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PET *versus* PEN: What difference Can a Ring Make?

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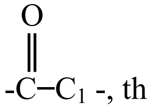
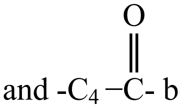
Poly(ethylene terephthalate) (PET) and poly(ethylene 2,6-naphthalate) (PEN) are structurally related polyesters. In each polymer the ethylene glycol diesters are separated by rigid rings, and are attached to the 1,4 pos-itions of the phenyl and the 2,6 positions of the naphthyl rings in PET and PEN, respectively. Because neighboring ethylene glycol units of each poly-ester are separated by phenyl or naphthyl rings, their conformations are independent of each other. As a consequence, their RIS conformational models should be identical, with the same populations of trans, gauche +, and gauche - conformations about the $-O-CH_2-$, $-CH_2-CH_2-$, and $-CH_2-O-$ bonds. This means that PET and PEN are equally flexible as judged by their conformational partition functions. However, because they differ geo-metrically, properties such as the mean-square end-to-end distance ($<r^2>_o$) or characteristic ratio ($C_r = <r^2>_o /n<l^2>$), though averaged over identical conformations, are not expected to be coincident. The terephthaloyl portion of PET can be considered to consist of the  $-\overset{\overset{O}{\|}}{C}-C_1-$, the $-C_1$----C_4-, and  $-C_4-\overset{\overset{O}{\|}}{C}-$ bonds, which are colinear, and only the conformations about the carbonyl carbon to phenyl ring carbon bonds may be altered. This results in the terephthaloyl unit acting as a freely-rotating link in both the statistical and dynamic senses. In the naphthaloyl residue, on the other hand, the carbonyl carbon to C_2 and C_6 to carbonyl carbon bonds are connected to a colinear, non-rotatable virtual bond between C_2 and C_5 and the non-colinear, non-rotatable real bond between C_5 and C_6, respectively. These geometrical differences between PET and PEN result in distinctly different values for properties like $<r^2>_o$ and C_r, even though they are averaged over the same conformational populations. Additionaly, volumes occuppied by their segments when confined to extended conformations and interconversions between these extended conformers were found to be particularily sensitive to the geometrical distinctions between PET and PEN, and several differences in their physical properties are discussed in this context.

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Transverse Compression of PPTA Fibers

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The behavior of several para-aramid fibers under transverse compression was investigated. Single fibers were placed on a flat, stiff platen, and compressed with a second, flat, stiff, parallel platen. The fibers deformed elastically, then inelastically under increasing load. This study examined 1.5 dpf and 6 dpf Kevlar® 29, 1.5 dpf Twaron® 100, 1055, and 2200 PPTA fibers, as well as un-heat-treated and heat-treated M5 PIPD fibers.

A fundamental problem to single fiber compression testing is creating platens which accurately approximate rigid, flat, parallel surfaces on the scale of the fiber (diameter D~12 μm). This study used a series of platens made from etched silicon wafers bonded together [Lin 1995], able to test fiber lengths from 5-75 μm. The test device used was supplied by DuPont, and was originally designed to assess the plane strain compression of coatings and films. The device consisted of a piezoelectric actuator, connected in a control loop to a capacitve displacement sensor. An in-line load cell transduced force.

Tests resulted in force-deflection curves, $F(U)$, and crushed fibers. Elastic response in the force-deflection curves was analyzed as the plane strain, transverse compression of a transversely isotropic cylinder between two rigid platens, which has been solved via Hertzian contact assumptions by [Phoenix & Skelton 1974, Jawad & Ward 1978], and was verified here by finite elements. For highly anisotropic fibers, the force-deflection curve essentially depends only on fiber transverse modulus, E_t, and D. Thus, force-deflection data was used to directly determine E_t, as well as the apparent strain, U/D, where fiber response became inelastic, and the stress state in the fiber up to that point. E_t was determined to be ~2.4 GPa for Kevlar® 29, and 1.6-2.1 GPa for the varying heat treatments of Twaron® examined, and 1.4 GPa for un-heat-treated and heat-treated PIPD fibers. The apparent strain at the elastic limit was determined to be $0.04<U/D<0.08$. Values of $2<E_t<3$ GPa have been found in PPTA fibers in most previous single fiber transverse compression tests [Kawabata 1990, Knoff 1992, Jones *et al.* 1997], and some efforts to back-calculate fiber properties from the response of unidirectional composites [Maksimov *et al.* 1980].

