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PREDICTING THE NEP NUMBER IN COTTON RING – SPUN YARN USING THE COEFFICIENT OF NEP AND TRASH VISIBILITY

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Abstract

The presence of neps in a yarn is not a positive phenomenon from the point of view of yarn quality. The presence of a nep not only decreases the yarn and fabric appearance, but also makes the further stages of processing, (process of warp preparation, weaving and knitting) difficult.

Assuming as follows:

- each cotton yarn linear density corresponds to the critical nep size, i.e., such size, beyond which nep or trash particles in the roving are identified and registered by the Uster tester as yarn neps,
- percentage distribution of nep size in the roving is similar for all rovings produced by the same spinning system (carded and combed),

we propose a coefficient of the nep and trash visibility η. This parameter describes the nep and trash number in the roving, which are transferred into the ring-spun yarn, and they are identified by the Uster Tester as yarn faults at device settings of sensitivity +200%.

Based on the laboratory measurements of a large amount of cotton rovings producing yarns, we determined the coefficient of the nep and trash visibility η for a different assortment of neps and trashes. This coefficient allows the assessment of the predicted nep number per 1000 m of ring – spun yarn according to the Uster tester.

Introduction

Neps occurring in a cotton yarn is not a positive phenomenon from the point of view of yarn quality. The nep presence not only decreases a yarn appearance, but also makes further stages of processing (processes of warp preparation, weaving or knitting) difficult.

The presence of neps in a cotton yarn also influences the aesthetics of fabrics produced from this yarn such as smoothness, surface appearance and dye evenness [Clegg G. G., Harland S. C. 1923, Goldtwait C. F., Wites R. L, Van Sales V. R. 1996, Marth Ch. T., Arthur H. E., Berkley E. E. 1952, Ravandi S., A., Naebe M., Amivshahi H. 2001]. Taking the above into consideration, the nep problem - its phenomenon, reasons and possibilities of limiting the nep presence in the yarn and fabric - is a subject of research of many scientists [Peters G. 1993, Frydrych I., Matusiak M. 1999, Furter R., Frey M. 1991, Alan G., Alexander E. 1978]. Studies have been carried out to limit nep formation in different stages of processing, starting from harvesting and ginning, through sliver and roving preparation, and finishing in the spinning process.

Trials are also undertaken to find a method of predicting the nep number in the yarn based on the nep characteristics of raw materials used for production that have been undertaken.

For the nep number assessment in cotton yarn, the Uster tester is commonly used. According to standardized procedure [Polish Standard PN - 76/P - 04804, 1976], the nep number in yarn is determined at the sensitivity adjusted to: +200% - for the ring-spun yarn, and +280% - for OE yarn. This means that as neps in the yarn are registered, only these neps and trash particles come into yarn, the size of which is large.

The nep size, beyond which it is identified and registered by the Uster tester as a yarn nep, is called the critical nep size [Färber Ch. 1996]. Each yarn linear density corresponds to a different critical nep size. Critical nep size values for the ring-spun and rotor yarns of different linear densities were determined experimentally [Peters G. 1993, Färber Ch. 1996]. Moreover, a theoretical relationship of the critical nep size as a function of yarn linear density allowing the calculation of the critical nep size for any linear density of rotor and ring-spun carded yarn was elaborated [Frydrych I., Matusiak M. 2002].

For rotor yarns, Färber [Färber Ch. 1996], the introduction of a nep and trash transfer coefficient, ϕ, from the sliver feeding the rotor spinning frame into the yarn is proposed. Moreover, the values of ϕ parameter for rotor yarns of chosen linear densities were experimentally determined. The experimentally determined values of ϕ parameter by Färber can have an application limited to the conditions of one spinning mill. Moreover, the values of coefficient ϕ should be checked periodically and corrected.

