Impact of Relative Humidity on Loom Shed Efficiency

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Abstract

The atmospheric condition with respect to temperature and humidity play very important role in the manufacturing process of textile yarn and fabric. The properties like dimensions, weight, tensile strength, elastic recovery, rigidity etc. of all textile material whether natural or synthetic are influenced by moisture regain. Among of which the yarn strength and elongation value at certain moisture content will be directly influenced the warp breakage rate in loom shed. This study will help to find out and set the standard atmospheric conditions in the weaving department to achieve the higher production rate. Trials are conducted by maintaining different RH % values in the weaving department. Impact of RH% in terms of end breakage was examined during weaving.

Keywords – Moisture content, elastic recovery, tensile strength

Introduction -

Relative Humidity (RH %) is defined as the ratio of the actual vapor pressure to the standard vapor pressure at the same temperature expressed as percentage. The moisture holding capacity of air increases dramatically with the air temperature. In practice RH indicates the moisture level of the air compared to the air's moisture holding capacity. The air movement in the form of infiltration and exhilaration from the building influences the relationship between temperature and relative humidity. Weaving operations cause the friction of the yarns; particularly warp yarns, with each other as well as with the metallic parts of the machines. These actions originate, especially in case of staple fiber yarns, the detaching of parts of fibers from the body of the yarn, with consequent formation of static electricity, sticking yarns, difficult shedding and difficult weft colors selection, but also fiber fly accumulation on all most delicate units as braking elements, weft control devices and even the grippers. It is therefore essential that the air conditioning system is designed in a way as to ensure an efficient control of temperature and humidity, differentiated for weaving preparation and weaving departments. Dust is removed from the machines by overhead travelling cleaners; moreover the air in the working rooms is exhausted under the machines continuously or intermittently. The air is conveyed to the conditioning stations and filtered on rotary filters, then remoistened and conveyed into the working room again. The humidity level affects considerably the possibility of reducing the end breakage, and has to be adjusted also according to the processed materials. The weaving operation contributes by far the largest proportion to the cost of conversion of yarns into fabrics. The simplest measure of productivity in weaving is the length of fabric produced per unit time. The production of fabric on weaving machines is depending on the loom speed and the efficiency. The loom efficiency mainly influenced by the warp breakage rate. The warp breaks during weaving are increases by a) preparatory deficiency. (b) Incorrect loom settings. (c) Defective loom parts and accessories. (d) Insufficient humidity and temperature around loom sphere. [4] Quality of yarn is the primary source influencing end breaks. Yarn qualities which influence the breakage of yarn during weaving are its strength and elongation. The modern high speed weaving machines generates large amount of heat and friction during weaving, which affects the size film coating to become dry which in-turn have extensive impact on yarn strength. The strength of the yarn increases at higher humidity or at higher moisture.

Literature Review

The amount of moisture that the atmosphere can hold increases with its temperature so that warmer air can hold more water than cold air. The converse of this is that when air containing moisture is cooled, a temperature is reached at which the air becomes saturated. At this point moisture will condense out from the atmosphere as a liquid: this temperature is known as the dew point. When considering the effects of atmospheric moisture on textile materials the important quantity is not how much moisture the air already holds, but how much more it is capable of holding. This factor governs whether fibers will lose moisture to or gain moisture from the atmosphere. The capacity of the atmosphere to hold further moisture is calculated by taking the maximum possible atmospheric moisture content at a particular temperature and working out what percentage of it has already been taken up. This quantity is known as the relative humidity (RH) of the atmosphere and it can be defined in two ways. In terms of the mass of water vapor in the atmosphere:

$$R.H\ \% = \frac{\text{Mass of water in given volume of air}}{\text{Mass of water vapor required to saturated this volume at same temperature}} \times 100$$

Alternative it can also be defined as the ratio of the actual vapor pressure to the saturated vapor pressure at the same temperature expressed as a percentage.

$$RH\ \% = \frac{\text{Actual vapor pressure}}{\text{Saturated vapor pressure}} \times 100$$

