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Comparative Study on the Impact of Carding and Blowroom Cotton Waste on Yarn Properties

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Abstract

The study investigates the impact of blending different types of cotton waste - carding waste and blowroom waste - into Ne16 yarns, using both ring and rotor spinning methods. Blending ratios of 10% and 20% were applied to evaluate their influence on yarn quality indicators, including thick places (+50%/km), thin places (−50%/km), neps (+200%/km), and hairiness. The results show that increasing the proportion of cotton waste significantly affects yarn evenness. For ring spinning (SNC) yarns, blending with carding waste at 10% and 20% led to increases in thick places by 17.2% and 37.9%, while blowroom waste increased thick places by 5.9 and 8.1 times, respectively. A similar trend was observed for thin places and neps, with blowroom waste having a much more pronounced negative effect than carding waste. The hairiness of SNC yarns also increased slightly with higher blending ratios, with blowroom waste contributing to greater hairiness than carding waste. In contrast, SOE yarns demonstrated better resistance to the negative effects of waste blending. For all indicators, rotor spinning (SOE) yarns exhibited significantly lower increases in defects compared to SNC yarns. For instance, the number of thick places in SOE yarns with 10% and 20% carding waste was only 20.5% and 23.3% of those in SNC yarns, respectively. Overall, while cotton waste can be used to reduce raw material costs in yarn production, the choice of waste type and spinning method plays a crucial role in maintaining yarn quality. Blowroom waste tends to deteriorate yarn properties more severely than carding waste, and SOE offers better tolerance to recycled material blending than SNC.

Keywords: Cotton waste, carding waste, blowroom waste, yarn quality, sustainable textiles.

1. Introduction

With an annual consumption of approximately 26 million tonnes [1], cotton is one of the fibres used most frequently by the textile industry, particularly in the clothing sector [2].

In our country, cotton fiber materials needed for yarn production account for over 80%, with an annual demand of approximately 1 million tons of cotton fiber. Since the domestic cotton-growing sector has not been able to meet the fiber material requirements for yarn and textile production, the majority - about 95% - of cotton fiber must be imported using foreign currency. As the cost of cotton fiber materials accounts for 60–70% of the yarn production cost, the use and recycling of cotton waste holds significant economic value. It helps reduce the cost of raw material purchases, increases the yield of usable fiber from raw materials, and lowers the yarn production cost. Therefore, the efficient use of fiber materials and the recycling of waste become even more crucial.

During the cotton spinning process from raw fiber materials, each machine discards a portion of waste cotton – primary cotton and cotton waste. When collecting this waste, it is necessary to distinguish between types that are still of good quality and can be reused immediately by returning to the production line, referred to as primary cotton. The types of waste that require additional processing before being reintroduced into the production line are called reusable cotton waste. Lastly, those that cannot be reused and must be discarded are referred to as non-recyclable cotton waste.

The classification of primary cotton waste and cotton waste helps optimize the use of waste materials. Using 100% recycled cotton waste or blending processed waste with virgin fiber to produce textile products can significantly reduce production costs while still ensuring product quality standards are maintained.

Primary cotton waste:

Primary cotton waste is generated from carding machines, comber machines, fly frames, drawing frames, and roving processes. It can be immediately reused in the main production line.

Good-quality cotton waste:

- *Bobbin waste*: This type of cotton waste is generated on machines that use extended bobbins, mainly drawing frames, roving frames, and spinning frames. The fiber length in bobbin waste is reduced by about 1–2% compared to the original raw material and

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is often contaminated with impurities due to accumulation and collection processes. Bobbin waste from the spinning frame may also contain broken yarns.

- *Pneumatic waste*: This type of waste is collected from machines equipped with end-suction systems, such as roving frames and spinning frames. The waste contains approximately 1.5% broken yarns (mainly from the spinning frame), which reduces its spinning value. The fiber content in this waste accounts for about 95–98%.

