CURRENT AND FUTURE TRENDS IN YARN PRODUCTION

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ABSTRACT

While developments in yarn manufacturing continue to be promoted by machinery makers, spinners are challenged to produce the best quality yarn at an acceptable price. This often results in a compromise, since improved yarn quality can usually only be achieved at a higher processing cost (including raw material selection). An additional difficulty is that the significance of the various attributes of quality change for different yarn’s end uses. While the solution to lowering yarn costs, that has been adopted in recent years has been to create large, almost fully automated spinning mills, this philosophy is presently being questioned, since this significantly reduces flexibility with respect to the fiber and yarn type that can be processed. This is obviously at odds with the current paradigm of customer driven, quick response manufacturing, since this demands inherent flexibility in the successful supplier. This paper reviews the current state of technological innovation in yarn production and examines the relative merits and disadvantages of each system. Some insight will also be given concerning those factors that limit further development of some of these systems. Historical trends in US yarn production have also been surveyed, and the combined information obtained is used as an indicator of the future directions in this key industry.

KEYWORDS: Yarn Production, Spinning, Vortex Spinning, Centrifugal Spinning

1. INTRODUCTION

Research into new technology for yarn formation peaked in the 60’s & 70’s. Since that time some systems have gained significant commercial acceptance, whereas other proposed systems have met with little (or zero) success. When viewed in terms of their potential for spinning a range of fiber types (as show in Figure 1), it is apparent that real success is only evident for rotor (open end) spinning and ring spinning. While other systems have promised significant benefits, these have met with limited success due to shortcomings in certain aspects of yarn and fabric quality (Figure 2). This aspect cannot be over stressed since while ring spun yarns may not be the best when considered from certain quality aspects, but they do provide an overall balance of quality aspects, which still make them the yarns of choice for most applications. Thus caution should be exercised when assessing a new system since good strength and regularity are meaningless if the fabric has a harsh handle or if the system is restricted in fiber type that can be successfully spun, etc.
The following is a review of potential systems for cotton (or short staple) spinning, indicating their current status and likely prospects for the future. It should be emphasized that while the current report is focused exclusively on the spinning machine, preparation for spinning is also critical and in particular the ability of these earlier processes to feed clean, nep free, well blended fibers with low variations in properties.

2. RING SPINNING

Ring spun yarns are still regarded by most yarn technologists as having the ideal blend of properties. This preference for ring spun yarns is also demonstrated by many fabric producers and apparel manufacturers and retailers. In terms of technological breakthroughs the ring frame lags behind other newer systems, but there have been significant changes in the system that have enabled spinning speeds to be almost doubled in recent years. The changes have interacted and it is likely that many of them would not have succeeded in isolation. The use of automatic doffing and link winding only became an attractive proposition with the introduction of much longer ring frames and improvements in splicing technology. These in turn meant that package size could be reduced, which enabled smaller rings to be used and thus higher spindle speeds and higher productivity.

There is still debate over which is the best format of supply to the ring frame and the alternatives of "light weight sliver" or "heavy weight roving". Both have major machinery makers as proponents. The advantage of the light weight sliver is the elimination of the roving frame, but there is the penalty of much greater space requirements for creeling at the spinning frame. The use of heavy weight rovings (obviously still requires the use of a roving frame) gives much greater productivity on the roving frame and offers the advantage of easily applied package transfer to the spinning frame. The benefits of either feed format can only be realized if the spinning machine is capable of higher than normal drafts. The benefits afforded by such a high draft system (offered by Howa) are shown in Figure 3, from which it should be realized that the benefits in productivity extend back to the finisher drawframe.

The current limitation on ring spinning is maximum traveler speed (about 40 m/s) and it is unlikely there will be any major increase in this speed in the near future. Different approaches to improving the performance (i.e. speed) of the ring & traveler combination have been tried but these have met with limited or no success.
Examples of these approaches are:

- Use of high tech materials for the ring and traveler – such as ceramic.
- The use of rotating rings – a system tried and subsequently discounted in the 70’s – has more recently been demonstrated by Howa.
- Replacement of the traveler with a rolling (rather than sliding) element has been recently suggested, however there is no reported experience of this device in an industrial environment.

Other ways of increasing production have been sought and the current vogue is towards systems that will permit spinning at lower twist levels while maintaining adequate yarn properties for subsequent processing (and satisfactory fabric properties). This can be achieved by various approaches to "Compact Spinning", which relies on modifications to the machinery to facilitate improvement in yarn formation and structure, resulting in improved tensile characteristics and surface properties in the resultant yarn. While the idea is not new (originally proposed by Fehrer as part of the DrefRing concept) several machinery makers have shown ring frames equipped to spin yarns with compact structure.