The absolute humidity is defined as the weight of water present in unit volume of moist air measured in grams per cubic meter. It is important to note that the relative humidity of the atmosphere changes with temperature even when the total quantity of water vapor contained in the air remains the same the dotted line below figure shown the increase in the atmosphere with increasing temperature for a constant relative for a constant relative humidity of 65%.[2] Correct ambient conditions are essential to prevent degradation of textiles materials during a series of operations right from beating in blow room to weaving fabric at loom shed or knitting the fabric or producing non-woven sheets. Fibers should have requisite properties so that the final product retains its basic shape, size and strength. In case of weaving, as the warp yarns are coated with size films, the environment should be suitable for the size film on the yarn. Too low humidity makes size film brittle resulting in cracking of the film, where as too high humidity makes the beam soft. During rubbing of yarn with several parts of loom such as heald, reeds etc. the size film is getting scrubbed off making the yarn bare. The bare yarn does not withstand wear during weaving and breaks. Thus both high and low RH % will detrimental to weaving operation. Correct RH % is therefore essential from several such technical requirements. Adequate yarn humidity (moisture in yarn) is needed to enhance the strength and the elasticity and to have smooth yarn surface. Both tensile strength and elasticity depend on fiber and spinning characteristics, on warp pre-treatment (sizing) and increase with moisture content of the yarn being fed into weaving process. Moisture content smoothens the hairs and lubricates the yarn surface. Abrasion between yarns, mainly in the shed area, removes short fibers (lint) and size dust from the warp yarn. Adequate yarn moisture reduces the fall out. While weaving, the yarn absorbs water from the air. Lint and dust falling out from the yarn are incorporated into the room air. Power consumed by the loom and other devices in the room is converted into heat and incorporated into the room air. This heat evaporates the moisture from yarn. Previous results show that yarns perform best in weaving machines when their moisture content is 7 – 9 % (parts of water in 100 parts of dry yarn). Less moisture reduces strength, elasticity and smoothness. Higher moisture may make the size glue the warp yarns together. Therefore, there is a need to humidify the area with suitable controls. [7][6]

The general reasons for controlling RH % and temperature in a textile mill

- Dry air causes lower regain and this contributes to poor quality and lower productivity.
- Yarns with low moisture content are weaker, thinner, more brittle, and less elastic, create more friction and are more prone to static electrification.
- Materials at optimum regain are less prone to breakage, heating and friction effects the handle better, have fewer imperfections are more uniform and feel better.
- Higher humidity reduces static problems. Reduced static makes materials more manageable and increases machine speed.
- Textile weights are standardized at 60% RH and 20°C. Low humidity causes lower material weights and lowered profits.
- Low humidity causes fabric shrinkage. Maintained humidity permits greater reliability in cutting and fitting during garment creation and contributes to the maintenance of specifications where dimensions are important, such as in the carpet industry.
- Humidification reduces fly and micro dust, giving a healthier and more comfortable working environment.[7]

Technical Hypothesis -

Moisture regain and moisture content:

The amount of moisture in a sample can be expressed as either regain or moisture content.

Regain is the weight of water in a material expressed as a percentage of the oven dry weight:

$$\text{Moisture Regain} = \frac{100 \times W}{D}\ \%$$

Where, D is the dry weight and W is the weight of absorbed water.

Moisture content is the weight of water expressed as a percentage of the total weight

$$\text{Moisture content} = \frac{100 \times W}{D + W}\ \%$$

Regain is the quantity usually used in the textile industry.

Role of Moisture:

Humidity is the amount of moisture in the air can hold before it rains. Moisture refers to presence of liquid, especially water. Moisture has important effects on the physical properties of textile material particularly tensile properties and other property descriptions normalized for weight. The increase in strength with increased moisture content is attributed to the release of internal stresses as hydrogen-bonding is weakened and to the ability of the structure to be pulled into a more oriented form.

