Application of air jet nozzle for the production of open end slub yarn

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A method for producing open end slub yarn by application of pressurized air is introduced. An experimental prototype was designed and attached to an O.E. machine. An air jet nozzle was utilized to blow and accelerate the fibers on the opening roller surface periodically. This results in increasing the linear density of the fiber flux inside the rotor during the pulse duration thus forming a slub. To evaluate the performance of the developed method, properties of the produced yarn were analyzed. An investigation of the influence of air pressure and the duration of application of pressurized air on yarn properties was carried out. Analysis of results indicates that the proposed method has proved to be satisfactory for the production of open end slub yarn. The produced slub length is shorter than rotor circumference. The tenacity of the produced yarn is nearly equal to normal yarn tenacity, hence allowing a wide range of slub designs to be processed and woven efficiently. Increasing air pressure causes an increase in slub diameter and a reduction of slub length, while increasing air pulse duration leads to an increase in slub length.

فى هذا البحث تم عمل طريقة لانتاج خيط ذات السمك المتغير على ماكينة الطرف المفتوح بواسطة استخدام الهواء المضغوط . تم تصميم هيكل معملى وتركيبه على ماكينة الطرف المفتوح٠ فى هذه الطريقة استخدمت فونية هواء لإزالة وزيادة سرعة الشعيرات من على سلندر التفتيح دورياً مما يؤدى إلى زيادة كتلة الشعيرات بداخل الروتور بالتالى يتكون جزء سميك يسمى (slub) . ولتقييم اداء هذه الطريقة تم عمل تحليل للخواص الخيط المنتج من حيث قطر الجزء السميك وطوله و الخواص الميكانيكية للخيط المنتج٠ تم بحث تأثير قيمة الضغط المستخدم و كذلك الزمن المؤثر فيه على خواص الخيط . تحاليل النتائج المعملية لتأثير المتغيرات المختلفة اظهرت ان الطريقة المقدمة تعمل بكفاءة وأن الجزء السميك الذى يمكن انتاجه بواسطة هذه الطريقة اقصر من محيط الروتور. ومتانة الخيط الناتج تساوى تقريباً متانة الخيط العادى وذلك عند ظروف التشغيل المتختلفة مما يسمح بعمل تصميمات مختلفة للجزء السميك كما أن الزيادة فى ضغط الهواء يؤدى إلى زيادة قطر الجزء السميك وتقليل طوله بينما زيادة فترة استمرارية الهواء يؤدى إلى زيادة طول الجزء السميك.

Keywords: Slub yarn, Open end yarn, Air jet nozzle, Pressure, Pulse duration, Slub diameter, Slub length, Tenacity

1. Introduction

Slub yarn is a type of fancy yarn characterized by an intermittent thickening of its diameter to form a slub, which could be periodic or non-periodic depending on the effect required to be enhanced in the fabric [1]. The slub may more or less be obvious for slub yarn volume, length and color. Slub yarn adds value to the end product by giving it a more attractive and natural look, hence gaining ground in a growing number of applications. Slub yarn is no longer just present in traditional fabrics used in upholstery, lace, net curtain and household fabrics in general, but it is becoming more popular in the production of shirts, knitwear and more vivid casual wear [2-4].

Open end slub yarn is widely known. The slub on open end machine can be produced by several methods [5-9]. The most common used method is feeding excess material to the rotor. This can be achieved by different methods such as varying the speed of the sliver feed roller or by intermittently feeding additional material at a constant or variable rate. However, slub length produced by the pervious methods is longer than the rotor circumference. It also needs additional costly attachment [5, 8, 9].

In order to overcome the disadvantages of the previous methods, a pressurized air method was introduced [6-9]. In this method, the

evenly distributed fiber flow in the transport tube is partly and periodically blocked by means of injecting pressurized air against the direction of fiber flow. This causes fibers to be braked and accumulated instantaneously resulting in a slub having a length shorter than the rotor circumference. However, braking and accumulation of fibers due to air barrier leads to the deterioration in fiber orientation hence decreasing yarn tenacity and resulting in a slub that was small and irregular. This effect is increased by increasing the air pressure value. In order to overcome the latter disadvantages, a modified pressurized air method was developed to produce open end slub yarn. The properties of the produced yarn were investigated.

