A Novel Air-Jet Texturing+Twisting (AJT^2) Technology

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ABSTRACT

This paper reports the development of a novel and innovative air-jet texturing + twisting (AJT^2) technology and elaborates on the potentials of this new technology in the field of technical textiles. The novel technology on-line combines the air-jet texturing operation with the twisting operation. Additionally there is a hot drawing unit for orientation of POY (Partially Oriented Yarn) supply. The principles of this new technology and the prototype machine designed and manufactured to realize this technology are explained in this paper. Since the air-jet texturing is the only process to texturise the non thermoplastic, especially glass, carbon and metallic fibers, this new technology has the unique features of combining these fibers to create composite fibers for technical applications. This technology has been developed by the support of TUBİTAK Research Grant No: 105M134 and has been filed as Patent Application (TPE Document Code: 69065, Registration No: 20072344).

Keywords: Air-jet texturing, direct twisting, combined yarns, hybrid yarns, composite yarns.

1. INTRODUCTION

In this work, our goal is to develop a novel process which on-line combines the air-jet texturing operation with the twisting operation. The air-jet texturing process forms a yarn with tightly convoluted, entangled and looped filaments resembling yarns spun from staple fibres such as cotton and wool.

In this process of air-jet texturing, multi filament yarn is fed into a narrow channel where it meets with a flow of compressed air and taken away from that channel at a lower speed than the feeding speed (called overfeed) and makes a right turn just after the narrow channel. At the exit of the narrow channel, filaments are entangled, convoluted and looped with each other.

The textile technology has been utilizing various twisting techniques such as ring twisting, two-for-one twisting for some centuries. On the other hand, the direct twisting is a relatively recently invented [1, 2, 3] and developed twisting method. In this method, there is no limit to the number and shape of the supply yarn to be twisted together.

The air-jet texturing process is one of the major texturing processes that impart additional properties such as bulk, warmth, flexibility and spun-like aesthetics to the synthetic filament yarns, enhancing the use of these yarns. Since the air-jet texturing is the only process in texturizing the non-thermoplastic, especially glass, carbon and metallic fibres, this new technology has the unique features of combining these fibres to create composite fibres for technical applications. This is the only technique that a metallic wire could be inserted into the centre of a yarn in one single operation to create hybrid yarns.

Parallel arrangement of the filaments are entangled, disrupted and changed by the air-jet texturing process. As a result of this process, the filament yarn gets bulkier and thus warmer and softer. Nevertheless, the frictional forces created by the entanglement of the originally parallel filaments only obtain the integrity of the yarn. There is no other binding force.

Since they look like spun staple-fibre yarns, by this virtue, the air-jet textured yarns are also termed as "spun-like" yarns. The air-jet textured yarns find many widespread end-uses all over the textile industry, ranging from apparel to technical uses such as carpets as well as car interior fabrics. However, the uses of these yarns are limited due to the low process speed and the lack of stability of the end yarn.

In this work, the twisting process which is slower than the air-jet texturing process is combined with the air-jet texturing process and the speed limitation of the air-jet texturing will be treated as an advantage. Also, additional forces between the filaments are added by the twisting process, eliminating the possibility of disentanglement of the air-jet textured yarns. The principle of this system is shown in Figure 1.

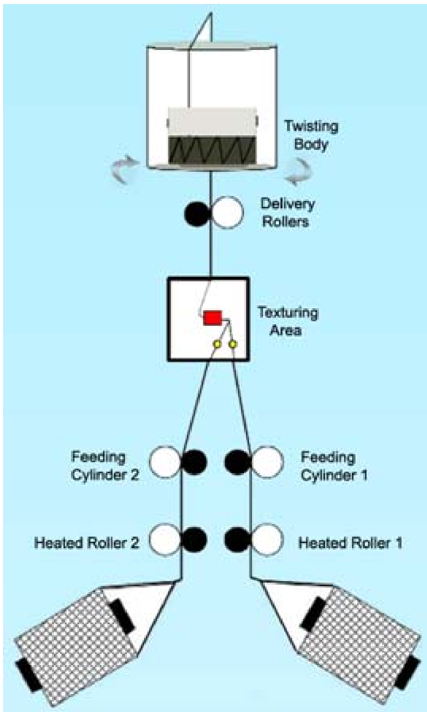

Figure 1. The working principle of the AJT^2 process

Application areas of this system

The application areas of this system are:
- Supply possibility of thermoplastic or non-thermoplastic filament yarns,
- Use of FDY and/or POY,
- Single-end, parallel and core-effect texturing possibilities,
- Fancy yarn production by means of feeding different colored, different linear density, different type yarns,
- Possibility of combining drawing and texturing processes,
- Dye variation by means of differential drawing of supply yarns,
- Creation of slub effect,
- Formation of free fibre ends,
- Mechanical and heat setting possibilities.

