TEKSTİL VE MÜHENDİS

(Journal of Textiles and Engineer)

http://www.tekstilvemuhendis.org.tr

Study on the Effect of Air Suction Pressure on the Quality of Compact Yarn by Changing the Frequency of Inverter

İnverter Frekansının Değiştirilmesi ile Farklılaştırılan Hava Emiş Gücünün Kompakt İpliğin Kalitesi Üzerine Etkisinin İncelenmesi

Amit CHAKRABORTTY[1*], Asif HOSSAIN[2], Joyjit GHOSH[1]

[1]Dept. of Textile Eng., Ahsanullah Univ. of Science and Tech., Dhaka, Bangladesh
[2]NZ Textile Ltd., Rupgonj Naraongonj, Dhaka, Bangldesh

Online Erişime Açıldığı Tarih (Available online):30 Eylül 2020 (30 September 2020)

Bu makaleye atıf yapmak için (To cite this article):

Amit CHAKRABORTTY, Asif HOSSAIN, Joyjit GHOSH (2020): Study on the Effect of Air Suction Pressure on the Quality of Compact Yarn by Changing the Frequency of Inverter, Tekstil ve Mühendis, 27: 119, 154- 158.

For online version of the article: https://doi.org/10.7216/1300759920202711903

Sorumlu Yazara ait Orcid Numarası (Corresponding Author's Orcid Number) :

https://orcid.org/0000-0002-8592-3757

TMMOB Tekstil Mühendisleri Odası
UCTEA Chamber of Textile Engineers
Tekstil ve Mühendis
Journal of Textiles and Engineer

Yıl (Year) : 2020/3
Cilt (Vol) : 27
Sayı (No) : 119

Araştırma Makalesi / Research Article

STUDY ON THE EFFECT OF AIR SUCTION PRESSURE ON THE QUALITY OF COMPACT YARN BY CHANGING THE FREQUENCY OF INVERTER

Amit CHAKRABORTTY[1*]
https://orcid.org/0000-0002-8592-3757
Asif HOSSAIN[2]
https://orcid.org/0000-0003-3586-7440
Joyjit GHOSH[1]
https://orcid.org/0000-0003-4755-3916
[1]Dept. of Textile Eng., Ahsanullah Univ. of Science and Tech., Dhaka, Bangladesh
[2]NZ Textile Ltd., Rupgonj Naraongonj, Dhaka, Bangldesh

Gönderilme Tarihi / Received: 31.05.2020
Kabul Tarihi / Accpted: 11.09.2020

ABSTRACT: Compact spinning is the modification of existing ring spinning technology. The structure and quality of yarn are improved by using this spinning technique. This experimental work explores the effect of air suction pressure on the quality of compact yarn. Due to this reason, five samples of 52 Ne yarn were produced using different negative suction pressures such as 17 mbar, 19 mbar, 21 mbar, 23 mbar and 25 mbar (1 mbar = 100 Pa) in Suessen Elite[@] system by changing the frequency of inverter. Samples were collected and then results were carried out. After that, the quality parameters of the produced yarn such as Mass variation (CV_m%), Imperfection index, Hairiness and Count Strength Product (CSP) were analyzed along with calculating the power consumption against different suction pressures using the inverter frequency. Finally, the test results showed that yarn obtained from 23 mbar negative suction pressure was optimum considering the yarn quality and power consumption compared to others. This experimental work will provide an idea for spinners' to choose optimum suction pressure for producing minimum imperfection and hairiness of compact yarn.