2. Materials and methods

2.1. Experimental prototype

In order to produce slub, a pressurized air prototype was designed to be attached to the rotor unit of an open end machine. It consists of an air jet nozzle connected to an air pressure regulator. In order to create sufficient air pressure, a compressed air supply is connected to a mechanical valve which controls the duration of air pressure application inside the air jet nozzle.

The nozzle, located in front of the opening roller, consists of a cylindrical tube with a tapered end. The edge of the tube has a width equal to that of the opening roller in order to ensure complete removal of fibers from the surface of the opening roller by the injected compressed air.

The nozzle is adjusted so that its air output will be tangential to and along the direction of rotation of the opening roller. This ensures complete removal of fibers at minimum air pressure values as shown in fig. 1.

2.2. Mechanism of slub formation

As the air valve starts to open, pressure builds up instantaneously (refer to fig. 2) and the existing flow of fibers on the opening roller

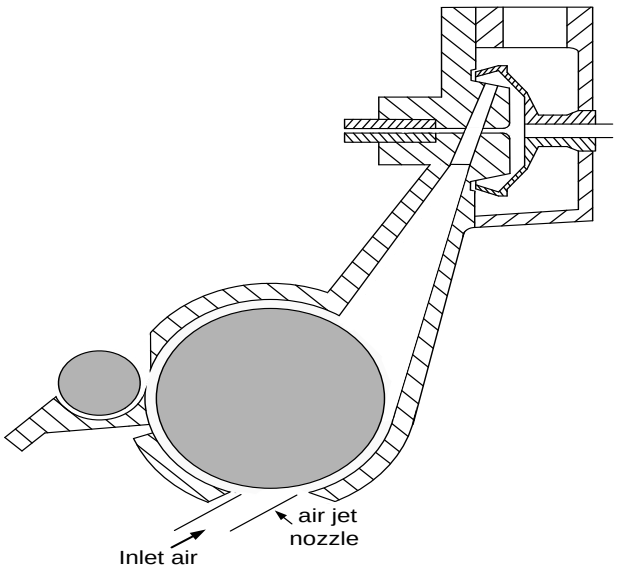

Fig. 1. Schematic diagram of experimental prototype.

surface is blown by the pressurized air. These fibers will leave the surface of the opening roller and will accelerate through the transport tube to the rotor surface. This leads to an increase in the linear density of the fiber flux on the rotor surface and consequently the main slub will be formed. The length of the slub will depend on the possibility of these fibers to redistribute their mass on the wedge of fibers inside the rotor. Due to continuous feed, a considerable amount of fiber flux will arrive to the blowing area. These fibers will be blown continuously by air and pass to the rotor to form a number of small slubs. This situation will be repeated until the pulse duration terminates. The small slubs can be called the secondary slub.

2.3. Study of open end slub yarn properties

Experiments were carried out to study the influence of air pressure and pulse duration on open end slub yarn properties. Open end slub yarns were spun of cotton Giza 80 which has a staple length 31.24 mm and micronaire 3.11 μg/in. Table 1 and 2 show the processing parameters of the experiments.

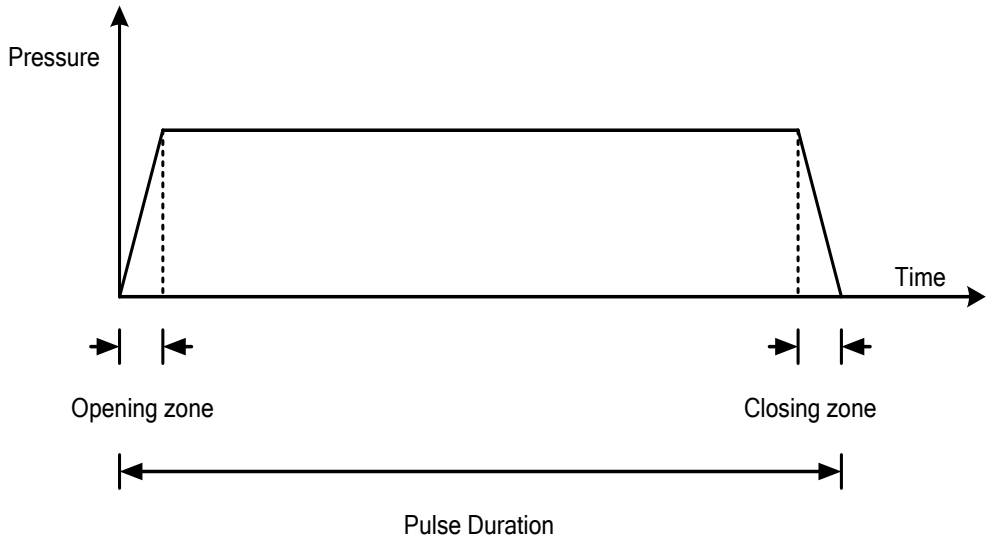

Fig. 2. The change of air pressure throughout pulse duration.