Effect of Moisture on Yarn Quality

A moisture content of 8-10% should be maintained in the sized cotton yarns. With excessive drying the size film becomes brittle and harsh. Very high moisture content is also undesirable. Correct amount of moisture for cotton helps to reduction of breakage rate at loom shed. [1]

Norms and Standards

The levels of relative humidity & temperature that have been found to be satisfactory under working condition in Indian mills are summarized in table:

Relative humidity and temperature in loom shed:

Count	RH%	Temperature
Coarse andMedium count	85 % ± 2%	$26^0C \pm 2^0C$

Table 1 - Norms For standard atmospheric conditions

Materials and Methods -

The trials were conducted for the following fabric sort

Warp – 60^sNe

Weft - 60^sNe

Ends per inch – 132

Picks per inch – 76

Weave – Plain

Fabric width – 116 inches

Method:

Trials were conducted for the above fabric sorts at following three different RH % values.

	A	B	C
RH% at Loom Sphere	76%	80%	84%

1) Loom efficiency was continuously observed in the interval of 2 hours for each range of RH %.
2) Shift wise data has been collected for loom shed efficiency for ranges of RH %.
3) RH % was continuously observed at the interval of one hour to analyze the relative impact on loom performance.
4) Impact of each range of RH% on loom shed efficiency for three shifts is taken under considerations.
5) Shift wise warp breakage rate (warp cmpx) was recorded to analyze the impact of RH%.
6) At each level of RH% sized yarn strength is measured to find the effect of humidity in terms of increase in moisture content in the yarn and similarly increase in yarn strength.

Results and Discussion

Following are the results obtained from the data collected

- By maintaining the Relative Humidity at 76 % average loom shed efficiency was found as

Loom shed efficiency (%)			
1st Shift	2nd Shift	3rd Shift	Avg. Efficiency (%)
75	72	78	75

Table 1.2 Loom shed efficiency

Above table shows the loom shed efficiency at 76 % Relative humidity. Meanwhile lower humidity in loom sphere is directly affecting the loom performance due to increase in warp breakage rate which is found up to 15 cmpx

- By maintaining the Relative Humidity at 80 % average loom shed efficiency was found as

Loom shed efficiency (%)			
1st Shift	2nd Shift	3rd Shift	Avg. Efficiency (%)
84.5	80	86	83.5

Table 1.3 Loomshed efficiency

Above table shows the loomshed efficiency at 80 % Relative humidity. Increase in relative humidity by 4% shows the slight increase in efficiency. This is due to the increase in moisture content in the yarn and cause the increase in yarn strength which leads to withstand the stress during weaving.

- By maintaining the Relative Humidity at 84 % average loom shed efficiency was found as

Loom shed efficiency (%)

1st Shift	2nd Shift	3rd Shift	Avg. Efficiency (%)
90.5	87.7	92.2	90.1

Table 1.4 Loomshed efficiency

Above table shows the loomshed efficiency at 84 % Relative humidity. At this stage warp breakage rate is significantly reduced up to 2 cmpx, mean at this level of RH % yarn strength is increased up to significant value.

- Average Loomshed efficiency at 76%, 80 % and 84 % relative humidity.

Relative Humidity	76 %	80%	84%
Average Loomshed Efficiency	75 %	83.5%	90.1%

Table 1.5 Average Loomshed efficiency at different RH%

- Sized yarn properties at different range of RH%

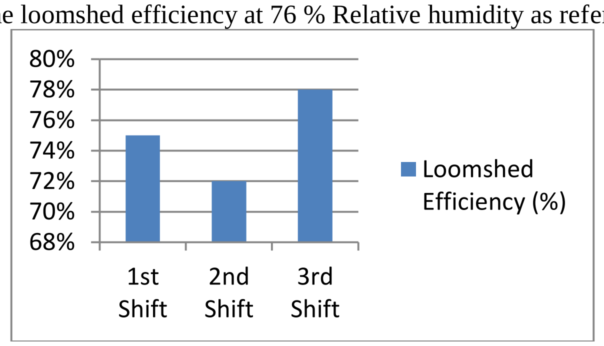
Yarn Properties	At 76% RH	At 80% RH	At 84% RH
Breaking force (gf)	215.8	220.5	223.5
R.K.M	21.13	22.11	22.15
Elongation (%)	3.24	3.92	4.51

Table 1.6 yarn properties at different range of RH%

Above table shows the significant increase in yarn strength, RKM value and elongation percentage as there is increase in relative humidity.

