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Analysis of Production Loss to Enhance the Productivity of a Knitting Floor

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ABSTRACT

This research investigates numerous approaches for improving the productivity of a particular knitting floor. There are numerous reasons to pursue an immediate reduction in inefficiencies on knitting floors. Several perceptions were implemented to unveil the disputes for initiating an optimum solution for the floor during knitting. Therefore, ten selected machines have been employed with an Adiabatic Cooling System for scrutinizing a comprehensive production efficiency analysis. Hence an equilibrium of both temperature and humidity was achieved on the floor, restraining minimal dust by spraying micro droplets of water. Neither of the mechanisms subsidized the production efficiency between 12% and 17%, which was lower than the esteemed level taken at the maximum time. Consequently, the plant began to receive 2% to 5% more production than usual once the mentioned methods were implemented gradually. Thus, it reduced the yarn breakage preserving humidity and temperature in a synchronized state. Meanwhile, a foremost response has been achieved by reducing the flying dust. Furthermore, the environment of the knitting floor, routine machine maintenance, and the strain on the machine operator all have vital contributions.

Keywords: Knitting Floor, Productivity, Efficiency, Adiabatic Cooling System, Flying Dust, Humidity, Yarn Breakage.

1 Introduction

Knitting is a widely used method in textile production due to its speed and versatility. However, factors such as machine settings, yarn quality, operator skill, and environmental conditions significantly impact production efficiency. Studies have shown that stitch length, yarn tension, and machine maintenance play a crucial role in minimizing defects and maximizing productivity [1]. Regular maintenance reduces downtime and prevents defects caused by accumulated lint or mechanical wear. Additionally, advanced monitoring systems allow real-time tracking of machine performance, contributing to stable production levels [2].

Previous research has highlighted the importance of optimized machine settings and skilled labor in achieving higher efficiency. A study on knitting technology suggested that an effective workflow and well-maintained machinery could reduce yarn breakage and fabric faults, leading to an efficiency increase of up to 15% [3]. Furthermore, implementing technological advancements such as automated quality control mechanisms has been shown to enhance production rates in knitting operations. Environmental conditions in textile manufacturing have a significant impact on yarn quality and knitting performance. Studies indicate that humidity control is essential for reducing yarn breakage, as higher humidity levels improve yarn elasticity and strength, thereby minimizing production losses. A well-balanced temperature and humidity level also prevent excessive fiber fly accumulation, which can lead to defects and machine inefficiencies [4]. Research on environmental control strategies suggests that maintaining optimal humidity levels (55% ± 5% RH) and temperature (25°C ± 1.1°C) can improve machine efficiency and reduce defects in knitted fabrics. Textile production environments equipped with climate control mechanisms, such as humidifiers and ventilation systems, have demonstrated improved production outcomes by mitigating the negative effects of excessive dryness or heat [5].

One of the innovative solutions for maintaining stable environmental conditions in industrial knitting floors is the use of adiabatic cooling systems. These systems operate by evaporating water droplets into the air, absorbing heat, and lowering the surrounding temperature without the need for traditional refrigeration. Adiabatic cooling has been successfully implemented in textile mills to maintain optimal humidity levels, reduce yarn breakage, and improve air quality by minimizing fiber dust in the workspace [6]. Studies on cooling system applications in textile production reveal that adiabatic cooling can enhance production efficiency by 3-6% due to improved working conditions for both machines and operators [7]. Furthermore, the introduction of these systems has been shown to reduce maintenance requirements and extend machine lifespan by preventing overheating and excessive mechanical stress. Overall, the integration of cooling systems, combined with effective environmental controls and optimized machine operations, has the potential to significantly enhance knitting production efficiency [8].