Keywords: Compact spinning, suction pressure, inverter, power consumption, yarn qualities

İNVERTER FREKANSININ DEĞİŞTİRİLMESİ İLE FARKLILAŞTIRILAN HAVA EMİŞ GÜCÜNÜN KOMPAKT İPLİĞİN KALİTESİ ÜZERİNE ETKİSİNİN İNCELENMESİ

ÖZET: Kompakt eğirme, günümüzde mevcut olan ring eğirme teknolojisinin modifiye edilmiş halidir. Bu eğirme tekniğinin kullanılması ile ipliğin kalitesi ve yapısı geliştirilmiştir. Yapılan deneysel çalışmada hava emiş gücünün kompakt ipliğin kalitesi üzerindeki etkisi incelemiştir. Bu amaca uygun olarak, 'Suessen Elite@' sisteminde 17 mbar, 19 mbar, 21 mbar, 23 mbar ve 25 mbar (1 mbar = 100 Pa) gibi farklı negatif emiş güçleri kullanılarak 52 Ne ipliğin beş farklı numunesi üretilmiştir. İnverter frekansının kullanımı ile farklılaştırılan emiş güçlerine göre enerji tüketiminin hesaplanmasının yanı sıra üretilen ipliklerin varyasyon katsayısı (CVm%), düzgünsüzlük indeksi, tüylülüğü ve CSP (Count Strength Product) gibi kalite parametreleri analiz edilmiştir. Sonuç olarak, diğer emiş güçleri ile karşılaştırıldığında ipliğin kalitesi ve enerji tüketimi açısından 23 mbar optimum emiş gücü olarak belirlenmiştir. Bu deneysel çalışma kompakt ipliğin minimum düzgünsüzlük ve tüylülük ile üretilebilmesi için optimum emiş gücünün belirlenebilmesi açısından iplik üreticilerine fikir verecektir.

Anahtar Kelimeler: kompakt iplikçilik, emiş gücü, inverter, enerji tüketimi, iplik kaliteleri

***Sorumlu Yazar/Corresponding Author:** amitavraj24@gmail.com*
***DOI:** https://doi.org/10.7216/1300759920202711903* *www.tekstilvemuhendis.org.tr*

1. INTRODUCTION

The yarn spun from ring spinning is considered to be superior to the yarn spun compared to other spinning technology, but it is not perfect. When ring yarn is examined under microscope, it is easy to see that the integration of surface fibres is partial. This arises due to some edge fibres being lost or attached to the yarn in a disorderly configuration during twisting of fibre. These edge fibres make little or no contribution to yarn strength and leads to creation of hairiness [1]. For that reason, necessary modification is required in the ring spinning system to minimize this problem. Compact spinning technique is a novel concept where compacting device is attached with the existing ring spinning frame. This technique has greatly influenced the improvement of yarn quality overcoming the existing ring spinning problem. The purpose of compact spinning is to reduce or eliminate the spinning triangle for decreasing yarn hairiness, improved yarn breaking strength and elongation at break, as well as to decrease the usual faults [2]. The spinning triangle is a critical region in the spinning process of staple yarn. Its geometry influences the distribution of fiber tension at spinning triangle directly and affects the qualities of spun yarns [3].

Hong-Cai Ma et al. studied on the effect of negative pressure and cleaning condition for ramie compact spinning with a suction groove and found that compact spinning with a suction groove increased the breaking strength, elongation at break and twist, and also reduced hairiness [4]. Zhuan Yong Zou et al. investigated the model of the yarn twist propagation in compact spinning with a pneumatic groove [5]. P. Mageshkumar and Dr. T. Ramachandran found the optimization of process parameters in Eli-Twist yarn [6]. Mourad Krifa and M. Dean Ethridge explained that compact spinning has influenced on cotton yarn quality [7].

Different methods are used to condense the fibre and reduced the spinning triangle before twisted. These methods are: a) aerodynamically compacting system: i) suction by drum and ii) suction through perforated apron, b) mechanical compacting system, and c) Magnetic compacting system [8]. Among these different methods, the principle of aerodynamically compacting system depends on amount of suction pressure provided in the compacting zone. The suction pressure is controlled by increasing or decreasing the frequency of inverter. High frequency indicates the high rotation speed of motor and then the high suction pressure in the condensing zone. The term inverter and variable-frequency drive are related and somewhat interchangeable. An electronic motor drive for an AC motor can control the motor's speed by varying the frequency of the power sent to the motor. An inverter, in general, is a device that converts DC power to AC power. An inverter controls the frequency of power supplied to an AC motor to control the rotation speed of the motor. There is a strong relationship between frequency and negative pressure. Higher frequency increases the motor rpm that is responsible for more power consumption [9-11].

