The secret of Booth 1531

In the CAMX Trade show in Orlando, Florida in October, a modest booth caused a flurry of interest and excitement. Its offerings promised huge boosts in efficiency in the composites supply-chain, slashing waste and down-time. A new brand – Airbond - has remodelled a mature technology known as splicing to meet the needs of the growing composites industry. This new development is set to transform the way plants run. In a world where shaving off one per cent of cost can be important, Airbond now offers improvements of perhaps 30%.

How can such efficiencies be made?

In the minds of many, engineering structures made from composites represent a golden future, but many composites plants harbour a guilty secret; plant efficiency, and the amount of waste material generated, can be truly appalling. Waste levels of 35 per cent are not uncommon, and machine down-times can often exceed their run-times.

The problem lies with how yarns are stored before processing. Most yarns are wound into forms commonly called bobbins. A bobbin contains a defined mass of yarn, wound onto a core tube in a helical pattern.

To make a fabric, perhaps in weaving, many threads, from many bobbins, enter the machine in parallel. Here, the yarns are shown converging towards a loom.

In conventional textiles, the fabric may be tailored and made into a garment, but in composites manufacture, the fabric is later impregnated with resin and cured, to become an element of a vehicle or an aircraft.

Because each thread comes from a single bobbin, many bobbins must be stored near to the machine, to deliver yarn smoothly to the process. They are stored on large frames called creels. This photograph shows a typical creel, loaded with 1000 or more bobbins.

What happens in a traditional textile mill when a bobbin runs out of yarn?

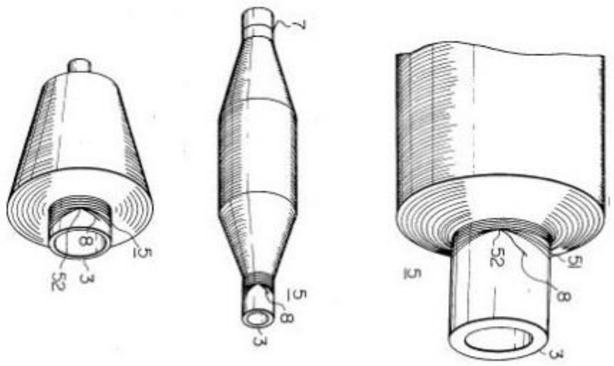
When the yarn runs out, the empty bobbin must be removed from the creel, and replaced by a full one. In traditional textile processes, in the simplest arrangement, the machine is stopped, while the trailing end of the old bobbin is tied with a knot to the leading end of the thread on the new bobbin. Then the loom is re-started, until the next bobbin is exhausted, when the tying-in process is repeated.

Down-time is considerable, and down-time damages machine efficiency.

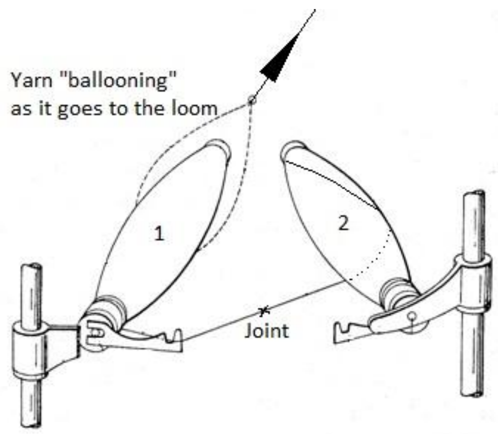
Magazine creeling as a potential solution to down-time

Many traditional textile mills solve this down-time problem by using "magazine creeling". Magazine creeling is a technique which effects a smooth transfer from a depleted bobbin to a full yarn package without necessitating any interruption in the delivery of the yarn. For every thread, two bobbins of yarn are placed in the creel; this doubles the size of the creel, but confers substantial improvements in efficiency. As part of the yarn manufacturing process, a short length of yarn is wound onto the tube after the bobbin has been filled. This short length of yarn is freely accessible and of usable quality. Such a piece of yarn is commonly referred to as a transfer tail; the tail of one bobbin, when unwound, can be secured directly to the outer end of the second bobbin.

The next drawing, taken from US Patent 4058264 A, shows transfer tails in three different forms of bobbin. Each bobbin has a length of yarn wound at the end; the helix can be unwound, to a length of perhaps 5 metres, and connected, by splice or knot, to the adjoining bobbin. The transfer tail can be seen most clearly on the right-hand image, where the helix is shown displaced at 52.



