Part A: English Edition

Journal of Textiles and Polymers

Vol. 10, No. 1, 23-30, January 2022

http://dx.doi.org/10.48302/jtp.2022.143608

ORIGINAL PAPER

# Providing a New Method for Evaluating the Nip Stability in Intermingled Yarn

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Received: 9 August 2021, Accepted: 1 December 2021

*Abstract*- **The aim of this study is to provide a method to evaluate the intermingled nip stability. For this purpose, polypropylene (fully drawn yarn) FDY with three types of intermingling Heberlein jet inserts (P412, P212, and S16) and three air pressure values of 2, 3, and 4 bar was subjected to the texturing process. In measuring the nip stability in the previous methods, i.e. using the nip number, it was observed that in some long nips with special structures, a nip with certain length under the stretching process may become several nips with a less total entanglement length. This can cause an error in evaluating the nip stability. Therefore, in order to evaluate the nip stability, it is suggested to use the nip length in the 360° study around the yarn axis to evaluate the effect of the change in the length of the intermingled areas due to stretching. Using the method presented in this research and after performing experiments, the maximum and minimum nip stability with considering the nip length were 97.3% (for P412 jet insert and 4 bar air pressure) and 48.55% (for S16 jet insert and 2 bar air pressure), respectively. However, the nip stability in the same test conditions based on nip density was 74.47 and 52.94%, respectively.**

*Keywords*: **nip length, nip stability, false twist textured yarn, nip structure, intermingling**

## I. INTRODUCTION

In the textile industry, texturizing techniques are being utilized on filaments to enhance properties such as bulky structure, coverage, handle, and thermal insulation that can be crucial based on the application [1]. The air intermingling is used to impart filament cohesion in flat and textured multifilament yarns [1]. The air interlacing technique is used to introduce periodic nips to a flat filament yarn to improve its performance in further textile processing [2]. Intermingling is one of the best alternative methods to make the multifilament yarns more resistant against high volume stress. This technique has started to replace prevalent methods such as sizing and twisting [3,4]. Multifilament yarns do not have any essential cohesion force like friction because of parallel placement of fibers. Due to the lack of enough cohesion force among the filament fibers, many problems come out in the processes of yarn winding, unwinding, knitting, weaving, tufting, and other similar fabric manufacturing processes [4,5]. Intermingling is a mechanical technique to impart desirable cohesion characteristics to synthetic filament yarns at relatively low running costs [1,6,7]. During the mingling process, the air flow impacts the yarn vertically, leading to the formation of an open part at the position where the air jet is subjected to act and a compact part called nip will form on either sides of the open part [8]. The process uses an air jet delivered by a nozzle to intermingle the constituent filaments of a continuous yarn, producing periodic nips, i.e., nips at reasonably regular intervals with undisturbed (unentangled) sections between them [6]. Nips density and stability are primary properties in terms of yarn structure, generally mentioned to describe the intermingling quality in a multifilament yarn [3,9]. The structure of nips in an intermingled yarn is the main factor affecting the variations in the intermingled yarn properties. Generally, the structure and properties (such as tensile strength) of intermingled yarns depend on the types of the supply yarn materials, the

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intermingling process parameters, and the air jet design [6,8,10,11]. Many researchers characterized the degree of intermingling in intermingled yarns by the nip density regardless of the nip structure [4,8,11]. However, other authors have categorized nips in multifilament intermingled yarns, on the basis of their structure, into four classes namely, twist, braid, wrap, and entanglement or into nine classes namely, twist, braid, loose braid, wrap, strong wrap, loose wrap, entanglement, loose entanglement and multi structures and their results show that the differences in yarn properties are mainly due to a variation in the nip structure [2,8,10]. As the nip frequency alone does not describe the extent of nips in intermingled yarns, other parameters like the percentage of degree of interlacing (total length of nips per length of yarn specimen×100) and average nip length in centimeters are also important [2,8]. Because some nips will disappear when tension is applied, nip stability has been introduced to measure the ratio of nip densities after and before applying a low mechanical stress to the yarn. This difference in nip "stability" implies that the structure varies from one nip to another [2]. Researchers argue that there is no correlation between nip density and nip stability; but a positive linear correlation between air pressure and nip stability [12]. A review of previous studies has shown that no specific standard has been established to evaluate nips stability [1-23]. In assessing the nip stability, at first the number of nips per unit length of yarn are counted, after applying a certain tension on the yarn specimen, the number of nips is counted again. Nip strength or nip stability is the ratio of the second to the first count of the nips, as can be seen in Eq. (1) [13-16]:

$$\text{Percentage nip retention or nip strength}(\%) = \frac{\text{count 2}}{\text{count 1}} \times 100 \quad (1)$$

