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Attention : Mr. Shaun Harte
Financial Director

Dear Shaun,

BACKGROUND TO FRICTION SPINNING

As agreed, I enclose some notes on the small fabric samples you have and comments relating to other non knitting applications for the SpinWell.

I have also enclosed extracts from 2 reports I prepared for my discussions with Schlafhorst. The first report I have already forwarded to them and the second I put on hold pending completion of discussions with Mackie. It will give you a background to this technology containing relatively insensitive technical information about the SpinWell itself.

The reason I have been so nervous about your visit round the trade is that the SpinWell technology has moved on so far from the MasterSpinner technology that I had planned to introduce this as a new technology rather than a re-working of the old MasterSpinner technology. This is the crucial feature of the Mark 12 prototype and why we persevered for a number of extra years to develop it to its present level. I had it all mapped out how this could be achieved.

This new concept idea certainly worked for the MasterSpinner. We went to great lengths, by way of presentations in the USA and Europe, to ensure that people were aware that there was no common ground between the yarns produced on the MasterSpinner and on the DREF range of friction spinning machines. Schlafhorst made a massive mistake in not realizing this was true when they adopted the DREF technology.

My feeling is that your "pre-emptive strike" will make this impossible and I have only reluctantly gone ahead with this approach because it is clearly a stumbling block for Mackie.

Hopefully, by providing you with sufficient background information will minimise the damage you will cause.

Yours sincerely,

Alan Parker

FABRIC SAMPLES

There are 3 fibre types each comparing commercial rotor (Autocoro) with SpinWell friction yarn. These samples were not produced for demonstrating to potential customers but were the start of a programme to establish the "variable optional" features to offer on the SpinWell.

SAMPLE 1

The first sample can be recognized by its mottled appearance. It is a 50%polyester/50% cotton blend with a small % of dyed fibre to provide a simulated linen look and the yarn count is 30 c.c. (20 Tex).

This sample was one in which I spent a reasonable time in getting the optimum conditions and represents the type of difference between friction and rotor which I am certain we will be able to repeat on all other yarns. The other samples were also run at these same conditions to give a base line for further optimization.

If we had been able to spin enough yarn of sample 1 I would have been happy to have them made into sports shirts and given them to say Marks and Spencers and other retailers for their opinion and full testing.

When we have the 32 position prototype machine operational(Mackie call it a pony) one of the first tasks will be to produce fabrics/garments from a range of yarns and use these as the marketing thrust. Your services might be called on again at that time.

SAMPLE 2

This is the white fabric and is made from 20 c.c.(30 tex) yarn of 100% polyester fibre. The friction fabric is far bulkier, has a much softer handle plus a dramatically better cover than the rotor equivalent.

However, this was run at the conditions optimised for sample 1 and, as such, I believe the yarn is too hairy and nowhere as regular as I will be able to achieve when I optimise conditions.

SAMPLE 3

This is the creamy coloured fabric made from 20 c.c.(30 tex) yarn of 100% cotton.

Although it is more bulky and slightly softer than the rotor equivalent I feel that I could make a far better sample.

The MasterSpinner always produced yarns that were cleaner and contained less trash than rotor yarns because of the dirt/short fibre extracted through the perforated rollers and the trash liberated at this stage.

On the eight Stage 1 prototypes I replicated this performance. However to provide this facility is why the power costs are only 5% lower than rotor. The precise reasons are complicated and at the moment confidential.

On the four Stage 2 prototypes I have been examining ways to reduce power consumption for particular yarns (as an example, on 100% synthetic yarns, a 30% saving is quite feasible).

The 100% cotton sample was produced with minimum trash removal giving a level of power saving which would not be appropriate for a 100% cotton yarn with this level of trash.

Consequently this sample is less clean than the rotor yarn.

SUITABILITY OF SPINWELL YARNS FOR FABRIC TYPES APART FROM KNITTING

TOWELS

For the majority of towels a soft and bulky product is the optimum product for the surface fibre (around 70% by weight of the weight of a towel).

Even though the surface fibre is the warp yarn the high bulk and soft handle of the SpinWell yarn is ideal and will need to be assessed against the marginally higher incidence (or lower weaving speed to maintain efficiency) of stoppages that will occur due to its greater bulk.

I would be very surprised if one of the first customers for the SpinWell was not a towel manufacturer. I believe all those purchasing machines for towel yarn manufacture would seriously consider the SpinWell for the face fabric.

Strength is not a primary requirement of yarns for towels. The balance is to get a yarn that is sufficiently bulky, has the correct surface characteristics, and is sufficiently strong enough to weave.

Even in one sector of the market different suppliers have different priorities.

For some towels high bulk but with a well bound in surface fibre is the optimum product because it gives high absorbency without shedding, particularly against men with a heavy stubble.

Others want the super soft high bulk characteristics and fibre shedding is an acceptable evil.

Others want simply the minimum standard at the cheapest price.

Because of the open structure of towels, fibre cleanliness is a crucial requirement for all towels, and in this aspect friction scores massively over ring.

VELOUR, VELVET AND CORDUROY

This is a highly specialized business and the standards and hence the price of the individual yarns vary tremendously. In the yarns containing cotton, fibre cleanliness is a vital parameter. The other important characteristic is the ability of the cut fibre to "burst" and in this respect rotor is very poor. The market has tended to split between the high quality end being ring spun and the lower quality end being rotor or cheap ring spun products.

The friction yarn structure is ideal for velour, velvet and corduroy fabrics and produces a superb product. This applies equally to home furnishings(e.g. velvet curtains) as it does to clothing. Some of the products are warp faced(velvet) products and others weft faced(corduroy) products

Friction yarn can compete across the board in these product areas and I would confidently expect that in time would become the "norm" for the industry.

There is no doubt whatsoever that a lot of friction spun yarn will end up in this product area and I believe all customers spinning yarn for yarns of this type would consider the SpinWell.

BRUSHED FABRICS

The same applies as for velour.