Many researchers have studied the various process parameters of compact spinning such as negative pressure with groove, twist propagation etc. but the effect of air suction pressure on the quality of 100% cotton yarn needs to be investigated. Therefore, this research work was carried out on suction pressure of compact spinning and tried to find out how it effects on yarn qualities such as Mass variation (CVm%), Imperfection index (IPI), Hairiness, and Count strength product (CSP) as well as Power consumption.

2. MATERIALS AND METHODS

2.1 Materials

100% Sanker-6 cotton was used for this research work. The properties of raw cotton fibres were measured by using HVI instrument, which is summarized in Table 1.

Table 1. Properties of raw cotton fibres

Parameters	Value
Fineness(Micronaire)	4.2
Maturity Ratio (Mat)	0.87
Fibre Strength(Str)	29 gr/tex
Elongation	5%
Uniformity index	83.5
Yellowness,+b	10.3
Reflectance,Rd	78
Upper half mean length	29.87 mm
Moisture regain	6.5%

2.2 Methods

The process flow chart shown in Figure 1. was required during experiment.

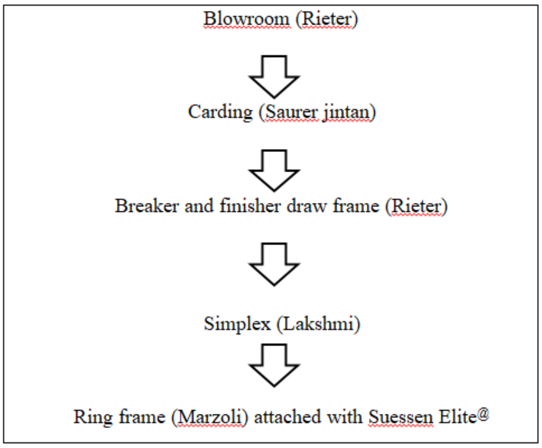

Figure 1. Process flow chart

Five samples of Ne 52 yarn were prepared according to Table 2 whereas the different values of negative suction pressure were selected and varied by changing the frequency of inverter. Figure 2 shows frequency of inverter vs. negative suction pressure. The frequency of inverter and negative suction pressure represented a linear relation.

The amount of suction pressure in the condensing zone is measured by pressure meter. This meter determines absolute pressure and (excess and negative) relative pressure for air, gases and/or liquids. Each handheld pressure meter is controlled by a microprocessor to guarantee the highest accuracy. The pressure gauge displays results quickly and has an enclosure which is resistant to dust and water jet, making the device perfect for research and development [12].

Table 2. Samples prepared.

Sample code	A	B	C	D	E
Negative suction pressure (mbar)	17	19	21	23	25

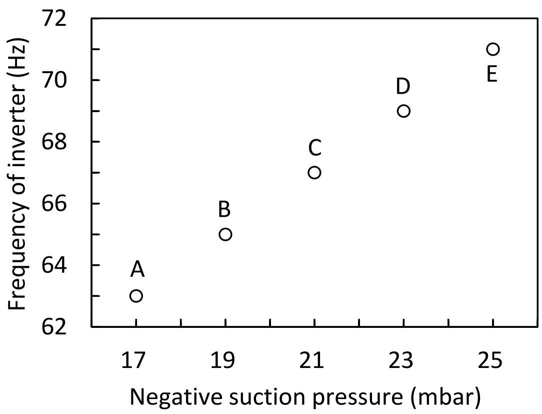

Figure 2. Frequency of inverter vs. negative suction pressure

During the samples preparation, the other parameters of the machine remained constants, which are given in Table 3.

Table 3 Technical parameters of ring frame.