The Advantages of the AJT^2 process

The advantages of this system may be listed as below:

- Since this novel process imparts at least two distinct improvements to the air-jet textured and mixed filaments by giving additional cohesion to the filaments.
- In the first distinct improvement, the air-jet texturing process may be carried out at much lower pressures (for example 5 bar by instead of 9 bar air pressure) providing economical benefits.
- The other improvement is due to a novel character obtained in the final yarn. While the air-jet texturing forms all sorts of fancy yarns by mixing different color, material, number of filaments, this novel combined process doubly widens this scope by adding all sorts of natural and/or spun staple yarn the air-jet textured yarns.
- In the end, the high tenacity and high wear resistance of the filament yarns is combined with the natural look and appearance as well as soft and warm feeling of spun staple yarns.
- Another advantage enabled by this novel process is that two or more simultaneously air-jet textured yarns may be combined (doubled, folded) to obtain softer yarns and hence fabrics.
- This technology gives the possibility of combining carbon, metal or all kinds of non-thermoplastic mono- or multi-filament yarn with air-jet textured filament yarns and/or spun staple yarns to create totally different technical yarns.

2. AJT^2 SYSTEM

This new machine, a photographic view of it is given in Figure 2, consists of three main processes.

These processes are:

- Drawing process,
- Air-Jet Texturing process,
- Twisting process
- in respect to the processing sequence.

Drawing Process

The drawing process is implemented by two units of ceramic plated cylinder–rubber cylinder pair (FC) and two units of heated cylinder–separator roller pair (HR). The yarn transferred from creel is wrapped around the HR and heated up to the glass transition temperature of the polymer. the yarn has to be fed by the HR at lower speed than the FS in order to create a draw between the FC and HR. After the drawing operation, the yarn is then ready as finished yarn to be fed into the yarn channel of the air-jet nozzle by the FC feed cylinders .

Texturing Process

The air-jet texturing process forms a yarn with tightly convoluted, entangled and looped filaments resembling yarns spun from staple fibres such as cotton and wool. In this process of air-jet texturing, multi filament yarn is fed into a narrow channel where it meets with a flow of compressed air and taken away from that channel at a lower speed than the feeding speed (called overfeed) and makes a right turn just after the narrow channel (Figure 3). At the exit of the narrow channel a supersonic, highly turbulent air jet is formed by the compressed air flow that pushes the freely available filaments in any direction in such a way that they entangle, convolute and loop with each other. Such converted yarn is much softer, bulkier and gives warmer feeling to wearer and possesses natural look and appearance than the supply yarn which may be composed of one or many filament yarns be thermoplastic, organic or metallic.