During the rotor spinning process, the removal of neps and trash included in the feeding sliver has place. Therefore, the nep and trash number in the fiber stream accumulating on the rotor circumference is different than the nep and trash number in the feeding sliver. Trash contained in a sliver is removed by 50% - 80%, whereas neps – by 30% [Frydrych I., M. Matusiak M. 2002].

The authors carried out investigations [Frydrych I., M. Matusiak M. 2002] that showed that there are significant differences in nep and trash removal efficiency by the particular opening rollers for one spinning frame.

The nep and trash number, which are removed from the sliver feeding the rotor spinning frame, depends on many other factors like: the technical shape, a degree of utility of opening roller covering, the kind of this covering, machine adjustment, among the others, value of underpressure, rotary speed of opening roller and so on [Frydrych I., M. Matusiak M. 2002].

The other situation is in the case of classical spinning. During the ring-spun yarn formation there is no removal of neps and trash contained in the roving feeding the ring spinning frame. Almost all trash and neps from the roving go into the yarn and thus can be the nep source.

In fact, if the nep arising from the roving is identified and registered by the Uster tester as a yarn nep, only its size is decided. Taking the above into consideration, the nep and trash transfer coefficient application for the ring – spun yarn neppiness prediction seems to be justified more than for the rotor yarns.

The Coefficient of Nep and Trash Visibility in the Ring-Spun Cotton Yarn

Before continuing the further considerations, we should think about the adequacy of the proposed and used ϕ parameter.

In the case of rotor spinning, the ϕ parameter reflects the nep and trash number, which after coming through an opening roller acting zone go into the yarn formed in the rotor, and are registered as yarn neps. As was mentioned earlier, this parameter was called "the parameter of nep and trash transfer". In reality, the parameter ϕ does not describe the transfer phenomenon in a direct meaning. It simply does not reflect the whole nep and trash number, which are transferred into the yarn, but only the part of them, of which the size is higher than the critical nep size for a given yarn linear density.

In the case of classical spinning, the transfer parameter is not adequate because, in the same process, almost all the neps and trash contained in the roving are transferred into the yarn. Therefore, treating the existing parameter directly, the value of ϕ parameter in each case should be equal to 1, independently on the produced yarn linear density.

In reality, the described parameter expresses the share of neps and trash, which are visible in the yarn, of the total number of neps & trashes contained in the roving, from which the yarn is produced.

Taking the above into account, more adequate for the ring-spinning system seems to be the parameter "coefficient of the nep and trash visibility". The value of this coefficient depends on two factors:

- the ring-spun yarn linear density, which determines the critical nep size,
- the nep and trash size distribution in the roving.

Influence of the yarn linear density on the value of this parameter deals with the yarn neppiness measurement principle. The higher the yarn linear density, the bigger the critical nep size, i.e., such a size, beyond which the particle (of nep or trash) being in the fiber stream is seen as a yarn nep. The relationship between the ring-spun yarn linear density and a critical nep size is presented below:

$$D_{ncrit}[mm] = 0.107 \cdot Tt_p^{0.663} \quad (1)$$

where:

Tt_p - yarn linear density,
D_{ncrit} - critical nep size for a ring-spun yarn.

The second important factor influencing the value of the described coefficient is the nep and trash size distribution in the roving. This distribution decides which part of neps and trash is transferred into the yarn will be beyond the critical value, and at the same time will be visible on the yarn surface as a nep.

In Figure 1, there is a distribution of nep size in the roving described by the survival function. The graph is prepared on the basis of results of AFIS measurements of 20 samples of cotton rovings produced by the carded system in different Polish spinning mills.

On the basis of the presented data in the figure, it can be stated that the percentage distribution of nep size in the roving is similar for different roving samples produced by the same spinning system (in this case – carded one). The distribution of values of trash particle size in the roving looks different. Research showed also that this distribution is random, so the particle share of size higher than the critical one is difficult for predicting. Nevertheless, in practice, trash influences the yarn nep number much less than neps. In the sliver after combing there are usually single particles of size in the range 50-500 μm; whereas in the sliver after carding there are a few or a dozen of trash particles in a majority of a size below 800 μm. Therefore, the trash number of size beyond the determined critical value can be, in many cases, neglected.