The joining process involved in magazine creeling is seen below. Bobbin 1 is supplying the yarn to the loom. The transfer tail of bobbin 1 has been unwound, and has been joined to the leading end of bobbin 2. When bobbin 1 is eventually exhausted, the yarn is immediately drawn from bobbin 2. Meanwhile bobbin 1 remains in position, visibly empty. An operator then brings a fresh bobbin for position 1, joining its leading end to the transfer tail of bobbin 2. The process is repeated for all bobbins as they run out; though the creel has been doubled in size, the technique ensures continuity of production.



So why not apply this to composites?

The key is in the connection between the yarns – the "joint" above. It's likely to be a knot. Even in traditional textiles, a knot can be bulky, ugly, and weak. But traditional manufacturers can often get away with it, in a natural, fluffy material like tweed or carpet. However, with composites, it's a very different story; the highest manufacturing standards are required, and knots are really bad news.

- The joints must pass through the process without causing "spikes" in yarn tension, or yarn breakages.
- They must pass through the process without becoming caught on components such as needle-eyes – which may damage the components and may cause further yarn breakages.
- They must have a strength which closely approaches that of the yarn itself.
- Their bulk must not disrupt the local structure of the fabric
- They must have an appearance which is essentially invisible in the final fabric.
- They must not be so consolidated as to inhibit the penetration of resin.

Knots fail on every count. They are simply unacceptable in a composite factory. So magazine-creeling cannot generally be used.

One solution to the problem of bad-quality knots is to load the machine with 1000 fresh bobbins, each containing the same length of yarn. They will all run out at the same time, and then can all be re-threaded. That represents a large chunk of down-time, but at least the knot problem goes away. However, it's not much of a victory. When the processor fills his creel with his 1000 bobbins, he might reasonably expect them to be of equal length, so that the bobbins will all be emptied at more-or-less the same time. But no yarn manufacturer can make bobbins with precisely equal lengths of yarn on each. So, of our 1000 bobbins, one will always finish first. And when the first bobbin is empty, the processor must also change the other 999. Each will contain some yarn; these "shorts" are usually thrown away as waste. So not only does our poor Production Manager have to stop his machine for hours, but he also has to throw away hundreds of part-filled bobbins.

So the poor quality of knots gives the processor a down-time problem, <u>and</u> a waste problem.

Heavyweight yarns and down-time.

It gets worse for our composites processor.

In apparel, yarn size is largely constrained by consumer requirements – it's not sensible to make a shirt from a yarn as thick as a tow-rope. But in some composites applications, there is no such constraint, and there is a move towards using heavier and heavier yarns to increase production speeds. The increase in weight – or count - promises faster production, but it falls foul of a fundamental human limitation; the bobbins have to be lifted into place. There is only so much weight which an operator can handle; in a normal factory environment, it gets tough to lift more than 15-20 kg. So the length of yarn on a real bobbin will reduce as yarn count increases.

Down-time of four or eight hours might just be acceptable if it takes several days to pull all the yarn off a bobbin. For instance, 20 kg of fine-count hosiery yarn will contain a length of about 10,000 kilometres – at a run speed of 10 metres per minute, the yarn will remain running happily on the machine for several weeks.
However, 20 kg of super-heavy glass fibre - maybe 5000 times the count of the hosiery yarn - will contain only about 2 km of yarn. If the process runs at the same 10 m/min, the bobbins will be empty after about <u>three hours</u>. Now, having the machine down for an entire shift when the bobbins only run for three hours completely wrecks the plant efficiency.

Using higher counts for greater efficiency is a poisoned chalice. Production may be faster in principle, but the down-time problem is exacerbated, and the waste problem remains.

So the poor quality of knots, together with heavy-count yarns, gives the processor a down-time problem, a waste problem, <u>and</u> a run-time problem. It's little wonder that his plant is inefficient.

Why not solve the problem using splicers?

In principle, it's easy to relieve our processor of his burden. He should use pneumatic yarn splicers – tools which have been used in conventional textiles since the 1970s. Pneumatic splicers make joints in many textile yarns – and the joints meet all of the quality criteria. But nobody has been able to splice carbon and glass fibre reliably.