In previous studies, nip counting has been done by different methods such as manual count [6,7,14-17], microscopic observations [2,8,10] and Itemat Lab TSI test device (Enka Tecnica GmbH Hallesche, Gröbzig, Germany) [1,3,9,11,13,18]. To the authors knowledge, scientific studies on different methods of measuring nip stability based on the nip density or nip lengths in intermingled and false twist textured yarns are not available in the literature.

The main aim of this study is to develop a more accurate procedure in evaluating the density of intermingled areas, stability and nip type structures. As a result, it can alleviate the challenges in the way of better understanding the correlation between their effect on the mechanical properties of the textured yarn. Accordingly, a state of art in-house device has been developed to evaluate the yarn in terms of nip stability and nip structure, along with a new method that will reduce the possible errors.

## II. EXPERIMENTAL

In this study, FDY polypropylene yarn with 371 denier (The denier is a measure of linear density expressed in terms of g/9000 m) and 72 filaments was subjected to false twist (friction disc unit) texturing system (folded yarn path) that the intermingling nozzles were located after intermediate rollers with a D/Y ratio of 2.25 for all samples. Production speed was considered constant at 400 m/min for all cases. Three types of Heberlein intermingle jets P412, P212, and S16, each with three different air pressures (2, 3, and 4 bar) were considered as texturing process variables. The treated yarn samples were evaluated in terms of nip structure and nip stability. The technical information of these jets, announced by the manufacturer, is summarized in Table I.

The average of nip density per meter of yarn length was measured for different yarn samples. Here the beginning of a continuous entanglement to its end is considered as a nip, or an intermingled area, which may have different lengths and different structures. The classification of nip structures in this study is based on nine classifications according to previous studies [10]. Since a comprehensive standard for measuring the nip stability of false twist textured yarns has not yet been established, a method similar to previous studies was used. In order to count the nips, due to the possibility of uneven nip density along the yarn, 10 yarn samples with 50 cm length were considered for each type of yarn. At first, these samples were examined under a Projectina microscope to count the nips with three times repetition. The results from the same samples in each examination repeat were different. This can be due to the fact that yarns have quasi-cylinders structure and are composed of a large number of fibers. Unwanted tension

TABLE I
TECHNICAL INFORMATION OF HEBERLEIN INTERMINGLING AIR JETS [24]

| Jet insert | Yarn count (denier) | (nips/m) | nips stability |
|---|---|---|---|
| P212 | Up to 400 | 80-100 | High |
| P412 | Up to 900 | 50-70 | High |
| S16 | 330-900 | Less frequent but longer interlacing nips | High |

on the yarn can also cause changes in the yarn structure. Therefore, it is better to use a method so that the yarn tension is close to zero. After undergoing the intermingling process at a certain desired length, they can show different nip frequencies, structures and lengths depending on the viewing angle of the observer. For example, Fig. 1 shows the nip area of the yarns with view angles being 180° apart (i.e. front and back views) treated by S16 and P212 jet inserts with a 3 bar air supply, which indicates the variance in structure between the two viewing angles. Different viewing angles are shown for a nip area of yarn processed with jet S16 in Figs. 1a and 1b, and yarn processed with jet P212 in Figs. 1c and 1d. Therefore, to determine the type of dominant structure and the length of the intermingled areas, the longitudinal section of the yarn sample was examined 360 ° to determine the structure of the nip and the dominant length of the fibers intermingling with each other more accurately.

This device keeps the yarn fix in place (in tension close to zero), and the microscope is mounted on a guiding rail to minimize errors that unwanted stretches to the yarn might generate. For this purpose, Bysameyee Digital Microscope 1000X [25] was used. To investigate this issue, three samples to repeat from each yarn treated with jet inserts (P412, P212, and S16) at all at 4 bar air supply were investigated in three different viewing angles around their longitudinal axis. Using the new device, the structure and length of each nip area and their number were recorded. Then each yarn sample was stretched for 30 s at 15% of the elongation at the maximum load point. After the applied tension, 3 min rest time was considered for the yarn to return to its original length completely. After complete rest the yarn samples were re-examined by the new device and were evaluated in terms of nips density, structure and length.

