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FASCIATED YARNS – A REVOLUTIONARY DEVELOPMENT?

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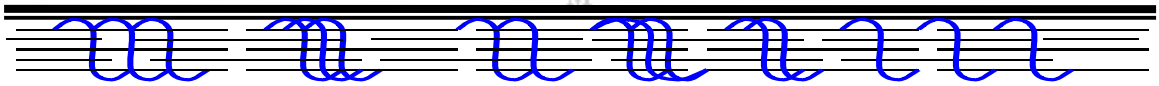
ABSTRACT

While Vortex Spinning is hailed as a revolutionary new technology it can also be viewed as a natural development in the technology of fasciated yarn production. From the earliest inception of fasciated yarns it was evident that there were limitations, which precluded its wide acceptance. From an understanding of the factors behind these limitations it has been possible to institute developments that have ultimately resulted in the present MVS system, which is being predicted to have profound impact on the cotton spinning industry.

KEYWORDS: spinning, vortex spinning, jet spinning, fasciated yarns, MJS, MVS



INTRODUCTION

The idealized structure of a fasciated yarn, which is shown above, consists of a core of parallel fibers held together by wrapper fibers [8]. The wrapper fibers and the core are composed of the same staple fiber material. If the structure of the yarn is the method adopted for characterizing this spinning system, then several different spinning machines, which have had varying levels of industrial acceptance, can be included in this group. These are:

- DuPont Rotofil
- Toray AJS
- Toyoda TYS
- Howa FS
- Murata MJS, MTS, RJS, Vortex
- Suessen PLYfil
- Fehrer DREF 3?

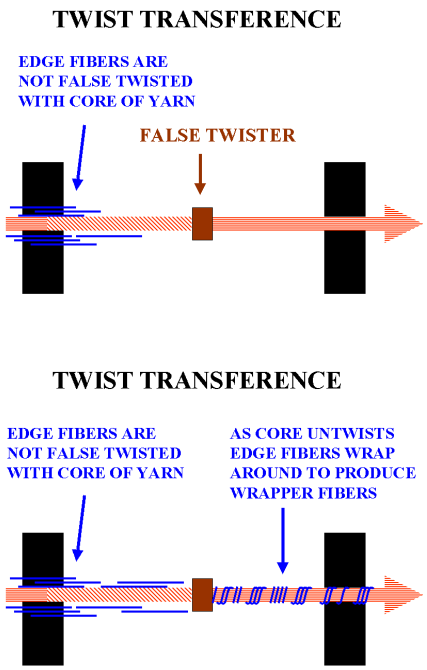


Figure 1

This yarn structure offers many potential advantages, one of the most important being that since no real twist is present in the final yarn it should be possible to achieve high production rates. The potential of using twist transference (see Figure 1) to create this "new" yarn structure was first promoted by Du Pont in their early patent (Figure 2), which utilized an air-jet to false twist the yarn [5]. While there were several publications concerning possible merits of the yarns produced, this system achieved little commercial success.