Determination of the Coefficient of Nep as well as Nep and Trash Visibility for Ring-Spun Yarns

Assuming the considerations are correct and assuming that:

- each ring-spun yarn linear density corresponds to the determined critical nep size, i.e., such a size beyond which the nep in the roving is identified and registered as the yarn nep,
- the distribution of neps in roving dependently on their size is the same for all rovings produced by the same spinning system (carded or combed),

we can assume that in an analogous way for the rotor yarn each linear density of ring-spun yarn can correspond to the coefficient describing the nep and trash number in the roving. These are visible on the surface of ring-spun yarn and are identified by the Uster tester as the yarn neps at an adjustment of system sensitivity +200%. For distinguishing the nep and trash transfer coefficient used for rotor yarn the coefficient of the nep and trash visibility in the ring-spun yarn is designed by the symbol η.

$$\eta = \frac{N_g}{N_{rov} + T_{rov}} \tag{2}$$

where:

N_g - the nep number per 1 g of yarn,
N_{rov} - the nep number per 1 g of roving,
T_{rov} - the number of trash particles per 1 g of roving.

We also proposed a simplified form of coefficient η_1 taking into account only the nep number, without the number of trash particles:

$$\eta_1 = \frac{N_g}{N_{rov}} \tag{3}$$

where:

N_g - the nep number per 1g of yarn,
N_{rov} - the nep number per 1g of roving.

Based on the results of laboratory measurements of a large number of cotton roving samples and ring-spun yarns produced from these rovings, the nep visibility η_1 and nep and trash visibility η were determined. Next, the values of η and η_1 were calculated for typical linear densities of ring-spun yarns as mean values of results obtained for particular samples of a given assortment. The obtained results are presented in Table 1.

On the basis of the presented results, it was stated that there is a deviation of parameter η & η_1 values for the particular linear densities of ring-spun yarn. The single results for the same yarn assortment, i.e., the same linear density, differ from the others, as well as from the mean value of this parameter for a given yarn assortment. The noted deviation can be caused by the variance of measured features, i.e., nep number in the unit of roving mass and the nep number per 1000 m of yarn. It can also result from the preciseness of nep measurement on the AFIS system and Uster tester.

Examining a large amount of roving samples, showed that in the case of nep assessment, a difference between the maximum and minimum values was noted in the successive repetitions for the same roving sample, can range from 20 - 30 neps /gram.

Also the nep number per 1000m of the cotton ring-spun yarn produced from the same roving, but on different spindles can differ depending on yarn linear density by a few dozen neps per 1000 m or even more than 100 neps per 1000 m of yarn. The above statement proves the stated deviation of η and η_1 parameters.

The parameters of nep or nep and trash visibility in a ring-spun yarn linear density is presented in Figure 2.

The determined coefficients of nep and trash visibility allow for the evaluation of the predicted nep number per 1000 m of ring – spun yarn according to the Uster tester from the given formula:

$$N_{1000} = (N_{rov} + T_{rov}) \cdot \eta \cdot Tt_y \tag{4}$$

or

$$N_{1000} = N_{rov} \cdot \eta_1 \cdot Tt_y \tag{5}$$

where:
- N_{1000} – the nep number per 1000 m of yarn according to the Uster tester,
- η – parameter of nep & trash visibility in the ring-spun yarn,
- η_1- parameter of nep visibility in the ring-spun yarn,
- Tt_y – yarn linear density,
- N_{rov} – the nep number per 1 g of roving,
- T_{rov} – the number of trash particles per 1 g of roving.

The proposed equations enable the calculation of predicted nep number per 1000 m of ring-spun cotton yarn based on the determined nep and trash content in the roving.

