Some science

How does splicing work?

Pneumatic yarn splicing has been established in the textile industry for many years. A splice is made by placing two yarns into a pneumatic splicer, in a flat “X” arrangement. An air blast intermingles the fibres, and integral cutters trim off the waste ends. The completed splice is then withdrawn. It is usually less obtrusive and stronger than a knot.

The critical component of a splicer is called a splicing chamber. This is a profiled metal block, which is designed to expose the yarns to a blast of compressed air. The airflow in the splicing chamber creates the splice; the chamber design defines the characteristics of the flow and thus determines the form and quality of the splice.

The general principles of the splicing action are common to all designs of pneumatic splicer. The dynamics of the splicing mechanism are actually very complex, but a basic account is easy to understand. The yarns to be joined are placed in the splicing chamber, entering from opposite sides. This is simplified by providing the chamber with a hinged closure pad. The actual splicing process starts after the yarns have been laid in the blast chamber, the pad closed, and the waste ends cut to length. An air blast enters the chamber at very high speed. The air is highly turbulent, and the violent small-scale disturbances radically disrupt the arrangement of the fibres in the splicing chamber. Those fibres which happen to lie across the opening of the air-feed hole are separated by the direct blast. Those which lie elsewhere in the chamber are subjected to a chaotic pattern of vortices downstream of the entry point, which produce twisting and intermingling.

When the air supply is cut off, and the chamber is opened, the resulting splice has a characteristic and reproducible form. The central section is essentially unchanged, with the fibres lying largely parallel. Either side of this central section, the fibres lie in dense clusters, highly twisted and intermingled together. Each cluster usually terminates in a small tail where the extreme tips of the spliced yarns have not been fully bound into the structure. When a load is applied to the splice assembly, the fibres in the clusters slip very slightly, until the entire structure stabilises, as the inter-fibre frictional forces take the load.

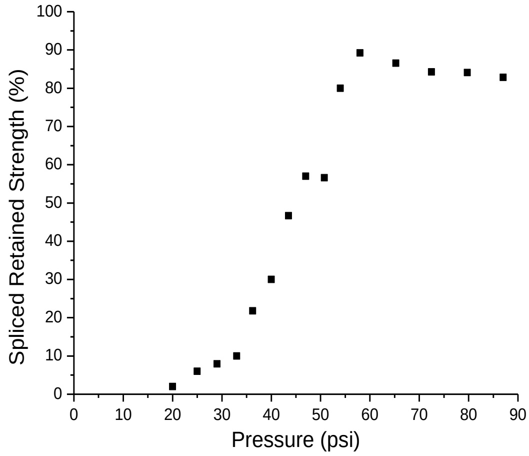
A splice is produced by the reaction of fibres to turbulent air. This is a random process, and therefore no two splices are the same on the micro-scale. Nevertheless, the length of the splice is much greater than the scale of the intermingling, so that the outcome is consistent from splice to splice. With continuous-filament yarns, very high splice strengths can be achieved, typically 90-95 per cent of that of the parent yarn.

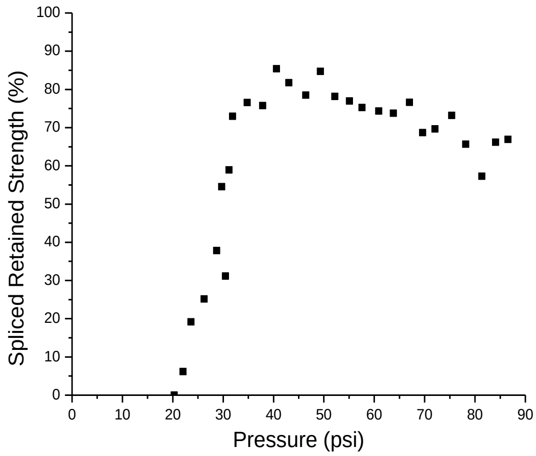
Splicing chambers

The active part of a splicer is known as a splicing chamber. The chamber is a small channel, which uses compressed air to intermingle the fibres and joins the yarns together. The shape of the chamber profile controls the air flow, so that the splicing chamber is the most important part of the splicer.

