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Sustainable Rotor Yarn Production From Knitting Industries Fabrics Wastes

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Abstracts

Sustainability is the world's most requirement at the present world. Production and processing of sustainable textiles not only help to reduce the negative impacts on the environment, but also support millions of workers to earn fair wages and ensure proper working. In this study, the collected knitted waste fabric was categorized according to color and then this fabric was converted to recycle fiber. This sustainable fibre (SF) was mixed in different rations with virgin Cotton (VC) fibre and produced 16Ne rotor yarn. The produced yarn quality was determined by comparing the yarn IPI, CSP, U% and H value with Uster Statistics 50% and control yarn quality. The sustainable yarn sample SYS 02 is better in comparison to the standard and control samples but its mixing ratio is 25% SF and 75% VC. It's not cost-effective for yarn production in bulk conditions. But the SYS 03 would be recommended due to its cost-effectiveness and its quality IPI 186, CSP 1350, U% 11.36 and hairiness 6.27 is better in comparison to the standard (Uster Statistics 50%) and control sample CYS 01. So, this produced sustainable rotor yarn is suitable to use in Denim industry where the yarn CSP is important. This sustainable yarn added the value of knitting waste as well as save the environment from unplanned landfilling.

Keywords: Sustainability, Knitting waste, Recycle fiber, Rotor yarn, Sustainable yarn.

Introduction

Bangladesh is a developing country's economy is driven by the Textile industry export. Since 2009, it's become the second-largest RMG exporter behind China (Hoque, 2019). The main raw material of the textile industry is yarn(Khandaker et al., 2021). This yarn is used to produce woven and knitted fabrics. Bangladesh Knitwear contributes significantly to the economy. This sector, Bangladesh's biggest exporter, has seen unprecedented expansion in the previous 20 years. It's risen quickly in foreign exchange profits, exports, industrialization, and GDP contribution. The industry creates jobs, empowers women, reduces poverty, improves health and nutrition, etc.(BKMEA, 2022). Knit T-shirt fabric waste during cutting, panel checking, sewing, and finishing was documented as a percentage of the original fabric weight. 13.57 percent of waste is unavoidable in the cutting phase, 6.91 percent in panel checking, 4.31 percent in sewing, and 1.72 percent in finishing(Rahman and Haque, 2016). The improper landfilling of this huge amount of waste is a serious diverse effect on our environment(Azad and Moon, 2022). Now the most growing export sector of Bangladesh is Denim. Bangladesh sent $798.42 million worth of denim clothes to its biggest export market in 2021, which was a 42.25 % increase from the previous year(Hossain, 2022). The main raw material of denim is rotor yarn(Hawlader and Hossain, 2021). So the rotor yarn requirement is an increasing trend in Bangladesh. So the production of sustainable rotor yarn would meet the requirement of the denim sector.

Sustainability means being able to meet our own needs without making it harder for future generations to do the same. We also need social and economic resources as well as natural resources. Sustainability is not just environmentalism. Most definitions of sustainability also talk about the need for social justice and economic growth(University of Alberta, 2022). Sustainable Development is a term used to describe economic development that is both environmentally and socially responsible. Environmental, economic, and socio-political sustainability are the three pillars of this approach. In order to achieve long-term sustainability, we must progressively alter the methods in which we create and use new technology in order to preserve and improve the resources we already have. There should be enough work, food, energy, water, and sanitary facilities for everyone in every country on Earth. A healthy, safe, and clean environment is a fundamental right for all people. Lowering pollution, poverty, and unemployment may be readily accomplished(Nebeskie, 2022).

Fabric made from eco-friendly sources such as sustainably cultivated fibre crops or recycled materials is referred to as sustainable textile material(Comfort World, 2022). Now sustainable textile is the world requirement. So, several fashion companies have turned to unsustainable practices in order to meet demand and create profits. The three pillars of sustainability are becoming more important to many current fashion companies(Barik et al., 2016). In order to be considered sustainable, clothing and textile manufacturers must have a minimal impact on the environment. It is also a global problem that many countries overlook the social and economic aspects of clothing and textile manufacture. Reduces environmental and social stress while

providing an ethical choice for eco-conscious shoppers to buy sustainable items via sustainable fashion(Barnes, Lea and Joergens, 2006).