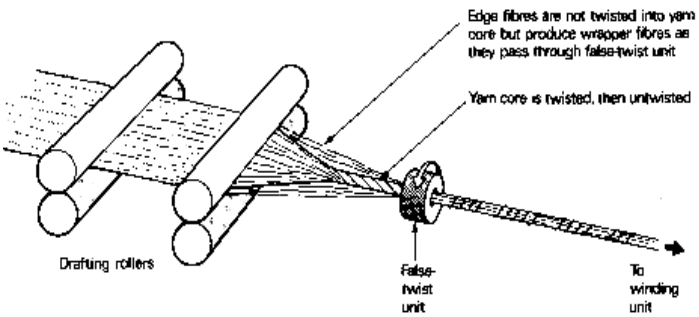


Figure 2 [5]
DUPONT SYSTEM

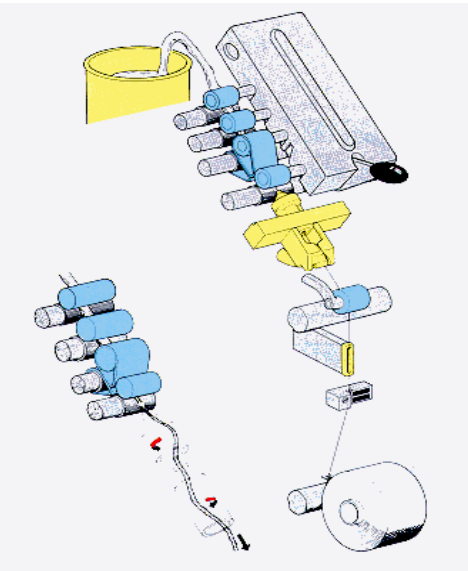


Figure 3
MURATA MJS

The basic requirements of a successful spinning machine for fasciated yarn include good drafting system, false twisting device and a take up unit. Automation, in the form of stop motions, automatic piecing, automatic doffing, yarn clearing and monitoring of process and product quality, enhance the commercial application of the spinning system. However, the most important factor determining the success of a fasciated spinning system is the ability to afford some control over the quantity and distribution of wrapper fibers created on the yarn surface, since this ultimately controls yarn quality [2,3].

JET SPINNING

The introduction of Murata Jet Spinning (Figure 3) seemed to address the issue of wrapper fiber distribution, since the use of two contra-rotating jets promotes better wrapping by ensuring later capture of the edge fibers. This effect is clearly shown in Figure 4 [6], which compares single jet, two jets twisting in the same direction (dual jets) and two contra-rotating jets (twin jets - as with MJS). While this appeared to offer a solution to the control of wrapper fibers and thus yield stronger yarns it is evident from Figure 5 that there are still problems associated with jet spinning [12].

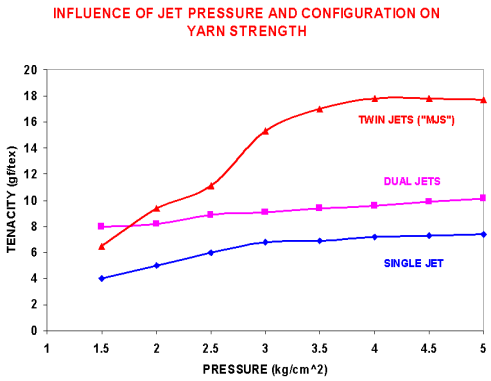


Figure 4 [6]

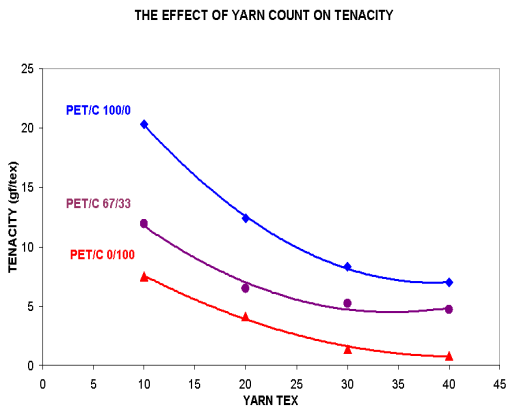


Figure 5 [12]

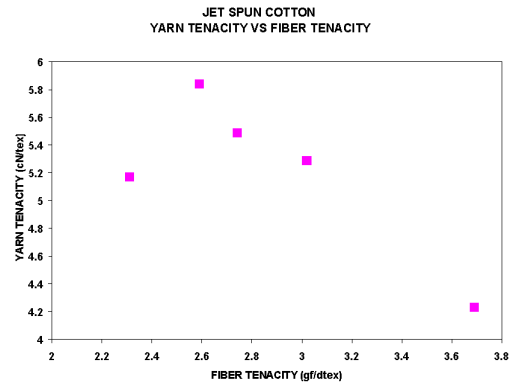


Figure 6 [10]

It is clear that the tenacity of the yarns appear to be influenced by both the yarn count (coarser yarns are much weaker) and by the fiber type (polyester and polyester blends are stronger than cotton).