Splicers are used throughout the wide spectrum of the textile business, so that different environments require different solutions. For this reason, splicers are fitted with interchangeable chambers; to splice different yarns, users simply have to fit new splicing chambers. Although the business of changing chambers is inconvenient, in general it is necessary and unavoidable, because no one splicing chamber can cover the whole range of yarns in use.

Airbond is deeply committed to research, and we have a profound understanding of how splicing chambers work. We have applied our research to improving the performance of splicing chambers, reducing the number of different chambers which are needed, and therefore reducing the frequency of chamber-changing. One of the reasons for our mastery of splicing brittle modern fibres is that we have developed new forms of splicing chamber, which reach optimal performance at lower air pressures than hitherto. When splicing fibres which are easily damaged, it is crucial to be able to operate at the lowest possible pressure.





The two graphs above serve to indicate how better chamber design can have an effect. In the first case, a useful splice strength (80 per cent of parent) is not reached until a pressure of 55 ps. A more efficient form of chamber achieves the same strength at 35 psi – damaging the fibres much less.

Optimising splicing performance– the consequences of increasing yarn count

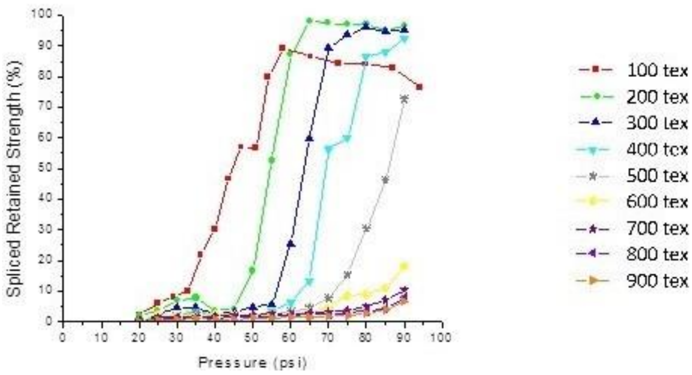
This is a topic which – as an outcome of our research – we now know to be of profound importance. For that reason, the effect of yarn count on splicer performance has been given a chapter of its own.

General

When first invented, splicing was applied to multi-filament synthetics of about 100 tex, or Nm 10. Things have moved on a lot in 40 years, and splicer manufacturers are expected to provide products which can join yarns of complex construction, and of ever-increasing count.

The graphs here show what happened when yarn count was increased, splicing ends-opposed in a simple trapezium-section splicing chamber. As count increased, progressively higher air pressures were needed. Eventually, above 5500 dtex, there was essentially no strength, even at high pressures.

First impressions were that the yarns had filled the chamber profile, preventing the yarns from intermingling.



Splice strength, various yarn counts, 32 mm splice length.

Cutter spacing and yarn count

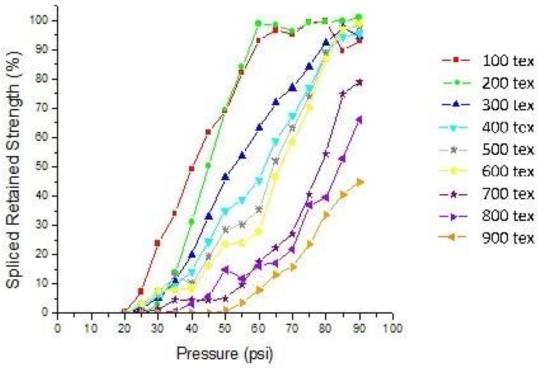
At this point, one more design parameter needs to be examined - one which is inherent in the design of the splicer itself. In most splicers, the cutting knives are mounted in fixed positions; this is understandable, because the knife drive mechanism usually has a fixed geometry. Most splicers have a knife separation of around 30 mm, so that the splice is also about 30 mm long. Thus, the absolute splice length is approximately constant, irrespective of yarn count as shown below.

Since knife separation is generally fixed, the splice length for a particular splicer cannot be altered. As the yarn count increases, the cross-section of the yarn will increase, while the splice length remains constant; therefore the ratio between splice length and splice diameter decreases. Consequently as yarns get bigger, the absolute splice length remains constant, but the relative splice length is reduced as shown here.

How will changing cutter spacing affect splice performance?

The graphs here show the effect of changing just one variable - the knife separation. The knife spacing - and hence the splice length - was increased from 32 mm. to 64 mm, all other parameters remaining the same. With this one change, the splicer began to produce joints comfortably in counts above 5500 dtex.