Low-quality cotton waste:

- *Floor waste from blowroom machines:*

The types of cotton waste discarded from blowroom machines contain about 50% spinnable fibers (depending on fiber length and quality). The fiber length in this floor waste is 3–4 mm shorter than that of the original raw material, with poor fiber length uniformity and a high content of impurities and defects. The total amount of waste generated by fiber feeding machines accounts for approximately 2.5% of the input raw material.

- *Carding cotton waste*

Flat cotton waste: This type of waste contains about 80–92% fiber. The fiber length in flat strips is 2–5 mm shorter than that of the original raw material, and the fiber length uniformity is about 8% lower. Defects and impurities are tightly bound to the fibers in this type of waste, making them difficult to remove.

Floor waste from large and small cans: The fiber length ranges from 4 to 10 mm and is mixed with dust and impurities.

Licker-in waste: Contains fibers longer than 15 mm, but also includes a significant amount of impurities, defects, and short fibers.

The total amount of waste generated from the carding machine accounts for approximately 5.5%.

- *Comber cotton waste:*

Comber cotton waste: This type of waste contains approximately 96–98% short fibers. The fiber length uniformity is 3–5% lower than that of the raw material. About 50% of the fibers are in the 16–20 mm range, while the rest are shorter than 15 mm. The proportion of defects and impurities is around 2–4%, mainly consisting of neps and seed coat fragments with fine fibers, which are tightly attached to the fiber and therefore difficult to remove.

Merati and Okamura studied the physical properties of recycled cotton yarns. They stated that the fiber length was a key factor on the strength of the yarn. As the fiber length increases, the strength of yarn also increases [3].

Halimi *et al.* implied that certain process parameters of open end system including rotor type, opening roller speed, rotor speed, and twist factor were the important factors for spinning of virgin cotton and cotton waste blends. They emphasized that addition of cotton waste at levels up to 25% in the draw frame did not affect the quality of rotor yarn [4]. El-Nouby compared the hairiness of open end rotor yarns produced by blending different ratios of cotton waste (flats, combing nail, spinning, and sliver wastes and long period stored cotton) and recycled waste (fabric waste). According to the results of the study, increases in the applied mechanical processes and the ratio of the recycled waste in yarns led to higher hairiness values for all yarns [5]

Hassani *et al.* investigated the optimum spinning conditions for rotor spun yarns that different proportional cotton wastes derived from ginning machines blended with secondary raw material [6]. Khan *et al.* studied on the prediction of the properties of cotton/waste blended Open-End (OE) rotor spun yarns using Taguchi OA design [7]. They concluded that the proportion amount of waste cotton is the most influential parameter on the properties of cotton/waste blended yarns. Taher *et al.* analysed the influence of spinning parameters and recover fibres from cotton waste on the uniformity and hairiness of rotor spun yarns [8]. They indicated that yarn count, rotor parameters such as diameter, form, and rotor speed have considerable effects as much as waste proportion.

Furthermore, they also denoted that using 25% of recycled fibre does not change the uniformity and appearance of rotor spun yarn in their study. Halimi *et al.* also examined the effect of cotton waste and spinning parameters on the rotor yarn quality [9]. Results of their study also verified that up to between 15% and 25% cotton waste ratio does not cause any change on rotor yarn quality with the optimum spinning parameters.

This study aims to investigate the effects of blending carding waste and blowroom waste with virgin cotton fibers on the quality of Ne16 yarns. The yarns were produced using two spinning technologies: ring spinning and rotor spinning. Various yarn quality parameters, including thick and thin places, neps, and hairiness, were analyzed at different waste blend ratios (10% and 20%) to assess the viability of using recycled cotton fibers in yarn production without compromising product quality.

2. Materials and Research Methods

2.1. Materials

The research subjects are two types of single yarns with a yarn count of Ne16:

SNC: Ring-spun yarn produced on ring spinning system and

SOE: Open-end rotor-spun yarn produced on Open-End system, respectively.

The cotton fiber material was blended with cotton waste collected from the breaker card and the blowroom line, with cotton waste blending ratios of 10% and 20%. The research uses cotton fiber imported from USA.

2.2. Research Methods

The tensile strength and elongation at break of the yarns were determined according to the international standard ISO 2062:2009, using the YG063E testing device manufactured in China.