As of right now, local businesses are buying knitting fabric scraps to use in the production of children's apparel. Dhaka's bedding industry is also dependent on it. Mattresses, pillows, cushions, seat stuffing, and padding in automobiles, public buses, and rickshaws are all made from recycled fabric and processed cotton(Khan, 2020). But small pieces of knitting waste are non-usable and dump in unplanned landfilling on the street side. This study would be converted the non-usable small pieces of knitted fabrics waste as rotor spinning raw material fiber and produce rotor yarn. So these wastes will be recycled as a raw material of rotor yarn and save the environment as well as added and increase the value of knitted fabrics waste. This rotor yarn would support the denim sector as the backward linkage**.**

Materials and Methods

The knitting waste fabric was collected from the different knitting industry. Those waste has been processed and mixed with virgin cotton to produce sustainable yarn. The spinning process was used to make the yarn, as shown in Figure 1. Then categorized the knitting fabric waste according to color. The pale color fabrics were converted into dark black color by the dyeing process. These black fabrics were cut into small pieces. These small pieces of fabric were fed into the willowing machine to convert the fiber called sustainable fibers (SF).

This SF was used as the raw material of the spinning process. This SF was fed to the blow room and carding section to proper opening, cleaning, mixing, impurity removing, and parallelize the fibers. Virgin cotton was chosen as fresh raw material. The virgin cotton and sustainable fiber were tested in HVI machine. Table 1 presents the characteristic summary of raw material properties. The virgin cotton and the SF were mixed in the blow room section. After carding process, the carded sliver was produced. These carded slivers fed into the drawing machine and found drawn slivers. Then these slivers were used as the rotor raw material and got the sustainable rotor 16Ne yarn as the Figure 2.

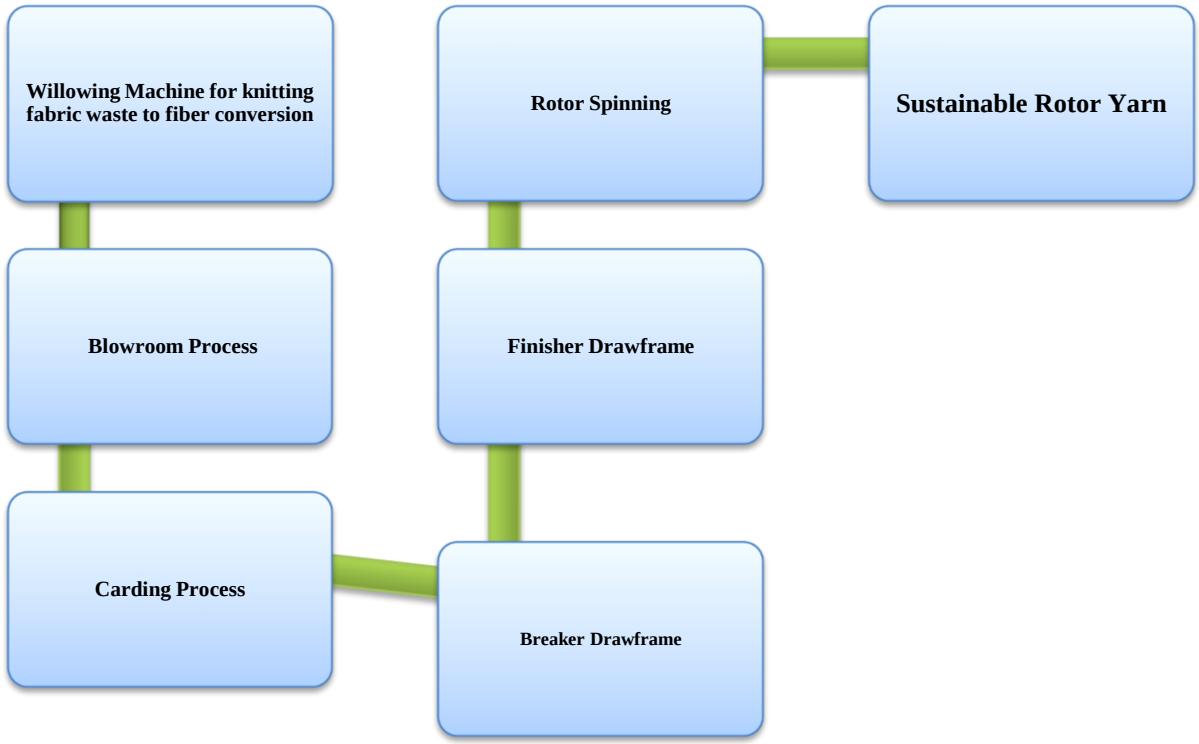

Figure 1: Processing steps for producing sustainable yarn

Table 01: Characteristics of Fiber

Characteristics	Virgin Cotton	Recycle Cotton
Moisture (%)	8.3	5.7
Micronaire	4.56	4.37
Maturity Index	0.86	0.81
Upper Half Mean Length	27.22	19.61
Uniformity Index	82.50	60.10
Short Fiber Index	13.60	71.90
Strength	28.60	20
Elongation	7.1	13.10

Source: Physically Test in HVI Machine

The Neps content of the virgin cotton and the sustainable fiber were tested in AFIS machine which presented in the Table 02.

