THE ELECTRICAL PROPERTIES OF STAPLE FIBERS AND YARNS DESTINE FOR FLAT KNITTED FABRIC

Iwona NIEWIADOMSKA, Krystyna PRZYBYŁ
Technical University of Lodz, Poland, Department of Spining Technology
St. Żeromskiego 116, 90–924 Łódź, Poland, tel./fax; 042 631 33 32,
e-mail: niewiadomska.iw@interia.pl, s-k44-1@adm.p.lodz.pl

Abstract
On the market are available different kind of electroconductive yarns, but they are mixed with natural or synthetic fibers. Thus the main aim of this paper is created the electrocoductive yarns from 100% electroconductive staples fibers. The yarn made from staple PAN fibers with copper sulfide particles. As a technological production system was used open end cotton system with rotor spinning machines. The knitted fabric is a finishing electroconductive product, made from created yarn. The volume and surface resistance measurement value ware also present in this paper.
Key words: fibers, yarns, electroconductive, parameters

1. Introduction

Nowaday in textile industry, multifunctional textiles are important market target. During typical industrial process based on material enginieering knowledge textiles get specjals propierties f.e. conductivity properties. It manufactures electroconductive fibers with different electroconductive particles. Multifilaments fibers are the best to special applications, but it is hard to find fibers with homogenous electroconductive property. Therefore authors focused on yarns from staple electroconductive fibers, which can be created from different kind of mixed fibers which obtained uniform elektrokonductive and mechanical properties. Thus they focused in this paper on created yarns from 100% staple electroconductive PAN fibers and flat knitted fabric. Their also measured mechanical and electrical properies of yarns anfd flat product.

2. The aim and area of research

The aim of the paper is check the possibility of creation yarns from 100 % PAN staple fibers which can be used in knitted process. In this paper presented quality model of fibers resistance measurement the value of technological and electrical parameters of fibers, the quality model of electroconductive yarn measurement, the metrological and electrical yarn properties. It created knitted fabric from electroconductive yarn and assessed its properties to knitting process. It is also presents receive results of surface and volume resistance.

3. The quality measurement model of fibers resistance

The quality fibers resistance measurement model and present in figure 1[2]. In this model take into consideration: ***RM*** **–** material of fibers, ambient conditions: ***T*** **-** temperature and ***H*** **–** relative humidity, ***d*** **–** geometrical dimentions and ***F*** **–** force of elcetodes pressure. This model can be described by equation (1) and shown in figure 1 [2].

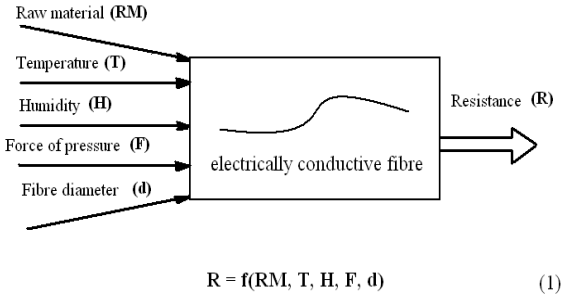


Fig.1. Qualitative model of measuring the resistance of an individual fibre and equation (1) describing this model. *Source:* [2]

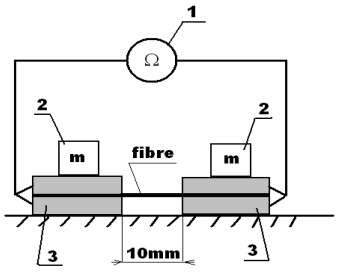


Fig.2. A simplified diagram of a measuring device. **1**- measuring device *Agillent 6.5 digits;* **2** – weights on electrodes **m = 10 g,** **3** – electrodes (brass)

Based on this model, we can make the assumption that fibers resistance depends on materials and geometrical dimensions, on constant ambient temperature and relative humidity and pressure force.

To research was used mix of fibers, consist of four kind of PAN electroconductive fibers with different resistance. The level of resistance is an effect of different quantity of copper sulfide. The simplification scheme of resistance measurement device of single fibers, present in figure 2. The resistance measurement ware made for 10 mm length. It was used copper electrodes (figure 2). It was put two weights m = 10 g, to the measurement electrodes for improve the contact. Agillent 6,5 digits was used as a recording devices.

4. The research of fibers electrical and mechanical properties

The measurement value of resistance and physical fibers parameters, present in table 1. The parameters of this fibers allow to used it in spinning process.

Table 1. Metrological parameters and resistance of fibers [3-5]

Lp.	Parameter	Symbol	Unit	Kind of fibers PAN			
				A	B	C	D
1.	**Resistance**	**R**	**MΩ/cm**	**0,188**	**0,654**	**3,518**	**1,773**
	Standard deviation	s	MΩ/cm	0,6	2,9	4,5	3,2
	Coeff. of variation	v	%	3,19	4,43	1,28	1,80
2.	Linear density	Tt	dtex	3,48	3,95	3,71	4,64
	Standard deviation	s	dtex	0,03	0,05	0,05	0,1
	Coeff. of variation	v	%	8,25	11,84	12,4	20,1
3.	Modal lenght	L_m	mm	56,14	57,01	56,84	56,32
	Mean lenght	L	mm	55,76	57,05	56,88	52,70
	Standard deviation	s	mm	5,18	8,11	4,24	11,94
	Coeff. of variation	v	%	9,29	14,21	7,46	22,65
4.	Breaking force	F_r,	cN	9,6	8	9,6	10
	Breaking tenacity	W_w	cN/tex	27,6	20,2	26,3	21,6
	Standard deviation	s	cN	13,68	18,62	11,97	11,22
	Coeff. of variation	v_F	%	22,8	29,6	15,5	14,4
	Elongation at break	$L_{śr.w}$,	mm	26,44	25,42	31,9	34
	Standard deviation	s	mm	1,40	1,54	1,05	3,69
	Coeff. of variation	v_L	%	26,5	30,4	16,5	54,2

