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EXPERIENCES IN THE AIR SPINNING TO MANUFACTURE MEDICAL DEVICES

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Abstract: *The work aims to determine, with scientific rigor, differences in key parameters of the yarns produced by conventional ring spinning systems, open-end and air spinning and its interrelation with the main parameters of those products that are intended for medical-sanitary sector. The experiences have been made in a Spanish company from short fibers sector that has three spinning systems, with tradition and prestige in world market, validating the results in Innotex Center laboratories of the Polytechnic University of Catalonia.*
Considering the results, it shows that the technology of manufacture of yarns by air is suitable for yarn, woven fabrics and knitting, structures to textile medical-sanitary application, by specific properties as well as enhanced competitiveness, due to the high production rate and shortened spinning process.
The viscose yarns manufactured by air mass are more mass regular. The new DR parameter clearly indicates a better look of the finished fabric when we work with yarns produced by air technology.The significant reduction of the hairiness means less formation of loose fibres by friction, very important in the application of these yarns in the manufacture of textile structures for medical-sanitary use. Also no-table increase of about 15% in the absorption capacity of the fluids, especially water, from the yarns made by air. In the functionalization of fabrics obtained from spun yarn by air will need to apply a permanent smoothing.

Key words: *Air spinning, Open-end spinning, Medical Devices*

1. INTRODUCTION

It is well known by experts in medical and sanitary sector and those responsible for textiles technology centers trend over the next 10 years textiles for these applications will experience exponential growth sustained. Much higher than the fabrics for the world of fashion and home textiles growth [1]. To focus on Spanish case, we understand can be extrapolated to many other countries, according to the National Institute of Statistics, in 2020 the 19.9% of the Spanish population will be over 65 years, implying an increase in spending on medical devices and, especially, all those products specifically for older people [1].

From technical literature studied [1], it follows that the yarns for medical-sanitary applications must accomplish with very strict specifications, some of them closely linked with the fibrillar structure of yarns, depending on the spinning system followed for manufacturing. The appearance on the world market of open-end systems and later the air spinning, much more productive than conventional spinning ring, has involved obtaining yarns with a different structure (Figures 1, 2 and 3), with different behavior in the rest of the textile production.

Fig. 1: *Structure of a yarn obtained in the ring spinning*

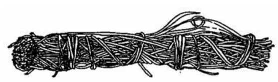

Fig.2: *Structure of a yarn obtained in open-end machine*

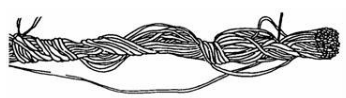

Fig. 3: *Structure of a yarn obtained in air machine*

It is well known that it has had to adapt technologies of woven fabric and knitting, dyeing, stamping and finishing to these new yarn structures. In general, we can say that air technology, we must have a minimum of 70 fibers in section, compared to 60 that are usual for a yarn of spinning ring.

It should be in mind that an open-end yarn is difficult to obtain, in an industrial production process, with less than 120 fibers per section [2].

A recent comparative study [3], from the economic point of view, between the conventional ring system and the spinning air to produce viscose yarns of 30 Ne, for knitted fabrics, with a production of 750 kilos / hour is deducted that in the study conditions established, air technology reduces the space occupied and the energy required to manufacture the yarn in 30% and it reduces the personnel required to 18 people instead of the 47 required in the ring continuous process.

2. EXPERIMENTAL PHASE

The spinning process followed cotton carding, comprising a blowroom, suited to the characteristics of the treated material, a card autoregulated short and long term, two steps of drawframe, the second self-regulating, a roving frame and a spinning frame. Subsequently, the yarns are cleaned and winding. We worked on ring spinning frames of 912 spindles, open-end machines of 312 spindles and air spinning machines of 40 spindles. Production speeds have gone from 21,5 meters/minute on ring spinning, 110 meters/minute in the open-end machine, reaching 330 meters/minute in the air spinning.

We have manufactured viscose yarn number 40 metric, with a twist of 700 turns/meter in Z direc-tion, by the carded cotton system, by open-end system and by air spinning. In open-end systems and spinning by air we start from the same second step of drawframe used in the manufacture of yarns in the ring spinning frame. In our study are strictly maintained environment conditions, both raw material and the spinning process. Only the parameters have varied in spinning machine. The work was carried out in a Spanish short fibers spinning that has three spinning systems in industrial production process, at normal speed for this type of production, with a large sample, over several days of production, so we must understand results as very significant.