This study addresses a critical gap by examining the impact of adiabatic cooling on knitting floor efficiency, an aspect largely overlooked in previous research. While prior studies focus on isolated factors like machine settings or maintenance, this research takes a holistic approach by integrating environmental control, dust reduction, machine servicing, and yarn handling. Unlike theoretical analyses, it is based on real-world data, and this makes the findings highly relevant for industrial applications. The study specifically aims to identify efficiency gaps in knitting production, assess regular knitting floor operations, and develop practical strategies to enhance productivity. Furthermore, the present work also provides a comprehensive and cost-effective solution for optimizing knitting production by tackling both environmental and mechanical challenges.

2. Materials and Methods

2.1. Materials

Yarn used for Single jersey-
Composition: [100% Cotton] 100%
Count: 30'S
Color: White, Indigo, Honey dew
Yarn used for Double jersey (Rib)-
Composition: [95% Cotton 5% Elastin] 100%
Count: 28+40D, 32+40D
Color: White, Green, Black

2.2. Machines and Methods:

There are two types of machines are used in this analysis i.e., Circular knitting machine and Hygrometer

$$\text{Target production in knitting} = \frac{\pi DG \times S.L \times \text{No. of Feeder} \times RPM \times \text{Time} \times \text{Efficiency}}{10 \times 2.54 \times 36 \times 840 \times \text{Count} \times 2.2046} \quad (1)$$

where, D= Cylinder Dia (inch), G= Cylinder Gauge, S.L= Stich Length

$$\text{Efficiency (\%)} = \frac{\text{Production Quantity}}{\text{Production}} \times 100\% \quad (2)$$

$$\text{Relative Humidity (\%)} = \text{Dry bulb temperature} - \text{Wet bulb temperature} \quad (3)$$

Here, the Relative Humidity Sling Psychrometry Table was used as a reference.

$$\text{The target Production/kg in 100\% efficiency (8 hours)} = \frac{\pi DG\times S.L\times \text{No. of Feeder}\times RPM\times \text{Time}\times \text{Efficiency}}{10\times 2.54\times 36\times 840\times \text{Count}\times 2.2046} \quad (4)$$

To collect and calculate the data, five successive actions have been conducted. Actual production was collected as data for two weeks before the suitable measures were taken. Upon the finalization of the essential procedures, actual manufacture was collected as data for two weeks.

The production of these smart textiles involves several disciplines outside of the typical textile domain, each with its vocabulary, specialized concepts, and methodologies [9]. After compiling the production data for two weeks, the following actions were carried out to enhance productivity. Second phase data have been recorded after ensuring such steps -

i. Ensuring standard humidity on the floor

Based on the data collected, it was discovered that when the temperature rises, outside relative humidity reduces significantly, ensuring favorable conditions for the use of adiabatic cooling [10]. Humidity level has a great impact on yarn strength and elasticity. The increased humidity strengthens the yarn, reducing breakage while maintaining great efficiency. So, to do this, an Adiabatic cooling system is adopted in which water is used to cool the air without the need for traditional refrigeration mechanisms. The cooling system combines the benefits of both dry and adiabatic cooling into a single [11]. The cooling system combines the benefits of both dry and adiabatic cooling into a single unit. Water is sprayed or dripped into the air stream or onto surfaces where it evaporates rapidly. This evaporation process absorbs heat from the surrounding air, lowering its temperature. Recommended conditions for prevention of the breakage are Temperature= 25°C ± 1.1°C and RH%=55% ± 5% RH. Increased humidity makes the yarn stronger, resulting in fewer breakages and more efficiency [12]-[13].

ii. Reductions of flying dust

Dust is defined as dust present in the air during the knitting or processing of yarn, which can contain a mixture of several components including ground-up plant matter, fiber, bacteria, fungi, soil, and pesticides [14]. This fiber fly causes substantial indoor pollution [15]. Data on knitting waste was collected to assess the effect of various yarn properties on knitting fly formation [16]. Sometimes flying dust and tufts get stuck in the machine. Dust accumulation in knitting machinery can increase wear and tear, leading to more frequent breakdowns and maintenance needs. This can result in downtime and decreased productivity as machines require cleaning and repairs. By implementing the Adiabatic system on the floor, the water vapor introduced into the air by the adiabatic system can bind with dust particles, causing them to become heavier and settle out of the air more quickly. This can help to reduce the amount of dust circulating in the environment of the knitting floor which will reduce machine breakage.

