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Impact of Production Floor Temperature on Weaving: A Case Study of Bangladesh

Samiha Islam Tanni[1,*], Rohani Us Shams Zaman[2], Md. Robiul Islam[3]

[1]Department of CSE, Green University of Bangladesh, Dhaka, Bangladesh.
[2]Islam Weaving Limited, Gazipur, Bangladesh.
[3]Department of CSE, Green University of Bangladesh, Dhaka, Bangladesh.

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***Corresponding author:** Samiha Islam Tanni, Department of CSE, Green University of Bangladesh, Dhaka, Bangladesh.

Abstract

Weaving is a method of fabric production in which two distinct sets of yarns or threads are interlaced at right angles to form a fabric or cloth Temperature variation is common in Bangladesh from season to season. This research is about the temperature effect on the weaving industry. To reach the goal of this research, we have to do the work in a non-chiller weaving floor because we face the huge temperature variation in Bangladesh during winter and summer season. We tried to find out this two season's differences on each steps of weaving process, such as sizing cost, production performance, fabrics quality, maintenance cost, machine lifetime etc. Reducing cost, increase productivity and better quality plays a vital role to survive in today's competitive market. Though the initial investment is high, but considering the both short term (fabric quality, maintenance cost, increased production etc.) and long term (machine lifetime, quick return on investment, safety etc.) benefit. Chiller and voltage stabilizer is the best solution to control the temperature and overcome from these problems.

Keywords

Temperature, Weaving, Production, Sizing Cost, Fabric Quality, Maintenance Cost, Machine Lifetime

1. Introduction

Weaving is acknowledged as one of the oldest surviving crafts in the world. Bangladesh has a glorious history of weaving. The art of weaving has developed over thousands of years by research and experimentation. It is a process to make fabric from yarn. Traditionally handloom weaving was more common. The way the warp and filling threads interlace with each other is called the weave. There are three basic weaves: plain weave, satin weave, or twill weave with which a large number of woven products are created. Pile, Jacquard, dobby, and leno etc. are Fancy weaves because to construct such types of weaves it requires more complex looms or special loom attachments [1].

One of the important components of Bangladeshi culture and history is the handloom weaving practice. Hand-woven Muslin, Jamdani, raw and refined silks, a variety of Khadi, Katan, and Benarashi, as well as exceptionally fine cotton, have helped Bengali artists gain recognition throughout the world. However, modern textile factories use automatic looms.

Now Bangladesh is the second largest readymade garments exporter country in the world after China. For fulfilling the demand of huge fabrics for garment industry have to import from China, India, and Pakistan etc. If those fabrics are made in this nation, it will save a lot of money on the cost of the raw materials. The situation has now quietly changed. To address that issue, a lot of weaving mills are come out to solve that problem and they are now producing a vast amount of fabrics for our readymade industry. Maximum weaving mills are located in Dhaka, Narayongonj, Narshingdi, Gazipur, Mymensingh, Tangail, Comilla, Chittagong and handloom in Sirajgonj. Other fabric manufacturing factories are located in different parts of the country.

Traditionally, in the sub-continent, most of the textiles are produced by the cottage industries in which artisans work in small groups. There were many such artisans in the area that was to become Bangladesh. The material produced by the artisans of Bengal started facing vigorous competition beginning in the eighteenth century after the growth of mechanized textile mills in the English Midlands. This eventually led to a great decline in the number of Bengali workers skilled enough to produce such high quality fabrics. According to popularly held beliefs, being the spinners and weavers of the region meant that their nascent textile industry would face competition [2].

Summertime cardiac stress is higher than wintertime cardiac stress, changing the work-rest cycle's schedule, working early or late. It is advised to consume more liquids and have adequate lighting throughout the summer. If the humidity is relatively higher, an increase in the relative humidity cause a large number of reduction in the warp breakages which leads to increase in production rate in the loom shed. To overcome this situation, maintaining standard atmospheric condition in the warp zone is important [3, 4]..