Inelastic response was characterized by initial, smooth force-deflection response and no visible cracking, transition to fibrillation under increasing deformation. In a minority of tests, the onset of inelastic behavior was marked by erratic force-deflection data, indicative of sudden cracking in the fiber. The smooth, inelastic response could be simulated by assuming elastic-plastic material response in finite element simulation. However, for all tests, compression beyond U/D~0.4 resulted in fiber compliance below elastic-plastic FE predictions. Cross sections of damaged fibers were viewed with laser-scanning confocal microscopy, with a resolving power of ~1μm. Fibrillation was seen in fibers compressed to more than U/D~0.4.

PPTA fibers are held to be highly crystalline (with crystalline contents from 85-100%, depending on the method used), and very aligned with the fiber axis. It has been argued that PPTA fiber elasticity should approximate at least the isostress, transversely isotropic average of the elasticity of PPTA crystals [Rutledge & Suter 1991]. Using this lower bound and any of several atomistic models of PPTA crystal elasticity gives reasonable estimates of experimental axial moduli of highly oriented PPTA fibers, such as Kevlar® 149. However, isostress estimates based on atomistic models predict $13<E_t<17$ GPa, a factor of 5-8 higher than experiment. This suggests that the continuum assumption on which the isostress average is based is not appropriate for the transverse properties of para-aramid fibers, and that a small volume fraction of the fiber cross-section must be much more compliant than the crystalline fibrils.

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Yarns of Basalt Continuous Fibers

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Recently, the interest in the use of mineral fibers to produce woven materials which find the widespread industrial application has been considerably increased. /1/.
The manufacturing technology of continuous basalt fibers (CBF) was developed in the Ukraine in the middle of seventies. At the same time the first reports regarding the production of textile yarns made of CBF were published. /2/. However, the development of basalt woven materials was restrained due to the non-stability of performance characteristics of basalt fibers. /3/.
A number of works concerning the improvement of commercial production of BCF have been carrying out in nineties /4,5/ and allowed to obtain basalt primary yarns suitable for textile processing. However, the fact that basalt fabrics were designed by analogy with glass fabrics adversely affected their development for a long time as the properties of glass fibers differ from that of basalt fibers substantially (see Table 1). As it is shown in the Table 1, the modulus of elasticity of basalt fibers is significantly higher and the elongation at break is significantly lower than these of E-glass fibers which are the most frequently used for manufacture of fabrics. Mentioned differences cause the specific character of the textile processing of basalt yarns.
In order to design the new generation of basalt fabrics, the additional study of parameters of textile yarns such as calculated (visible) diameter, average density, specific strength, and elongation had to been carried out. Above mentioned parameters, and also calculated filling up the fabric are the most important factors which govern the fabric forming on the looms. /6/.
Reference data concerning the analogs, e.g. glass yarns, did not allow to predict the properties of designed fabric to the sufficient accuracy as the main design parameters are often specified within large interval. So the values of average density δ of glass yarns given in the reference book /7/ are from 0.7 to 2 mg/mm^3. Besides that it is necessary to determine the constant A which characterizes the features of textile processing of specific type of fibers for basalt yarn, while it is well-known for the most yarns used in practice.
Basalt twisted yarn consists of the large number of continuous monofilaments. The number of monofilaments currently used in basalt twisted yarns is 200 or a multiple of 200. As there are channels and voids between the filaments, the sizing is applied and the strand is twisted (80 to 100 twist./l.m.) to impart the yarn integrity and suitability for further processing. The of experimental data allows to make conclusions as follows:
To determine the calculated diameter of the yarns and filling up the woven fabrics made of basalt fibers the constant A could be taken as 0.96, and the degree of filling up the basalt woven fabrics – as 0.50 (at the stress σ = 1 cN/tex and the density of basalt fiber γ = 2,8 g/cm^3) to the sufficient accuracy.

Basalt textile yarn distinguish itself by relatively high strength: the tensile strength is between the limits 22.6 cN/tex and 29.2 cN/tex (25.9 cN/tex on the average) although it is lower than the specific strength of primary yarns and roving probably due to partial break of monofilaments during the twisting.