Table 02: Neps Content in Fiber

Fiber Type	Total Nep Cnt (cnt/g)	Total Nep Mean Size(um)	Fiber Nep Cnt (Cnt/g)	Fiber nep Mean Size(um)	SCNep Count (cnt/g)	ScNep Mean Size
Virgin Cotton	235	731	208	664	27	1246
Recycle Cotton	702	793	544	680	158	1182

Source: Physically Test in AFIS Machine

Table 03: Fiber mixing ratio

Sample No.	Fiber Mixing Ratio	
	Virgin Cotton (VC) %	Sustainable Fiber (SF) %
CYS 01	100	0
SYS 02	75	25
SYS 03	50	50
SYS 04	25	75
SYS 05	00	100

Yarn quality depends on the mixing ratio of the SF and virgin cotton. The mixing ratios of the different samples are presented in Table 03. The control yarn sample is denoted by CYS and the sustainable yarn sample is denoted by SYS.

The 05 sample yarns were prepared from different mixing ratios of fiber. Then this samples were tested in Uster Tester machine. Then the comparative analysis was done between the control samples to other samples. IPI, and CSP expressed the yarn qualities. The following equation calculated imperfection Index (IPI) (i) and Yarn Count Strength Product (CSP) of yarn was calculated by equation (ii).

IPI of rotor yarn =
Thin places/ km (-50%) + thick places/km (+50%) + Neps/km (+280%) /km……(i)

CSP of yarn=
Strength of one lea yarn in pound × Count in English system…….(ii)

Yarn quality was analyzed by comparing all data with uster statistics (50%) and control sample 1.

Figure 2: Knitting fabric waste recycling process diagram

Results and Discussions

The characteristics of produced 05 yarn sample are presented in Table 04. CYS 01 is the control sample and SYS means the sustainable yarn sample. The yarn IPI, and CSP, were calculated from Table 04 data. The yarn Imperfection Index (IPI) presented the yarn quality which was calculated from the yarn major falts Thick place, Thin Place, and Neps content. On the other hand, CSP presented the yarn strength with respect to the yarn count. So all the values of yarn IPI and CSP are very important for yarn quality assessment.

Table 04: Yarn Characteristics

Yarn Characteristics	CYS 01	SYS 02	SYS 03	SYS 04	SYS 05
U%	9.83	10.29	11.36	19.87	27.74
CVm%	12.45	13.42	14.63	16.11	17.77
Index	1.53	1.61	2.14	2.96	3.12
CVm 1m%	4.37	4.39	8.27	8.89	9.67
CVm 3m%	2.81	2.78	7.02	8.21	9.87
Thin -40%/km	61.5	60.5	61.00	42	37
Thin -50%/km	6	4	0.00	0	0
Thick 35%/km	207	156	177.50	297	324
Thick 50%/km	8	26	30.00	87	106
Neps 200%/km	68.5	487	654.40	780	798
Neps 280%/km	7.36	112	156.00	188	256
H	5.67	5.88	6.27	11.88	19.39

Source: Physically Sample Yarn Test in Uster Tester Machine

The yarn IPI is linearly increasing with increasing the ratio of sustainable fiber. Figure 03 represents the yarn samples IPI. The standard IPI for 16Ne rotor yarn is 58 (Uster Statistics 50%) but the control yarn sample (CYS 01) IPI is 82.50. The minimum IPI of sustainable yarn sample is 142 for the sample SYS 03.