Parameters	**values**
Drafting zone	3 over 3
Spindle speed	16500 rpm
Ring cup diameter	40 mm
Top roller gauge	44×48 mm
Bottom roller gauge	43×48 mm
Traveller no	12/0
TPI	35
Compacting device	Suessen Elite@

Produced yarn samples were conditioned at a standard atmospheric condition of 65 ± 2% RH and 20 ± 2 °C temperature for 24 hr and then testing was done by using Evenness tester-5, Wrap reel, Lea strength tester, and Digital balance.

The power consumption for different suction pressures as well as different frequencies of inverter was calculated by using the following power equation for three phase system [13]:

$$P = \sqrt{3}\, VI \cos\theta \qquad (1)$$

where P is power, V phase voltage, I phase current and θ phase angle.

3. RESULTS AND DISCUSSIONS

3.1 Mass variation (CV_m%) of yarn

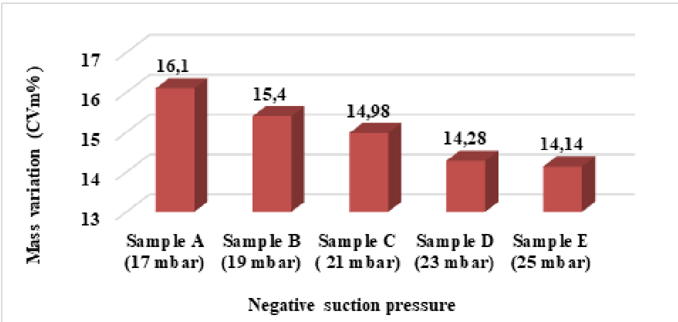

Figure 3. Effect of negative suction pressure on mass variation.

Figure 3 indicates mass variation (CV_m%) of yarn against negative suction pressure. The mass variation was higher for Sample A. The mass variation of Sample D and Sample E were reduced by 11.30% and 12.4% due to higher suction pressure compared to Sample A. The difference between Sample D and Sample E was insignificant. Sample D (23 mbar) was optimum considering the power consumption (mentioned in Figure 7) against different suction pressure. Low suction pressure does not reduce the spinning triangle properly and also increases entanglement of protruding fibres in the compacting zone that leads to mass variation.

3.2 Imperfection index (IPI) of yarn

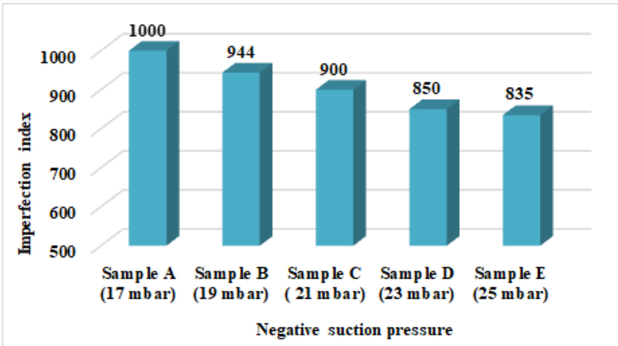

Figure 4. Effect of negative suction pressure on imperfection index (IPI).

Imperfection index (IPI) is shown in Fig. 4. "IPI is the total number of thin places (-50%), thick places (+50%) and neps (+200%) per 1 km of yarn. Sample A showed higher imperfection value among all. In Fig., imperfection values of Sample D and Sample E were decreased by 15.0% and 16.5% with respect to Sample A. It happened that higher suction pressure reduced the irregularity and entanglement of fibres, which is introduced due to tension draft in the compacting zone. But the variation of Sample D was closer to Sample E. Therefore, it can be said that Sample D (23 mbar) was optimum compared to Sample E because it consumes less power (mentioned in Fig. 7).

3.3 Hairiness of yarn

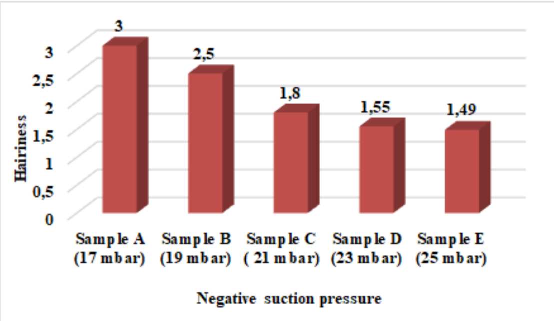

Figure 5. Effect of negative suction pressure on hairiness.