Splicing is a violent process; it blasts fibres with air at a pressure of around 7 bar, at supersonic speed. Such speeds and pressures are essential, to create the required degree of intermingling of the fibres. Intermingling requires that the fibres be bent repeatedly, so that they wrap around each other on a micro-scale. Conventional fibres, such as nylon, can survive such treatment with minimal damage.

If the bending modulus of the fibre increases, the fibres resist distortion, and intermingling becomes more difficult. For successful splicing, high modulus fibres must be exposed to more violence – higher air pressure and greater flow rate. Fibres like glass and carbon have high modulus, but they are brittle; at the pressures needed for normal splicing, they are destroyed by the air blast.

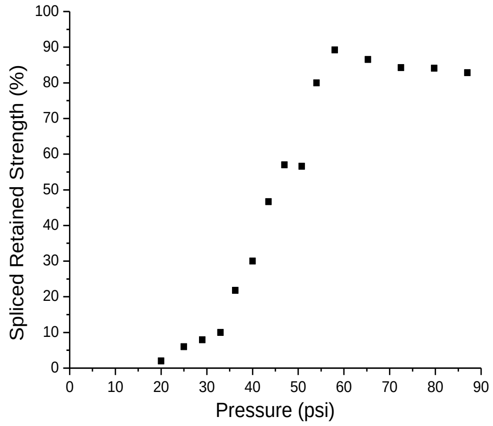
The pictures show (above) a neat splice made in a normal tough synthetic, and (below) the serious damage done to brittle carbon fibre when it is exposed to a conventional splicer.

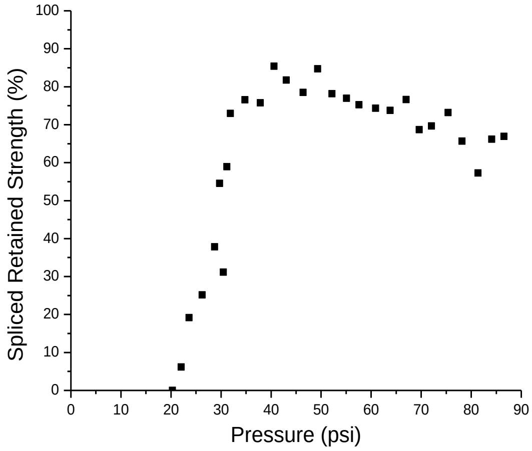
Yarns used in composites are not only brittle – they tend to be big. Bigger yarns need more air flow, because of their mass, and this further increases filament damage. So

- Big, stiff yarns for composites need high air pressures and harsh treatment.
- Big, stiff yarns for composites are brittle, demanding low air pressures and delicate handling.

This conflicting set of requirements had never been resolved – until now.

After years of trying, Airbond found the complete solution. The company undertook a programme of research on the mechanisms controlling splicing. Airbond has found new splicer designs which are more efficient, and more tolerant of pressure variations than their predecessors. Consider the following cases – actual results from real experiments:





The first graph shows the variation of splice strength with air pressure with a traditional splicer. The splice strength is expressed as a percentage of the parent yarn strength. Adequate splice strength is not achieved until a pressure of about 60 psi, 4 bar. The second graph shows the variation of splice strength with air pressure with a new-style splicer. Good splice strength is achieved at a much lower pressure of about 2.5 to 3 bar. This new form of splicer is more efficient than its predecessor; it reaches maximum strength at a lower pressure, and it maintains this strength from 2.5 bar to 4 bar.

The significant advance is that good splices can be made at pressures which do not damage glass and carbon.

And the secret of Booth 1531?

Airbond solved the problem of making strong, smooth joints in brittle fibres such as carbon and glass. And they solved the problem of making joints in extremely heavy-count yarns.

Airbond has developed a completely new range of splicers for the composites supply chain. These splicers are quite unique; they can join the big, brittle yarns, they can join them strongly, and they can join them strongly and discreetly.

A few years ago, we were restricted to tough yarns, with a maximum count of about 800 tex; now the new splicers can join brittle yarns of counts up to around 15000 tex.

With these advances, splicers are now able to set Production Managers free; by offering super-efficient splicers which work at relatively low pressure, splicing yarns from the finest to the heaviest, we can bring true magazine-creeling – and continuous running - to composites processing for the first time.

There need be no more machine stoppages; no more cutting-out of knots. Just a smooth, continuous manufacturing process, and a huge improvement in efficiency.