iii. Balancing machine tension

In practice, knitting tension is significantly influenced by the pattern type and stitch length [17]. As we know during knitting production, yarn is pushed over the previously placed yarn which increases the abrasion among them and leads to yarn breakage. And yarn breakage reduces the production efficiency. So correct tension for knitting operation is maintained to reduce yarn breakage.

iv. Servicing of the knitting machine

Investing in machine servicing not only increases knitting production but also improves operational reliability, quality, and safety. Knitting tension is significantly influenced by the pattern type and stitch length [17]. So, during our research, we ensured that after each program changed, the machine was checked and cleaned properly. Also, no dust or oil leakage is happening.

v. Prevention of yarn entanglement

The amount of yarn breaks is proportional to the quantity of single and plied yarns used. Twist multipliers have an inverse effect on the number of yarn breaks [18]. When the machine pulls the yarn for knitting, the yarn gets tangled when released from the cone. Constantly dealing with yarn entanglement slows down production processes, reduces overall efficiency, irregularities or defects in the knitted fabric, and can jam knitting machines, leading to downtime as operators work to resolve the issue. To prevent this, scotch tape is used at the head of the cone to prevent yarn entanglement.

vi. Prevention of fabric faults

One of the most significant issues in knit fabric production is reducing fabric flaws [19]. By preventing faults such as yarn breaks, drop stitch holes, snagging, vertical stripes, color fly, dirty cloth, oil stains, soil stripes, spirality, broken ends or holes bunching up, needle break, star marks, etc. Can minimize downtime associated with stopping the machines to fix issues.

3. Result and Discussion

3.1 Estimation of Production Efficiency for Jersey Machine

The investigation regarding knitting production had been performed at Liberty knitwear Ltd. (Unit-2), Gazipur, Bangladesh. Initially, the data respecting to the knitting production of jersey machine were registered prior to the implementation of proposed methods from S/J fabric production. The jersey machine's production data is shown in Table 1 before any measures are taken. On the contrary, following the implementation of the essential steps, the knitting machine data is displayed in Table 2.

Table 1 Production Data of Single Jersey Fabric (Conventional method)

Parameters	M/c 24	M/c 26	M/c 27	M/c 29	M/c 33
Target Per Week, Kg	930	905	1032	930	1067
Week -1, Kg	805	765	875	785	918
Week -2, Kg	808	748	887	798	892
Average Production, Kg	806	756	808	791	905
Efficiency (%)	86.7%	83.6%	85.9%	85.1%	84.8%
Remarks	S/J	S/J	S/J	S/J	S/J

Table 2 Production Data of Single Jersey Fabric (Proposed method)

Parameters	M/c 24	M/c 26	M/c 27	M/c 29	M/c 33
Target Per Week, Kg	930	905	1032	930	1067
Week-1, Kg	825	778	896	805	931
Week-2, Kg	818	796	906	818	923
Average Production, Kg	822	787	901	812	927
Efficiency (%)	88.3%	86.9%	87.3%	87.2%	86.8%
Remarks	S/J	S/J	S/J	S/J	S/J

After reviewing the two data sets from Tables 1 and 2, Fig. 1 can be illustrated. The graph displays a greater level of production efficiency than the existing situation when the necessary actions have been put into place. Before putting those necessary steps into place, production efficiency is found to be between 14 and 17 percent lower.