DENIM

The modern rotor machines are ideal for denim and except for brushed denim the penetration in this market will be small in the first instance. However, the improved economics combined with the characteristics of the SpinWell process and yarn should enable some penetration in those making both the top(different product) and bottom(price) of the range denims. It is probable that this market would only be penetrated by a company selling yarn onto the open market.

WOVEN SHIRTS

Woven shirts cover a very wide field of products using yarns which are from very coarse to very fine.

The conventional business shirt uses the finest yarns and the more cotton in the yarn the more expensive the shirt.

It will take some time, if ever, to make a large penetration in 100% cotton and 50% cotton 50% polyester warp yarns in mens dress/business shirts. The increased bulk and soft handle of the SpinWell yarns rather than strength will require changes to the size specification to make an optimum product. Additionally the increased bulk will create greater fibre abrasion at the healds and reed than leaner yarns. As a "ball park figure" yarns finer than 36 c.c. will be the break off point for a few years at least.

The abrasion problems do not exist on weft yarns and the yarn stresses are much lower and thus SpinWell yarn may find applications in these areas.

Also there should be far less problems in warp consisting of 65% polyester/35% cotton, 100% polyester yarns or polyester/viscose yarns.

The yarn is ideal for the casual woven shirts which are made from coarser yarns and in which a bulky product and a soft handle are marketable features.

WOVEN SHEETS

This is a complex area in that there is a preference, in many instances, for a soft handle (winceyette is the soft extreme), but fabric strength does have a part to play also. Yarns are coarser than business/dress shirts and there will certainly be some areas in which the improved aesthetics/appearance will balance out the lower fabric strength.

YARNS CONTAINING ELASTOMERICS

The SpinWell process is ideal for incorporating elastomeric yarns and the additional yarn feeders can readily be incorporated and by-passed to produce normal spun yarns. This market is quite large, particularly for trousers in a range of fabric and fibre types but like most things in textiles has ups and downs. I would be very surprised if one of the first SpinWell machines was not for a company providing these products.

GENERAL WOVEN FABRICS

The friction spinning process does have the ability to handle very dirty cottons and to produce reasonably clean yarns by removing trash, dirt and short fibre. In effect to turn a sows ear into a silk purse.

As mentioned earlier, features to achieve this would be one of the optional features of the machine.

There is little need for cleaning if synthetic fibres are being used and less need if combed or tandem carded cotton is employed and therefore the extra power needed would reduce the commercial advantage for no gain.

FIRST REPORT EXTRACTS

START POINT FOR BELROY

The start point in 1986 for the development of both the SpinWell's friction spinning technology and the engineering design of the spin-box was the positive and negative features of the MasterSpinner. I thought it would be useful to give you my interpretation of this start point to enable you to compare them with your own understanding of the situation.

SOFTER FEEL THAN ROTOR

In the early days of development, of what later became known as the MasterSpinner, it was apparent that the MasterSpinner technology could produce yarns with a softer feel than rotor. This was in complete contrast to the surface of DREF friction spun yarns. The DREF machines are associated with fabrics having a very harsh feel. Friction spinning as a technology does not therefore FUNDAMENTALLY PRODUCE a yarn with a soft handle. This was a feature of the technology which we had developed at Platt Saco Lowell.

Without this technological advantage, friction spinning would have to rely solely on its potential for higher speed to enable it to compete with the already established rotor spinning technology. A key objective of the SpinWell has been to expand the marketable advantages that fabrics from friction spun yarn can offer to complement the potential for higher throughput speed.

STRATEGY BEHIND THE MASTERSPINNER SPINTESTER PROGRAMME

Yarns produced on the MasterSpinner were significantly weaker than could be produced on rotor machines.

Knitting yarns represent about 40% and weaving 60% of all yarns. Because of the experiences on the Repco Self Twist Spinner, in which a radically different yarn structure, with a strength of only about 40% of ring spun yarn was successfully marketed, it was known at Platt Saco Lowell that strength was not crucial for knitting yarns.

It was also well known that the exact strength needed for any particular application depended on many things and could only be established by commercial trials. There were many weaving applications as for example velvet, corduroy, and the plush in towels plus many other weft applications in which either surface appearance or yarn "bursting characteristics", rather than strength, was the crucial yarn parameter.

Additionally, the strength and elongation of 100% synthetic yarns is so much higher than cotton yarns that there were some woven fabrics, including warp yarns, for which the aesthetic appeal of friction yarns was considered to be a marketable feature to counter its lower yarn strength.

Consequently, a policy decision was taken by the UK operation of Platt Saco Lowell to try to replicate the success of the Repco on the much larger market for short staple yarns by establishing markets for which the yarn was suitable, rather than be put off because the yarn was weaker than either ring or rotor yarn. ▽

As a consequence of this past success with Repco, the strategy of marketing the MasterSpinner was similar to that adopted for Repco in that interested companies were required to purchase, rather than be supplied free of charge, 10 position spintesters and no exceptions were made. These companies were then able to produce sufficient yarn for their knitting and weaving customers to sample the yarns. The mills customers could then decide if the yarns were strong enough and also whether the fabrics were marketable for their particular application.

In this way, only customers seriously interested in purchasing full length machines were likely to be involved in the Spintester programme. However, they only had to risk a relatively small amount of money to be able to spin enough yarn on their own premises, and under their own control, to establish whether they could establish a market for the yarn produced on the MasterSpinner.

At the strength level achieved with the MasterSpinner, there was great interest in the machine. If the position to position uniformity, engineering performance and automation had worked satisfactorily, then a business worth between 100 and 150 million Deutschemarks (£40-60 million) per annum would, without any question, have resulted.

The original purpose of the the SpinWell's friction spinning technology, and also the engineering design of the spin-box, was to prevent a machine incorporating the SpinWell failing for any of these reasons. Clearly, if friction yarn strength achieves parity with rotor spinning the increased speed potential of friction spinning will enable it to supersede rotor spinning as the major competitor to ring spinning.