An obvious suggestion may be that improvements in the quality of cotton may lead to improvements in the strength of jet spun. Research in this area using a wide range of combed cotton fibers yielded surprising results as can be seen in Figures 6 and 7 [9,10]. These are samples of many such results that appear to indicate that strong, long, fine cotton fibers give weaker jet spun yarns. The explanation to this seeming paradox is that the properties of the cotton fibers used showed very strong correlation between the individual fiber properties and thus the finest fiber also happened to be the longest and exhibit the highest tenacity.

If the results of Figures 5 and 7 are considered together it is clear that they hold some of the same information, which is that jet spinning seems to be sensitive to the number of fibers in the yarns cross section (this obviously increases both for coarser yarns and for finer fibers).

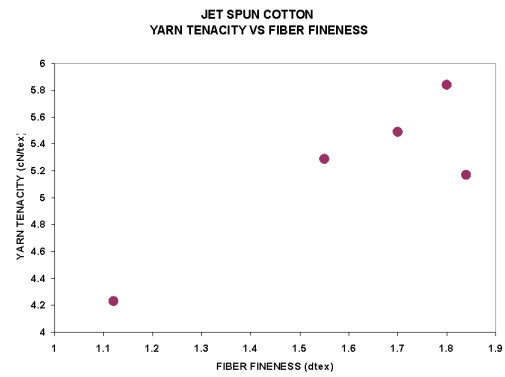


Figure 7 [10]

Explanations to this behavior can be seen in Figures 8 and 9. Edge fibers ultimately produce wrapper fibers, which in turn promote yarn strength. However the number of edge fibers is obviously restricted to those fibers at the outside and this is independent of the total number of fibers (Figure 8).

Thus, as the number of fibers in the yarn increases the percentage of wrapper fibers decreases and thus yarn tenacity declines. An additional feature, which is deliberately exaggerated in Figure 9, is that the wrapper fibers' wrapping length declines, as the yarn becomes coarser.

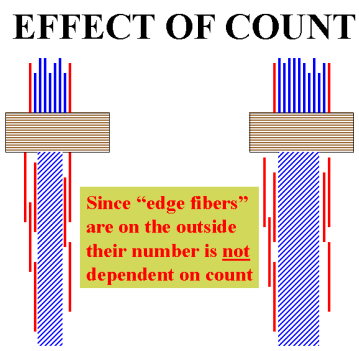


Figure 8

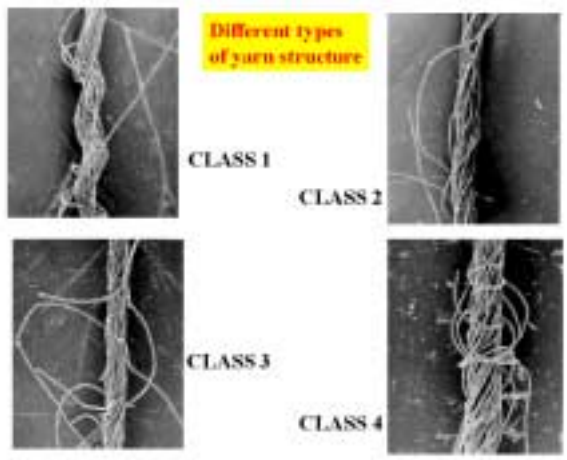


Figure 10 [7]

