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A new technique of producing sliver of Estabragh fibres

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In order to produce a 100% Estabragh sliver, an experimental apparatus has been designed and assembled. The sliver of Estabragh fibres has been produced and the arrangement of fibres in the sliver is studied. The results show that the fibres are arranged approximately parallel in the sliver. The angle of 70% of fibres to the sliver axis is found to be less than 10°. The mean angle of Estabragh fibres is about 10.69° while that of viscose fibres on a traditional sliver is about 18.84 °.

Keywords: Carding process, Estabragh fibres, Fibre arrangement

1 Introduction

Estabragh (Milkweed) is an indigenous plant found along the southern regions of the central plateau of Iran. This plant which belongs to the Asclepiadacae family produces a silky needle- like fibre with a relatively smooth surface and is mostly cylindrical[1]. Estabragh fibres are cellulosic seed fibres growing in groups inside the large seed of the plant. Each seed contains uniform, longitudinally oriented fibres[2]. These fibres are naturally hollow, with a thin wall relative to their diameter, and the ratio of the hollow area to the fibrous area is considerable. Therefore, they are lightweight and are expected to provide excellent insulation properties[1-4]. Some physical and mechanical properties of Estabragh fibre (*Asclepias procerais*) such as silky lustre and hollowness, make this fibre similar to the milkweed (*Asclepias syriaca*) or Rux fibres (*Caleotropis gigantea*), which grow in the USA and Southeast Asia[5-7]. Estabragh fibres have a noticeable and exclusive advantage over other natural or man-made fibres, which can be potentially useful in a variety of applications[8].

There are many investigations on the characteristics of milkweed fibres such as their molecular weight and molecular-weight distribution[9], physical and mechanical properties[1,2,5,7] and their chemical behavior[3,4]. Hasanzadeh *et al.*[10] predicted the noise reduction coefficient (NRC) of nonwoven layers produced from Estabragh/ polypropylene blends of fibres. Bakhtiari *et al.*[8] studied the thermal comfort properties of Estabragh fibres.

Estabragh fibre also has a good potential of becoming an excellent source of fibre in the manufacturing of textile products. According to the historical evidence, the cloth woven from the yarns of these fibres are very beautiful[2]. Estabragh fibres present a very low elongation at break and they are very brittle. These fibres break easily during mechanical processing[5]. These fibres are also straight and there is no crimping along the fibre length. The lack of cohesiveness of Estabragh fibres, however, causes several barriers in processing and can affect the spinning of the fibres. Recently, a few studies have been done on producing the yarn of Estabragh fibres blended with other common textile fibres[4, 5, 7, 11]. These studies have also examined the physical and mechanical characteristics of the Estabragh blend yarns. However, there is no published research on producing the pure Estabragh sliver and yarn. Both qualitative and quantitative studies show that Estabragh fibres experience serious damage during the carding process[2, 5]. Ghareaghaji and Davoodi[2] showed the likely mechanism of fibre damage during the carding process of Estabragh fibres. They reported that carding of the Estabragh fibres without spinning oil is almost impossible and a high extent of fibre drop occurs. The damaging

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effect of carding and Estabragh fibre dropping considerably decreased when other traditional fibres were blended with Estabragh fibre. These traditional fibres could have better control on the crimpless straight and may have supported the Estabragh fibres against mechanical damage, which could cause shortening of the fibres[2]. Therefore, reported studies confirm that the Estabragh fibres have to be processed in a blended form with other fibres such as PET, cotton or polypropylene[2, 5, 7, 8, 10]. There is a possible idea to control the Estabragh fibres during the carding process through the chemical treatments of the fibre surface. The chemical treatment may increase low frictional resistance offered by Estabragh fibres because of its smoothness and brittleness. However, this treatment may deteriorate the main properties of the primary Estabragh fibres, such as smoothness, fluffiness and lustre. Therefore, diminishing the effect of fibres cohesion and crimping of Estabragh fibre by chemical treatment is not a proper procedure to improve their performance in spinning processes such as carding.