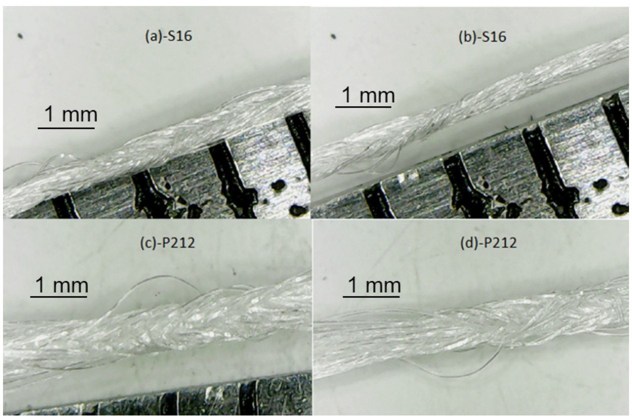


Fig. 1. Different viewing angles on the nip structure, treated with 3 bar air supply with: jet S16 (a) front and (b) back and jet P212 (c) front and (d) back.

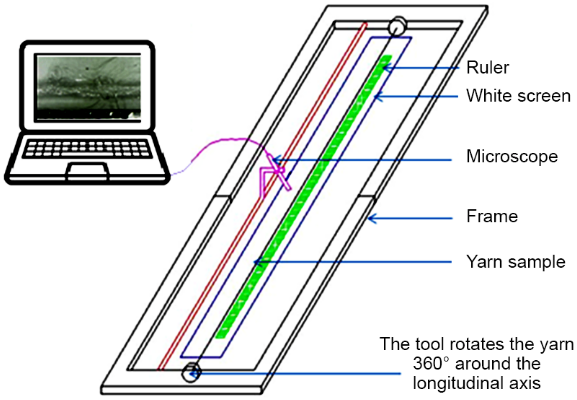


Fig. 2. Schematic of the state of art in-house device.

*A. Experimental Setup*

The effect of viewing angle around the longitudinal axis of the yarn on the number of nips and their length was investigated and statistically analyzed. In order to study the longitudinal section of the yarn in 360°, a special in-house device was built which was used to study the length, structure and density or frequency of the nips. A schematic of the new device is shown in Fig. 2.

In order to investigate the viewing angle effect on the nip frequency and nip length, and to validate the initial hypothesis about the necessity of studying the yarn structure 360° around the longitudinal axis of the yarn, three samples with 50 cm length of the same yarn were selected. After installing them on the in-house device they were viewed at three 120° angles apart around the yarn axis and each time 4 mm of yarn length was photographed. The images are taken in a way that as they are placed next to each other, the complete image of the thread can be obtained in a certain angle of view. By comparing the data obtained from 11,250 images and statistical analysis by “IBM SPSS 26” software [26], it was found that the viewing angle did not have a significant effect on the number of nips and their length. However, if only one nip is considered, it is better to examine the structure from different angles, as shown in Fig. 1.

## III. RESULTS AND DISCUSSION

Comparing the number of nips before and after stretching to determine the nip stability using the number of nips, it was observed that in some samples the number of nip zones after stretching has increased compared to those before stretching. After several observations, it was found that the decomposition of a particular structure which mainly includes nips that are symmetrical with the twisted or tangled structure, into two or even more different structures with less length than the original nip structure caused the increase in number of nip zone. A nip can also be reduced in