CUSTOMERS LIKED THE FABRICS PRODUCED FROM MASTERSPINNER YARN

The purchasers of the full length MasterSpinners had already established markets for the yarns from their work on the 10 position Spintesters. Most spinners had potential markets far in excess of what they could supply on the machines they purchased.

Almost without exception the purchasers of the friction yarn liked the fabric it produced. Unlike rotor yarn, which is still frequently sold at a discount price in relation to ring, the yarn spinners frequently got a premium for friction spun yarn.

OVER 3 MILLION KG. OF YARN PRODUCED ON MASTERSPINNERS

At a conservative estimate, over 3 million Kg. (3,000 tonnes) of yarn from the 30 full length MasterSpinners went into commercial fabrics. Although this is tiny in relation to the world consumption of yarn, it is a significant amount of cloth. I give a brief explanation below as to the problems experienced by the spinners in commercially producing this quantity of yarn on the MasterSpinner.

POSITION TO POSITION VARIABILITY

My brother in his note of the 17 September 1994 mentions the operational difficulties and position to position variability of the MasterSpinner.

It was not until we had full length machines operating that the scale of the position to position variability on the MasterSpinner became apparent. ▀

The problem was so fundamental that I could see no solution without a complete re- design of the spin-box. It was kept under control for a number of years by having Platt Saco Lowell technicians, either permanently on site, or instantly available to visit those mills with full length machines.

COMPLAINTS BY KNITTERS ABOUT MASTERSPINNER YARN

There were complaints by the knitters about the yarn. These fell into four categories

- There was a greater incidence of dye bars in critical colour plain fabrics produced on multi end knitting machines. This was established as a position to position problem.
- Complaints about yarn weakness were always found to be associated with extremely weak yarn packages. These were found to be due to a deterioration in performance caused by fly build up during round the clock operation.
- Unwinding difficulties due to yarns snagging caused problems at knitting. This was a feature of the yarn and is an area I believe I have resolved on the SpinWell.
- Those customers who did not re-wind the yarn had too many piecings that showed up as faults. This is a fundamental problem of manual piecing and why Schlafhorst have sold so many Autocoro machines.

MOST BLAME TECHNOLOGY NOT MACHINE

I remain convinced that the marketing strategy adopted for the MasterSpinner served its purpose in that it established friction spinning as a viable spinning system for short staple yarns. Applying the lessons learned from the full length MasterSpinner machines operating in a commercial environment will transfer the technology into a commercial process.

It has always surprised me that MOST otherwise knowledgeable textile machine engineers have referred to the MasterSpinner's problems as problems inherent in the fundamental technology of friction spinning.

All the problems are clearly resolvable, but demand :-

- A machine builder with the engineering capability to manufacture mass production components to precise engineering standards and build a reliable automated machine producing good quality piecings
- A spin-box of adequate friction spinning technology to compete successfully in the staple yarn market and such a spin-box having a well thought out engineering design.

TO MARKET THE SPINWELL

It is my belief that Jet spun yarns and the higher speed rotor machines with small rotors are producing yarns which are moving closer to having performance characteristics and, when knitted, clearly defined stitch clarity to compete with textured continuous filament products. However, this is at the expense of having fabric characteristics which are looking less and less like staple products.

There is a substantial market for these type of high performance aesthetically unattractive products and by special finishing techniques some of the fundamental deficiencies of the staple yarn structure can be amended. However, there remains an EVEN MORE substantial market for yarns having the characteristic aesthetic appeal associated with staple yarns. It is quite clearly in the commercial interests of Schlafhorst to promote these high performance characteristics rather than the aesthetic appeal associated with ring spun yarns.

The two features that distinguish the SpinWell yarn at its present level of performance from rotor yarn are :-

- Those fabrics in which the soft handle is a requirement, or a marketable advantage.
- The present yarn structure, although having well aligned fibres, produces yarns which are bulkier than achieved with the MasterSpinner and significantly more bulky than rotor yarns. This occurs EVEN when the surface of the yarn is more highly twisted and therefore can have a greater abrasion resistance than rotor yarns.

It is those potential customers who value these particular characteristics highly who will be the ones that should be initially targeted. They are the ones who are unlikely to have purchased rotor spinning machines or who will be seeking to replace existing rotor machines with a technology which offers them something better.

During the next few months I will be seeking, with the help of Courtaulds, to produce fabric samples exhibiting a range of different surface characteristics.

SECOND REPORT

INTRODUCTION

In this report I expand on the points made in the first report which laid out our thinking on friction spinning.

I remain convinced that the marketing strategy adopted for the MasterSpinner served its purpose in that it established friction spinning as a viable spinning system for short staple yarns. In this report I discuss in some detail the experiences of the MasterSpinners operating in a commercial environment and how the lessons learned have been applied to the SpinWell development to enable a machine incorporating the SpinWell to commercially exploit the advantages offered by the friction spinning technology.

START POINT FOR BELROY

The start point in 1986 for the development of both the SpinWells friction spinning technology and the engineering design of the unit was the positive and negative features of the MasterSpinner. I expand on the points made in the first report of this start point.

OVER 3 MILLION KG. OF YARN PRODUCED ON MASTERSPINNERS

As mentioned in the first report over 3 million Kg. (3,000 tonnes) of yarn from the 30 full length MasterSpinners went into commercial fabrics. I give a more detailed examination than in the first report as to the problems experienced by the different spinners in commercially producing this quantity of yarn on the MasterSpinner.

HISTORY OF MASTERSPINNER IN COMMERCIAL OPERATION

Seven spinning mills who purchased 10 position spin-testers subsequently purchased two or more 144 position MasterSpinner machines. These customers were 3 mills in Europe, 3 in the USA and 1 in the Far East. This represented about 50% of those who had bought 10 position spin-testers (excluding fibre producers).

The 3 USA mills, who had 6 machines each, and were all targeted at knitted products, and Schoeller Textil in Germany, who had two machines, finally rejected them. This being because they had all purchased manually operated machines with the "written guarantee" that they would be automated with robotic piecing at a later date. When this promised automated piecing-together after a yarn-end break didn't work, the machines were all returned, money refunded, and the MasterSpinner was no longer offered for sale.