Table 1
Processing parameters of experiment (1)

Parameter	Value
Yarn count (Ne)	10
Twist factor	4
Pressure range	1-4 bar
Duration of pulse	0.08 sec

Table 2
Processing parameters of experiment eq. (2)

Parameter	Value
Yarn count (Ne)	10
Twist factor	4
Pressure	1 bar
Duration of pulse	0.16 sec to 0.053 sec

3. Results and discussion

3.1. Characteristics of open end slub yarn

In the present work, pressurized air method was used to produce open end slub yarn. It leads to the formation of slub yarn consisting of a main slub and a variable number of smaller slubs called the secondary slub. The diameter of the main slub is always more than the secondary slub. The diameter ratio, which is the ratio between the slub diameter and the normal yarn diameter, was found to vary from 1.49 to 1.89 for the main slub and from 1.24 to 1.55 for the secondary slub. The portion of the yarn, where slub occurred, was shorter than the rotor circumference. The main slub length varied from 1.47 to 1.95 cm, while the secondary slub length varied from 0.14 to 0.92 cm. However, it was found that the length of the main slub and the secondary slub were highly variable along the yarn. The coefficient of variation of these effects may reach up to 27.2% and 44.5% respectively. This may be due to the lack of precise control of fiber flow during application of pressurized air. If the blown fiber tuft is deposited near the peeling off point, these fibers will be delivered within a short period of time which in turn reduces the possibility of distribution of these fibers resulting in a short slub length. On the other hand, if the blown fiber tuft is deposited at the start of the fiber wedge, there will be more time for these fibers to distribute inside the rotor and consequently a longer slub length is formed. In addition, it can be observed that the secondary slub can be minimized by reducing the duration of the pulse and increasing the pressure value. Fig. 3 shows the appearance of the open end slub yarn.

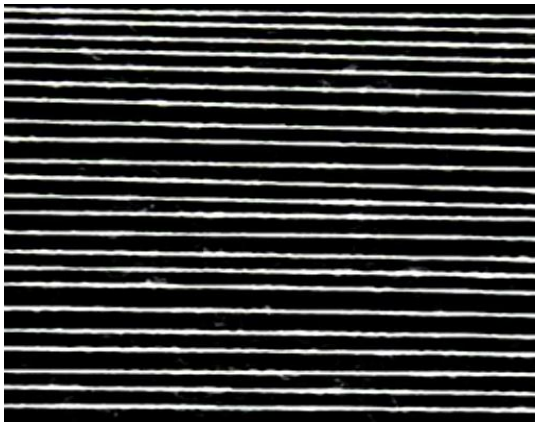

Fig. 3. Appearance of slub yarn (Ne 10, twist factor 4, pressure 3 bar and pulse duration 0.08 sec)

It was also found that the produced open end slub yarn of the developed method has superior tenacity and elongation as compared to the open end slub yarn produced by the pressurized air method mentioned by Kwasniak et al [6-9]. This can be attributed to the difference in direction of application of pressurized air. The latter method is characterized by application of pressurized air against the fiber flow in the fiber transport tube. This results in hindering the passage of a portion of the moving fibers and causes periodical accumulation of the fibers which provides the required slub. However, the accumulation and braking of the obstructed fibers by the air barrier leads to loss of fiber orientation as well as reduction of fiber extent. Consequently, the yarn tenacity is lower as compared to normal yarn tenacity.

On the other hand, the method proposed in the current work has the advantage of application of air pressure along the direction of the fiber flow hence no fiber flow disturbance occurs. Fibers, as a result, reach the rotor in a more oriented and straightened fashion as compared to the previous method.