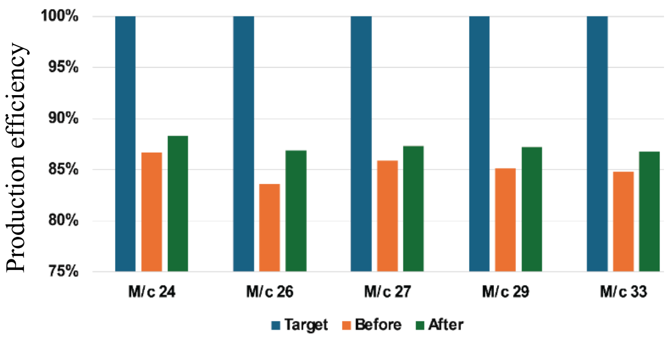

Fig. 1 Efficiency analysis of Single Jersey fabric

However, following implementation, the production efficiency grew by a respectable proportion, ranging from 3 to 6%. For example, after one week at that specific knitting floor, the production of one jersey fabric climbed to an average of 16 kg, 31 kg, 93 kg, 21 kg, and 22 kg for machines 24, 26, 27, 29, and 33. Consequently, it can be said that the manufacturing of Single Jersey fabric has risen with greater production efficiency once all the required steps have been performed.

3.2. Estimation of Production Efficiency for Double Jersey Machine (Rib)

Before executing any of the aforementioned procedures wherein rib fabric was made, the production data of the Double Jersey machine is displayed in Table 3. However, once the required actions have been taken, the knitting machine data is displayed in Table 4.

Table 3 Production Data of Rib Fabric (Conventional method)

Parameters	M/c 07	M/c 09	M/c 11	M/c 64	M/c 74
Target Per Day, Kg	318	425	470	312	312
Week -1, Kg	254	367	388	254	258
Week -2, Kg	275	355	405	278	264
Average Production, Kg	264	361	396	266	261
Efficiency (%)	83.2%	84.9%	84.5%	85.3%	83.7%
Remarks	Rib	Rib	Rib	Rib	Rib

Table 4 Production Data of Rib Fabric (Proposed method)

Parameters	M/c 07	M/c 09	M/c 11	M/c 64	M/c 74
Target Per Day, Kg	318	425	470	312	312
Week -1, Kg	268	365	398	264	278
Week -2, Kg	279	382	415	288	254
Average Production, Kg	273	373	406	276	266
Efficiency (%)	86.1%	87.8%	86.5%	88.5%	85.3%
Remarks	Rib	Rib	Rib	Rib	Rib

Upon reviewing the data from Tables 3 and 4, Fig. 2 can be presented. The graph displays a greater level of production efficiency than the existing situation when the necessary actions have been put into place. Production efficiency was determined to be between 12 and 17 percent lower before the implementation of the aforementioned processes.

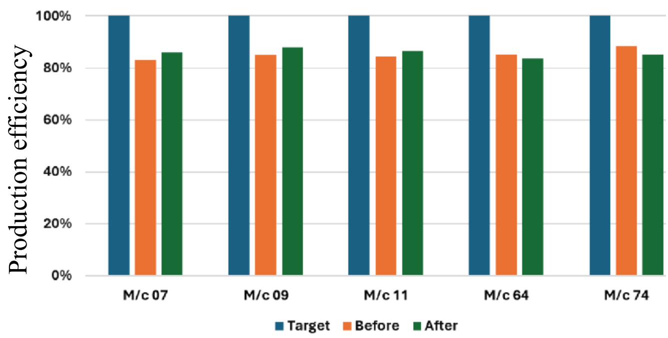

Fig. 2 Efficiency analysis of Rib fabric

However, following implementation, the manufacturing efficiency grew by a respectable amount, between 2 and 5 percent. The production of Double Jersey Rib fabric increased by an average of 9 kg, 12 kg, 10 kg, 10 kg, and 5 kg for machines 07, 09, 11, 64, and 74 after one week at that specific knitting floor. Consequently, it is possible to conclude that, following the necessary steps, rib fabric production has increased with improved production efficiency.

3.3. Estimation of Relative Humidity and Temperature for the knitting floor

Table 5 shows the data of weekly Relative Humidity RH% and Temperature of the knitting floor before implementing any of the above-mentioned. On the other hand, Table 6 shows the data of weekly Relative Humidity RH% and Temperature of the knitting floor after implementing the mentioned steps.

