yarns in Agteks 2C-10’’ twisting machine

2.2. Production of composite yarn giving twist in the ‘Z’ direction

Produced new plied thread was wrapped around tungsten wire in the core for production of composite yarn using Agteks 2D-6’’ twisting machine (Figure 3). It is showed features of used machine and production conditions on this stage in Table 2.

Table 2. Features of machine and production conditions for production of composite yarn

Model of machine	Agteks 2D-6’’
Direction of twist	Z
Twist	307 T/m
Speed of machine	11.40 m/min.

Figure 3. Production of composite yarn giving Z-twist

2.3. Tests on the tungsten reinforced composite yarn

Follow tests were made for determining physical, mechanic and electrical characteristics of produced composite yarn and forecasting performance of fabrics will be produced from this composite yarn.

- Determination of the count
- Determination of twist
- Breaking strength and elongation at break,
- Measurements of surface temperatures of tungsten reinforced composite yarn

2.3.1. Determination of the count

Numbers of yarns are identified using spinning wheel and Uster Autosorter 4 precision scales (according to TS 244 EN ISO 2060 standard).

Numbers of sheath yarns, produced tungsten wire reinforced composite yarn and tungsten wire are compared in Table 3.

Table 3. Counts of sheath yarns, produced tungsten wire reinforced composite yarn and tungsten wire

	Counts
Tungsten wire	30 micron
1. sheath yarn	1400 dtex
2. sheath yarn	1400 dtex
3. sheath yarn	2100 dtex
Tungsten wire reinforced composite yarn	1,06 Ne

2.3.2. Determination of the twist

First stage; twist range of combined new yarn giving S twist is 150 T/m and second stage; twist range of produced tungsten wire reinforced composite yarn giving Z twist is 307 T/m.

2.3.3. Strength tests

Strength tests were made using Prowhite-PMT-08-B2 device (accordings to TS 245 EN ISO 2062 standard). 10 measurements were made for tungsten reinforced composite yarn and bare tungsten wire separately. Breaking force and elongation (%) at break of yarn were measured and tensile strength values of produced yarns was calculated after all measurements were done by using breaking load (cN) and yarn count (tex) values.

It is showed tensile properties of bare tungsten wire in table 4.

It is showed tensile properties of tungsten/nylon 6.6 composite yarn in table 5.

Tablo 4. Tensile properties of bare tungsten wire

Tungsten Wire			
Test No	**Breaking force (cN)**	**Elongation at break (%)**	**Tensile Strength (cN/tex)**
1	251	1	6,12
2	195	1	4,75
3	123	1	3
4	247	2	6,02
5	245	1	5,97
6	244	2	5,95
7	247	2	6,02
8	254	2	6,19
9	248	2	6,04
10	253	2	6,17
Mean value	230,7	1,6	5,62
Standart Deviation	41,6	0,5	1,01

Tablo 5. Tensile properties of tungsten/nylon 6.6 composite yarn

Tungsten/nylon 6.6 composite yarn			
Test No	**Breaking force (cN)**	**Elongation at break (%)**	**Tensile Strength (cN/tex)**
1	33912	21	60,92
2	34824	25	62,56
3	37097	26	66,64
4	37445	25	67,27
5	36318	26	65,24
6	36101	25	64,85
7	35394	25	63,58
8	33047	26	59,37
9	36280	29	65,18
10	29117	18	52,31
Mean value	34954	24,6	62,79
Standart Deviation	2466	3,02	4,43

2.3.4. Measurements of surface temperatures of tungsten reinforced composite yarn

Surface temperatures of produced tungsten wire reinforced composite yarn and bare tungsten wire were measured gradually giving voltage and current (Figure 4). Totally 10 measurements were made and each measurement time was 3 minutes.

The electrical current was given to composite yarns and bare tungsten wire from TT-Technic RXN-303D power supply (30 voltage, 5 ampere).

Voltage and current values of electronic fabric circuit were measured using AC current 2 mA/200 mA/ 20 A and AC voltage 2V/20V/200V/750V multimeter.

Surface temperature of composite yarn was measured using Testo 922 two-channel thermometer. Thermocouples working with seebeck principle are used for measurement of surface temperature of composite yarn.

All tests were made 20^{0}C ambient temperature.

Measurement results of surface temperatures of bare tungsten wire are shown in Table 6.