Hairiness of yarn is shown in Fig. 5. In ring spinning of cotton fiber, yarn hairiness is greatly influenced by the geometry of the spinning triangle [14-15] and by various fiber properties, among which the most commonly cited are length (length distribution) and fineness [16-18]. In Fig. 5, it can be explained that Sample D and Sample E produced lower hairiness compared to Sample A. This will happen because the fibre bundles emerged from the front roller nipping point contracted and their width and height narrowed in the gathering area due to higher suction pressure. Therefore, the spinning triangle was reduced or eliminated that leads to lower hairiness [4]. Sample D (23 mbar) was optimum because it showed closer value to Sample E (25 mbar) considering the power criteria.

3.4 Count strength product (CSP) of yarn

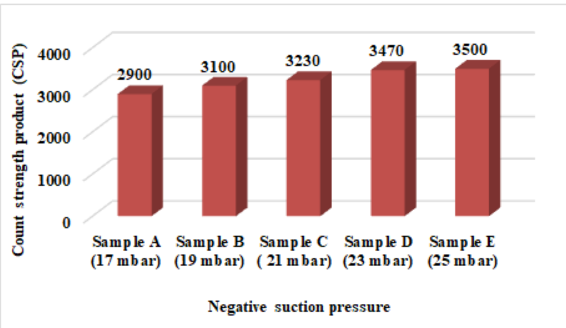

Figure 6. Effect of negative suction pressure on count strength product (CSP)

Figure 6 indicates the count strength product (CSP) of yarn defined by the multiplication of fineness of yarn and breaking load in a unit of lb. Sample D and Sample E-showed 16.4% and 17.14% higher values of CSP compared to Sample A. Higher suction pressure condenses the fibres properly after emerging from the front roller delivery nipping line and also sucks the protruding fibres from the fibres bundle resulting in long fibres twisted properly that contributes to the yarn strength. Sample D (23 mbar) was optimum with respect to Sample E (25 mbar) considering the power criteria.

3.5 Power consumption for different frequencies of inverter

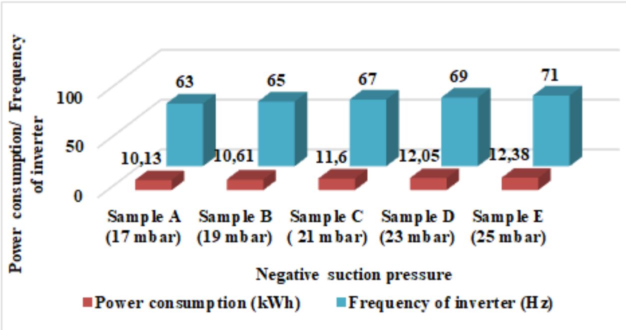

Figure 7. Effect of negative suction pressure on power consumption

Figure 7 represents power consumption against different suction pressures. From this figure, Sample A consumed less power among the others. But yarn produced at 17 mbar negative suction pressure did not show good quality as far as others. Sample E produced at 25 mbar suction pressure showed good yarn quality. However, it required more power. Yarn quality parameters of Sample D was very closer to those of Sample E as well as it consumed less power. Therefore, it can be said that Sample D was optimum considering the yarn quality and power consumption.

4. CONCLUSIONS

The results in this experiment demonstrated the effect of suction pressure on the quality of compact yarn by changing the frequency of the inverter. From experimental data it can be said that 23 mbar and 25 mbar suction pressures showed better yarn quality among the others. The yarn quality parameters such as CV_m%, IPI, Hairiness and CSP for 23 mbar suction pressure were 0.98%, 1.76%, 3.87% and 0.85% lower than 25 mbar suction pressure. These values were closer compared to each other. But 25 mbar suction pressure consumed 2.6% higher power than 23 mbar suction pressure. Moreover, power consumption is concerning issue in textile industry. So, 23 mbar negative suction pressure in Suessen Elite[@] system was optimum in view of both yarn quality parameters and power consumption criteria.