All the three USA mills had bought the machines for the sole purpose of supplying knitting yarn on cone directly off the machine (i.e. with no subsequent yarn clearing process). When these manually operated machines spun yarn with engineering technicians from the manufacturer - Platt Saco Lowell - keeping a watching eye on them, the only major complaint by knitters was that the number of unacceptable manual piecings meant a higher level of faults than from the Autocoro rotor spun yarns with robotic piecings.

By having a manufacturer's engineering technician permanently at the mill, together with the setting up of a controlled programme to ensure regular spin-box cleaning, it was possible, at least at one of these spinning mills, to get the yarn-end break rate so low, and thus very few piecings, that this problem was overcome.

- To give some idea of the scale of manufacturer's back-up required, one engineering technician needed to be available for spin-box cleaning/inspection/re-setting, as appropriate, for about 20 hours per week to handle 6 x 144 position machines running 168 hours per week on carded cotton/polyester yarns.

Schoeller Textil in Germany was considered a crucial customer by the UK management of Platt Saco Lowell (UK) Limited. Without doubt, Schoeller Textil did everything possible to exploit the advantages of friction spun yarn. Platt Saco Lowell retained a technician on site and I personally used to visit this operation every few weeks. Schoeller Textil also purchased a second MasterSpinner machine having had one machine for more than a year and had others on order. As mentioned above, it was only when the automation failed that they lost interest in the MasterSpinner.

A Swiss spinning mill had two 144 position manually operated MasterSpinners to spin 100% cotton, package dyed knitting yarns. They operated them for about 4 to 5 years before finally, when Platt Saco Lowell engineering technicians were no longer readily available, they became overburdened with the machines' operational problems. This was in the late 1980s or early 1990s. They bought the second of their two machines some twelve months after the first. Thus indicating a level of satisfaction with the saleability of the yarns from the MasterSpinner's "spin-box technology". This Swiss mill didn't have the same problems as most other purchasers because :-

- Piecing quality was not important. This being because all the yarn had to be re-wound and cleared after dyeing anyhow.
- Package dyed yarn is normally used in multi-coloured fabrics. Thus any slight spin-box to spin-box variation in yarn properties was less critical.

A French spinning mill (I cannot remember the name) also had two 144 position MasterSpinners for a number of years. These were used to spin very dirty cottons in the yarn-count range 10 to 20 c.c. (60 to 30 tex). The French were very satisfied with the resultant friction yarns. Unfortunately, by using very dirty cottons, the amount of fibre-dust (fly) build-up inside the spin-boxes necessitated them having to be taken off and cleaned every few days.

As in the other spinning mills, when a manufacturer's engineering technician was in constant attendance, the MasterSpinners ran well. In fact, they then produced much better and cleaner yarns than those of the French mill's ring spinning plant. The mill had tried rotor yarn, but their customers rejected it as being totally unsuitable.

- My last information, about 12 months ago, was that the six 144 position manually operated MasterSpinners in the Far East were still operating. It is my understanding that they operated a controlled spin-box cleaning programme along the lines we set up in the USA to ensure a low rate of yarn-end breaks, and thus few manual piecings.

SPIN-BOX TO SPIN-BOX VARIABILITY IN YARN

This came to light when 144 position machines were operating in the mills

My brother Roy in his note of the 17 September 1994 mentions the operational difficulties and the variability that could occur in the yarns spun from some spin-boxes in comparison with that from the majority on the same MasterSpinner.

It was not until Platt Saco Lowell (UK) Limited (hereinafter referred to as PSL) had 144 position MasterSpinners commercially operating in the mills that the extent of the position to position variability became apparent. Although I, as the inventor of the spin-box technology, believed that the problem was so fundamental that I could see no solution without a complete re-design of the technology, I explain below why others in PSL believed this was a controllable and resolvable problem.

No direct setting on machine

On friction spinning there is no direct setting on the spin-box which determines the twist in the yarn. Neither is there on the friction texturing machines produced primarily by Barmag and Rieter/Scragg and which constitute almost all the textured yarns with which staple yarns have to compete. I have therefore never seen this as a particular problem.

On Austria's DREF range of friction spinning machines the level of wrapper-fibre means twist cannot be measured and therefore spin-box to spin-box yarn uniformity is determined by the settings on the machine and cannot be checked.

On the MasterSpinner, twist could be measured. Every spin-box was able to be "tweaked" by adjusting the position of the slot situated within the perforated roller to equalize the twist between individual spin-boxes.

There can be no doubt that the ability to adjust the twist by "tweaking" individual spin-boxes in the mills, plus the presence of PSL engineering technicians at all the spinning mills which bought 144 position MasterSpinners, was the primary reason why over 3 million kilos of commercially acceptable yarn was able to be produced.

No process is perfect - the MasterSpinner was not quite good enough

No textile process is perfect. As you will know only too well, on rotor spinning machines some spin-boxes perform differently than others and produce stronger, or weaker yarns for no apparent reason.

Unfortunately, the MasterSpinner's scale of imperfection was outside commercially acceptable standards.

- This being evidenced when a spin-box was stripped down and rebuilt with the same components and frequently it then produced yarns with very different twist levels and twist/strength characteristics than before.

This to me was devastating because it demonstrated a totally out of control situation.

- Position to position yarn variability was simply a symptom.
- The disease was a friction technology whose design did not permit the guaranteed setting up of its spin-box during assembly.

During a very detailed examination of this problem, I discovered there were some parameters affecting twist which were totally unexpected.

- Unfortunately, the fundamental problem was that it was totally impossible to overcome this problem and retain the existing method of piecing-up after a yarn-end break.
- By this time, the design of an automated method of piecing-up was so well advanced that nobody at PSL wanted to think about any changes.

After extended commercial running spin-box performance changed and some spin-boxes had to be re-"tweaked".