Basalt textile yarn distinguish itself by high stiffness in tension: the elongation at break is between the limits 1,6% and 2,2% (1,8% on the average). This fact has a significant influence on the basalt fiber processing features in weaving. Besides that, the properties of basalt twisted yarns important for practical purpose such as mechanical strength at elevated temperatures in the range from 100 ^{0}C to 400 ^{0}C and chemical resistance to boiling solutions of NaOH (0.5N to 10N) and sulfuric acid have been also examined. It was shown that basalt yarns with paraffin sizing became to loss their strength to a large extent at temperatures higher than 200 ^{0}C while yarns with the sizing based on organosiloxanes retain sufficient strength properties up to 350 ^{0}C. Substantial reduction of the strength of basalt primary yarns and roving at 400 ^{0}C probably results from the thermal decomposition of the main adhesive components of sizing which runs at a highest rate during the first hour of heating and comes to the end after 8 to 10 hours. The destruction of the film combining the filaments into primary yarn and roving breaks their integrity and leads correspondingly to the reduction of strength due to cascade break of separate filaments. The study of interaction between basalt primary yarn and boiling solutions of NaOH (0.5N to 10N) and sulfuric acid showed that the basalt has the same rather good resistance both to alkali and acid media. These properties distinguish substantially the basalt from well-known commercial glasses. Obtained results allow to consider textile yarns of BCF to be a promising material to develop a new generation of woven fabrics having excellent strength properties and chemical resistance which could be used both for filter media and composites.

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Properties and Processing of Plant Fiber

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Comparing to some other fibers, the micro structures, the mechanical and some physics properties of the pineapple and banana fibers, constituent of these fibers have been tested and studied in this paper. Meanwhile, for improving some characteristics and the spinnability of these fibers, the chemical treatments were used to modify the fibers. The results show that after chemical treatment, both of these fibers can been processed in traditional worsted and cotton spinning systems and to be converted pure or blended yarns. Of course, the coarser and more brittle banana fiber shows inferior qualities in the yarn product compare to the pineapple fiber's.
Keywords: pineapple, banana, properties of fibers, chemical treatment, spinning, yarn.

Plant fibers such as flax, jute, hemp, pineapple and banana fibers etc. are all made up of thick walled cell tissue and they are bonded together by natural gums and support the branches, stems, leaves and fruits. Although pineapple and banana plants and fibers are available in tropical regions in abundance, their application potential has not been exploited fully. The fiber extracted from the plant is strong, white and silky. 50 years ago, it was already used by Philippines to make clothing by hand. At present, the limited application of pineapple and banana fibers are used in making ropes, mats, and in some other fields such as the composite materials. In recent years, more and more plant fibers were considered to be "environmentally friendly" fiber resources [1], and many countries are emphasizing the utilizing of these fibers. After cultivated, the leaves and trunks of pineapple and banana plants become the wastes of agriculture. After extracted either by mechanical method or by retting, these fibers can be got in the rate around 3% from plants (weight ratio to fresh leaf and leaf sheath). These fibers can be used as raw material for further processing.

Some research works on pineapple and banana fibers have carried out in China and some other countries [2-6], the newly researches on these fibers are reported in this paper.

Properties of pineapple and banana fibers Constituent

Table 1. Constituent of pineapple and banana fibers (%)

Fiber	cellulose	hemicellulose	pectin	lignin	water soluble materials	fat & wax	ash
Banana	50-60	25-30	3-5	12-18	2-3	3-5	1-1.5
Pineapple	56-62	16-19	2-2.5	9-13	1-1.5	4-7	2-3

Physical properties

Table 2. Physical properties of pineapple and banana fibers

	Sing cell		Bundle fiber					
	Length (mm)	Diameter (um)	Fineness (tex)	Length (mm)	Elongation (%)	Tenacity (CN/tex)	Initial modulus (CN/tex)	Density (g/cm^3)
Banana	2-4	10-35	13.35	8-30	1.11	34.2	31.2	1.321
Pineapple	3--8	7--18	2.5--5.5	10--90	3.42	42.6	10.2	1.543

The structural data of pineapple and banana fibers

Table 3. Structural properties of pineapple and banana fibers

	Orientation		Crystallnity	Birefringence
Fiber	Factor(fx)	Angle(°)		
Pineapple	0.972	5	0.727	0.058
Banana	0.810	14	0.443	0.048

Water absorbabilty and water-release

Figure 1 and Figure 2 show the water-absorption and water-release ability of banana and some other comparing fibers.