The earlier inference, that splicing fails when heavy yarns fill the chamber, was clearly inadequate; splices can sometimes be formed in heavy yarns simply by increasing splice length.



Splice strength, various yarn counts, 64 mm splice length.

The conclusion had profound implications for the design of new splicers; when count increases, the geometry of the entire splicer / chamber system must increase in proportion to yarn diameter. With increasing count, performance levels can only be maintained if:

- The splicing chamber cross-section becomes larger.
- The total splice length increases.
- The airflow increases.

Ideally, all splices, regardless of the diameter of the yarns, should have a similar geometry; it then follows that – in rough terms – the length of a splice should increase in direct proportion to the diameter of the yarns being joined. As yarns increase in size, strict performance parity can only be achieved by making a corresponding increase to the size of the splicer, and the separation of the cutters. The yarn diameter changes roughly as the square root of the tex; therefore a 2400 tex yarn is about five times the diameter of a 100 tex yarn. To maintain strictly correct scaling, therefore, a splice length five times longer might be expected to be desirable with 2400 tex.

No standard splicer can do this. Our Model 111, which is optimised for 100 to 200 tex, can splice 1000 tex, but with a small loss of strength compared to the ideal. However, the same splicer, when used for a 2400 tex yarn, produces a weak splice. Under certain circumstances, the weak yarn may be OK, but we do not recommend it as a general practice. So when we consider the problem of scaling, we are left with one of two options:

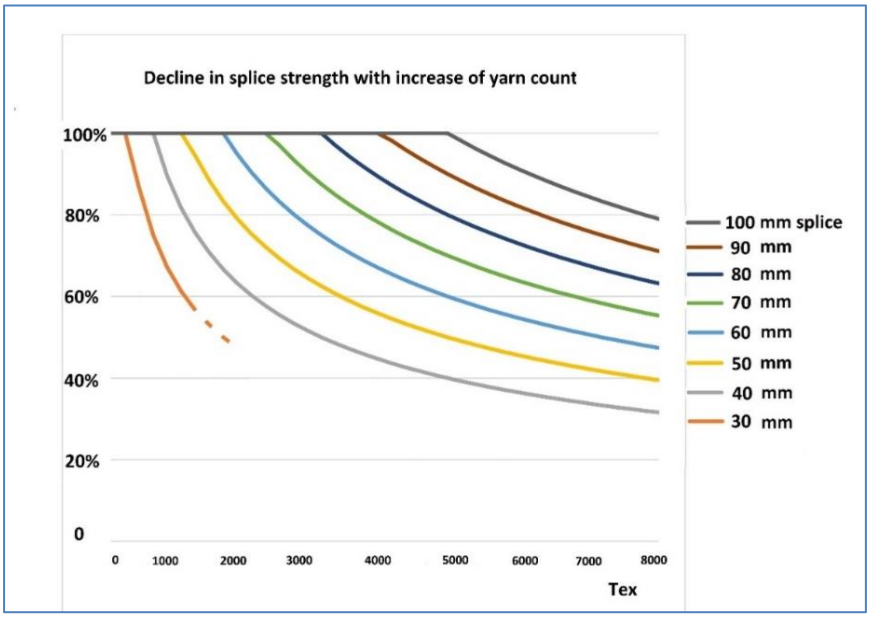
- Do away with the knives, and trim by hand.
- Make a big and complex splicer, with wide or variable knife spacing.

We have adopted both approaches; one is simpler and less expensive, while the other offers better quality at much greater expense.

The simpler approach has led to the introduction of the Model 110 and its successors. These splicers have no knives.

The more complex approach has led to the Models 121 and 122. These splicers have wide-spaced knives.

The table which follows gives an indication of how knife separation (overall splice length) needs to change as count increases. The figures in the boxes show the percentage strength of a splice, at a given knife separation, and a given yarn count (tex). They show clearly that a standard 30 mm knife separation begins to fail at counts of above 300 tex. The table is merely illustrative, because the figures cannot be accurate for all forms of yarn.



The lesson is quite clear, however – big yarns need long splices. No normal splicer with standard knife spacing of 30 mm – can make strong splices in big yarns such as 9600 tex glass. Another approach must be used – and taking a different approach has led Airbond to introduce its clever new products.