3.2. Effect of pressure on slub yarn properties

It can be seen from figs. 4 and 5 that with the increase of air pressure, the diameter ratio of the main slub and secondary slub increase, while the main slub length decreases. The cause of this effect may be due to the fact that with the increase of the pressure value, fibers leave the surface of the opening roller in a larger fiber bundle and with a higher speed, hence it distributes in a smaller rotor length. However increasing air pressure above 3 bar has no significant influence on main slub length and increase of air pressure above 2.5 bar has no significant effect on the secondary slub diameter ratio. It was also found that the increase of pressure from 1 to 1.5 bar leads to a considerable reduction of the secondary slub length. Further increase of air pressure above 1.5 bar has no significant effect on the secondary slub length. Consequently it is recommended to use pressure value above 1.5 bar in order to obtain a slub yarn with minimum secondary slub.

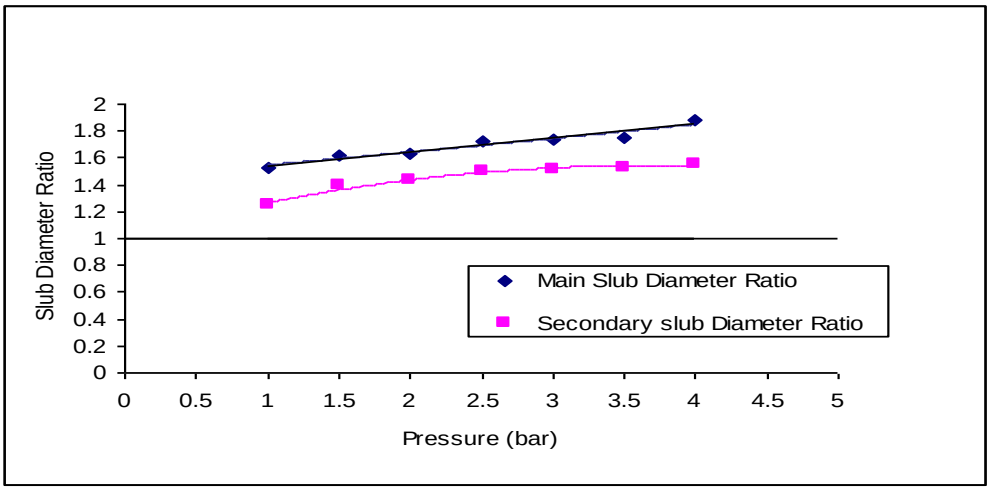

Fig. 4. Effect of pressure on slub diameter ratio.

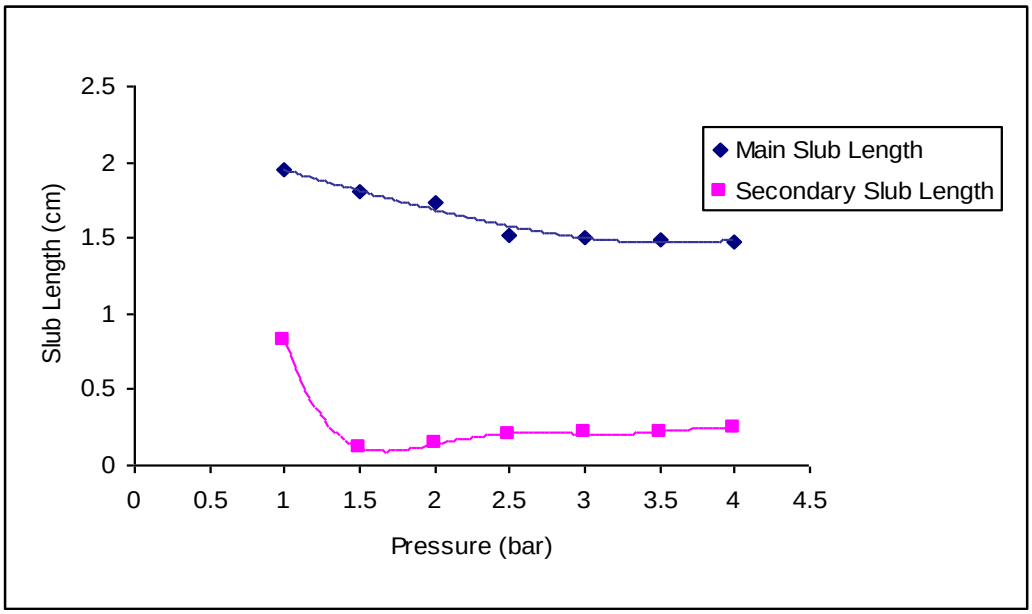

Fig. 5. Effect of pressure on slub length.