Table 5 RH% and Temperature of knitting Floor (Conventional Method)

Parameters	RH%	Temp. °C	Wet bulb – dry bulb temp.	Yarn breakage (8*6=48) hours
Target/Week,	70% ± 5%	25°C ± 1.1°C	(3-5)°C	72- 120 times
Week-1	59%	28°C	6°C	175 times
Week-2	55%	30°C	7°C	168 times
Average	57%	29°C	6.5°C	171.5 times

Table 6 RH% and Temperature of Knitting Floor (Proposed Method)

Parameters	RH% (1)	Temp. °C (1)	Wet bulb – Dry bulb temp.	Yarn breakage (8*6=48) hours
Target Per Week,	70% ± 5%	25°C ± 1.1°C	(3-5)°C	72- 120 times
Week-1	69%	24°C	4°C	103
Week-2	75%	22°C	3°C	98
Average	72%	23°C	3.5°C	100.5

Based on the study of Tables 5 and 6, Fig. 3 can be illustrated. Following the required actions, the graph displays a lower temperature and a greater relative humidity than in the current situation. As we can see, there was a noticeable decrease in yarn breakage. After doing the required actions, it can be concluded that the knitting floor's temperature decreased and its relative humidity (RH%) rose.

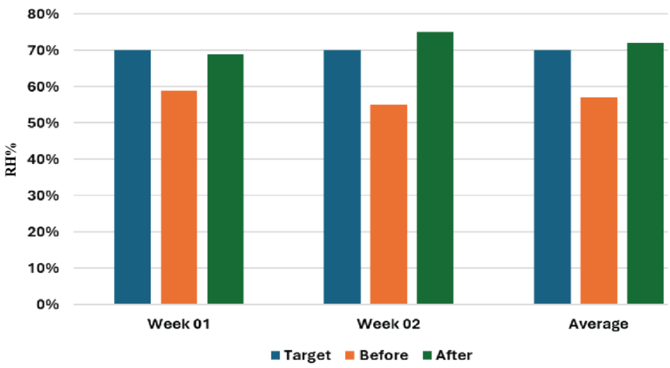

Fig. 3 Relative Humidity (RH%) analysis of the knitting floor

4. Conclusion and Recommendations

The study highlights the significant impact of environmental controls, machine maintenance, and optimized operational procedures on improving knitting floor productivity. The implementation of an adiabatic cooling system effectively stabilized humidity levels, reduced yarn breakage, and minimized airborne fiber dust, leading to a measurable increase in production efficiency. Additionally, ensuring proper machine servicing, tension balancing, and fabric fault prevention contributed to improved operational reliability. To scale up these interventions in larger textile facilities, fully automated climate control systems should be explored to regulate temperature and humidity in real time. This would enhance the consistency of environmental conditions and further reduce production losses due to fluctuating humidity and fiber breakage. The adoption of Internet of Things (IoT)-based solutions for machine performance tracking, humidity regulation, and production efficiency analysis can also provide real-time insights. Smart sensors can alert operators to deviations in environmental conditions, enabling timely interventions. Furthermore, future research should investigate the feasibility of scaling up adiabatic cooling systems for larger knitting operations, including energy consumption analysis and cost-benefit assessments. Hybrid cooling systems combining adiabatic and mechanical cooling could be explored for enhanced efficiency.

Additionally, integrating machine learning algorithms to predict and mitigate potential production disruptions by analyzing historical data on machine performance, environmental factors, and defect rates could optimize the manufacturing process. Further studies should also assess the long-term sustainability of these interventions, particularly in terms of water usage for adiabatic cooling, energy efficiency, and overall environmental impact. Life-cycle assessments of different environmental control strategies can guide the development of more eco-friendly solutions. By implementing these advanced technological solutions, large-scale textile industries can further enhance production efficiency, reduce material waste, and create a more sustainable manufacturing environment.

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