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ANALYSIS OF THE EFFECT OF SIZING ADD-ON% AND SIZING PROCESS PARAMETERS ON THE AVERAGE WARP BREAKAGE RATE FOR 30Ne 100% COTTON WARP YARN

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ABSTRACT

Sizing is one of the essential steps in fabric manufacturing for increasing weaving production efficiency in the case of cotton and cotton blend fabrics by providing a protective coating to warp yarn that does not add any functional value. This research aimed to analyze the effects of size add-on% and two sizing process parameters, such as sizing machine speed and squeezing roller pressure, on the average warp yarn breakage rate during weaving. The sizing experiments have been conducted based on the size add-on% (8.93 %, 9.94%, 11.23%), sizing machine speed (35 yards/min, 38 yards/min, 40 yards/min), and squeezing roller pressure (2.2 kg, 3.3 kg, 3.5 kg) on the 30Ne 100% cotton warp yarn. It was found from the experimental results that the warp yarn breakage rate was increased with the rise in sizing machine speed and squeezing roller pressure. In contrast, the lowest warp yarn breakage rate was exhibited in size add-on% 9.94 in the loom during weaving. Based on the research, promising industrial application is highlighted for future fabric production.

Keywords: *Sizing recipe, Sizing machine speed, Squeezing roller pressure, Airjet loom.*

1. INTRODUCTION

Bangladesh is the second largest exporter of the worldwide textile market, particularly in ready-to-wear clothes, of which knit and woven garments are the most popular. In any manufacturing industry, it is always focused to maximize output while maintaining product quality. It is done so that the industry can satisfy the requirements of both domestic and international markets and customers in terms of cost and product quality. Every textile industry is struggling to increase productivity in order to compete, and they must produce high-quality items at a reasonable price. Cotton, more than almost any other fiber, covers half of the world's clothing demand. It is extensively utilized because of its outstanding wearability, exceptional wearing comfort, high moisture permeability, and extraordinary breathability. It is essential to size the cotton yarn before weaving it to produce woven cotton fabric (Ahmed *et al.,* 2021). The core objective of sizing is to provide warp yarns that will weave well without experiencing any damage from contact with the loom's moving elements. The other goal is to give the fabric distinct aspects such as weight, texture, softness, and handling. During the weaving process, warp yarns are subjected to corrosive forces at the heald frame, reeds, drop wires, and other moving sections of the loom. Furthermore, continuous loading and unloading of warp beams result in yarn fatigue (Gandhi, 2020). The warp yarns may break during the weaving process owing to complicated mechanical activities such as cyclic extension, abrasion, and flexing. To minimize excessive breakage of warp yarns under such weaving circumstances, the threads are sized to provide higher abrasion resistance and yarn strength (Fernando & Jayawardana, 2015).

Since machine stoppages are more expensive due to large loss of output, the adoption of very high-speed shuttle-less looms has elevated the relevance of sizing manifolds in recent years. Despite significant advancements in size technology, there are several conceptual and practical issues affecting sizing optimization. There are challenges in planning the efficiency of looms and the final product quality since no standardized test techniques exist to establish to what extent the end breakage rate would lessen on the loom after sizing. Sizing is applied to the yarn surface by employing various rounds and strategies based on the prerequisites (Kovačević & Penava, 2004). The loom will experience more warp yarn breaks and machine breakdowns if sizing is not performed correctly. It results in a loom that runs inefficiently and produces a fabric that is of poor quality, which are the primary causes of fabric rejection. A variety of sizing formulas, add-on%, and process-related parameters have an impact on the performance of sized warp yarn throughout the textile weaving process as stated in the past research investigation. Therefore, it is crucial to look into the impact of process variables to identify the most effective and relevant sizing parameters in the weaving process and produce end goods that meet customer requirements. Numerous studies have been conducted on the sizing process and characteristics of sized warp

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yarn. Penava *et al.*, (2004) focused on the sizing effect on the physio-mechanical properties of yarn, as well as the benefit of maintaining an ideal size percentage to facilitate improved weaving productivity and enhancing grey fabric quality. Takebira *et al.*, (2020) executed an analysis by varying the temperature of the size box, yarn count, sizing machine speed, and squeeze roller pressure. Here, various types of fabric designs were constructed to obtain improved results in terms of yarn breakages. Kovačević & Gordoš, (2009) conducted an empirical analysis using data from a laboratory sizing machine. The authors try to construct a correlation between warp yarn's physical parameters and size percentage by changing the squeeze roller pressure and size recipe. Pleva & Rieger, (1992) performed a series of studies to investigate the parameters that are crucial to producing economical and high-quality fabric. Size percentage was observed to be directly connected to the warp breakage rate in weaving. Temesgen *et al.*, (2019) conducted a comparative study on the functionality of potato, corn, and cassava starches and their impact on the fabric, including tensile strength and elongation, abrasion resistance, stiffness character, fabric thickness, size removal percentage after desizing, and end breakage rate on the loom.