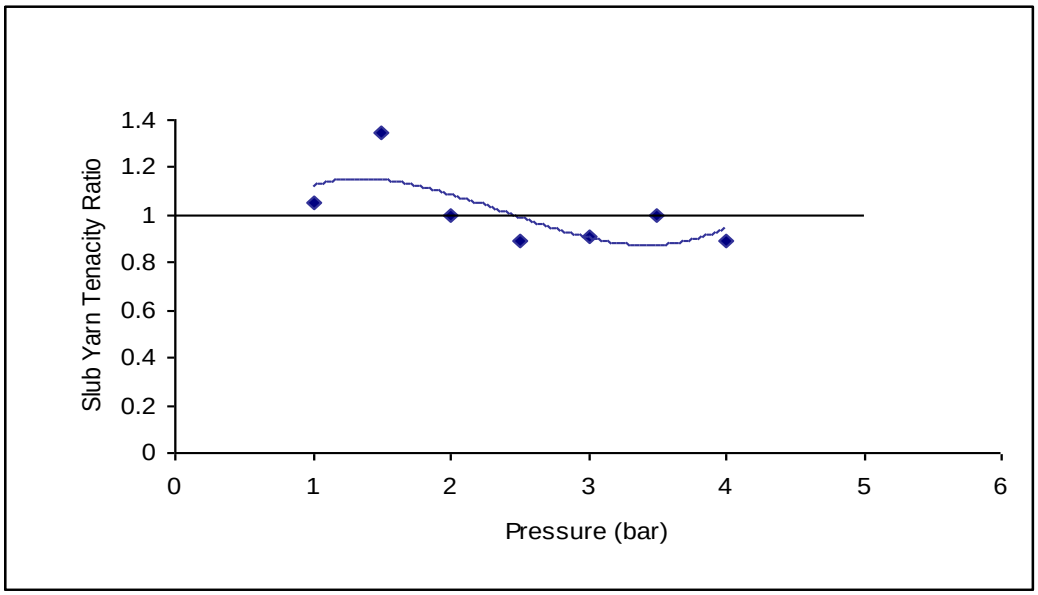

Fig. 6. Effect of pressure on slub yarn tenacity ratio.

It was also observed from figs. 6 and 7 that the slub yarn tenacity ratio, which is the ratio between slub yarn tenacity and normal yarn tenacity, is not affected by the increase of pressure. Slub yarn elongation ratio, which is the ratio between slub yarn elongation and normal yarn elongation, is also not affected by the increase of pressure. The above two observations occurred in spite of the presence of a difference in slub length and diameter. This can be considered one of the merits of the current system since a wide range of slub designs can be processed and woven efficiently.

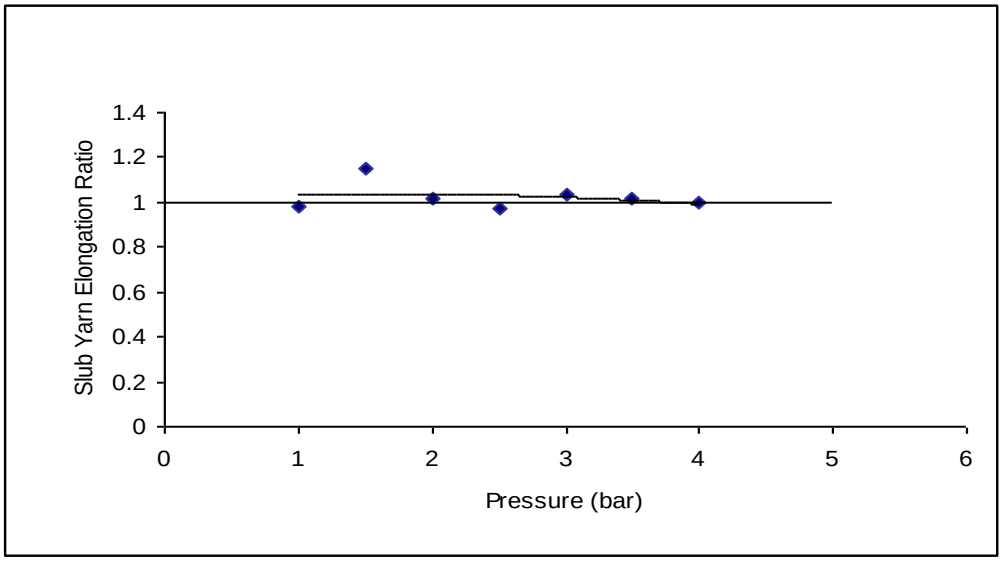

Fig. 7. Effect of pressure on slub yarn elongation ratio.