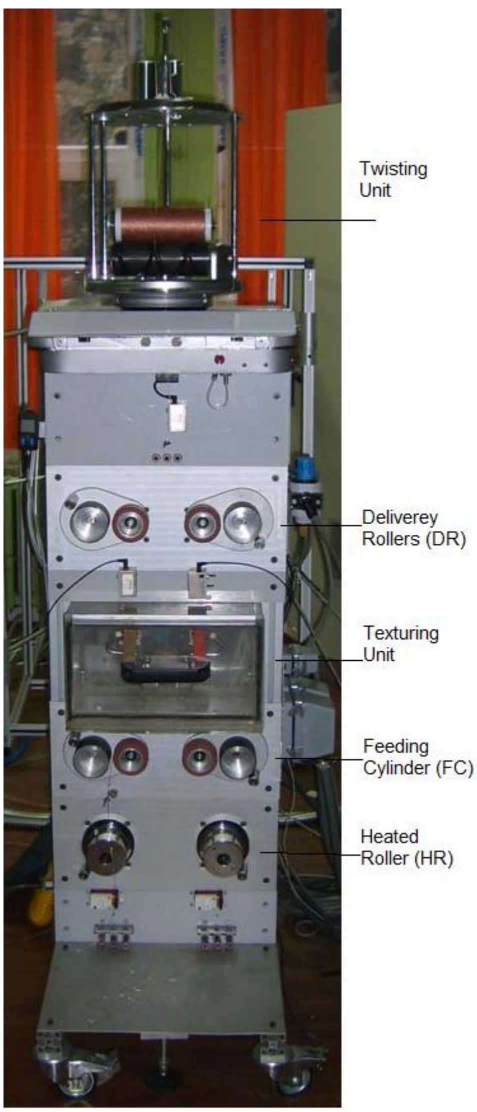

Figure 2. The AJT^2 machine

The air-jet texturing box: After the drawing operation, the yarn is then ready as finished yarn to be fed in the yarn channel of the air-jet nozzle by the FC feed cylinders. The yarn passes through the ceramic guides, which are selected as ceramic to prevent friction between the yarn and the touching surfaces, placed underneath the texturing box. Just before the entry of the feed yarn into the yarn channel, it is wetted by a water jet to wash off most of the spin finish oils as well as to reduce the friction between the filaments and between the filaments and all surrounding yarn guides including the yarn channel of the air-jet nozzle itself. Reduction of the friction improves the texturing tremendously. Such overfed and wetted filaments encounter the air flows coming from a 5-10 bar pressurized air source. The air flow(s) drag and separate the filaments to the exit of the yarn channel where a supersonic, turbulent free air jet is created and where the filaments are forced to turn at a right angle and pulled at a lower speed by the delivery rollers (DR) that rotates slower than the FC rollers. The supersonic and highly turbulent jet of air blows the filaments in all possible directions and hence causes them to entangle and mix together. After the texturing process, the yarn passes through the ceramic plated guides to the twisting head (Figure 4) [5].

In the air-jet texturing box, two separate yarn groups can be textured. Moreover, three yarn types can be used in each group.

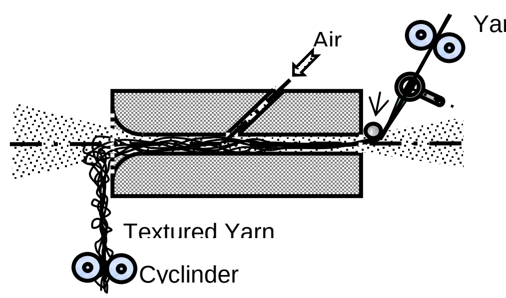

Figure 3. Air-Jet Texturing process

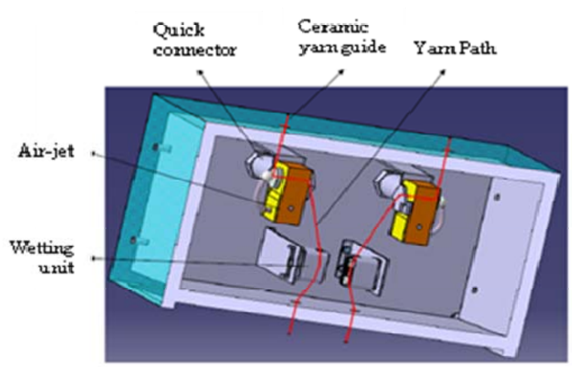

Figure 4. Air-Jet Texturing Box [5].

Twisting Process

Yarn twisting process is a well known textile process. Although there has been many twisting methods developed, there are only three distinct types of twisting techniques industrially widespread used. The rest is of a property of patent literature. These widespread used twisting techniques are ring twisting, two-for-one twisting as shown in Figure 5 and DirecTwisting® developed very recenlty.

During the two-for-one twisting the yarn holding packed is not rotated. In this technique, when the point A of the yarn makes one tour, B and C points make one turn creating two twist on the yarn. That is why this process is named as two-for-one twisting. In this process, the supply bobbin has to have a hollow tube through which an unwound yarn is passed and directed to the radially positioned exit of the rotating spindle. The supply package is magnetically stabilized on this rotating spindle. The radially out fed yarn is then threaded through the yarn guide positioned above the spindle and then wound onto cross wound bobbin in the form of cylindrical or conical shape. By one rotation of the spindle, the yarn is twisted once while it is fed from the package to the spindle and twisted again from the spindle to the yarn guide positioned above the spindle forming the twisting balloon. In the process of two-for-one twisting, the supply yarn is limited to one or two bobbins stacked one above the other on the rotating spindle [4].