The prior literature review revealed that no research had been done to determine how different processing factors would affect the typical rate of warp breakage for 30Ne Cotton warp yarn. Therefore, the primary objective of the present study was to examine the effects of the sizing add-on % and two sizing process parameters, including sizing machine speed and squeezing roller pressure, on the average warp breakage rate of the loom. The main goal of this research is to improve loom performance by reducing the rate of warp breakage to produce high-quality fabric.

2. METHODOLOGY

2.1. Materials and Machineries

2.1.1. Yarn

In this study, warp yarn composed of 100% Cotton and 30Ne was utilized. For sizing, a total of 7500 ends and 21000 meters of warp yarn were used.

2.1.2. Chemicals

The basic objective of sizing is to apply size materials to the warp yarn. All the other processes like creeling, splitting, drying, winding, etc. are secondary yet important processes for making the sizing process work properly. Apparently, the selection of sizing chemicals is very important which includes environment-friendly and reusable sizing chemicals (Ul-Haq & Nasir, 2012). A size paste, named size mix also is a combination of some mandatory ingredients such as an aqueous solution that acts as a carrier (typically water), a sizing chemical, a binder that binds the small particles of the sizing agent together, a softener which softens the sizing agent and reduces the coefficient of friction and so on. For sizing in this study, the one-shot chemical Geo size 101 (Brand: INDOKEM) was utilized. Its components are 70% starch, 27% binder, and 3% softener. In order to make the size blend, water was added.

2.1.3. Machineries

Warp yarns were sized using K. AWAMOTO (Japan) sizing machine. The machine had two-box sizing and there were consequently two unique squeezing rollers. The yarn was dried fast and delicately with the use of various combinations of cylinder dryers. 14 cylinder-shaped drums were utilized for drying. The Toyota Airjet Loom (India) was used to weave fabric, introducing weft yarn into the path of the warp during the shedding process.

2.2. Experimental Section

2.2.1. Preparation of Sizing Solution

In the sizing process, some key steps are involved such as selecting the right sizing recipe, size cooking, and sizing application to warp yarns. By following the above three steps correctly, the quality of the sized yarn can be determined. The sized yarn quality is critically dependent on the size quantity which is added to the yarn (Kabir & Haque, 2021). In this study, the factory's current sizing recipe was first examined to determine the chemical pick-up % (size solution mass that remains in the yarn after being squeezed by rollers to oven-dried unsized yarn unit mass) and add-on % (size solution mass that is absorbed in the size box to oven-dried unsized yarn unit mass). Two more trials were carried out by reviewing the recipe and altering the total volume of the size mix and the quantity of solid size chemicals as stated in Table 1.

The sizing mix was prepared by taking solid size chemicals and water in the sizing tank and stirring was done for 5 mins at 60^0C initially. After that, the chamber was closed and cooking was done at 96^0-120^0C for up to 40 min.

Steam was continuously added to the sizing tank. Stirring was continued for 45-50 min and after that Refraction% was measured. Refraction% indicates the uniform mixing of the sizing chemical. If the requisite refraction% is not found, the tank should be provided with the necessary amount of sizing chemical or water.

Table 1: Sizing Solution.

Parameters	Unit	Levels		
Amount of size chemical	kg	320	360	400
Total Volume Used	L	2700	3000	3000
Chemical Pick-up	%	87.09	96.77	96.77
Add-on	%	8.93	9.94	11.23

2.2.2. Sizing

The penetration and distribution of sizing chemical to the yarn are affected by both the physical characteristics of the yarn and the parameters related to the sizing machine. Sizing machine speed is one of the most important parameters which determines the level of chemical pick-up% and add-on%. Squeezing roller squeezes the excess amount of size chemical from the warp, hence is another important parameter for sizing (Fernando & Jayawardana, 2015). The warp yarns were sized using different add-on%, sizing machine speeds, and squeezing roller pressure as described in Table 2.

Table 2: Size Recipe.