- It was these spin-boxes which frequently gave rise to dye bars in fabric and weak packages of yarn.
- However, dye bars are not only associated with the twist in a friction spun yarn, but are also associated with changes in the yarn structure and is an area we have studied in depth on the SpinWell.

Additionally, when any particular parameter, as for example yarn count, yarn twist, delivery speed, or fibre specification were changed, a number of the spin-boxes (typically about 10%) had to be re-"tweaked". This was quite understandable.

However, and put simply, there are about 10 different parameters that affect the twist in a friction spun yarn.

- To equalize twist we adjusted only one of these parameters.
- For different yarns the relative contribution would not be the same.

Almost all of the engineering technicians who were seconded into the mills were members of PSL's Research & Development Department.

- They worked directly for me.
- They knew the spin-box "backwards".
- They were put on secondment to the mills, but remained on the R&D budget.
- Consequently, the true costs of keeping these small number of 144 position machines operating never showed up in PSL's management accounts.

Companies like Schoeller were very pleased with what PSL were doing and commented on many occasions "We never get this sort of help from Schlafhorst".

I reported to PSL's board that the MasterSpinner process was not commercially viable at this level of PSL's engineering supervision of the mills' day to day operation.

- Unfortunately, PSL's top management regarded the situation as detail technical problems which were all resolvable, and were convinced that everything would be OK once the automated machine came on stream.

With the benefit of hindsight it is obvious that having my well trained R&D engineering technicians controlling the problem in the mills, I was in fact hiding the very point I wanted to bring home.

AUTOMATION FAILURE - NOT THE TECHNOLOGY - WAS THE MAJOR PROBLEM

Although the MasterSpinner gained a poor reputation, it must be borne in mind that it was only when the promised automation failed that it was taken off the market.

- Schoeller Textil operated its manual machines for 3 to 4 years.
- A French spinning mill processing very dirty cottons had machines in operation for at least 3 years.
- A Swiss spinning mill operated their machines for 4 to 5 years.
- Those in the Far East have operated for over 6 years.
- I am less certain of the timescale of operation of the machines in the USA spinning mills, but believe it was between 1-3 years.

THE POINT I AM MAKING

The point I am making is that during 5 years or so of commercial operation in various spinning mills around the world, PSL's top management couldn't bring themselves to accept that automation wouldn't be the panacea to make the MasterSpinner's friction spinning process into a viable commercial operation.

- Whereas in reality, commercial viability of the MasterSpinner would still require another major advance in addition to automation.

However, once automation came along, it was a process which was easy for everyone to assess.

- One did not need to be a yarn technologist to see that the piecing-up quality after a yarn-end break was simply not good enough.
- Additionally, the mechanical reliability of the automation was not up to the standard that had been established as the industry norm by Schlafhorst's Autocoro rotor spinning machine.

COMPLAINTS BY KNITTERS ABOUT YARN

With any yarn spinning process, the purchasers of the yarn - the knitters and weavers - will have complaints to make.

- ❑ But, unlike the MasterSpinner's predicament, their resolution don't normally result in the process becoming commercially inviable for the spinner.

Despite the MasterSpinner's lack of commercial viability, there is adequate proof that the friction technology did enable a number of spinning mills to produce yarns with an acceptable quality and strength for the commercial knitting of fabrics.

- ❑ Albeit, this only being achieved by PSL engineering technicians on stand-by in the mills to carry out individual spin-box "tweaking" of those 144 spin-box MasterSpinners and also ensuring regular programmes of spin-box cleaning.

Without doubt, those packages of yarn which were so '*hidden-expense*' produced, and also without a yarn-end break, were of an acceptable quality and strength for the commercial knitting of fabrics.

However, those packages with yarn-end breaks were unable to be sold without going through the added expense of a yarn re-winding and clearing process.

- ❑ Such process being necessary to identify and replace any unacceptable manual re-joinings made by machine operators to piece-up after a yarn-end break interrupted the combined process of spinning and winding the yarn onto these particular packages.
- ❑ Some unacceptable re-joinings/piecing could snag in a knitting machine's needle-heads causing down-time for the spinner's customer, whilst others showed up as fabric faults.

The Chairman of PSL, Edward Smalley, was at this time actively canvassing the large retailing chain of Marks and Spencer to get them to encourage suppliers of yarn to their fabric and clothing contractors to purchase the MasterSpinner because of the improved handle of its yarns in comparison to rotor spun yarns.

I reiterate: PSL top management had an unshakeable belief that they could resolve the MasterSpinner's problems by robotic automation.

- ❑ They had an '*ostrich-like*' perception that once the re-joining/piecing-up problem was resolved by an automatic travelling robot with similar functions to that on the Schlafhorst Autocoro rotor spinning machine, whose robotic piecing are accepted as being '*fault-free*', then all would be well.

I summarised in the first report the complaints by the knitters about the MasterSpinner yarn and examine below each of these problems in more detail.

DYE BARS

With MasterSpinner yarn there was a greater incidence of dye bars in critical colour plain fabrics produced on multi-end knitting machines.

- ❑ This was established as emanating from the previously mentioned spin-box to spin-box variability problem.

However, the scale of this dye bar problem needs to be put into the context of the actual commercial situation that exists.

- Very few fabrics employ the fabric constructions and dye specifications that lead to this problem of dye bars at the level of variation that could be controlled on the MasterSpinner by spin-box "tweaking".
- Therefore, to many knitters this was not a problem they were aware of.

A particular problem of using the "tweaker" to tune the twist was that dye bars were not always associated with twist. I mentioned earlier that it was not until we had machines with 144 spin-boxes operating in the mills that the scale of the spin-box to spin-box variability on the MasterSpinner became apparent.

- This was never fully appreciated by many of the mills who purchased 144 spin-box machines, because it was the PSL engineering technicians who were trained to handle this problem as it arose in the mills.

It was particularly interesting to talk to David Whitehead the Manager of Courtaulds Swan Lane Spinning Mill.