TABLE II
AVERAGE NIP PARAMETERS

| Texturizing process variables | | Average of measured interlacing parameters in 50 cm of yarns specimen | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jet insert | Air pressure (bar) | Before tension nips number | After tension nips number | Before tension nips length (mm) | After tension nips length (mm) | Nips stability based on nips length (%) | Nips stability based on nips density (%) | Before tension degree of interlacing (%) | After tension degree of interlacing (%) |
| | 2 | 37 | 20 | 123 | 73 | 59.35 | 54.05 | 24.60 | 14.60 |
| P212 | 3 | 23 | 19 | 116 | 69 | 59.48 | 82.61 | 23.20 | 13.80 |
| | 4 | 49 | 40 | 233 | 173 | 74.25 | 81.63 | 46.60 | 34.60 |
| | 2 | 42 | 44 | 231 | 184 | 79.65 | 104.76 | 46.20 | 36.80 |
| P412 | 3 | 37 | 40 | 272 | 256 | 94.12 | 108.11 | 54.40 | 51.20 |
| | 4 | 47 | 35 | 222 | 216 | 97.30 | 74.47 | 44.40 | 43.20 |
| | 2 | 34 | 18 | 138 | 67 | 48.55 | 52.94 | 27.60 | 13.40 |
| S16 | 3 | 37 | 24 | 128 | 75 | 58.59 | 64.86 | 25.60 | 15.00 |
| | 4 | 21 | 19 | 96 | 75 | 78.13 | 90.48 | 19.20 | 15.00 |

length by force, although the nip is included in the second stage count, it should be noted that the intermingling quality in this area has changed. The results of this evaluation are presented in Table II.

Fig. 3 shows a complete nip of yarn processed with P412 jet and 3 bar air pressure before (Fig. 3a) and after stretching (Fig. 3b). As this image presents, a nip can be counted before and after stretching that are the same length of yarn. However, the length of the nip before stretching is about 16 mm and after applying 15% of the extension at the point of maximum load in the yarn strength test, it is about 4 mm. If we use the number of nips to calculate the nip stability, the corresponding formula for this single nip shows 100% stability, while the observations show a change in the quality of entanglement.

This indicates that the number of nips is not a reliable parameter to determine the stability of the nips, and a reliable parameter should be considered to determine the nip stability. Further investigation revealed that the length of the nip or in other words the total length of the nips with

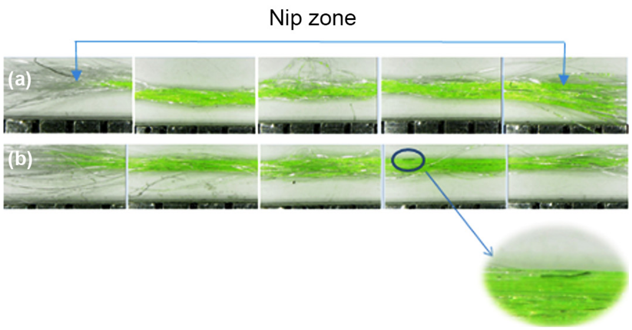


Fig. 3. Images of a nip area of intermingled yarn with a Heberlein P412 jet and 3 bar air pressure: (a) before and (b) after stretching.

different structures is a reliable parameter to determine the stability of the nips and the percentage of nip stability is proposed at Eq. (2). These studies have shown that although the number of nip zones may increase after stretching due to the breakdown of a relatively long nip zone into two or more nip zones with different structures, the length of the filament entanglement zone will decrease:

$$\frac{\text{Total length of the nips after tension}}{\text{Total length of the nips befor tension}} \times 100 = \text{nips stabiliy}(\%) \quad (2)$$

On the other hand, because the length of the fibers entanglement in each nip area of a yarn sample can be distinct from each other, this factor makes the number of nips not be used as a reliable parameter for evaluation and it is better to evaluate the length of nip areas for different yarns. In Table II, another concept is used as the degree of interlacing before and after tension [2]. As can be seen in Table II, the nip stability is calculated using Eqs. (1) and (2). Considering Fig. 3 and the given description it seems that Eq. (2) is more suitable in calculating the nip stability. Also in Table III, based on the nine structures introduced for the nip [10], the percentage of each type of nip structure to the total length of the nips in each yarn sample before and after the tension process can be seen. The length of the yarn sample under investigation was 50 cm. By comparing both the before and after columns in Table III, the behavior of a particular structure of a yarn sample before and after tension can be investigated.

As mentioned in the introduction, according to previous research [10], 9 categories have been considered for the nips, this structural classification can be seen in Fig. 4.