These particular problems cause difficulty in manufacturing of a pure Estabragh sliver using the carding process. Therefore, it appears to be impossible to manufacture a pure Estabragh sliver using a carding process. Thus, it is important to utilize an apparatus to make pure Estabragh sliver essentially without fibre breakage and surface damages. In this research, a new technique of producing the sliver of pure Estabragh fibres has been developed and an experimental apparatus is designed to achieve the production of sliver of this fibre.

2 Materials and Methods

Estabragh fibres used in this study were procured from the jungles of Minab, a town in Hormozgan province of Iran. The physical properties of the fibres are: fibre mean length 26.6 mm, fibre tip diameter 15.76 µm, fibre middle diameter 28.93 µm, fibre end diameter 39.16 µm and fibre mean strength at break 3.65 cN.

2.1 Experimental Apparatus

The surfaces of circular cylinders of the carding machine which are usually covered with saw-toothed clothing make serious damage on the Estabragh fibres. The mechanical process of card clothing may break the fibres and shorten its length. Therefore, a new apparatus was designed to produce the sliver of pure Estabragh fibres (Fig. 1). In this apparatus, the fibres do not experience mechanical damage and the individual fibres align to be parallel with each other by means of an air circulation. The principle of this apparatus is to form a uniform web; in such a way that the certain number of fibres are brought together at the right place, essentially without fibre breakage. This apparatus is mainly composed of an air blower and fibre collecting zone. The fibres are manually fed with air flow into the apparatus. The apparatus walls lead the fibres and air toward the air outlet zone. The collector in the air outlet zone is a mesh which allows the air flow to pass freely while the fibres are collected on the mesh. Other parts of the wall are made of a coated fabric with a smooth and slippery surface. The smooth surface of the wall fabric provides a slippery surface in order for easy fibre movement to reach the collector or the sliver forming zone.

The blower air opens and transfers the fibres and then collects them on the collector making a sliver. This apparatus produces a discontinued sliver with a defined length which is equal to the linear length of the fibre collecting zone (Fig. 1). Therefore, the fed fibres in each passage should be determined in order to produce a sliver with a defined linear density. For instance, to produce a sliver of 2 g/m, about 3.8 g of Estabragh fibres are fed into the apparatus in each passage to produce 188cm of sliver equal to the length of the fibre collecting zone. It should be kept in mind that the Estabragh fibres should be carefully opened and free from trash and impurities before feeding into the apparatus.

2.2 Modelling of Flow

The fibres in the sliver should be longitudinally oriented. Therefore, it is necessary to consider the air

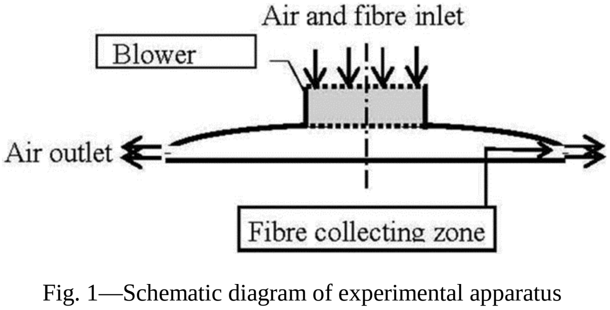

Fig. 1—Schematic diagram of experimental apparatus

flow in the apparatus and the fibre orientation in the produced sliver. To consider the fibre flow in the apparatus, the air and fibre flow in the apparatus are studied by the numerical CFD model. In numerical modelling, the FLUENT software is used to simulate the fluid. In FLUENT, the pressure-based approach was developed for low-speed incompressible flows. The Navier-Stokes equations, which express the conservation of mass and momentum form a coupled set of nonlinear partial differential equations (PDEs). FLUENT uses a finite-volume discretization to convert the PDEs to a set of nonlinear algebraic equations. The solutions obtained here employ the segregated solution algorithm, in which the equations are solved sequentially, as opposed to being assembled into a single matrix equation and solved simultaneously[12].