- Courtaulds examined this problem in great detail on the 10 spin-box spintester they belatedly purchased and were not satisfied with this "tweaking" feature.
- They reported to PSL that "tweaker" control of the spin-box to spin-box variability on the 10 spin-box spintester still left too great a variability.

Although Courtaulds were undoubtedly correct in their technical laboratory analysis of the yarns, there are no black and white areas in textiles.

- For example, at the same time as Courtauld's denigrating report to PSL, Schoeller Textil's two 144 spin-box MasterSpinners were operating round the clock and taking business away from Courtauld's Autocoro rotor spun yarn.
- Schoeller Textil obtained Courtauld's business from knitting companies in Leicester who were suppliers to Marks & Spencer.
- They all preferred the MasterSpinner friction spun yarn to rotor spun yarn.
- This being because it produced knitted fabrics with softer handle and thus more comfort in clothing, particularly those worn next to the skin, for examples underwear and sports shirts.

On a number of occasions, I visited these UK knitters in Leicester with Schoeller Textil's yarn technologist Mr. Schenk.

- These visits were to determine customer satisfaction with the knitting performance of cleared Schoeller MasterSpinner yarn. (I don't believe Schoeller actually told these knitters that the yarn was friction spun).
- Dye bars were never brought up as a major problem by these knitters.

YARN WEAKNESS

There were some products for which the friction yarn wasn't strong enough and these were acknowledged at the 10 spin-box spintester stage.

Weakness was also a problem of yarn produced on the 144 spin-box MasterSpinners after a period of running around the clock, and it ranks alongside faults due to piecings as the major complaint by knitters. I examined this problem in great detail and discovered that complaints about yarn weakness were always associated with extremely weak yarn packages.

Because the MasterSpinner's friction yarn was weaker than rotor yarn anyhow, most industry pundits on the side-lines have linked these two strength problems together, when in fact they are completely unrelated - a $2 + 2 = 3$ scenario!

- If the friction yarn had been twice as strong as rotor yarn, the problems of extremely weak packages of yarn would have existed at the same level.

Schoeller Textil eliminated their extremely weak packages by literally getting their employees who packed the yarn to give a quick pull on the friction yarn, and those that felt weak were isolated and subsequently tested in the laboratory. Obviously, not a satisfactory long term solution, but this simple action prevented Schoeller's customers realizing the full extent of the problem.

After extended round the clock operation, spin-box performance changed and the more short fibre in the feed-stock, the quicker the problem of extremely weak yarn packages came to light, thus highlighting a fly/fibre dust related problem. When the offending spin-boxes were stripped down for examination, there was one or more of the following barriers to the spinning of good quality yarn :-

- Fly/fibre dust trapped between the edge of the fibre transfer tube and the perforated roller running into the nip. This was the most common finding, and which on some occasions was enough to stop this roller rotating.
- Fibres trapped in the fibre transfer tube itself.

It was only when a spin-box was permitted to become too contaminated by such feed-stock debris, that dye bars in fabric and weak packages of yarn occurred.

- A similar type of problem to the build up of fly/fibre dust in the rotor groove of a rotor spin-box, but obviously much more serious and necessitating a costly, feed-stock dependent, and strict cleaning regime, whereby regular spin-box dismantling at defined intervals had to take place - defined either by operating time or kilos of yarn produced.
- Once identified, this technological flaw was clearly resolvable, but only in a new friction technology, as it has been in the SpinWell's design.

YARN SNAGGING

Yarn unwinding itself caused problems at knitting. This was due to snagging and was a feature of the yarn. Another area I have resolved on the SpinWell.

Also, those customers who did not re-wind the yarn had too many piecings that showed up as faults. This is a fundamental problem of manual piecing on any spinning process and why Schlafhorst have sold so many Autocoro machines. ■

SPINWELL AUTOMATION

Automation of Open-End Spinning Machines

Before considering friction spinning automation, it is essential to discuss the impact that automation has had on rotor spinning machines. I am certain that Schlafhorst gained their 1960s dominating position in rotor spinning because your automation worked more reliably in a commercial spinning machine environment. Whereas, that of Rieter, Schubert & Saltzer, Platt Saco Lowell, Savio and the Czech's B.D. machines did not. In particular, the quality of the Schlafhorst Autocoro piecings was such that yarn could be sold by the spinners directly off the spinning machine and classed as fault free without any further processing.

I believe this should be put in the context that it was Schlafhorst who were particularly good, rather than those other companies being particularly poor.

History of MasterSpinner Automation

Manual Piecing

In the early 1980s, our start point on the MasterSpinner Project was the need to devise a manual method of satisfactorily re-joining the yarn that could be applied to a multi friction spin-box machine by a textile operator working in a mill environment. The method of piecing-up after a yarn-end break on Austria's DREF range of coarse yarn friction spinning machines was abysmal and not worth emulating, so we were in fact starting from scratch.

When we eventually achieved a satisfactory system of manually re-joining yarn-ends together without knotting, we considered it a big breakthrough. My skilled engineering technicians in the R&D department became so dexterous with this system that were able to make some reasonable quality manual piecings which were better than PSL ever achieved, either manually, or with the automatic piecer on their rotor machine. We refined this system until it became possible for textile operatives of average dexterity to be able to piece up manually without knotting.

Platt Saco Lowell had no skill in Automatic Features

I was the instigator to get PSL to accept in the early 1980s that the company shouldn't attempt to devise and make automated mechanisms, but instead should subcontract this work to a specialised robotic company. At my initiation in the early 1980s Edward Smalley, the then Managing Director and Chairman, even visited Schlafhorst to see if PSL could do some deal in which Schlafhorst would supply the automation. The negotiating stance taken up by your top management and John D. Hollingsworth, the US owner of PSL, was so far apart that Edward Smalley didn't bother to pursue it any further.

Eventually, a UK company who manufactured specialist knitting machines and associated automation were commissioned to design and manufacture the automated features. I cannot remember their name.