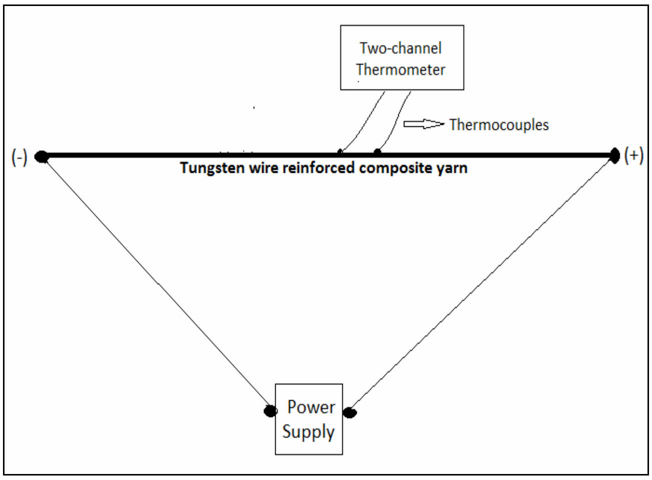

Figure 4. Measurement of surface temperature of tungsten reinforced composite yarn

Measurement results of surface temperatures of tungsten/ nylon 6.6 composite yarn are shown in Table 7.

Tablo 6. Measurement results of surface temperatures of bare tungsten wire

Test No	Voltage (V)	Current (A)	Surface temperatures (^{0}C)
1	3	0.04	31.2
2	6	0.07	33.2
3	9	0,11	36.5
4	12	0.14	41
5	15	0.16	45.2
6	18	0.18	50.2
7	21	0.20	52.2
8	24	0.22	63.5
9	27	0.24	67.4
10	30	0.25	70.5

Tablo 7. Measurement results of surface temperatures of tungsten/ nylon 6.6 composite yarn

Test No	Voltage (V)	Current (A)	Surface temperatures (^{0}C)
1	3	0.03	30.6
2	6	0.06	30.9
3	9	0.08	31.7
4	12	0.11	33.4
5	15	0.13	36.1
6	18	0.15	38.4
7	21	0.17	41
8	24	0.19	43.9
9	27	0.21	46.9
10	30	0.22	49.4

3.RESULTS AND DISCUSSION

It is shown that change of surface temperatures depending on given voltage and current for bare tungsten wire in figure 5 and 6. It is observed that surface temperatures of bare tungsten wire are increased directly when voltage and current are increased. Surface temperature of bare tungsten wire is 70.5 ^{0}C and the current is 0,25 A when given voltage is 30 V.

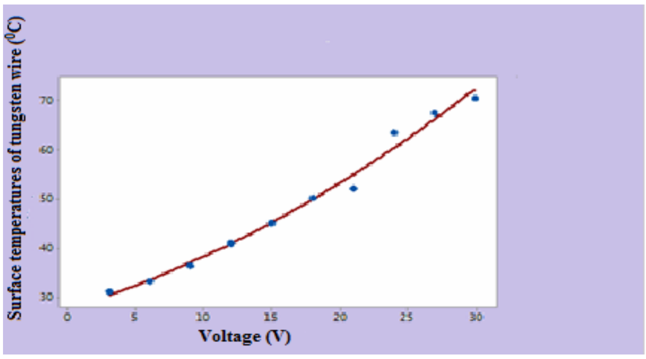

Figure 5. Change of surface temperatures depend on voltage for bare tungsten wire

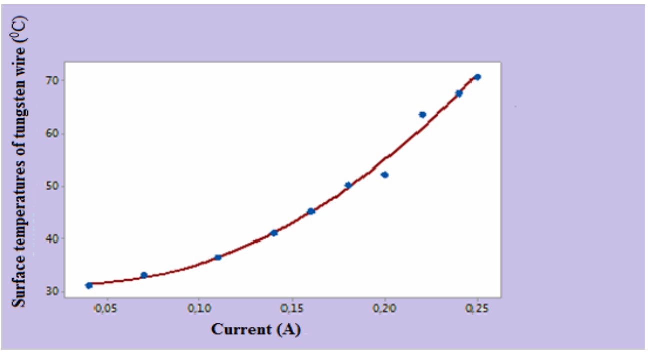

Figure 6. Change of surface temperatures depend on the current for bare tungsten wire

It is shown that change of surface temperatures depend on the voltage and current for tungsten reinforced composite yarn in figure 7 and 8. It is observed that surface temperatures of tungsten/nylon 6.6 composite yarn were increased directly when the voltage and current are increased. Surface temperature of composite yarn is 49.4 ^{0}C, the current is 0,22 A when the voltage is 30 V.