It can also be seen which structure has the highest value

TABLE III
PERCENTAGE OF EACH TYPE OF NIP STRUCTURE TO THE TOTAL LENGTH OF THE NIPS

| Texturizing process variables | | Average ratio of structures in each yarn with a length of 50 cm to the total length of interlacing before and after stretching | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jet insert | Air pressure (bar) | Twist (%) | | Braid (%) | | Loose braid (%) | | Wrap (%) | | Strong wrap (%) | | Loose wrap (%) | | Entanglement (%) | | Loose entanglement (%) | | Multi structures (%) | |
| | | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After |
| P212 | 2 | 17.89 | 12.3 | 0 | 0 | 2.44 | 5.48 | 26.83 | 27.4 | 0 | 0 | 4.07 | 0 | 22.76 | 15.1 | 8.13 | 5.48 | 17.89 | 34.2 |
| | 3 | 3.45 | 5.80 | 12.93 | 5.80 | 0 | 10.1 | 3.45 | 7.25 | 0 | 0 | 0 | 4.35 | 39.66 | 29 | 11.21 | 15.9 | 29.31 | 21.7 |
| | 4 | 4.29 | 8.67 | 1.29 | 4.05 | 0.86 | 4.05 | 6.44 | 15.6 | 0 | 0 | 0 | 0 | 32.19 | 32.4 | 25.32 | 4.62 | 28.33 | 30.6 |
| P412 | 2 | 0 | 2.72 | 8.23 | 7.61 | 0 | 0 | 13.85 | 14.1 | 0 | 0 | 0 | 3.80 | 28.57 | 18.5 | 7.79 | 12.5 | 41.56 | 40.7 |
| | 3 | 3.68 | 2.34 | 2.21 | 4.69 | 0 | 5.08 | 6.99 | 15.2 | 0 | 0 | 0 | 0 | 35.29 | 21.1 | 6.62 | 10.2 | 43.75 | 41.4 |
| | 4 | 7.21 | 0.93 | 8.11 | 6.02 | 0 | 0 | 17.12 | 16.7 | 2.25 | 0 | 3.15 | 0 | 25.68 | 28.2 | 0.90 | 12.5 | 35.59 | 35.6 |
| S16 | 2 | 13.04 | 0 | 19.57 | 16.2 | 0 | 0 | 10.14 | 29.9 | 2.17 | 0 | 0.72 | 0 | 22.46 | 32.8 | 0 | 0 | 31.88 | 20.9 |
| | 3 | 7.03 | 6.67 | 6.25 | 6.67 | 3.13 | 0 | 10.16 | 12 | 0 | 0 | 8.59 | 1.33 | 27.34 | 21.3 | 8.59 | 0 | 28.91 | 52 |
| | 4 | 9.38 | 0 | 3.13 | 0 | 3.13 | 0 | 9.38 | 18.7 | 0 | 0 | 3.13 | 0 | 47.92 | 53.3 | 0 | 4 | 23.96 | 24 |

in each sample according to the process conditions. Please note that the content presented above is only related to false twist texturing operations and may not be true for other texturing methods.

In Table IV, the classification of nips based on the length of the nip is classified in terms of millimeters, regardless of the type of structure, and the number of each type of the nip can be seen according to the longitudinal classification. Fig. 5 compares the average number of nips counted using the Projectina microscope with the average number of nips counted using the new in-house device.

Given the difference between the values recorded for the two methods and that the number of nips counted in all samples by the new method is equal to or greater than the number of nips counted using the Projectina microscope, it seems that the human error ratio in using the Projectina microscope in using it for counting tips is more than the method introduced.

Table V shows the significance probability in two-way analysis of variance of jet type and air pressure with