The company with the greatest experience with this technology is Rieter. While they introduced the terminology "Compact Spinning" they renamed their commercial application of this technology Comfort Spinning then subsequently Com4, since this implies a better fabric hand (as opposed to "compact"). The system relies on condensing the strand, which emerges from the drafting system and promotes a better yarn structure with lower yarn hairiness. This is achieved by utilizing suction to consolidate the strand prior to twisting as shown in Figure 4. The resultant effect on yarn structure is clearly apparent from the comparison of Com4 and conventional ring-spun shown in Figure 5. The consolidated structure yields better yarn properties. The benefits that can be achieved over conventional ring spun yarns can be realized as stronger yarns (for the same twist) or similar yarn strength can be obtained at twenty per cent lower twist (Figure 6).

Alternative approaches to this technology are typified by the EliTe system of Suessen, which uses a perforated system after the normal drafting system (Figure 7). In addition Suessen also apply a slight draft to enhance consolidation and reduce the width of the strand during yarn formation (Figure 8). While it is agreed that this technique can produce higher quality ring spun yarn, there is no doubt that the systems are complex and usually require roving stop motions, which inevitably increase the costs per spindle.
There are also concerns about the type of fibers which can be successfully processed using this approach and many agree that the system will be more successful processing longer (combed ?) cotton staples. Recent mergers and acquisitions in the textile machinery industry (in particular Rieter’s purchase of Suessen) seem to indicate that there will be a rationalization of the types of systems that will be offered in the future.

3. ROTOR SPINNING

Rotor spinning is the only system to offer a real challenge to ring spinning for coarser yarn counts. While it offers successful processing of cotton at significantly higher speeds than ring spinning, and it is generally agreed that the yarn processes better during fabric formation, the system has not been a universal success and its acceptance has been restricted to certain geographic areas. Since the introduction of rotor spinning, there have been major increases in processing speeds that have necessitated a reduction in rotor size, which in turn has resulted in deterioration in yarn quality (Figure 9). Lately there has been concern that the differential in price between ring spun and rotor spun yarn seems to have increased. An examination of data on yarn prices over several years indicates that this is indeed not a recent phenomenon but appears to be a systematic trend, which can be traced back over 15 years (Figure 10). There is no doubt that rotor spinning will, for the foreseeable future, hold a place in the coarser yarn sector, but in order to gain in other sectors some mechanism of improving certain aspects of yarn quality is essential.
4. FRICTION SPINNING

The considerable hype concerning friction spinning as a potential replacement for rotor spinning was never realized. There are several reasons behind this failure, but the major shortcoming of the system is shown in Figure 11. It is clearly evident from this chart that there is a distinct drop in yarn tenacity at higher processing speeds, even though a constant twist may be maintained by using higher friction roller speeds. It appears that this technology will be restricted in end-use to certain “technical” applications, such as those areas which are currently being successfully covered by use of DREF spinning machines.

5. JET SPINNING

The status of jet spinning is summarized in Figure 12. The major issue with this system is that, despite repeated promises, it was not possible to produce 100% cotton yarns of acceptable quality. In addition there are some restrictions on yarn count, which precluded the spinning of coarse yarns. Jet spinning has also had limited success in producing knitting yarns. The system has, however, proven to be successful in niche markets for the processing of polyester rich blends. The future of Jet spinning must however be questionable with the introduction of Vortex spinning which is viewed to be technically superior.
6. VORTEX SPINNING

A summary of the status of Vortex spinning is given in Figure 13. It must be emphasized that this system should not be confused with vortex open-end spinning, which was developed in Poland during the early 70's. While there must be a significant amount of data on this system, most of this is regarded as proprietary, since much of the early work on the system has been carried out in selected spinning mills in the USA. The system has been exhibited as a cotton spinning machine and much has been made about the ability to spin carded (and drawn) cotton, as distinct from the requirement of combed cotton for jet spinning. It is believed that significant development work is still underway on this system and in particular refinements in nozzle (jet) design will be an ongoing feature. Initial information indicates that the system is easily applicable to polyester/cotton blends and that acceptable yarns can be produced with greater cotton content than was achieved with Jet spinning (Figure 14). This is no doubt due to the improvement in the number of wrapper fibers that are available in vortex spinning and it can be seen from Figure 15 that, when locally untwisted, the two part structure of the yarn is clearly visible. There is limited commercial production of 100% cotton yarns and there are concerns over the amount of waste generated during spinning (> 5%).