Yarn twisting with DirecTwist®: In DirecTwist® Method developed by a Turkish engineer, yarns with lots of types can be produced. In this machine, twisting involves a rapidly rotating spindle where the supply yarn(s) are fed through the centre and led out from the radially positioned tunnel. The rotating and hence twisted yarn is then directed to the yarn guide positioned above the spindle axis [6].

The twisted yarns can be used all of the textile industry. Especially, these yarns are used in the weaving clothes [6].

In this machine, S and Z twisting can easily be made. The yarn is finally wound onto bobbin by the winder located within the sphere of the yarn balloon. The movement and energy transfer into the sphere formed by the rotating yarn balloon is the subject of another granted patent. By such a process there is no limit of the number and shape of the supply yarn to be twisted [6].

Yarn forwarding system: In air-jet texturing and twisting machine, the yarn before and after the air-jet is forwarded by transportation cylinders and pressure cylinders. When the pair of these cylinders grip the yarn and yarn is then forwarded continuously [5]. Separator rollers are placed with an inclined angle to the axis of the transport cylinder. Thanks to this inclination, the yarn cannot exit during the operation (Figure 6).

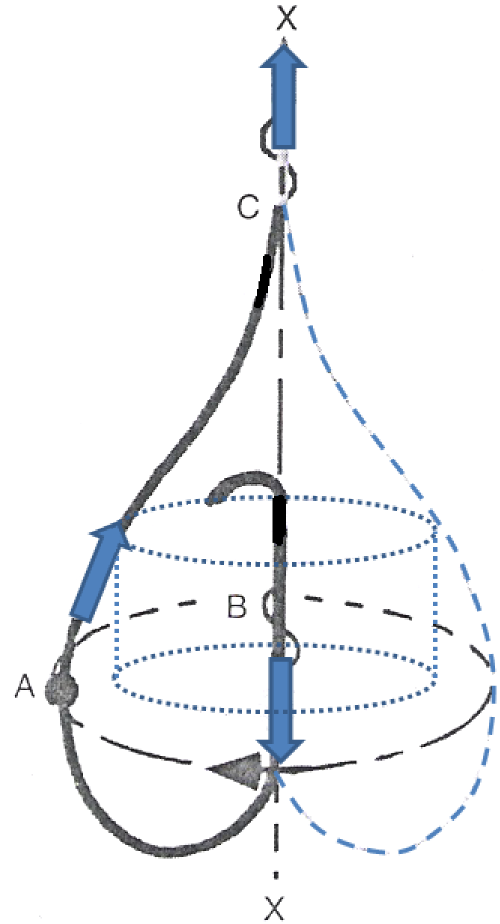

Figure 5. Yarn Path in the Two-for-one Twisting Method [4].

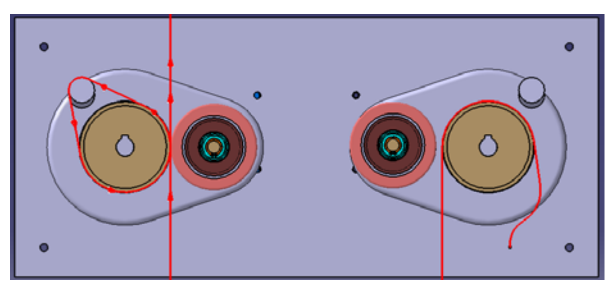

Figure 6. Yarn forwarding system

Yarn gripping mechanism: Yarn gripping mechanism is released by an eccentric mechanism. After the movement of this eccentric rod, the pressure roll comes into contact with the transportation cylinder. The rotation of the eccentric rod is done with a pneumatic motor which can turn 45°. But in the operation, after turning 30°, yarn pressure mechanism touches to the transportation cylinder (Figure 7).

3. YARN EXPERIMENTS

The following yarn examples are for explanation only and therefore the newly developed technology is not limited with these examples.