At this stage, I was so enmeshed in the problems of the manual machines operating in the spinning mills that I took little notice of what was happening on the automation side.

I Examined Fundamentals Of Piecing

If you refer back to the section titled HISTORY OF MASTERSPINNER IN COMMERCIAL OPERATION you will see that piecing quality was a particular problem on the manually operated machines in the USA spinning mills. Consequently, I then started to examine piecings in great detail.

I examined many thousands of piecings by having them extracted from knitted fabrics that had been produced in the USA, arranging for Schoeller Textil to save me all the piecings they removed at yarn-clearing over a period of weeks, and for control piecings to be made in our development department.

A somewhat complicated pattern began to emerge.

About 50% of the manual piecings produced in the USA mills were clearly very poor and attributable to operator malpractice. I considered that an automated system should be able to eliminate these.

As part of evaluating the Schoeller Textil piecings, I correlated the number of actual yarn-end breaks with the number of piecings picked up by the yarn clearing process as being faults. Even though all of Schoeller Textil's friction spun yarn went through the yarn clearing process, great care was taken to ensure good manual piecing quality. So much so, that if the piecing was visible with the naked eye as it was being wound onto the package, the operator broke down the yarn and re-joined until a non visible piecing was produced.

About 50% of the Schoeller Textil piecings were not picked up by the yarn clearing process, and their extra care taken in manual piecing also eliminated the gross faults that were evident in the yarn produced on the USA run machines.

Schoeller Textil were very professional and ensured that the customer didn't become aware of their problems. So much so, that there were less faults attributable to piecings in commercial knitted fabrics produced from Schoeller Textil cleared friction yarn than from their Autocoro rotor spun yarn produced at that time. This demonstrates that friction piecings can be commercially acceptable from a customer's standpoint. It was certainly a big plus in getting knitters to buy friction spun yarn.

Examination of Non Gross Piecings

When I examined the faults either picked up at the yarn clearing process at Schoeller Textil, or the non gross faults but still visible in fabric produced from the USA friction spun yarns, I discovered a common characteristic in these piecings.

Consequently, I then carried out a control experiment by having a large number of piecings made by my skilled engineering technicians in PSL's R&D department.

- When examining those piecings which, similarly to Schoeller Textil's diligent operators, my skilled technicians considered had not been visible as they were being wound onto the package, there was the same common characteristic in all of those piecings which were subsequently picked out as faults when the yarn went through the yarn clearing process.
- Additionally, many of those not picked out as faults at yarn clearing had this same characteristic, but of a less severe nature, whereas some didn't.

What Was The Problematic Characteristic ?

At this stage, I am not prepared to divulge this knowledge. Suffice it to say that it was to overcome this problem that the SpinWell piecing concept is as it is.

Does This Guarantee Good Piecings ?

This doesn't guarantee good piecings at all. However, all the other elements necessary to guarantee good piecings are controllable on an automated piecing system, whereas this one particular characteristic was not.

Did MasterSpinner Automation Work ?

Because in the early days, as previously discussed, my skilled technicians were able to make some reasonable quality manual piecings, we concluded at this early time in the MasterSpinner Project that when the system was robotically automated the automation would resolve the other problems.

- Unfortunately, this proved to be an error of judgement because there was an in-built variability in the piecing procedure we had adopted which couldn't be improved by automation.

I left PSL before the first automated prototype was tested.

- However, I had set up a simulated system which confirmed that the automated piecing quality would almost certainly be worse than that which could be manually produced by a dexterous textile operative.

Engineering of Automation Was Poor

The company PSL contracted to manufacture the automated features didn't do a particularly good job, even on the relatively straightforward automatic features of package doffing. Although the failure of the MasterSpinner to produce acceptable quality automatic piecings was a fundamental technological problem, the knitting machine company made a poor engineering effort with the detailed engineering requirements and it was mechanically unreliable.

Failure of Automation Destroyed MasterSpinner

The failure to achieve the level of automatic piecing performance and piecing quality, established by then as the industry norm by the Schlafhorst Autocoro rotor spinning machine, was the reason why the MasterSpinner was withdrawn from sale.

One could make a good argument that it failed because PSL decided to mechanically emulate an existing manual system of piecing, rather than instruct robotic engineers to come up with a system conducive to automation, but this is far too simple a reason.

- The development of the Schlafhorst Autocoro started when manual rotor spinning had already been an in-mill established technology for over a decade.
- Consequently, unlike PSL, Schlafhorst didn't have a fundamentally new and commercially untried spin-box technology to deal with.
- Anyhow, the rotor spin-boxes and spinning technology were the sole responsibility of their very experienced joint venture partner Suessen.

It is clear that Schlafhorst's responsibility in the joint venture with Suessen was to copy other manufacturers and develop a relatively simple mounting frame incorporating electric motors and drive belts, so that over 200 of Suessen's rotor spin-boxes could be slotted in and the necessary mechanical motion for spinning imparted to each spin-box

In addition to such a relatively uncomplicated engineering task, Schlafhorst simply had to again copy existing manufacturers and build into this frame the already well established mechanical devices to supply fibre feedstock (sliver) individually into each of Suessen 200+ spin-boxes, together with installing already tried and tested individual mechanisms for winding the spun yarn onto packages.

The resultant rotor spinning machine became vastly superior to those already in the market by superb quality production engineering manufacture and the following :-

- ❑ Even though they had never built a spinning machine, Schlafhorst had years of experience in the development, automation and production manufacture of their very high speed yarn package winding machine - the Autoconer.
- ❑ So Schlafhorst's existing expertise included the automatic piecing together of the yarn ends from the relatively small bobbins of ring spun yarn to form a single package of yarn big enough for commercial knitting and weaving.
- ❑ At this time in the mid 1970s, the textile industry press was full of information from many spinning mills discussing their years of manual rotor spinning experience in a commercial environment and highlighting problems.
- ❑ I don't know who thought of re-configuring Schlafhorst's automated methodology of yarn piecing into a suspended box to continually travel around their new frame, stopping at a spin-box as necessary to automatically piece up after a yarn-end break, or doffing a full package and restarting spinning on an empty package - but this is how the world-beating Autocoro was born.