Parameters	Unit	Recipe		
Add-on	%	8.83	9.94	11.23
Sizing Machine Speed	yards/min	35	38	40
Squeezing Roller Pressure	kg	2.2	3.3	3.5

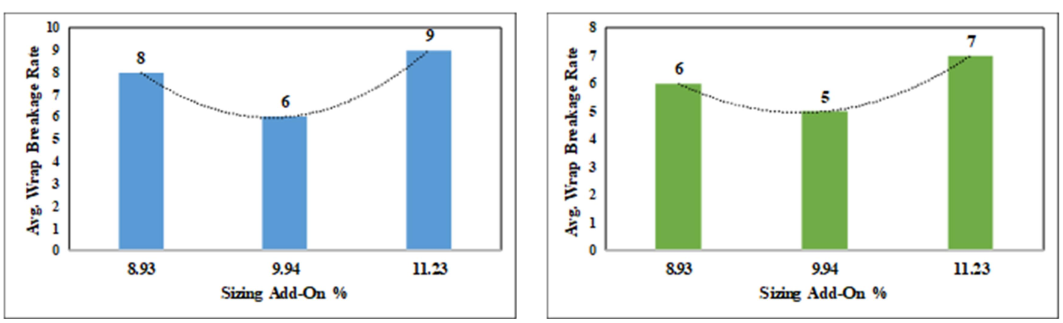
2.2.3. Warp Breakage Study

The sized warp yarn was loaded onto the Airjet loom after the warp yarn was sized to produce the fabric. On the loom's monitor, information such as shift reports, stop analysis graphs, and warp yarn breakage was shown. To assess the results, the warp breakage report of two shifts- shifts A and C was noted for varying add-on%, sizing machine speed, and squeezing roller pressure.

3. RESULTS AND DISCUSSION

Experimental research on the effects of the sizing add-on% and two process parameters on 30Ne cotton warp yarn has been conducted. The results are also discussed bellows:

3.1. Effect of sizing add-on% on the average warp breakage rate



(a) (b)

Figure 1: Different sizing add-on% and their impact on the average warp breakage rate (a) for shift A and (b) for shift C.

As schematically shown in Figure 1, the loom performance of sized warp yarn as measured by warp breakage rate is shown against varying the add-on%. The add-on% is varied from 8.93% to 11.23% while maintaining the other two parameters, sizing machine speed 38yards/min and squeezing roller pressure 3.3kg, unchanged.

Figures 1(a) and 1(b) show that the warp breakage rate initially decreases and then increases with an increase in add-on% after reaching a particular threshold. It is evident that at an add-on% of 9.94, the minimum warp breakage rate is found to be 6 for shift A and 5 for shift C, substantially satisfying the sizing-weaving curve. As add-on% increases from 8.93% to 9.94%, yarn strength likewise increases while yarn hairiness reduces, which is the cause of the initial drop in warp breakage. After a while, as add-on% rises from 9.94% to 11.23%, more warp breaks happen in the loom because too much add-on% makes the warp yarn rigid and the coating of size film thick, which makes the yarn prone to shedding and causes many warp breaks (Goswami *et al.,* 2004). The experimental data thus confirms the general direction of earlier studies.

3.2. Effect of sizing machine speed on the average warp breakage rate

The Effect of the sizing machine speed on the warp yarn breakage rate has been graphically demonstrated in Figures 2(a) and 2(b) for shift A and shift C, respectively. In this experimental study, sizing machine speed has been varied from 35 to 40 yards/min keeping other two parameters such as size add-on% 8.93 and squeezing roller pressure 3.3 kg fixed.

It is found from Figures 2(a) and 2(b) that the warp yarn breakage rate increased with the rising of the sizing machine speed and the minimum warp breakage rate is found to be 5 for both shifts A and C at sizing machine speed 35 yards/min. This may be due to the high speed of the sizing machine allowing less time for the sizing chemical to penetrate the warp sheet and failing to provide enough strength to warp yarn. Less speed allows proper time for sizing chemicals to penetrate, and a good result is found from the weaving zone resulting in fewer warp breaks in the loom (Takebira et al., 2020). So, the experimental data follows the trend of previous research work.