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**MURATA VORTEX SPINNING**
- Vortex spinning machine utilizes one jet to impart false twist;
- System is being heavily promoted because it is claimed to process carded cotton slivers;
- Major development carried out with US mills;
- Yarns already in stores in certain products.

**Figure 13**

**Figure 14**

**Figure 15**

**Figure 16**

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**CENTRIFUGAL SPINNING** (Techmerchispun)
- Drafted sliver is delivered into a rotating centrifuge (7) until the preset quantity of yarn is produced.
- The system then automatically winds (7) the spun yarn onto a small cylindrical package.
- This package is then automatically diced whilst more yarn is being spun.
7. CENTRIFUGAL SPINNING

The idea of utilizing a centrifugal chamber to twist and collect the yarn is not new and indeed the Topham Box was a feature of early Rayon filament spinning lines. Other incursions into this type of spinning included the Greenbank Axispinner, which was designed for producing two-fold worsted yarns. Recently there has been renewed interest in this technology and such a system was shown as a prototype at ITMA '99 by the Russian Company Techmaschexport (see Figure 16). In this machine the yarn was spun into a relatively small pot operating at 35,000 revs/min. When sufficient yarn is produced the yarn is withdrawn from the pot and wound onto a small (70 g) cylindrical package. The illustrations of a full machine indicate automatic doffing and transport of these packages and it is probable that these would be fed to a rewinding machine to produce larger packages for knitting and weaving. While this must be still judged as a developing technology it should offer the benefit of yarns with properties almost identical to ring spun yarns. It is believed that other machinery makers also have an active interest in this technology.

8. COMMERCIAL TRENDS

At the present time there is a decline in yarn production in the USA (Figure 17) and this is accompanied by much adverse publicity about mill closures. The reasons for this trend are complex and include such features as:

- relocation of other parts of the textile chain to other countries;
- higher speed machinery requires less facilities and people to maintain the same national production;
- the availability of lower cost yarns from other countries provides direct competition;
- changes in the driving forces within the textile supply chain;
- ability to supply competitively priced smaller lot sizes.

The factors above inter-relate and it is apparent that the issue is not simply associated with lower labor costs because with automated spinning machinery, the labor forms only a small part of the overall yarn costs. International financial exchange rates have recently been a significant factor in the overall pricing of yarns and a dollar which has been strong against other currencies has favored the import of yarns.

An additional factor contributing to the current situation in spinning in the US, is the past trend to invest in large automated mills. These proved to be extremely effective in competing on cost and analyses indicated that very few countries could produce yarns cheaper than the US and even then the differences were marginal. The downside of this philosophy is that to balance the production lines, the mills lose flexibility with respect to fiber type (blend composition) and yarn specifications (count and twist factor). Thus the economic benefits previously afforded are lost when there are greater labor requirements and down time due to lot changes. This is a major issue that the US industry has to address, possibly by creating sub-units within the mills.

When viewed from the processing machinery involved it is clear that there is a general downward trend in the investment in ring spinning and a leveling off of the investment in rotor spinning (Figure 18). The number of positions of jet and vortex spindles is estimated to be around 110,000. The decline in spinning positions during the 90’s was not reflected in a sharp decline in production (figure 17). This arises because the reduction in ring spindles was significantly offset by the switch to rotor spinning and jet spinning, and the upgrading of older generation rotor spinning machines with newer (and faster) machines. Figure 19, which is based on recent data from Schlafhorst (US), clearly indicates the
significant increases in production that has taken place in most spinning systems over the ten years up to 2000. Typically over 45% increase in productivity was achieved by most technologies, enabling a reduction of about 30% in “spindles” while maintaining the same production level. Indeed if some of the ring spindles were replaced with rotors (as seems evident in figure 18) then there could be an increase in production with less “spindles”.

While there has been a decline in the spinning capacity it is apparent from figure 20 that the US is still a major force in yarn production. It is also clear that the US has a much greater global share of higher speed spinning technologies.

9. CONCLUSIONS

Most spinning machinery makers are cautious about where the spinning industry is going, both technologically and geographically. While some existing technologies will retain niche markets (composite yarns for sewing threads, jet spinning for sheeting, etc.), there is no doubt that ring and rotor will continue to be the dominant spinning technologies for at least the next decade. There is, however, also no doubt that there is significant interest in the potential of newer systems such as vortex, but at the present time, details are not yet
generally available about this system. The direction of spinning is thus hard to predict, but a clearer picture will emerge when the following questions can be answered:

- Is Vortex spinning good enough?
- Will interest in ring spinning continue to dominate?
- Will compact spinning succeed?
- How fast can rotor spinning go?
- Does centrifugal spinning have a future?
- Is there another spinning technology being developed?

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