In Innotex Center laboratories of the Polytechnic University of Catalonia, we have validated the results. To characterize the yarns we compared its dynamometric behavior, regularity mass, hairiness, coefficient of friction and bulk. Has been extended the study of conventional mass regularity (Uster, CV, thin points, thick points and neps in 1000 meters length yarn) with a new parameter, developed in our laboratories in collaboration with Keisokki, called DR (Deviation Rate), which is much better parameter related to the appearance of the finished fabric than conventional parameters [4] [5]. A DR of 45% means that 45% of the analyzed meters exceed, more or less, the average mass of the yarn increased and decreased by 5%. For this determination we consider reference yarn lengths of 1,37 meter (1,5 yards), working the mass evenness installation at Inert Test. In Figure 4, the concept of DR is described. It has been completed the comparative study of the regularity of yarns mass by determining CV_L (%), obtained with the same reference lengths.

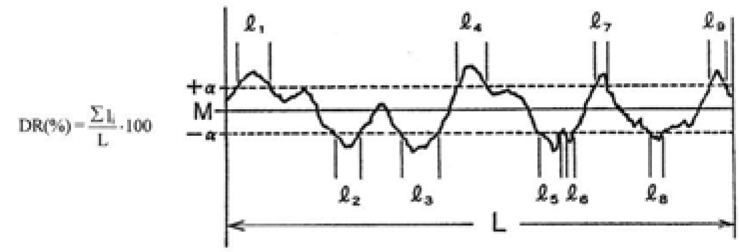

Fig. 4: *DR concept to determine the regularity of yarns and predict the appearance of the finished fabric*

Hairiness of the yarns is measured by the number of hairs of different lengths, in 400 meters of yarn. We define H index, an index of hairiness, with complex formulation, and S3 and as the amount of hairs length equal or higher than 3 mm. The bulk is measured on a Bulkometer indicating the bulkiness of the yarn in cm^3/g of yarn. With yarns obtained in three spinning systems to be compared, it has been manufactured knitted in a circular small diameter laboratory machine to determine their propensity to pilling, abrasion behavior and their ability to absorb fluids, especially water. The scale of pilling propensity varies from 1-5, reserving grade 1 for yarns with high propensity to pilling and level 5 for items that are not pilling in a normal use of the garment or medical device.

3. DISCUSSION OF THE RESULTS

In table 1, 2 and 3 indicate the main parameters of the yarns obtained in the ring spinning, open-end and air spinning, respectively.

Table 1: *Main parameters of yarns manufactured by spinning ring (viscose), 40Nm, 700 turns/meter*

PARAMETERS	RESULTS
Behavior dinamométric	
Breaking strength (cN)	377,7 ± 6,1
CV Breaking strength (%)	8,1
Elongation at break (%)	15,0 ± 0,1
CV Elongation (%)	5,0
Tenacity (cN/tex)	15,2
Mass regularity	
CV (%)	11,5
U (%)	8,9
Thin points (-50%)	0
Thick points (+50%)	8
Neps (+200%)	38
Neps (+400%)	1
DR (%) (1,37 m ± 5%)	21,2
CV_L (%) (1,37 m)	4,2
Hairiness	
N1	64137
N2	12635
N3	7590
N4	6975
N6	2045
N8	154
N10	2
H	15
S3	16766
Bulk (cm^3/g)	3,54
Pilling	2/3
Abrasion to 15.000 cycles	
Weight loss (%)	8,7
Water absorption (s)	6,8
Coefficient of friction	0,28

Table 1: *Main parameters of yarns manufactured byopen-end spinning (viscose), 40Nm, 700 turns/meter*

PARAMETERS	RESULTS
Behavior dinamométric	
Breaking strength (cN)	300,9 ± 6,4
CV Breaking strength (%)	10,6
Elongation at break (%)	12,1 ± 0,3
CV Elongation (%)	11,8
Tenacity (cN/tex)	12,1
Mass regularity	
CV (%)	13,2
U (%)	10,3
Thin points (-50%)	0
Thick points (+50%)	33
Neps (+200%)	39
Neps (+400%)	0
DR (%) (1,37 m ± 5%)	26,8
CV_L (%) (1,37 m)	4,5
Hairiness	
N1	10314
N2	1789
N3	1017
N4	1328
N6	685
N8	87
N10	1
H	33
S3	3118
Bulk (cm^3/g)	3,25
Pilling	3/4
Abrasion to 15.000 cycles	
Weight loss (%)	8,9
Water absorption (s)	6,7
Coefficient of friction	0,30