Thin places (–50%/km), thick places (+50%/km), neps (+200%/km), and yarn hairiness were measured using the USTER ME100 device manufactured in Switzerland.

The yarn samples were conditioned under standard conditions (temperature 24 ± 2 °C, relative humidity 65 ± 4%) for 24 hours prior to testing. The experiments were conducted at the Yarn Quality Testing Laboratory – Tan Phuong Textile Co., Ltd., under standard laboratory conditions.

3. Research Results

3.1. Yarn Tensile Strength and Yarn Elongation

The test results for tensile strength and elongation at break of the two yarn types: ring-spun yarn (SNC) and open-end yarn (SOE) with a count of Ne16 - blended with carding waste and blowroom waste at blending ratios of 10% and 20% are presented in Table 1.

The research results on the tensile strength of two yarn types Ne16, blended with card waste and blowroom waste at blending ratios of 10% and 20%, indicate a general trend of decreasing tensile strength as the proportion of waste cotton increases. The tensile strength of SOE yarn decreased more significantly than that of SNC, and yarns blended with blowroom waste showed a greater reduction in tensile strength compared to those blended with card waste.

The effect of cotton waste:

- For yarns blended with card waste, compared to yarns without waste cotton, the tensile strength of SNC decreased by 6.8% and 15.9% when blended with 10% and 20% card waste, respectively. The tensile strength of SOE yarn blended with 20% card waste was 18.5% lower than that of SOE yarn blended with 10% card waste.

- For yarns blended with blowroom waste, compared to yarns without waste cotton, the tensile strength of SNC decreased significantly by 24.5% and 29.2% when blended with 10% and 20% blowroom waste, respectively. The tensile strength of SOE yarn blended with 20% blowroom waste was 12.8% lower than that of SOE yarn blended with 10% blowroom waste.

- The tensile strength of SNC yarn blended with 10% and 20% blowroom waste was 18.9% and 15.8% lower, respectively, than that of SNC yarn blended with card waste. Similarly, the tensile strength of SOE yarn blended with 10% and 20% blowroom waste was 12.6% and 6.5% lower, respectively, than that of SOE yarn blended with card waste.

Effect of Spinning Method:

For yarns blended with 10% and 20% card waste, the tensile strength of SOE yarn decreased by 30.4% and 37.2%, respectively, compared to SNC. For yarns blended with 10% and 20% blowroom waste, the tensile strength of SOE yarn decreased by 25.0% and 30.3%, respectively compared to SNC.

Table 1. Yarn tensile strength and yarn elongation Ne16

Sample	**Waste blending ratio**					**Waste blending ratio**				
	0%	**10%**		**20%**		**0%**	**10%**		**20%**	
	Yarn tensile strength (cN/tex)					**Yarn elongation (%)**				
	SNC	SNC	SOE	SNC	SOE	SNC	SNC	SOE	SNC	SOE
Yarn Ne16 blended carding waste	23.3	21.7	15.1	19.6	12.3	7.0	6.7	5.2	5.2	5.1
Yarn Ne16 blended blowroom waste	23.3	17.6	13.2	16.5	11.5	7.0	6.2	5.0	5.0	4.8