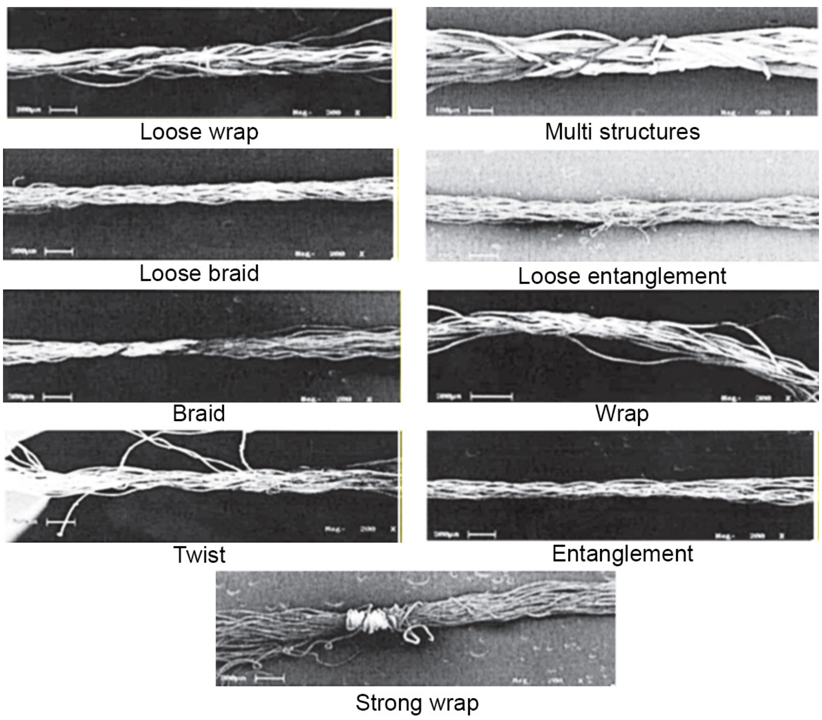


Fig. 4. SEM microscope images of nip structure (intermingled) classification [10].

TABLE IV
NIP CLASSIFICATION BASED ON NIP LENGTH

| Jet insert | | | S16 | | | P412 | | | P212 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Air pressure (bar) | | | 2 | 3 | 4 | 2 | 3 | 4 | 2 | 3 | 4 |
| Total interlacing length (mm) | | | 138 | 128 | 96 | 231 | 272 | 222 | 123 | 116 | 233 |
| Longitudinal classification of nips (mm) | 1 | QTY | 1.00 | 6.00 | 0.00 | 0.00 | 0.00 | 2.00 | 1.00 | 1.00 | 3.00 |
| | | (%) | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| | 2 | QTY | 5.00 | 10.00 | 2.00 | 4.00 | 1.00 | 6.00 | 10.00 | 2.00 | 7.00 |
| | | (%) | 0.07 | 0.16 | 0.04 | 0.03 | 0.01 | 0.05 | 0.16 | 0.03 | 0.06 |
| | 3 | QTY | 6.00 | 7.00 | 8.00 | 5.00 | 4.00 | 10.00 | 12.00 | 4.00 | 8.00 |
| | | (%) | 0.13 | 0.16 | 0.25 | 0.06 | 0.04 | 0.14 | 0.29 | 0.10 | 0.10 |
| | 4 | QTY | 11.00 | 5.00 | 3.00 | 7.00 | 5.00 | 7.00 | 7.00 | 6.00 | 6.00 |
| | | (%) | 0.32 | 0.16 | 0.13 | 0.12 | 0.07 | 0.13 | 0.23 | 0.21 | 0.10 |
| | 5 | QTY | 4.00 | 4.00 | 2.00 | 6.00 | 5.00 | 5.00 | 5.00 | 0.00 | 9.00 |
| | | (%) | 0.14 | 0.16 | 0.10 | 0.13 | 0.09 | 0.11 | 0.20 | 0.00 | 0.19 |
| | 6 | QTY | 4.00 | 1.00 | 2.00 | 10.00 | 6.00 | 8.00 | 1.00 | 2.00 | 2.00 |
| | | (%) | 0.17 | 0.05 | 0.13 | 0.26 | 0.13 | 0.22 | 0.05 | 0.10 | 0.05 |
| | 7 | QTY | 3.00 | 1.00 | 3.00 | 3.00 | 7.00 | 3.00 | 1.00 | 4.00 | 4.00 |
| | | (%) | 0.15 | 0.05 | 0.22 | 0.09 | 0.18 | 0.09 | 0.06 | 0.24 | 0.12 |
| | 8 | QTY | 0.00 | 2.00 | 0.00 | 3.00 | 3.00 | 2.00 | 0.00 | 2.00 | 8.00 |
| | | (%) | 0.00 | 0.13 | 0.00 | 0.10 | 0.09 | 0.07 | 0.00 | 0.14 | 0.27 |
| | 9 | QTY | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 1.00 | 1.00 |
| | | (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.08 | 0.04 |
| | 10 | QTY | 0.00 | 0.00 | 0.00 | 2.00 | 2.00 | 1.00 | 0.00 | 1.00 | 1.00 |
| | | (%) | 0.00 | 0.00 | 0.00 | 0.09 | 0.07 | 0.05 | 0.00 | 0.09 | 0.04 |
| | 12 | QTY | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 |
| | | (%) | 0.00 | 0.09 | 0.00 | 0.05 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 |
| | 13 | QTY | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | (%) | 0.00 | 0.00 | 0.14 | 0.06 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 19 | QTY | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 20 | QTY | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 32 | QTY | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |

TABLE V
SIGNIFICANCE PROBABILITY IN TWO-WAY ANALYSIS OF VARIANCE-THE EFFECT OF PROCESS VARIABLES ON THE STRUCTURAL PARAMETERS OF THE YARN

| Independent variable | Significance probability (dependent variable) | | |
|---|---|---|---|
| | Nips density | Degree of interlacing | Nips stability |
| jet | 0.000 | 0.000 | 0.000 |
| Air pressure | 0.000 | 0.000 | 0.000 |
| Jet+Air pressure | 0.000 | 0.000 | 0.000 |

P-value=0.05

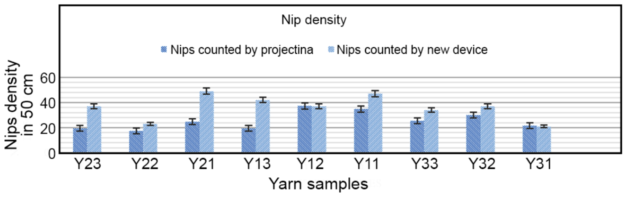


Fig. 5. The average number of nips observed between the two methods (jet insert/air pressure).

the dependent variable of nip density per unit length of yarn, percentage of entanglement and nip stability at 95% significance level. As can be seen in Table V, the effect of jet type and air pressure on nip density, percentage of entanglement degree and nip stability was significant.

Also, the effect of these factors simultaneously on nip density per unit length of yarn, percentage of degree of entanglement and nip stability is statistically significant. Fig. 6 shows the effect of air pressure on the nip stability calculated based on the nip length. As can be seen, increasing the air pressure will increase the quality of fibers entanglement and will increase the nip stability, of course, if Eq. (2) is used. As it is known, the intermingling process with S16 air jet has the lowest nip stability and P412 air jet has the highest nip stability. Performing the entanglement process with S16 air jet has the lowest total nip length and P412 air jet has the highest total nip length per yarn unit. Increasing the air pressure has increased the nip length per unit length of yarn.

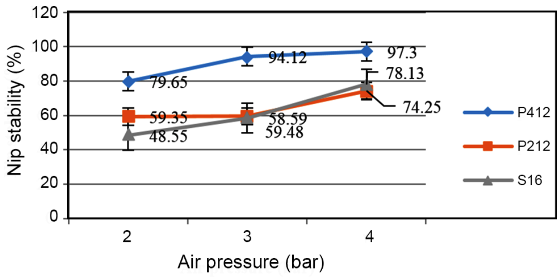


Fig. 6. Effect of air pressure on nip stability, as the air pressure increases, the nip stability increases.

## IV. CONCLUSION

In this paper, the proposed method of evaluating the nip frequency, stability and structure of nip zones in false twist textured yarn was studied. According to the observations, it seems that it is better to use the total nip length per unit length of yarn to measuring the nip stability. Also, in determining the number, the length and type of nip structure, the angle of view around the longitudinal axis of the yarn has no statistically significant effect, and any desired angle of view around the longitudinal axis of the yarn can be considered. The reason for the difference in the average number of nips in the two methods used is the higher human error and unwanted tensions in using the Projectina microscope for this particular application. Based on previous observations and research, it seems that the cause of opening the nip areas and also the increase in the number of nips in some cases after stretching, is related to the structure of the nip. Since the filaments are turned at the middle of their extremely long length, the braiding and twisting actions on them should be “false”. This means that the ideal braid or twist nip structure is of two symmetrical parts, carrying an equal but opposite number of directional braids or twists; hence the structures will easily unravel themselves when bearing load, unless some form of locking nip structure is present. When the applied tension fails to fully unravel a twisted or braided nip, the nip begins to open from the center of symmetry and the two ends, so it may become more than one nip with less fiber entanglement length.

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