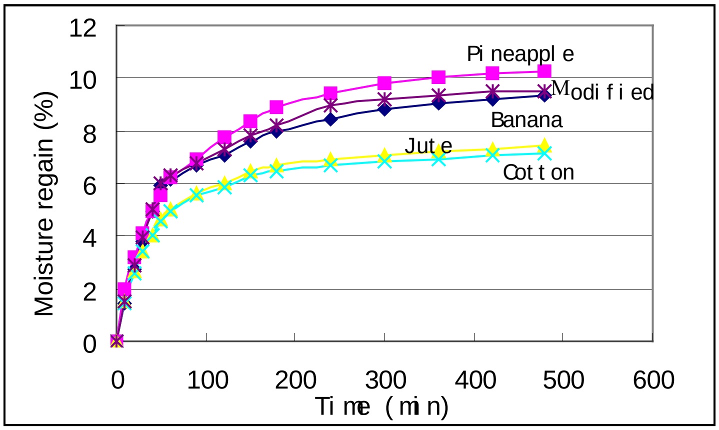

Fig.1. Water absorption of fibers

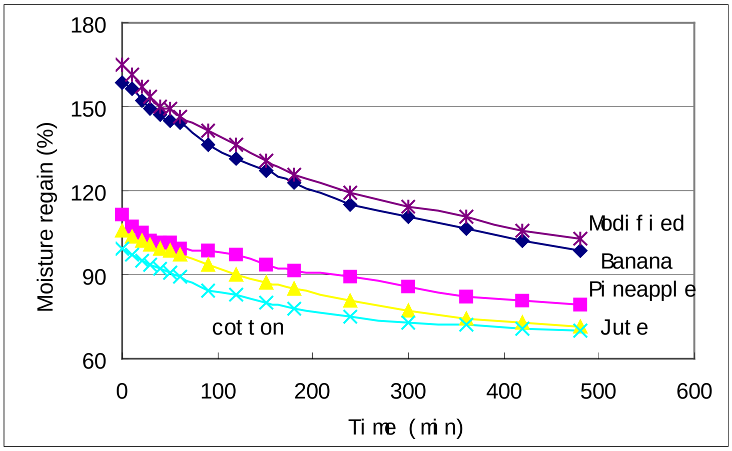

Fig.2. Water-release of fibers

Table VI. Quality of pineapple and banana fibers yarn products

	Count (tex)	Tenacity (CN/tex)	CV% of tenacity(%)	Elongation (%)	CV% of yarn	Thicks (1/400m)	Thins (1/400m)	Neps (1/400m)
Pure P.* yarn	100	10.91	14.6	3.2	-----	----	----	----
Cotton/P	32	10.1	13.8	3.14	33.15	972	1164	1664
Polyester/P B/Cotton	20	7.89	15.0	3.7	28.5	1434	352	2530

* P means pineapple fiber, B means banana fiber.

The properties and component of pineapple fiber are similar to that of many other bast and leaf fibers such as ramie, flax and jute, as a leaf fiber, pineapple fiber, comprising of more non-cellulosic materials especially lignin, is harder than ramie and flax fiber. Because of the short sing cell like flax, pineapple fiber should be chemical treated (degummed partly or modified), to leave some non-cellulosic material to bind the sing cells to be bundle fiber, which is long enough to be processed in spinning system. After reasonable chemical treatment, pineapple and banana fibers can be processed both in pure or blended form in ramie (or worsted) spinning system and cotton spinning system (cut to match the length of cotton fiber) to be quality yarns.

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Computer simulation of needled nonwoven mechanical behaviour.

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In order to make a simulation of the production process of needled nonwoven, we split the program into three parts: one for the production of the web with a card, one for the needling process and one for standard mechanical resistance tests. In this paper, the implementation of this last simulation module will be presented.