With the MasterSpinner, Hollingsworth's PSL were the first and still the only company to market a short staple friction spinning machine.

- ❑ With the benefit of hindsight, it is obvious that the manufacturing strategy was too much for a company which had been formed by the American \$billionaire John D. Hollingsworth simply buying the Official Receivership residue of its similar named predecessor, which by this time in 1980 was unsaleable as a going concern and whose tools of production manufacture had been investment starved for decades - a common engineering picture in Britain.
- ❑ Hollingsworth's newly named PSL then offered jobs to such as myself and other redundant employees with knowledge of the friction spinning intellectual property asset or who would be of some use in its commercial exploitation.
- ❑ Because of the precise similarity in name, same factory address, spare parts business and product list, most in the textile industry bracketed Hollingsworth's PSL with its predecessor which in its hey day as a subsidiary of the massive UK engineering conglomerate Stone Platt Industries, had sold a multitude of both ring and rotor spinning machines world-wide.
- ❑ Unlike the Schlafhorst/Suessen partnership, Hollingsworth's PSL decided to go it alone and also manufacture everything themselves, with no component or sub-assembly outsourcing whatsoever.
- ❑ To do all the machining in-house necessitated buying sophisticated plasma spray coating machinery and multi-head machines to drill the masses of hair size holes in the perforated roller, instead of subcontracting to specialists
- ❑ However, in all other manufacturing aspects, Hollingsworth's PSL worked with its predecessor's outdated tools of production - not a CNC machine in sight - and in antiquated factory premises. Consequently, it now seems somewhat incredible that the company got as close as it did to achieving success.

FIRST STAGE - MARK 1 to 8 PROTOTYPES

In our first stage of development we retained the basic concept of the MasterSpinners friction spinning technology. However, the new unit incorporated a completely new engineering design to enable the 10 or so parameters that determine the twist and structure of a friction spun yarn to be set to closely defined limits.

As part of this new design we separated the elements for piecing away from the spinning unit. This resulted in a piecing concept which would be much easier than a rotor unit to automate and produce piecings as good as the Autocoro.

Initially the yarns I was producing on the SpinWell exhibited similar snagging problems to those experienced with the MasterSpinner. It was almost by accident that I discovered a way to overcome this problem.

I was always aware that the snagging was an important negative feature of friction spun yarn and was particularly pleased to find a solution to this problem.

SECOND STAGE - MARK 9 to 12 PROTOTYPES

Unfortunately, to overcome the snagging problem meant that I had to completely re-design the spinning unit.

At the time, Belroy could not afford to carry out the necessary development work to produce the SpinWell Mark 9 prototype.

As a consequence, the project was put into abeyance whilst I was assigned, for just under two years, to do consultancy work for a company in Scotland who manufacture special carbon fibre products .

During the second half of 1993 the development of the SpinWell Mark 9 to 12 Prototypes was started.

I have had to work to a very tight budget and have experienced delays due to always having to employ outside companies to manufacture prototype components for the prototypes. As a consequence I have made less progress in raising the strength of the yarn than I had hoped.

However I have made very significant progress in other areas

- I now know for certain that I am achieving a fibre alignment that is better than on the MasterSpinner and significantly better than rotor spun yarn.
- I feel confident in saying that the fibre alignment is as good as one is ever likely to get from an open end system.
- Consequently any increase in yarn strength will not come in this area.

I believe further increases in strength can be achieved from a modification to the structure of the yarn.

- By changing certain of the SpinWell's components I am able to adjust the surface and yarn structural characteristics to meet different fabric requirements and thus widen the appeal of the SpinWell yarn.
- This is the area I propose to concentrate on for the next few months.
- However, it is too large a development area for Belroy to undertake properly with our limited resources.

The engineering design of the SpinWell unit has always been very different from the MasterSpinner.

The changes incorporated in the Mark 12 SpinWell unit have now taken the technology far beyond that achieved with the MasterSpinner.

EXTRA NOTES

There is no doubt that the extreme weakness of DREF yarn from 100% staple products without a core(filament or drafted staple)is due to the fact that the fibres are buckled and therefore do not contribute properly as stress is put on the yarn.

The earlier concept I established and which subsequently became the technology of the MasterSpinner made major improvements in this area. Others have tried and failed to create fibre alignment by causing the fibres to flip and other such strange ideas.

On rotor spinning the fibres are accelerated as they contact the rotor groove and which prevents fibres buckling whereas the opposite is true of friction spinning.

With the SpinWell I have taken the fibre alignment a stage further than I achieved with the MasterSpinner. By examining the yarn and even more clearly by examining clumps of untwisted fibres fed with the friction rollers stopped the fibres are aligned remarkably well along the yarn axis.

Although there has been a strength uplift due to this improved fibre alignment it has been very much less than I anticipated.

Now that I have achieved what I believe to be the ultimate in fibre alignment any future improvements are going to come from other areas.

TO MARKET THE SPINWELL

I indicated in the first report that the two features that distinguish the SpinWell yarn at its present level of performance from rotor yarn are :-

- Those fabrics in which the soft handle is a requirement or a marketable advantage.
- The present yarn structure, although having well aligned fibres, produces yarns which are bulkier than achieved with the MasterSpinner and significantly more bulky than rotor yarns. This occurs EVEN when the surface of the yarn is more highly twisted and therefore can have a greater abrasion resistance than rotor yarns.

I believe that there is considerable scope to make significant changes to the structure of the yarn

It is those potential customers who value these particular characteristics highly who will be the ones that should be initially targeted. They are the ones who are unlikely to have purchased rotor spinning machines or who will be seeking to replace existing rotor machines with a technology which offers them something better.

During the next few months I will be seeking, with the help of Courtauld's Swan Lane Spinning Mill, to produce fabric samples exhibiting a range of different surface characteristics.