REFERENCES

1. Kumar, A., Ishtiaque, SM., Salhotra, KR., (2003), Compact spinning: a critical review."ASME International Mechanical Engineering Congress and Exposition. American Society of Mechanical Engineers Digital Collection.
2. Nikolić M., Stjepanovič, Z., Lesjak, F., Štritofand, A., (2003), Compact spinning for improved quality of ring-spun yarns, Fibres & Textiles in Eastern Europe, 4(43), 30-35.
3. Liu, X., Su, X., (2015), Theoretical Study of Effect of Ring Spinning Triangle Division on Fiber Tension Distribution, Journal of Engineered Fibers and Fabrics, 10**(**3), 20-28.
4. Ma, H.C., Cheng, L.D., Yan, G.X., Xu, S.P., (2014), Studies of Negative Pressure and Cleaning Condition Effects on Gathering for Ramie Compact Spinning with a Suction Groove, Fibres & Textiles in Eastern Europe, 22**(** 10),54-57.
5. Zou Z.Y., Guo, Y.F., Zheng, S.M., Cheng, L.D., Liu, S.R., (2011), Model of the Yarn Twist Propagation in Compact Spinning with a Pneumatic Groove, Fibres & Textiles in Eastern Europe, 19(1), 30-33.
6. Mageshkumar, P., Ramachandran, T., (2012), Optimization of Process Parameters in Eli-Twist Yarn, International Journal of Engineering Inventions, 1(1), 24-31.
7. Mourad, K., Ethridge, M.D., (2015), Compact Spinning Effect on Cotton Yarn Quality: Interactions with Fiber Characteristics, Textile Research Journal, 76(5), 387-399.
8. Singh, R.P., Kothari, V.K., Different technologies to spin compact yarns , Available on World Wide Web<http://www.indiantextilejournal.com/ articles/FAdetails.asp?id=503>, [Accessed 25.11.2019]
9. Inverter, Available on World Wide Web<http://www.lighthouseplcs.com/ inverters/Intro_to_VFDs.pdf>, [Accessed 25.11.2019].
10. Motor RPM controlling system, Available on World Wide Web <http://www.lighthouseplcs.com/inverters/Intro_to_VFDs.pdf. >, [Accessed 25.11.2019].
11. Zhang, X.C., Zhang, H.X., Cheng, L.D., (2013), Effect of Negative Pressure on Yarn Quality in Compact Spinning with Inspiratory Groove, Advance Material Research, 627, 288-292.
12. Pressure meter, Available on World Wide Web <https://www. pceinstruments.com/english/measuring instruments/test-meters/pressure-meter kat_159016.htm.>, [Accessed 25.11.2019].
13. Boylestad, R.L., (2003), Introductory circuit analysis, Pearson Education India.
14. Wang, X., Huang, W., Huang, X.B., (1999), A Study on the Formation of Yarn Hairiness, Journal of Textile Institute, 90(4), 555–569.
15. Klein, W., (2003), Spinning Geometry and its Significance. Intl Textile Bull.Yarn + Fabric Forming, 39(3), 22-26.
16. Barella, A., Manich, A.M., (1989), Influence of cotton Fiber Properties on Yarn Hairiness, Textile Research Journal, 59(10), 632–633.
17. Viswanathan, G., Munshi, V.G., Ukidve, A.V., Chadran, K.A., (1989), Critical Evaluation of the Relationship Between Fiber Quality Parameters and Hairiness of Cotton Yarns, Textile Research Journal, **59**(11), 707–711.
18. Zhu, R., Ethridge, M.D., (1997), Predicting Hairiness for Ring and Rotor Spun Yarns and Analyzing the Impact of Fiber Properties, Textile Research Journal, 67(9), 694–698.