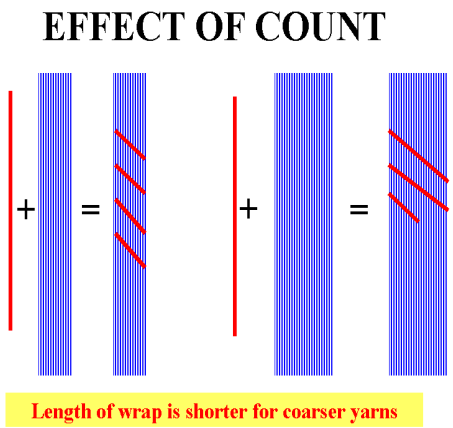


Figure 9

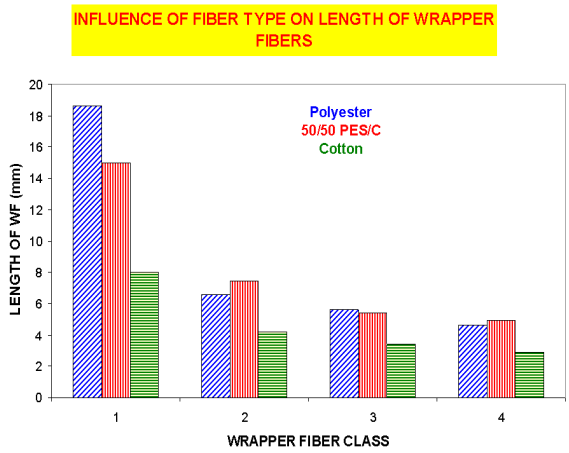


Figure 11 [1]

While the above offers an explanation concerning the fibers in the cross section it fails to address the issue of fiber type and in particular "why can polyester be spun and not cotton?"

A possible reason was thought to be associated with the yarn structure and that there may be differences between cotton and polyester in the number and type of wrapper fibers. While the idealized structure of jet spun yarns is a core of staple fibers reinforced by wrapper fibers, examination of actual yarns show that the structure is much more complex. Although there is no single structure associated with these yarns four different categories of structure can be identified and these are shown in Figure 10. It is believed that "class 1" structure (tightly wound wrapper fibers) is primarily responsible for the yarn strength [7]. Analysis of different yarns indicate that while there are differences in the incidence of different classes of wrapper fiber, one of the most significant differences between polyester yarns and cotton yarns is the length of the class 1 wrappers. It is clearly shown in Figure 11 that the stronger polyester yarns have much longer wraps than the significantly weaker cotton yarns [1].

From the above analysis of jet spinning it is clear that there are shortcomings in the system. Indeed it can be inferred from the above, that in order to spin acceptable

quality yarns from cotton, two improvements are required. These are:

more wrapper fibers;

longer extent of wrapper fibers;

both of which should result in higher yarn tenacity. Efforts have been made to modify jet design in order to increase the tension on the wrapper fibers during yarn formation, which should yield longer and tighter wraps. These have met with limited success with greater benefits being achieved for finer yarns.

VORTEX SPINNING

Increasing the number of wrapper fibers requires a re-examination of the original concept shown in Figure 1 and the problem identified in Figure 8. Simplistically it is evident that the only way to increase wrapper fibers is to increase edge fibers, but this is not possible in the set up shown, since only the outside fibers in the plane of the drafted strand are "edge fibers". However it is also logical to assume that changing the system from "two dimensional" to "three dimensional" offers the possibility of dramatically increasing the number of edge fibers and hence the number of wrapper fibers. This scenario is shown schematically in Figure 12 [11].

Examination of literature associated with Murata Vortex Spinning reveal that the three dimensional approach is being pursued. While the components shown in Figure 13 is only part of a much more complex set up, there are obvious similarities between the schematic in Figure 12, and Figure 13 which is from a US Patent concerning Vortex spinning. If the system functions as illustrated it should yield not only many more wrapper fibers, but these fibers should also have greater wrapping lengths.

Recent analysis of the general structure of Vortex yarns, indicate that they are quite different from Jet Spun yarn in respect of the proportion of wrapper fibers. While there is no unified structure, there is evidence of a definite two-part structure, which is clearly