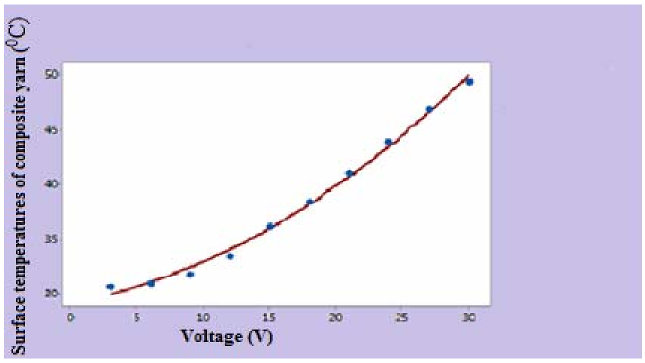

Figure 7. Change of surface temperatures depend on voltage for tungsten/nylon 6.6 composite yarn

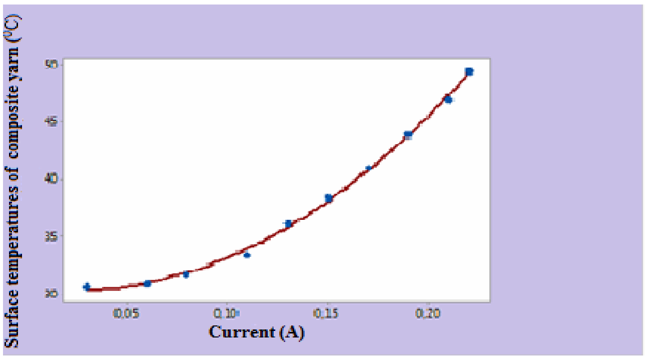

Figure 8. Change of surface temperatures depend on the current for tungsten/nylon 6.6 composite yarn

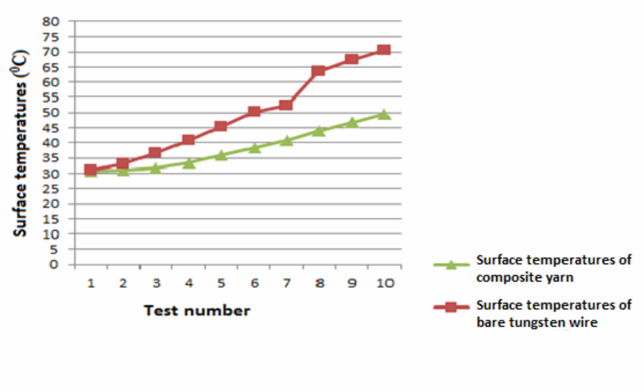

Figure 9. Comparison of surface temperature changes between the bare tungsten wire and composite yarn.

Figure 9 is shown comparison of surface temperature changes between the bare tungsten wire and composite yarn. It is seen that there are differences between surface temperatures of bare tungsten wire and tungsten reinforced composite yarn. Surface temperatures of composite yarn decrease according to bare tungsten wire when the same voltage and current is given. But both curves continued to increase separately when voltage and current are increased. It is observed that the surface temperature of composite yarn reached over 40 ^{0}C.

Spread of heat from tungsten wire reinforced yarn takes time due to the use of 3 different sheath yarn to cover the tungsten wire. It is needed to idealize fineness of used sheath yarns and the number of fibers in cross-section of sheath yarns to solve this problem.

4. CONCLUSIONS

Metal wire reinforced composite yarn was produced in twisting machine. Tungsten wire was used in core of yarn in this study and nylon 6.6 yarns were used as sheath of composite yarn. Produced composite yarn will be used for heating so three nylon 6.6 yarns were used to cover tungsten wire completely. The count, twist, breaking force and elongation at break and surface temperatures of produced composite yarn were measured and test results are analyzed.

When tensile properties of the composite yarn were examined, it is seen that breaking force and elongation at break of tungsten reinforced composite yarn significantly have been increased according to bare tungsten wire. Tungsten wire used in core of yarn and three nylon 6.6 yarns used sheath of yarn were increased strength of produced composite yarn and were caused to increase its thickness.

Compared to copper and steel reinforced composite yarns in the literature; tungsten reinforced composite yarn has a higher elongation at break and tensile values because of the high tensile properties of tungsten.

Although the heat transfer coefficient of tungsten wire is lower than copper and steel wires, heating performance is better due to its high melting temperature (approximately 3000 ^{0}C).

When measurements of surface temperatures were examined, it was observed that surface temperatures of produced composite yarn were lower than bare tungsten wire,but it was reached above target surface temperature of 40 ^{0}C.

According to all results, produced tungsten reinforced composite yarn can be utilized to add flexibility to heating systems. For example; it can be used in production of textile based heater wallpaper, heater curtain.

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