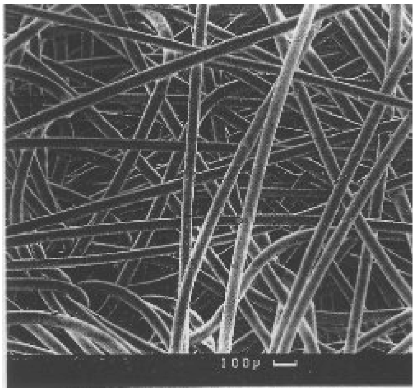

Figure 1 : needled non woven structure

Lots of works have been done on the simulation of nonwoven mechanical behaviour, mainly using a finite element approach [1, 2]. Considering the structure of non-woven as seen in figure 1, we preferred a mesoscopic approach, inspired by previous work on bonded non-woven using a finite displacement method [3, 4, 5] which yielded interesting results. A two-dimensional model was used, where the bonds between the fibres could only break. Due to the differences between bonded and needled non-woven, the model had to be modified: the structure is now three-dimensional and both friction and fibre slippage are taken into account. The fibre web is considered as an assembly of single node at fibre ends and paired nodes where they are in contact with one another. For each node are stored:

Its position
The next and previous nodes on the fibre
The node it is in contact with
The unstressed length between this node and the next one
The twist along the fibre between this node and the next one
A few coefficients and counters used in the calculation of equilibrium for this node.

The finite displacement method also had to be slightly modified but the principle remains the same: the web is stretched step by step and for each step, a new geometry is calculated for which quasi-static equilibrium is reached. This means that, for each pair of nodes, the forces resulting from the strain of the fibres as well as the moments caused by these forces and the twist in each strand must be balanced. Indeed, the fibres are supposed to be more likely to roll on one another than to glide, but gliding as well as fibre breakage are nonetheless checked for when equilibrium is reached. They are dealt with and the new configuration is calculated until equilibrium is reached again with no slippage or breakage of fibres. Then the web is stretched again and the whole process is repeated until complete failure of the web. In order to reach equilibrium, the resulting force $\sum \vec{F}$ is calculated for the first paired nodes. If it is higher than locally stored percentage of the highest individual force, they are moved in the direction of $\sum \vec{F}$. The distance is proportional to $\left\|\sum \vec{F}\right\|$. If it is higher than the radius of the fibre R_f, R_f is used as the distance and the proportionality coefficient, which is stored for each pair of nodes is lowered. In order to avoid the situation when nodes oscillate between two positions, this distance is multiplied by a random value between 0 and 1. For each iteration, we count when each node has reach equilibrium or not and if one of these counters reaches a given limit, the percentage used to evaluate if $\sum \vec{F}$ is sufficiently small, is lowered or risen. These limits can be used to adjust the balance between speed and accuracy. The same kind of process is used for the moments but there is no movement. Instead, the distance is converted into a twist in a fibre and the corresponding length is transferred from the initial length of one strand of the other fibre to the initial length of the other strand. As the initial actual lengths are used to calculate the strain and thus the stress in each strand, the next round of force evaluation should do the actual movement. Thus we get a global stress strain curve for the sample, as in a real test using a dynamometer at low speed. But local values for stress, twist or energy can be obtained and densities calculated. In order to obtain reference input data for the program, X-ray microtomography is planned to be used. Indeed, the three-dimensional web structure can be extracted from the cross-sections without destroying the sample. This way, the same sample can also be tested with a dynamometer and the results can be compared to validate the model and the simulation.

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Polyblending for the Production of Dyeable Polypropylene Fibers

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Polypropylene fiber has a wide range of application, the fiber is characterized by high strength and good resistance to abrasion and chemicals. The main disadvantage of this fiber is the lack of dyeability.

Dyeing of isotactic polypropylene fibers (i-PP) by conventional dyeing method is insufficient. The problem originates from lack of chemical affinity between the fiber and dyestuff due to absence of ionic or polar groups on the polymer chain.

In this work, we present a new method for the production of polypropylene dyeable fibers in an aqueous dyebath by melt mixing polypropylene with polyamid 6. Binary blends of isotactic polypropylene and polyamid 6 (PP/PA) were prepared by melt mixing in a double screw extruder, with the ratios of 100/0, 90/10 and 85/15 with and without compatibilizer(maleic anhydrid grafted polypropylene). All blends were extruded in the form of filaments through a semi-industrial spinning extruder at 240 ^{o}C with a spinneret having 120 holes.

Dyeing experiments were carried out in water with 1% o.w.f disperse dyestuff at boil for 1 hour. After rinsing, light and washing fastnesses of samples were carried out according to ISO standards.