It is not possible to determine the parameters which would enable prediction of the nep number per 1000 m of yarn directly on the basis of raw material neppiness. It is caused by the fact that during the technological process in the spinning mill, starting with the raw material and finishing with the roving, changes of the number and size of neps and trash in cotton take place. These changes are not constant, but depend on many factors dealt with in the processing conditions.

Simultaneously, we should be conscious that using the proposed method we can predict the nep number per 1000 m of yarn with a certain approximation. The results depend significantly on the yarn unevenness. Nevertheless, the further research tending to the increase of precision of the predicted nep number in yarn is necessary.

Summing Up

On the basis of carried out research the following was stated:

- Each linear density of cotton ring-spun yarn corresponds to the value, which reflects a percentage of neps & trash in the roving, size of, which is big enough to be visible on the yarn surface as a nep. This value is called a coefficient of nep & trash visibility.
- The coefficient of nep & trash visibility η can be used for predicting the nep number per 1000 m of ring-spun yarn based on the known nep & trash percentage in the roving used for the yarn production.
- It is not possible the determination of parameters, which would enable predicting the nep number per 1000 m of yarn directly on the basis of raw material neppiness & trash content.
- The proposed method enables an estimation of predicted nep number in the cotton ring-spun yarn. There is a need of continuation of research on improving the predicting preciseness.

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Table 1. The values of nep as well as nep and trash visibility in the ring-spun yarn.

	Yarn			**Roving**				
Spindle	**Tt_p [tex]**	**N_{1000}**	**N_g**	**Nep Cnt/g**	**Trash Cnt/g**	**Nep +Trash**	**η**	**η_1**
spindle111	15	1068	71,2	131	10	141	0,50	0,54
spindle201	15	1355	90,3	152	12	164	0,55	0,59
spindle284	15	1622	108,1	135	11	146	0,74	0,80
spindle364	15	1263	84,2	129	11	140	0,60	0,65
spindle424	15	917	61,1	128	13	141	0,43	0,48
	Mean						**0,57**	**0,61**
	S						**0,115**	**0,123**
	Min						**0,43**	**0,48**
	Max						**0,74**	**0,80**
spindle 46	20	718	35,9	138	12	150	0,24	0,26
spindle114	20	1243	62,2	150	14	164	0,38	0,41
spindle226	20	1216	60,8	134	8	142	0,43	0,45
spindle316	20	720	36,0	134	11	145	0,25	0,27
spindle441	20	798	39,9	125	11	136	0,29	0,32
spindle241	20	700	35,0	111	11	122	0,29	0,32
spindle242	20	707	35,4	91	9	100	0,35	0,39
spindle243	20	672	33,6	104	10	114	0,29	0,32
spindle245	20	657	32,9	82	6	88	0,37	0,40
spindle244	20	709	35,5	89	10	99	0,36	0,40
spindle246	20	461	23,1	110	13	123	0,19	0,21
spindle247	20	721	36,1	95	9	104	0,35	0,38
spindle248	20	825	41,3	114	6	120	0,34	0,36
spindle249	20	713	35,7	96	8	104	0,34	0,37
spindle250	20	707	35,4	95	8	103	0,34	0,37
	Mean						**0,32**	**0,35**
	S						**0,062**	**0,066**
	Min						**0,19**	**0,21**
	Max						**0,43**	**0,45**
spindle241	25	508	20,3	91	11	102	0,20	0,22
spindle235	25	518	20,7	103	9	112	0,19	0,20
spindle234	25	360	14,4	105	8	113	0,13	0,14
spindle237	25	304	12,2	99	8	107	0,11	0,12
spindle240	25	364	14,6	102	6	108	0,13	0,14
spindle238	25	358	14,3	104	8	112	0,13	0,14
spindle239	25	266	10,6	104	3	107	0,10	0,10
spindle233	25	418	16,7	100	7	107	0,16	0,17
spindle242	25	464	18,6	102	9	111	0,17	0,18
spindle236	25	306	12,2	119	11	130	0,09	0,10