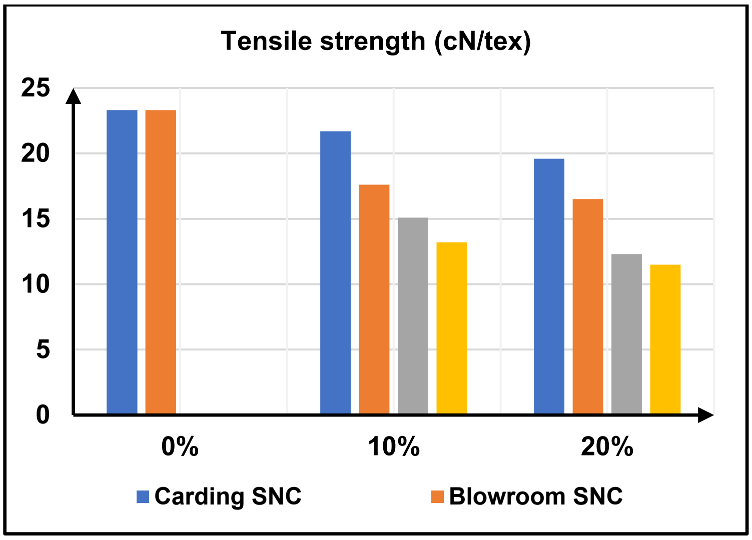

Fig 1. Yarn tensile strength Ne16 blended carding và blowroom waste

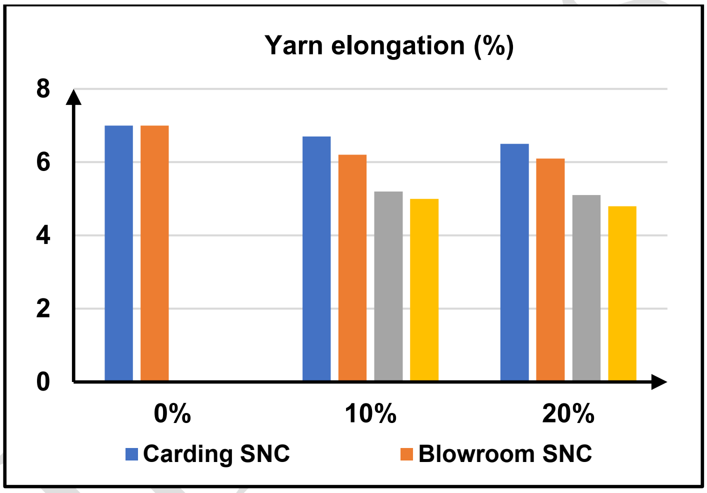

Fig 2. Yarn elongation Ne16 blended carding và blowroom waste

The elongation at break of the two yarn types Ne16, blended with card waste and blowroom waste at blending ratios of 10% and 20%, showed that as the proportion of waste cotton increased, the elongation at break of both SNC and SOE decreased significantly. Yarns blended with blowroom waste exhibited lower elongation at break compared to those blended with card waste. The reduction in elongation at break was more pronounced in SOE yarn than in SNC yarn as the waste cotton content increased.

For Ne16 yarns blended with 10% and 20% card waste, the elongation at break decreased by 4.3% and 25.7%, respectively, compared to yarns without waste cotton. For Ne16 yarns blended with 10% and 20% blowroom waste, the elongation at break decreased by 11.4% and 28.5%, respectively. The elongation at break was strongly influenced by the blending ratio of waste cotton. In the case of SOE yarns, blending ratios of 10% and 20% waste cotton had a smaller effect on elongation at break, with reductions of approximately 2–4%.

3.2. Thin places (–50%/km), Thick Places (+50%/km), and neps (+200%/km) of Yarn Count Ne16

The experimental results for thick places (+50%/km) and thin places (–50%/km) in Ne16 yarns blended with card waste and blowroom waste are presented in Table 2, while the results for neps (+200%/km) in Ne16 yarns blended with card waste and blowroom waste are presented in Table 3.

Table 2. Thick places, thin places Ne16 blended carding và blowroom cotton waste

Sample	Waste blending ratio					Waste blending ratio				
	0%	10%		20%		0%	10%		20%	
	Thick places +50%/km					Thin places -50%/km				
	SNC	SNC	SOE	SNC	SOE	SNC	SNC	SOE	SNC	SOE
Yarn Ne16 blended carding waste	87	102	21	120	28	1	1	2	2	3
Yarn Ne16 blended blowroom waste	87	520	45	705	51	1	3	5	8	9

Table 3. Neps and hairiness Ne16 blendd carding và blowroom cotton waste

Sample	Waste blending ratio					Waste blending ratio				
	0%	10%		20%		0%	10%		20%	
	Neps +200%/km					Hairiness H				
	SNC	SNC	SOE	SNC	SOE	SNC	SNC	SOE	SNC	SOE
Yarn Ne16 blended carding waste	142	214	107	250	115	6.3	6.6	5.9	6.7	6.1
Yarn Ne16 blended blowroom waste	142	607	142	821	208	6.3	6.7	6.2	6.9	6.5