To generate the mesh, a structured grid was applied to the geometry of the apparatus using Gambit software. A total of 712k was obtained after generating the grid. In the simulation, a uniform mass flow rate profile is assumed at the inlet as the boundary condition. The air blower in the inlet of the apparatus is a fan. The fan mass flow rate and pressure drop are calculated. Also, the no-slip condition for the velocity components is considered at the walls.

The results of the simulation show that the velocity in the centre of the bed is near zero and it causes a vortex to be created in the mechanism (Fig. 2). In this figure, the velocity distribution in the middle path of the mechanism has been shown. The air flow weakens in the air outlet. The velocity in the lower region of the outlet is found higher than that in the upper region.

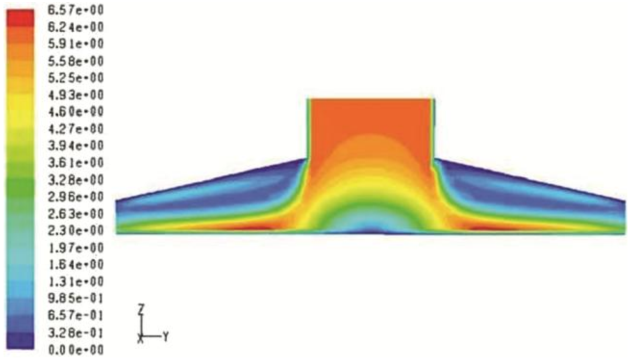

Fig. 2—Contours of velocity magnitude in the middle path of mechanism

3 Results and Discussion

The sliver of 2.5g/m (2500 tex) were prepared by feeding the Estabragh fibres on the experimental apparatus. To consider the irregularity of the sliver, the linear density of the produced sliver was measured. The results of measuring 30 samples of 10 cm length show that the coefficient of variation of the sliver linear density is about 17.5%.

The directional arrangement of fibres in the sliver significantly determines the internal structure and the mechanical properties of the produced yarns. The fibre orientation in the sliver can be used in practice as a quality parameter for the slivers and also to judge the effectiveness of the sliver preparation processes. In this research, the characteristic of fibre orientation in the sliver is considered through measuring the angles of the tracer fibre segments and the longitudinal direction of the sliver. In order to evaluate the directional arrangement of fibres in slivers, samples of Estabragh sliver were produced while a small amount of dyed tracer fibres were fed on the surface of the sliver [Fig. 3(a)]. The angle of tracer fibres is measured on the images of sliver using the image analysis software of Digimizer [Fig. 3(b)]. The experimental data obtained on Estabragh sliver is compared with those of polyester sliver processed in a traditional manner.

The angles of 200 randomly selected representative fibres of the samples on the sliver in the images were measured. Figure 3(b) shows a few examples of the method of measuring the tracer fibre angle on the sliver in the Digimizer software. The results show that the directions of more than 70% of Estabragh fibres have an angle of less than 10° with the longitudinal direction of the sliver [Fig. 4(a)]. The angle of fibres in a traditional viscose sliver was also measured in the same way. The results show that the mean angle of the viscose fibres (18.84°) in a traditional sliver is more than that of Estabragh fibres (10.69°) in a sliver produced in the new manner [Fig. 4(b)]. It is obvious that the viscose fibres have more crimp than the Estabragh fibres. Therefore, the small segments of the viscose fibres have a significant angle with the sliver axis. As a result, the measured angles on the Estabragh sliver are a representative of the direction of fibre axis, while the measured angles on the traditional viscose sliver show the partial direction of the fibre segments.