Table 1. continued

	Yarn			Roving				
Spindle	**Tt_p [tex]**	**N_{1000}**	**N_g**	**Nep Cnt/g**	**Trash Cnt/g**	**Nep +Trash**		1
spindle56	25	558	22,3	114	10	124	0,18	0,20
spindle172	25	516	20,6	145	15	160	0,13	0,14
spindle297	25	604	24,2	133	13	146	0,17	0,18
spindle398	25	415	16,6	152	12	164	0,10	0,11
spindle451	25	546	21,8	133	8	141	0,15	0,16
	Mean						**0,14**	**0,15**
	S						**0,033**	**0,038**
	Min						**0,09**	**0,10**
	Max						**0,20**	**0,22**
spindle 24	30	610	20,3	149	9	158	0,13	0,14
spindle110	30	992	33,1	154	12	166	0,20	0,21
spindle188	30	479	16,0	129	9	138	0,12	0,12
spindle274	30	558	18,6	145	12	157	0,12	0,13
spindle428	30	663	22,1	136	6	142	0,16	0,16
spindle242	30	286	9,5	110	8	118	0,08	0,09
spindle241	30	326	10,9	104	12	116	0,09	0,10
spindle240	30	416	13,9	107	12	119	0,12	0,13
spindle233	30	292	9,7	94	9	103	0,09	0,10
spindle234	30	334	11,1	91	9	100	0,11	0,12
spindle235	30	302	10,1	109	13	122	0,08	0,09
spindle236	30	430	14,3	103	7	110	0,13	0,14
spindle237	30	228	7,6	87	7	94	0,08	0,09
spindle238	30	218	7,3	103	10	113	0,06	0,07
spindle239	30	406	13,5	102	7	109	0,12	0,13
	Mean						**0,11**	**0,12**
	S						**0,034**	**0,035**
	Min						**0,06**	**0,07**
	Max						**0,20**	**0,21**
spindle 26	40	321	8,0	147	9	156	0,05	0,05
spindle 78	40	345	8,6	150	12	162	0,05	0,06
spindle102	40	300	7,5	125	12	137	0,05	0,06
spindle198	40	292	7,3	109	12	121	0,06	0,07
spindle340	40	333	8,3	124	11	135	0,06	0,07
	Mean						**0,06**	**0,06**
	S						**0,004**	**0,006**
	Min						**0,05**	**0,05**
	Max						**0,06**	**0,07**
spindle 26	50	212	4,2	127	14	141	0,03	0,03
spindle104	50	230	4,6	132	8	140	0,03	0,03
spindle246	50	225	4,5	132	17	149	0,03	0,03
spindle278	50	323	6,5	132	7	139	0,05	0,05
spindle360	50	189	3,8	128	15	143	0,03	0,03
spindle238	50	144	2,9	106	11	117	0,02	0,03
spindle242	50	116	2,3	121	15	136	0,02	0,02
spindle241	50	96	1,9	95	8	103	0,02	0,02
spindle240	50	144	2,9	102	11	113	0,03	0,03
spindle234	50	162	3,2	110	10	120	0,03	0,03
spindle235	50	160	3,2	98	9	107	0,03	0,03
spindle239	50	134	2,7	98	11	109	0,02	0,03
spindle237	50	166	3,3	100	11	111	0,03	0,03
spindle236	50	156	3,1	116	9	125	0,02	0,03
	Mean						**0,03**	**0,03**
	S						**0,007**	**0,007**
	Min.						**0,02**	**0,02**
	Max						**0,05**	**0,05**