For SNC yarn:

The study results on thick places (+50%/km) in Ne16 yarns blended with card waste and blowroom waste at blending ratios of 10% and 20% show that the number of thick places tends to increase significantly as the blending ratio increases. Compared to yarns without waste cotton, the number of thick places in Ne16 yarns blended with 10% and 20% card waste increased by 17.2% and 37.9%, respectively. For Ne16 yarns blended with 10% and 20% blowroom waste, the number of thick places increased by 5.9 times and 8.1 times, respectively, compared to the control yarns. The number of thick places in blowroom waste–blended yarns increased rapidly with higher blending ratios. When the blending ratio increased, Ne16 yarns blended with blowroom waste showed a greater increase in thick places compared to those blended with card waste. At the same blending ratios of 10% and 20%, the number of thick places in yarns blended with blowroom waste was 5.1 times and 5.8 times higher, respectively, than in yarns blended with card waste.

For SOE yarn:

The number of thick places (+50%/km) was significantly lower compared to SNC. In yarns blended with 10% and 20% card waste, the number of thick places in SOE yarn was 20.5% and 23.3%, respectively, of that in SNC yarn.

In yarns blended with 10% and 20% blowroom waste, the number of thick places in SOE yarn was only 8.6% and 7.3%, respectively, of that in SNC yarn.

The study results on thin places (–50%/km) in SNC yarns with a count of Ne16 blended with card waste and blowroom waste at blending ratios of 10% and 20% show that the number of thin places tends to increase as the blending ratio increases. Compared to yarns without waste cotton, SNC yarn blended with 10% card waste showed no change in the number of thin places, while a 20% card waste blend led to a twofold increase. For SNC yarns blended with 10% and 20% blowroom waste, the number of thin places increased by 3 times and 8 times, respectively. Thus, in blowroom waste–blended yarns, the number of thin places increases sharply with higher blending ratios. SNC yarns blended with blowroom waste exhibited a much greater increase in thin places compared to those blended with card waste. At the same blending ratios of 10% and 20%, the number of thin places in yarns blended with blowroom waste was 3 times and 2 times higher, respectively, than in yarns blended with card waste.

Compared to SNC yarn, SOE yarn showed an increase in the number of thin places (–50%/km) as the blending ratio of waste cotton increased. The number of thin places in yarns blended with blowroom waste was higher than in yarns blended with carding waste.