The supply yarns are used in these experiments;

- Yellow 334 dtex FDY (Yarn 1),
- Red 167 dtex FDY (Yarn 2),
- Gray 167 dtex FDY (Yarn 3).

Process characteristics are given in Table 1. And the photographs of the manufactured yarns are given in Figure 8.

The experiments have created the following yarns:

- Yarn 1 is textured and twisted in Ex. 1, 2, 3
- Yarn 1 and 2 are textured together in Ex. 4.
- Yarn 2 and 3 are textured together and then twisted with yarn 1 in Ex. 5, 6, 7, 8.
- Yarn 1, 2, 3 are textured and twisted together in Ex. 9, 10.
- Yarn 1, 2, 3 are textured and then twisted with Ne 40 combed cotton yarn in Ex. 11.

4. CONCLUSION

This work has developed a novel combined process by which the air-jet texturing and twisting processes are carried out simultaneously on a filament and staple spun yarn. In the conversion of the thermoplastic or organic filament yarns into a yarn with improved and better qualities, the air-jet texturing plays an important role. But this process is limited in widespread use due to high amount of compressed air consumption. On the other hand, the twisting operation achieved by the rotation of an end of a yarn brings together the yarn forming fibres or filaments together hence increase the cohesion and imparts strength as well as creates fancy and high value yarns from simple yarns. This new developed technology involves a combined single one step process in which the air-jet texturing and twisting processes both of which are individually unique processes. The combined process offers both improved process economics as well as limitless possibilities to create fancy effects on filament and spun staple yarns.

The combined process also offers covering of non-thermoplastic yarns such as metallic, carbon, ceramic, glass mono- or multi-filament yarns to be used in intelligent textiles for the electrical conductivity or heat dissipation.

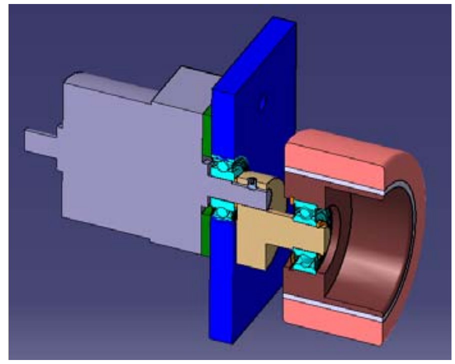

Figure 7. Yarn gripping mechanism [5].

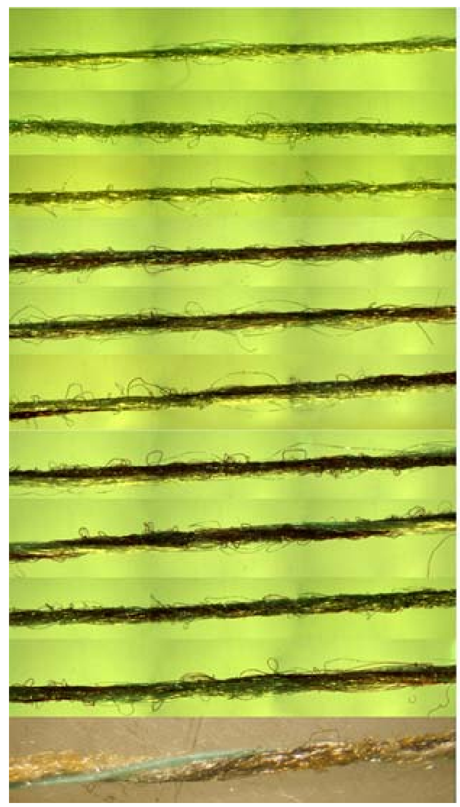

Figure 8. Yarn examples produced with AJT^2

Table 1. Process characteristics of manufactured yarns

	Single Yarn			Double Yarn	Triple Yarn						With Cotton
	Ex 1	Ex 2	Ex 3	Ex 4	Ex 5	Ex 6	Ex 7	Ex 8	Ex 9	Ex 10	Ex 11
Process Speed (m/d)	80	80	80	80	80	80	80	80	80	80	100
Overfeed (%)	10	30	20	20	10 10	10 20	10 30	10 40	30	40	40
Twisting (T/m)	80	80	80	80	60	60	60	60	60	60	60
Air Pressure (bar)	7	7	6	7	8	8	8	8	8	8	9

5. ACKNOWLEDGEMENT

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