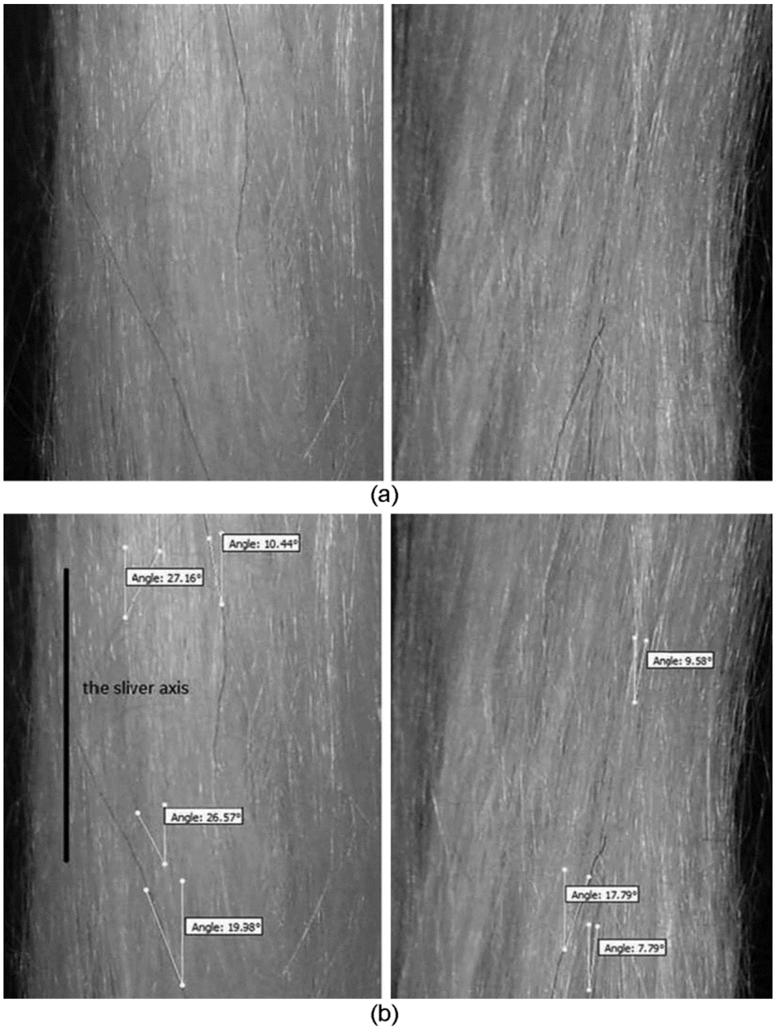

Fig. 3—(a) Two typical images of tracer fibres on Estabragh sliver, and (b) two typical image of measuring method of fibre angle on sliver in the Digimizer software

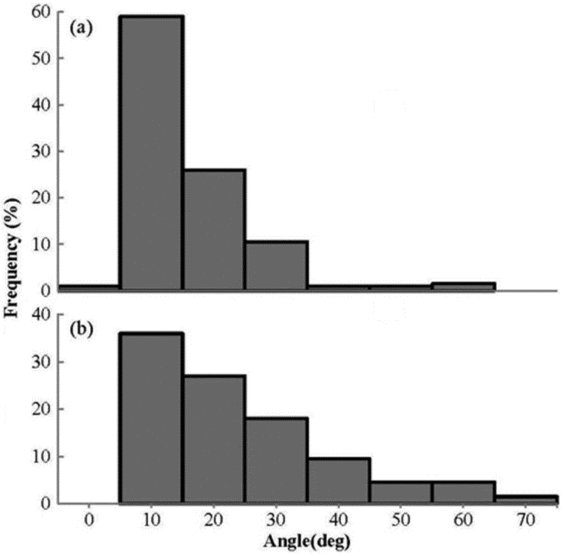

Fig. 4—Histogram of angle between sliver axis and viscose fibres axis (a) Estabragh and (b) viscose fibres axis

4 Conclusion

A newly designed experimental apparatus has been assembled and employed to produce the Estabragh sliver without any mechanical damage on the fibres. The Estabragh sliver was produced on this apparatus and its characteristics were evaluated. The results show that more than 70% of fibres align in sliver longitudinal direction with an angle of less than 10°. The mean angle of Estabragh fibres to the sliver axis is found about 10.69° while that of viscose fibres on a traditional sliver is about 18.84°. Consequently, production of the Estabragh sliver of proper quality is possible using the newly designed apparatus.

Acknowledgement

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