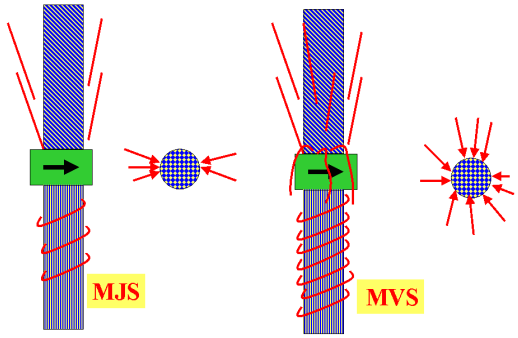


Figure 12

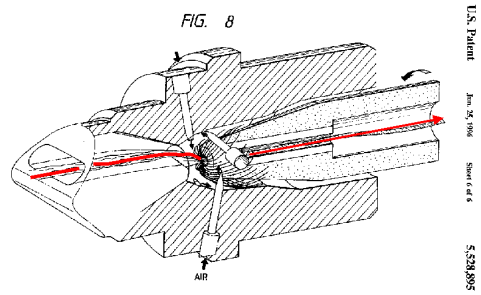


Figure 13

seen if small sections of the yarn are untwisted. The results to date have shown that the amount of "untwisting" required to reveal the yarn structure, varies considerably along the length of the yarn. Figure 14 shows a typical photograph of a cotton vortex spun yarn and Figure 15 shows an example of an untwisted sample. In the latter it is easy to differentiate the core (which is now twisted due to the untwisting action to prepare the samples) and the wrapper fibers (parallel strand unwound from the yarn core).

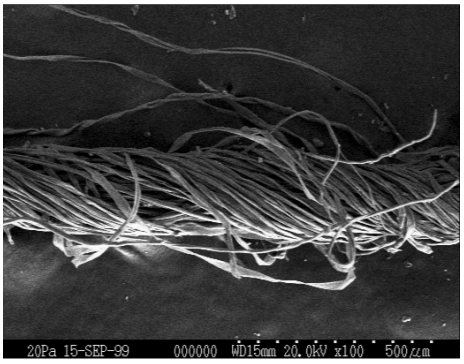


Figure 14

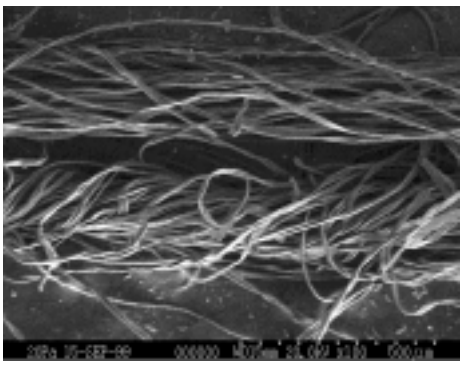


Figure 15

There is little independent data on the properties of the yarn due to the proprietary nature of most of the research carried out to date. Figure 16 is an extract of data obtained from a comparative study of vortex and jet spinning using different polyester cotton blends but with the same raw material feed to each machine. The same yarn count was spun on both machines (20 tex) at production speeds of 200 m/min for Jet, and 350m/min for Vortex. It is apparent that the Vortex yields greater tenacity advantage as the cotton content increases. While data was not available for 100% cotton this was due to problems in material preparation and there are many reports that acceptable quality yarns can be produced from cotton fibers using Vortex spinning [4]. It is also evident from the data that the extension at break for the Vortex yarn is lower than the Jet spun yarn and this would be expected from a structure where the tensile properties are the primarily the product of parallel core fibers [13].

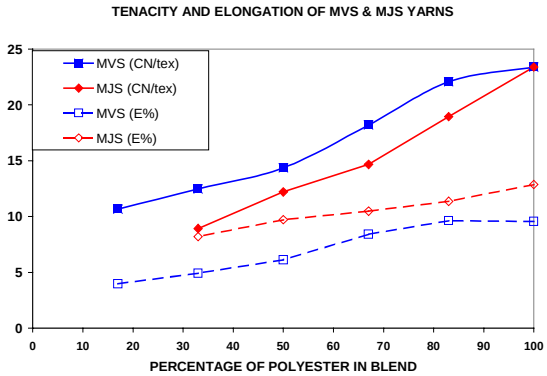


Figure 16

CONCLUSIONS

It thus seems that from the original concept of twist transference to produce a fasciated yarn, there has been a gradual development in the technology up to the current time where we are on the threshold of a major launch of Vortex Spinning. The road from the original DuPont set up to the Vortex system has been viewed as an evolution since, at each stage, sources of problems and limitations have been determined and elegant solutions have been found. While jet spinning was a major improvement over other fasciated systems it still was limited in areas of application. Vortex spinning represents the next logical development and there is no doubt that experience gained with the system and ongoing refinements in component design, will lead to potential improvements in both yarn quality and productivity. Indeed if it realizes the potential being claimed, it will represent a major breakthrough in spinning technology as we enter the new millennium.

ACKNOWLEDGEMENTS

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