The results show that uptake of dye from the dyebath for the polyblend fibers is excellent compare to i-PP and reasonable in comparison to usual fibers. Besides, light and washing fastnesses of the polyblend fibers are much better than those of pure i-PP fibers while retaining similar mechanical properties.

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Workskill Development in Introductory Textile Classes

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There is a pressing need for improved teaching methods to better prepare students for their future careers. Our ongoing research work has focused on developing and refining teaching methods to achieve these goals for students in textile-related majors. Because of the content-intensive nature of the introductory textile class, in which students are introduced to all aspects of the textile industry, a traditional method of classroom lectures and "cookbook" laboratory demonstrations has typically been used. Our research focus has been on developing effective supplements to this traditional method in order to improve students' higher-order cognitive skills (HOCS) including the ability to analyze, synthesize, and evaluate information. These skills are valued in the workplace. Evaluation of the effectiveness of these supplements is accomplished by surveys distributed to students at the end of the semester, instructor observations, and observations of a pedagogically trained objective observer. A variety of supplements have been studied. Students have completed *learning style surveys* to identify preferred methods of learning. Most students utilize a mixture of learning styles, and important differences have been identified across the various textile majors. Students submit individual *chapter summaries* that are completed before the material is covered in class. This supplement provides students with exposure to the vocabulary and concepts before lecture and affords the instructor the opportunity to focus on the more difficult concepts in class. *Group projects* provide students with the opportunity to deconstruct a finished product and apply their knowledge of textiles in analyzing the product to identify how its various constituents were manufactured. A *formatted discussion* protocol has been developed to promote creative and analytical thinking as well as communication skills. Overall, the use of these supplements fosters development of HOCS, aids students in the synthesis and evaluation of information, and increases the performance of borderline students.

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Laser Fusion of Textured Yarns to Impart Inter-filament Cohesion

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Textured continuous synthetic filament yarns have very open, loose structures and may not conveniently be used for fabric formation processes without imparting inter-filament cohesion to the filaments to prevent them from opening and separating. The most common method used to impart the necessary cohesion to the multi-filament yarn is known as intermingling. This uses a high-speed air-jet, positioned in the path of the yarn being textured, that creates knot-like intermittent entangled nodes in the yarn (referred to as 'nips') which significantly increases the inter-filament cohesion.

Such a nozzle operating under given processing conditions produces a fixed number of nips per unit length of yarn. This depends on the properties of the filament yarn and up to an extent on the air pressure used. However it is almost impossible to produce nips at a different frequency for a given nozzle and yarn. Different applications require different nozzles. It is also very difficult to design a nozzle that operates at the desired nip frequency. Although performed by a steady-flow jet, previous research shows that the intermingling of the continuous multi-filament yarn is an intermittent process with a degree of irregularity. So it is extremely important for the texturing industry to have a nip formation technique which is programmable to different processing conditions that produces very regular nips at the required frequencies.

This paper reports a feasibility research into the use of a pulse laser to fuse synthetic continuous multi-filament yarn at regular intervals to impart the desired cohesion at required frequencies. Since the constituent filaments of a synthetic yarn are of thermoplastic material, such as polyester and polyamide, it is possible to heat the yarn at discrete points along its length with an intense heat and fuse them to form nips. A pulse laser beam focused on the yarn was used in the research that created the required energy to heat and hence fuse the yarn at required points. Pulse frequency and duration hence the heat intensity were varied in the research to determine a suitable range of operating conditions for different yarns. Results from a range of polyester and nylon yarns shows that fusing textured filament yarn to create nips at regular intervals is feasible using pulse laser as an alternative to nip formation by air jets.

Th multi-filament yarn was also modelled to compute the heat flow in the yarn when heated by a pulse laser. This model can be used as a useful tool to estimate the heat energy required to fuse a given textured yarn.

The main advantages of the laser fusion over the intermingling process would be as follows:

Laser fusion is a non-contact method which does not interfere with the yarn being transported at high speed that in turn eliminates the nozzle wear which requires frequent replacement and frequent cleaning and maintenance.

Laser fusion creates nips at regular intervals and allows frequency and heat intensity to be adjusted to suit needs.

Laser fusion is an environmentally friendly process that eliminates the noise pollution associated with intermingling nozzles.

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