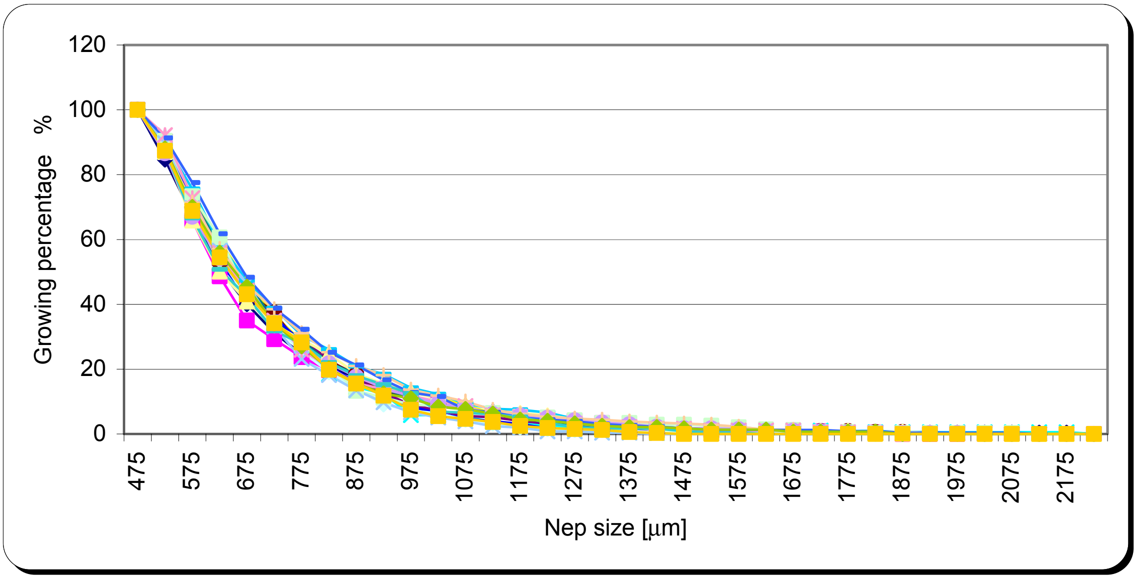

Figure 1. Survival function curve of the nep shares of given size in the total nep number in the roving samples produced from different middle staple cotton blends.

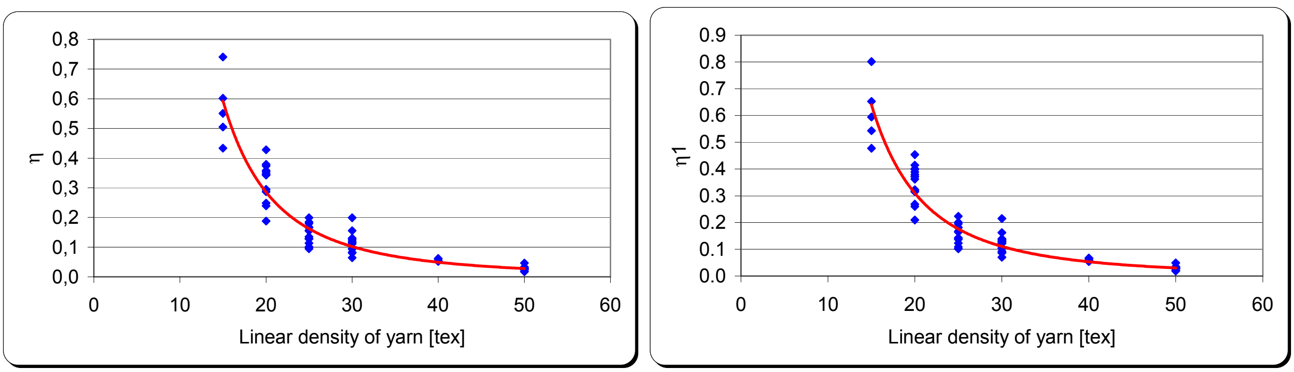

Figure 2. The nep as well as nep & trash visibility coefficient (η and η_1) in the ring-spun yarn in a function of linear density.