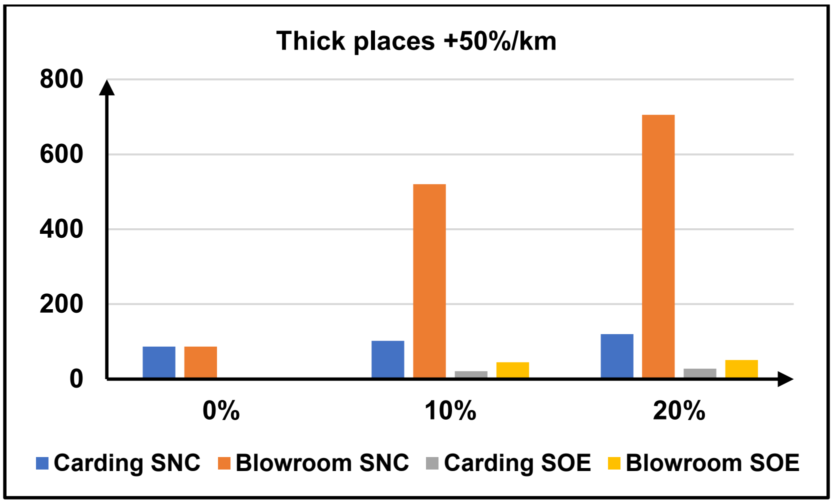

Fig 3. Thick places +50%/km Ne16 blended carding và blowroom waste

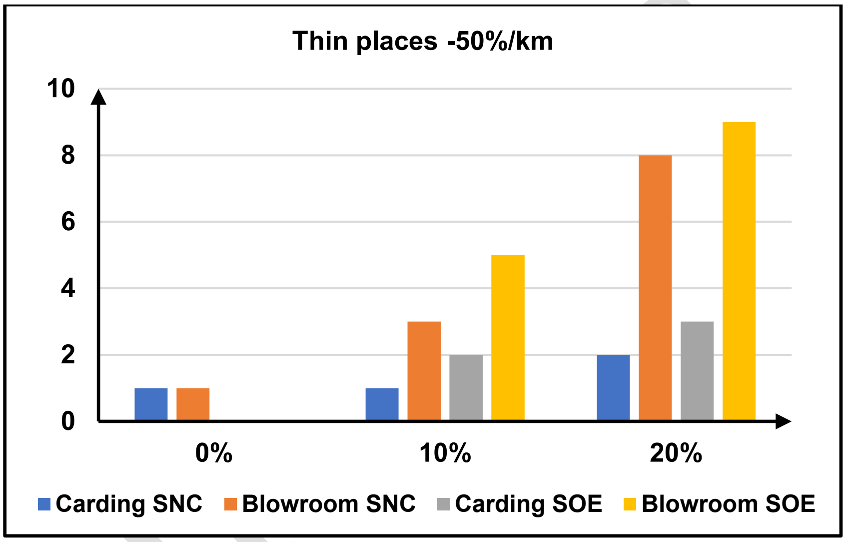

Fig 4. Thin places -50%/km Ne16 blended carding và blowroom waste

The research findings on the number of neps (+200%/km) in Ne16 yarns blended with card waste and blowroom waste are presented below.

For SNC yarn:

The study results on neps (+200%/km) in Ne16 yarns blended with card waste and blowroom waste at blending ratios of 10% and 20% show that the number of neps increases significantly with higher waste cotton content. Compared to yarns without waste cotton, the number of neps in SNC yarn blended with 10% and 20% card waste increased by 1.5 times and 1.76 times, respectively. For Ne16 yarns blended with 10% and 20% blowroom waste, the number of neps increased by 4.3 times and 5.8 times, respectively, compared to the control yarn. In blowroom waste–blended yarns, the number of neps increases rapidly as the blending ratio rises. When the blending ratio increases, Ne16 yarns blended with blowroom waste exhibit a much greater increase in neps compared to those blended with card waste. At the same blending ratios of 10% and 20%, the number of neps in blowroom waste–blended yarns was 2.8 times and 3.3 times higher, respectively, than in card waste–blended yarns.

For SOE yarn:

The number of neps (+200%/km) was significantly lower compared to SNC. In yarns blended with 10% and 20% card waste, the number of neps in SOE yarn was 50% and 46%, respectively, of that in SNC yarn. For yarns blended with 10% and 20% blowroom waste, the number of neps in SOE yarn was 23.4% and 25.3%, respectively, of that in SNC yarn.