As it is well known, the yarn manufactured in the ring spinning has a greater tenacity. The yarns made by air increased toughness in comparation with open-end and their traction breaking elongation is very close, being smaller than that obtained when manufacturing the same yarn in the ring spinning.The yarns manufactured by air, as shown in the tables of comparative results, have excellent mass regularly. For most medical and health textiles, yarn regularity is a technical conditioning. The yarns manufactured by air improve regularity, whether measured with conventional parameters such as the new parameters used in this work (DR and CV_L). We move from a DR of 21,1% for the yarn obtained in the ring spinning, considered as reference, to values of 12,6% and CV_L is reduced from 4,2 to 3,2%. The yarns produced by air have very low hairiness, both in number of hairs in each length and respective hairiness rates. This point is essential to reduce the amount of loose fibers formed by friction in textiles for medical-sanitary use. We also note that the yarn produced by air has a higher water absorption capacity [6]. We go from value of about 6,8 seconds to 5,8 seconds only, implying an increase of the absorption capacity of 15%, most determinant factor in medical-sanitary applications.In contrast tests to assess the softness of the fabrics made with three sets of yarns, made by several expert evaluators in marketing fabrics [5], following a specific procedure essay that takes into account international standards, we obtain the softest are made of yarn of ring spinning, followed by open-end and the harsher are manufactured by air technology. This end finds its justification in the internal structure of these yarns. For some medical applications we leverage operations functionalization of fabrics, to confer specific properties to apply a permanent softening product compatible with the rest of applied products and the requirements marked in application protocols of these fabrics in the medical-sanitary sector.

4. MAIN CONCLUSIONS

***Table 3:** Main parameters of yarns manufactured by air spinning (viscose), 40Nm, 700 turns/meter*

PARAMETERS	RESULTS
Behavior dinamométric	
Breaking strength (cN)	327,1 ± 6,9
CV Breaking strength (%)	10,5
Elongation at break (%)	11,9 ± 0,3
CV Elongation (%)	12,2
Tenacity (cN/tex)	13,1
Mass regularity	
CV (%)	12,0
U (%)	9,4
Thin points (-50%)	1
Thick points (+50%)	19
Neps (+200%)	6
Neps (+400%)	0
DR (%) (1,37 m ± 5%)	12,6
CV_L (%) (1,37 m)	3,2
Hairiness	
N1	2781
N2	68
N3	11
N4	4
N6	1
H	3
S3	16
Bulk (cm^3/g)	3,25
Pilling	3
Abrasion to 15.000 cycles	
Weight loss (%)	5,1
Water absorption (s)	5,8
Coefficient of friction	0,32

Considering the results, it shows that the technology of manufacture of yarns by air, is suitable for yarn, woven fabrics and knitting, structures to textile medical-sanitary application, by specific properties as well as enhanced competitiveness, due to the high production rate and shortened spinning process. The viscose yarns manufactured by air mass are more mass regular. The new DR parameter clearly indicates a better look of the finished fabric when we work with yarns produced by air technology.The significant reduction of the hairiness means less formation of loose fibres by friction, very important in the application of these yarns in the manufacture of textile structures for medical-sanitary use. Also no-table increase of about 15% in the absorption capacity of the fluids, especially water, from the yarns made by air. In the functionalization of fabrics obtained from spun yarn by air will need to apply a permanent smoothing.

Considering all economic elements that make up the cost of spinning in Spain, at present day in a company with a high degree of automation and modern machinery, and considering the cost of ring spinning yarn as pattern, we reduced spinning cost of the order of 27% for open-end yarn and 22% for the yarns made by air. This slight increase in yarns cost made by air, comparing with open-end, is due to the high cost of the technological air required in the air spinning machine. On the market are available technological solutions to reduce this air cost, with small investments, but they were not available at the company which has made a comparative study.

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