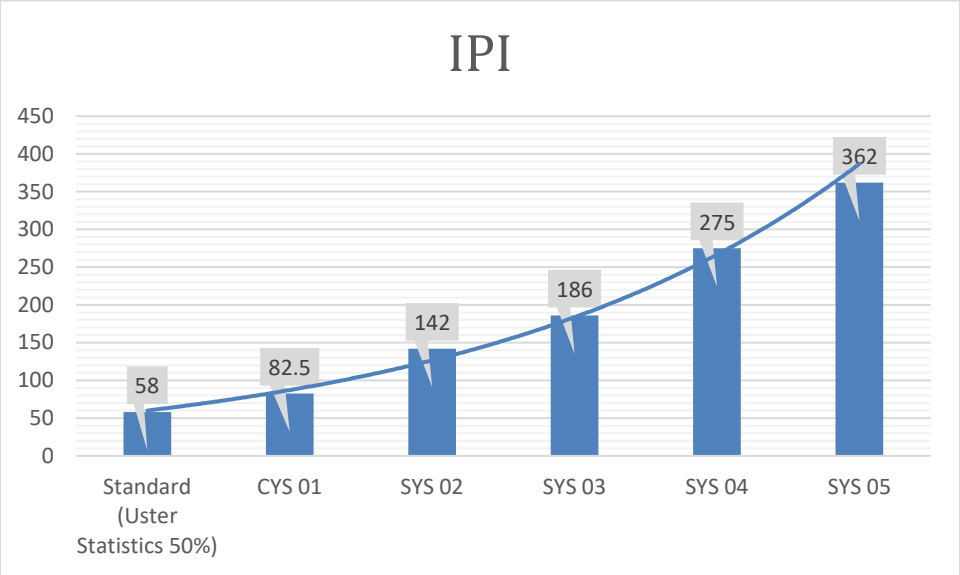

Figure 3: IPI of Rotor Yarn

Another important property of yarn is Count Strength Product (CSP) is presented in Figure 04. Here the CSP of 16Ne rotor yarn standard is 1400 (Uster Statistics 50%) and the control sample CYS 01 is 1200. The sustainable yarn sample (SYS) presents a better CSP than the control sample. The CSP of sample SYS 02 is 1411 and sample SYS 03 is 1350. The CSP is decreasing trend for samples SYS 04 and SYS 05.

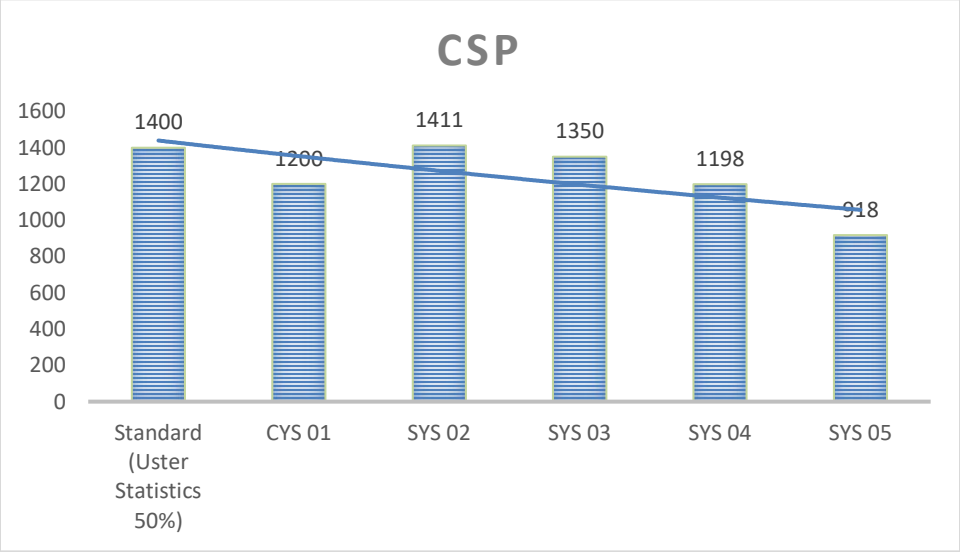

Figure 04: CSP of Rotor Yarn

The Uniformity of this sample yarn is presented in Figure 05. The U% is linearly increasing trend with an increase of sustainable fiber ratio in the sample yarn. The sample SYS 03 shows the u%

of 11.36 and the control U% is CYS 01 9.83 but the standard U% is 9 (Uster Statistics 50%). The samples 04 and 05 the U% is so much higher than the others.