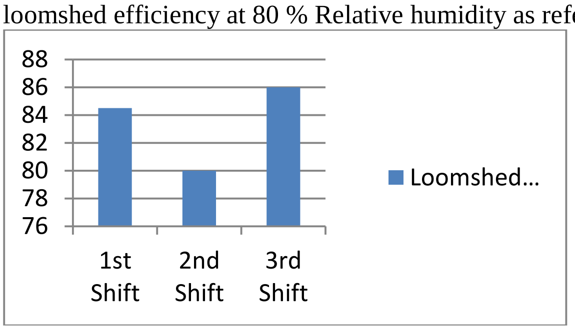
Graphical Representation of results

- Following graph shows the loomshed efficiency at 76 % Relative humidity as referred to table 1.2.



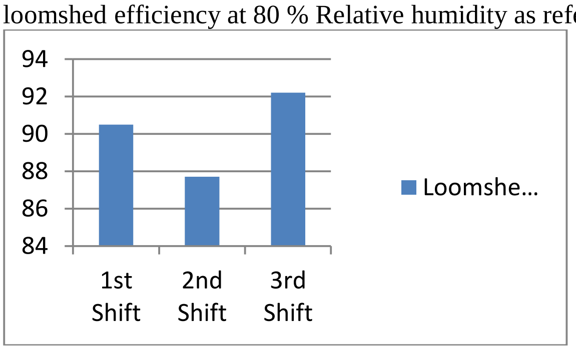
Graph No. 1 Loomshed efficiency at 78 % RH

- Following graph shows the loomshed efficiency at 80 % Relative humidity as referred to table 1.3



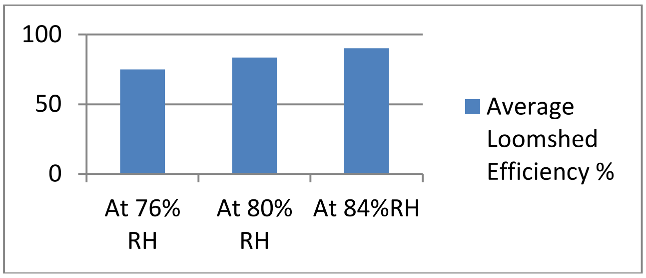
Graph No. 2 Loomshed efficiency at 82 % RH

- Following graph shows the loomshed efficiency at 80 % Relative humidity as referred to table 1.4



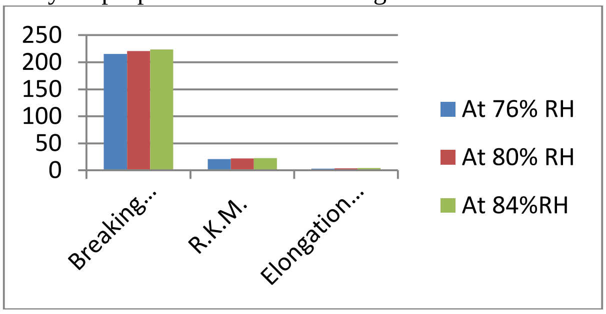
Graph No. 3 Loom shed efficiency at 84 % RH

- Following graph shows average loom shed efficiency at different range of RH% as referred to table 1.5



Graph No. 3 Average Loomshed efficiency

- Following graph shows Sized yarn properties at different range of RH% as referred to table 1.6



Graph No. 4 Sized yarn properties at different range of RH%

Conclusion

From the above study it has been concluded that an increase in the relative humidity leads to increase in production rate in the loom shed, due to significant reduction in the warp breakages. This is the result of increase in moisture content in the yarn and which laid its impression by improving the sized yarn properties. Particularly in cotton yarn weaving rupture of size coating is the main problem which leads to cause multiple breaks. To overcome the same it is beneficial to maintain the standard atmospheric condition in the warp zone. An attempt has been made to guide to set the standard atmospheric conditions.

References

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