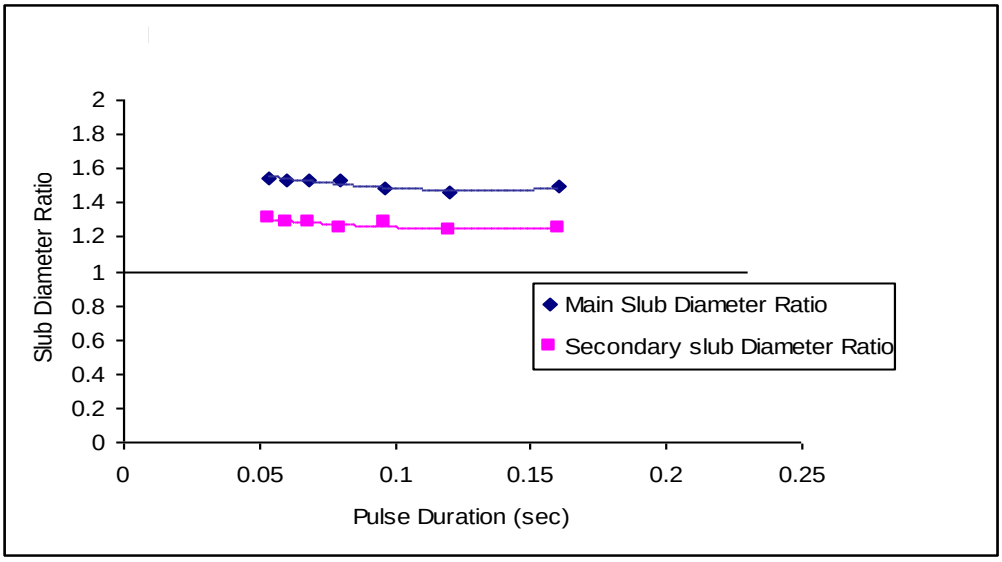

Fig. 8. Effect of pluse duration on slub diameter ratio.

3.3. Effect of pulse duration on slub yarn properties

Figs. 8 and 9 show the effect of pulse duration on slub yarn properties. It can be observed that the main slub diameter ratio and length are not significantly affected by the duration of the pulse. This may be due to the fact that the main slub is formed during a very small portion of the pulse time. It can be also observed that with the increase of pulse duration, secondary slub diameter ratio is not significantly affected while the secondary slub length increases. The increase of secondary slub length can be explained by the increase in time available for formation of the secondary slub as the pulse duration increases. Consequently, more fibers will be blown by the injected air and will redistribute on a longer length on the surface of the rotor.

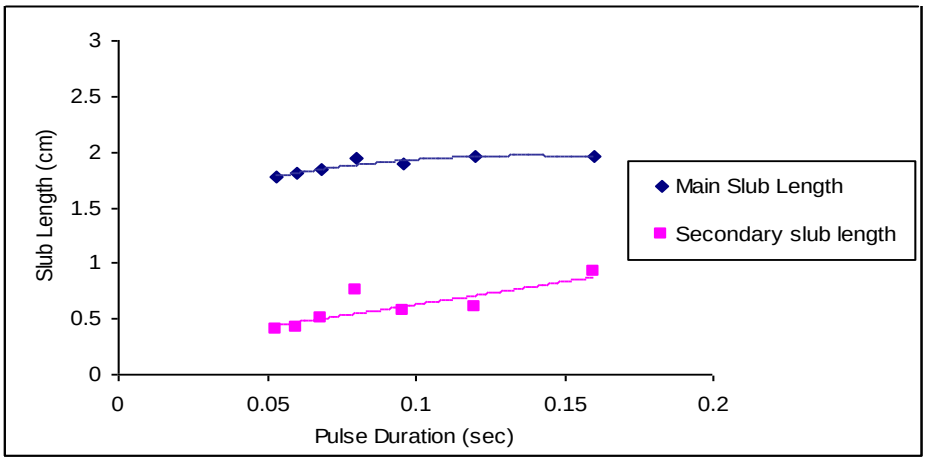

Fig. 9. Effect of pluse duration on slub length.