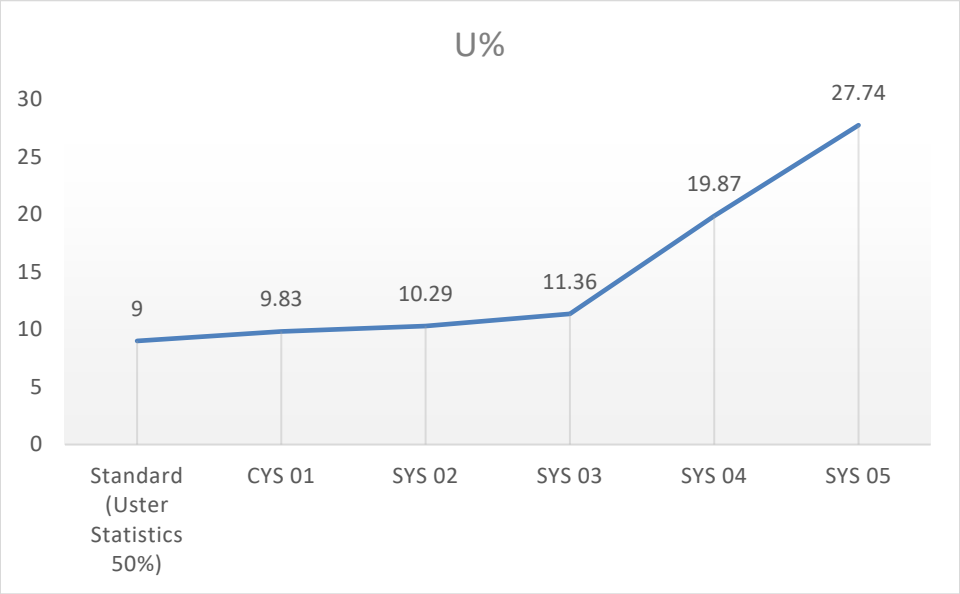

Figure 05: U% of Rotor Yarn

The yarn hairiness is an important yarn property. The standard hairiness is 5.3 (Uster Statistics 50%) and the control sample CYS 01 hairiness is 5.67. The Hairiness of the sustainable yarn sample (SYS) is linearly increasing trend with the increasing the sustainable fiber ratio. The minimum sustainable yarn hairiness is 5.98 for sample SYS 02 and 6.27 for SYS 03. The yarn hairiness of the samples are presenting in Figure 06.

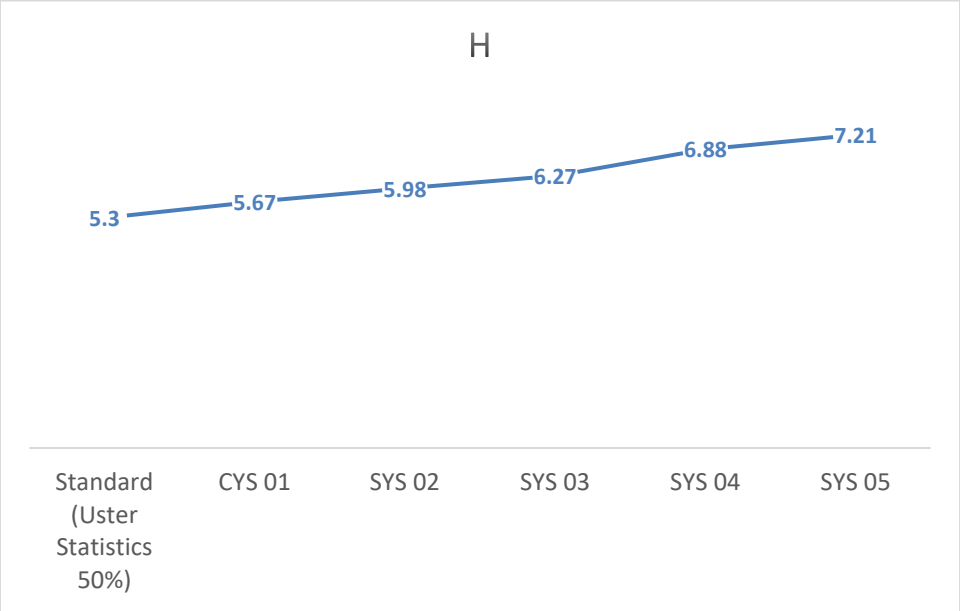

Figure 06: Hairiness of Rotor Yarn

Recommendation and Conclusions

Sustainability is the present world requirement. Sustainable yarn production from knitting wastes is the new door for the spinning sector of Bangladesh. The sustainable yarn sample SYS 02 would be recommended for this quality IPI 142, CSP 1411, U% 10.29 and Hairiness 5.98 with the comparison of standard and control yarn samples. But the sustainable yarn sample SYS 02 is produced with only 25% sustainable fibre and 75% virgin cotton. So its production cost will be higher than SYS 03. That's why the sustainable yarn sample SYS 03 would be suggested for further production at the bulk level that's quality is IPI 186, CSP 1350, U% 11.36 and Hairiness 6.27 which is closer to SYS 02.

This study would be helpful for the industrial person to implement and produce low-cost rotor yarn as well as help to use the knitting small fabric wastes which were non-usable and dumped in the open place. On the other hand, this study also helps the knitting industry create the knitting waste demand for a sustainable fibre market. Sustainability makes the world greener and saves us. It also reduces environmental pollution and energy losses as well as creates new employment.

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Disclosure Statement

The authors reported no potential conflict of interest

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