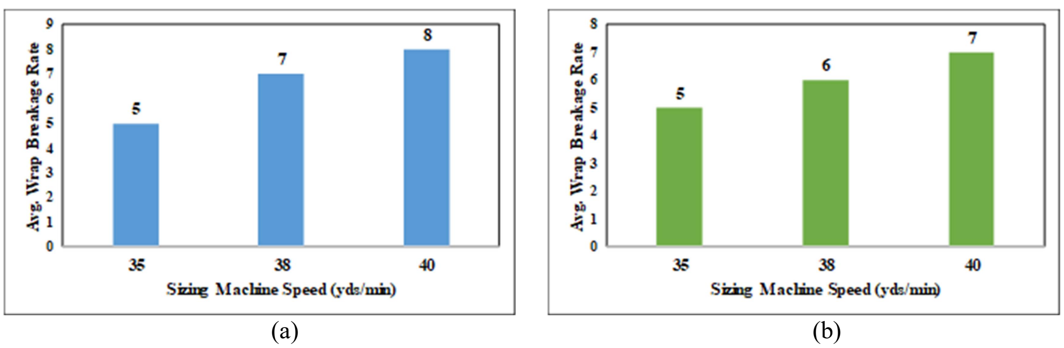


Figure 2: Various sizing machine speed and their impact on the average warp breakage rate (a) for shift A and (b) for shift C.

3.3. Effect of squeezing roller pressure on the average warp breakage rate

The warp breakage rate of 30Ne sized yarn at different pressure of squeezing roller ranging from 2.2 to 3.5 kg keeping add-on% 8.93 and sizing machine speed 38yards/min constant is shown respectively in Figure 3(a) and 3(b) for shift A and shift C. It is observed from Figures 3(a) and 3(b) that the warp yarn breakage rate increases with the increase in squeezing roller pressure and the lowest warp breakage rate are noted 4 and 7 for shifts A and C, respectively, at squeezing roller pressure 2.2 kg.

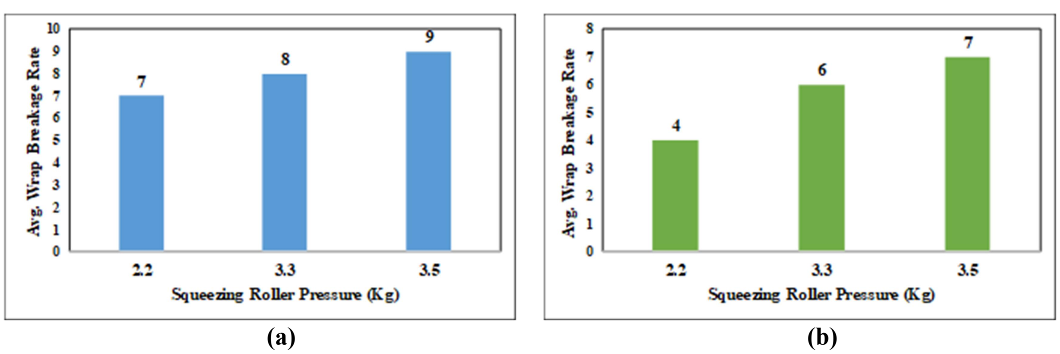


Figure 3: Varying squeezing roller pressure and their effect on the average warp breakage rate (a) for shift A and (b) for shift C.

This is because high squeezing pressure in sizing makes the yarn flatten and damages the yarn greatly which results in more warp breaks in the loom. Less squeezing roller pressure ensures better penetration of size mix in the core of yarn (Fernando & Jayawardana, 2015). So, the experimental data follows the trend of the former research work.

4. CONCLUSIONS

A highly effective sizing procedure necessitates the ideal application of size to warp yarns in order to create fabric that is error-free. Since there is no technique for measuring standardized recipes that can precisely compute the amount of size chemical needed, the sizing recipe differs from factory to factory. On this study, various sizing chemical dosages and add-on percentages were tested to see if they produced better results in the loom in terms of warp breakage rate. With 9.94% add-on%, warp yarns had shown the best result in a loom with a minimum warp breakage rate both for shift A and shift C. Minimum warp breaks ensure fewer stoppages of the loom and better-quality fabric. Furthermore the size process and warp breakage rate are both significantly impacted by machine-related parameters since a sizing machine is made up of many different sections and segments. Two machine parameters, sizing machine speed and squeezing roller pressure and their effect on warp breakage rate were analyzed in this research. By keeping all the other parameters constant, with 35yds/min sizing machine speed, a minimum warp breakage rate was found for both shift A and shift C. With 2.2kg squeezing roller pressure, warp yarn showed the best result with minimum breaks for both shifts A and shift C. The Airjet loom with 21,000 m of warp yarn is used to collect all warp break data for three days. The research work was done in an industrial environment and a bulk quantity so the results that are found have a great industrial significance.

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