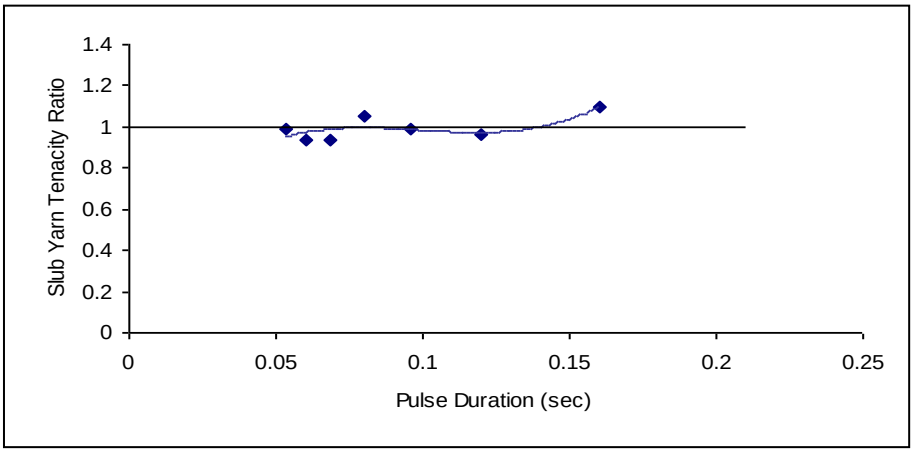

Fig.10. Effect of pluse duration on slub yarn tenacity.

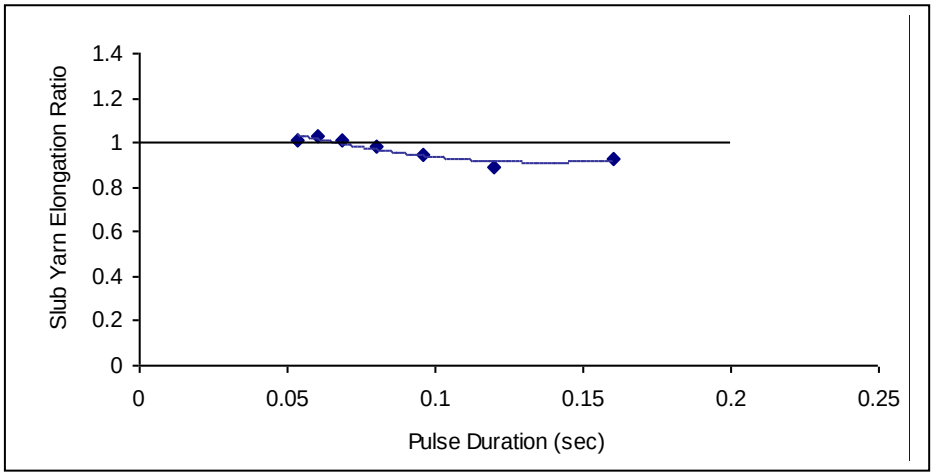

Fig.11. Effect of pluse duration on slub yarn elongation ratio.

It can be also seen from figs. 10 and 11 that the other yarn properties, slub yarn tenacity ratio and slub yarn elongation ratio, are not influenced by the pulse duration.

4. Conclusions

The developed pressurized method has proved to be satisfactory for the production of open end slub yarn. The produced slub has a length shorter than the rotor circumference. The tenacity and elongation of the produced yarn are not significantly different from normal yarn under various processing parameters, which allows a wide range of slub designs to be processed and woven efficiently. The properties of slub are influenced by air pressure and duration of air pulse. The main slub and secondary slub diameter ratio are increased by increasing air pressure, while the main slub length is reduced with increasing air pressure. The secondary slub length is considerably reduced by increasing air pressure value from 1 to 1.5 bar. However, further increase in air pressure above 1.5 bar has no significant effect on the secondary slub length. In addition, the secondary slub length increases with increase of pulse duration. Hence it is recommended to reduce pulse duration and increase pressure value above 1.5 bar in order to obtain a slub yarn with minimum secondary slub. To obtain longer and larger slub, it is suggested to investigate the position of the nozzle near the feed roller.

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