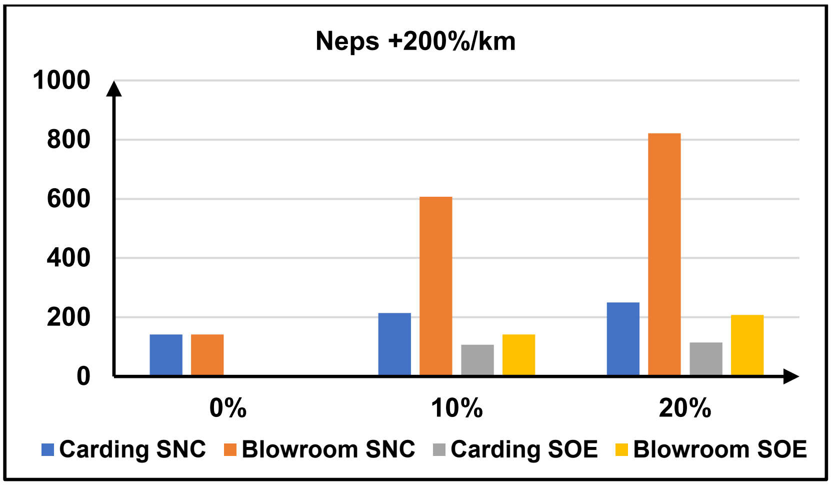

Fig 5. Neps +200%/km Ne16 blended carding và blowroom waste

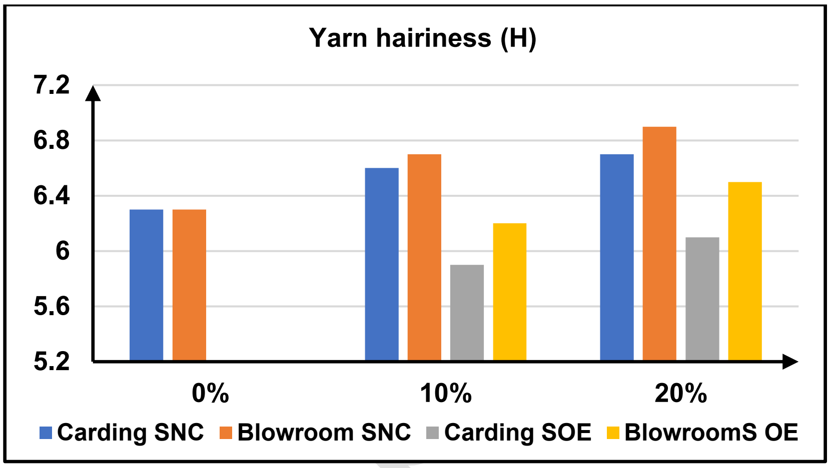

Fig 6. Hairiness Ne16 blended carding và blowroom waste

3.3. *Yarn Hairiness Ne16*

The experimental results of hairiness for Ne16 yarns blended with carding waste and blowroom waste are presented in Table 3.

The experimental results on the hairiness of two types of Ne16 yarns blended with carding waste and blowroom waste at blending ratios of 10% and 20% indicate that yarn hairiness tends to slightly increase as the proportion of cotton waste increases.

For SNC: Compared to the yarn without waste cotton, the Ne16 yarn blended with 10% and 20% carding waste showed an increase in hairiness by 4.7% and 6.3%, respectively. For Ne16 yarns blended with blowroom waste at the same blending ratios, hairiness increased by 6.3% and 9.5%, respectively. In general, yarn hairiness tends to increase slightly with a higher proportion of waste cotton, and yarns blended with blowroom waste exhibit greater hairiness than those blended with carding waste.

For SOE yarn: The hairiness is lower compared to SNC. For yarns blended with 10% and 20% carding waste, the hairiness of SOE yarns is equivalent to 89% and 91% of that of SNC yarns, respectively. For yarns blended with 10% and 20% blowroom waste, the hairiness of SOE yarns is equivalent to 92.5% and 94.2% of that of SNC yarns, respectively.

4. Conclusion

The research results clearly demonstrate the impact of blending cotton waste (carding waste and blowroom waste) on the quality characteristics of two types of yarn: Ring-spun yarn SNC and open-end rotor yarn SOE, both with a yarn count of Ne16. As the blending ratio of cotton waste increases from 10% to 20%, the overall yarn quality declines. Specifically, yarn strength and elongation decrease, while unevenness, the number of thick places, thin places, neps, and hairiness tend to increase.

Comparing the two types of waste, yarn blended with blowroom waste shows a more significant deterioration in quality than yarn blended with carding waste.

Notably, the number of yarn faults (especially thin places and neps) increases rapidly when using blowroom waste, particularly at a 20% blending ratio.

Regarding spinning technology, SOE demonstrates better appearance characteristics, with significantly fewer yarn faults and lower hairiness compared to SNC, although SOE yarn exhibits lower strength. This indicates that OE spinning technology is more effective in masking raw material defects.

In summary, the use of cotton waste at a reasonable level (up to 10%) is acceptable in terms of yarn quality, especially when using carding waste. However, caution should be exercised when increasing the blending ratio or when using blowroom waste, to ensure that the yarn quality still meets the technical requirements of production.

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