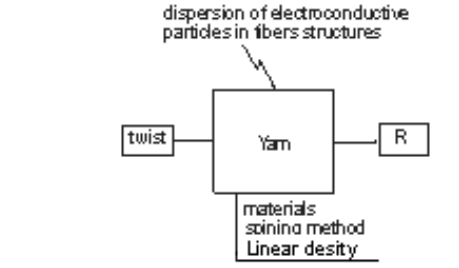
5. The yarns technology

The initial research of basic fibers parameters show possibility of using spinning cotton system to yarns production with rotor spinning machines. In this machine mixing process of

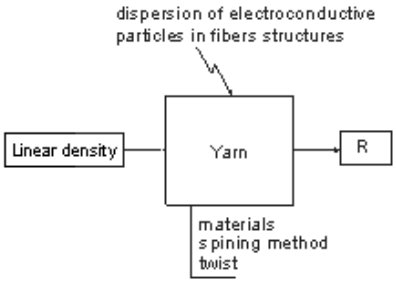
fibers conducted very intensives. Thus this rotor spinning system is prefer to created yarns from mixing fibers with different properties [9].

6. The quality model of yarns resistance measurement

In next part of the paper is present quality model of yarn resistance measurement. The scheme of quality measurement model present in figure 3A and 3B. The first model type A, shows the influence of twist on resistance, on constant yarn linear density. Second model type B, shows the influence of linear density on resistance, on constant yarn twist. These models can help to analyzing the chosen technological parameters influence on yarns resistance.



A)



B)

Fig. 3. The quality model of resistance measurement,
(A) resistance depending on twist,
(B) resistance depending on yarns linear density

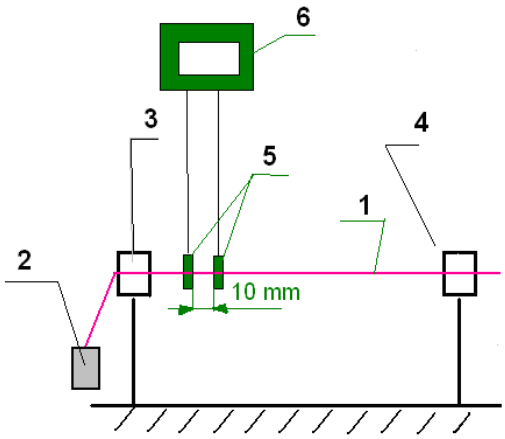


Fig. 4. The scheme of a measuring device,
1 - yarn, **2** - load, **3, 4**- clamps, **5** - measurement probes,
6 – recording devices, multimeter

7. The yarn parameters

The mechanical and technological rotor yarn parameters are present in table 2. The presented mechanical coefficient counted based on polish norm [6-8].

Table 2. Resistance, mechanical and technological basic parameters of rotor yarn [6-8]

Lp.	Parameter	Symbol	Unit	Value
1.	**Resistance**	**R**	**MΩ/cm**	**1,46**
	Standard deviation	s	MΩ/cm	0,04
	Coefficient of variation	v	%	3
2.	Linear density	Tt	tex	40
3.	Twist	T	T/m	723,90
	Standard deviation	s	T/m	31.06
	Coefficient of variation	v	%	4.29
	Twist factor	α_{Tt}	----	144.78
4.	Breaking force	F	cN	329.73
	Breaking tenacity	$F_{wł.}$	cN/tex	8.24
	Standard deviation	s	cN	50.34
	Coefficient of variation	v	%	15.27
	Breaking elongation	$W_{zryw.}$	%	11.03
	Standard deviation	s	%	2.67
	Faktor of coefficient	v	%	24.23

The scheme of yarn resistance measurement device, present in figure 4. The yarn stretched between to mechanical clamps. To the measurement used self catching measurement probes. The probes ware situated 10 mm between each other. To the measurement used Agillent multimeter.

8. The flat knitted sample

From electroconductive yarn manufaktured knitted flat samples using simple left-right stitches. The volume and surface resistance value of this kind of fabric ware measured. The resevied value results presented in table 3. The measurement ware done using Keithley 8009 Resitivity Test Fixture [10], which is an equipment of ProHumanoTex laboratory. The current (A) and voltage (V) ware automatically calibrated during the measurement by resistance test meter equipment.

Table 3. Volume and surface resistance of knitted fabric [10]

Lp.	Parameter	Conditions of measurement	Symbol	Unit	Value
1.	**Volume resistance**	U=39,92V, A=0,0337mA	**R_s**	**MΩ/cm**	**230**
	Standard deviation		s	MΩ/cm	5
	Coefficient of variation		v	%	1,95
2.	**Surface resistance**	U=0,067V, A=0,0001mA	**R_p**	**MΩ·cm^2**	**1,47·10^3**
	Standard deviation		s	MΩ·cm^2	9·10^3
	Coefficient of variation		v	%	6,01

9. Conclusions

Analyzing the received measurement results of volume and surface resistance, authors found that is possibility of created yarns from 100% staple electroconductive fibers. This yarns can be useful for knitted process. The surface and volume resistance value of created fabric, suggest that it can be used as a materials to carrying away of electrical charge. They can be used in to protective clothing construction f.e. gloves for electrician services. The biggest influence on electrical properties of spinning product has got dispersion of electroconductive agent in fiber structures. This phenomenon influence on electroconductive properties of yarns and knitted product. This subjects need detailed research.

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