In textile industry, the productivity is largely correlated with the hot work climate. The level of productivity decreases according to the increase of hot work climate. The hot work climate measurement shows that 3 of 5 measurement points exceed 29°C. Hot work climate will increase the temperature of the human body due to the body's metabolism that adapts to ambient temperature cause health problems and decreases work performance [5]. Empirical evidence from the manufacturing sector in India suggesting that manufacturing output may decrease as temperatures increase. The literature on heat stress and the impact of temperature on human performance indices to argue that this physiological mechanism may result in labor that is less productive as ambient temperatures rise and this reduction in labor productivity may in turn impact industrial output [6, 7].

There are 828 textile mills in Bangladesh that produce fabrics, according to the Bangladesh Textile Mills Association (BTMA). 328 of those are BTMA associate members and 500 are general members. Many of these mills are not controlling the temperature properly though temperature plays a vital role in weaving industry. Chiller is commonly used to control the temperature in industry. Without chiller, temperature varies in summer and winter season which is directly affecting the preparation process cost (sizing), production efficiency, fabric quality and machine lifetime.

2. Research Methodology

2.1 Work Plan

In order to identify the effect of temperature on weaving industry, need to do work on NON-CHLLER weaving production floor, because temperature variation is found in two seasons such as WINTER and SUMMER. In Bangladeshi weather temperature changing slowly i.e. day by day it increasing or decreasing. Temperature range 10 degrees to 40 degrees Celsius (approx.) for different season. For this reason, it should collect the production data on different temperature with 5/10-degree range.

2.2 Data Collection

All data which is used to complete this case study is primary data and are authentic and collected physically. Data were collected during 1st January 2022 to 31st December 2022. During data collection, observation and experiments methods are followed.

2.3 Calculate the sizing chemical cost for winter, standard temperature and summer

At first we have collected the name, price and origin of chemicals that will be used for sizing, this chemical is known as sizing chemical. Then we collected the sizing chemical recipe for **one creel of yarn** (means, maximum length of warp yarn that can be sized by one batch of sizing recipe. Maximum length depends on yarn count, total ends and capacity of sizing chemical mixing tank) of 3 different fabric construction on 3 different temperatures (winter, standard temperature and summer) i.e. 3 sizing recipe for each fabric construction and total number of sizing recipe will be 9. To identify each fabric construction throughout the study 3 different fabric construction will be record as different name, such as Case-1, Case-2 and Case-3. After that calculate the sizing cost for 3 different constructions for winter, standard temperature and summer.

Sizing cost calculation formula

Fabrics construction	= 30 x 20+70D/160 x 72 (3/1 Left hand twill)
Water	= 400 liter (chemical mixing tank capacity)
Warp yarn count	= 30/s Ne
Total ends	= 8232
Cost of sizing chemical	= 9801.75 Tk.
Sized yarn length	= 4374.40 yards

Sized yarn weight	= (8232 x 4374.40)/ (30 x 840)
	= 1428.97 pound
So, sizing cost per yards	= (9801.75 Tk./4374.40 yards)
	= 2.24 Tk.
So, sizing cost per pound	= (9801.75 Tk./1428 97 pound)
	= 6.86 Tk.

2.4 Measure the production efficiency

Here collect the production data of three individual shift (where, one shift is equal to 8 hours i.e. three shift is equal to 24 hours or 1 day) for those 3 fabric constructions of four looms for seven days and calculate the production efficiency for different temperature. After that found the production or efficiency difference for different sizing recipe or cost of different temperature.

Production efficiency calculation formula

Fabrics construction	= 30 x 20+70D/160 x 72 (3/1 Left hand twill)
So, warp yarn count	= 30/s Ne
Weft yarn count	= 20+70D
Ends per inch	= 160
Picks per inch	= 72
Weave	= 3/1 (Left hand twill)
Loom RPM (Rotation per minute)	= 550 (for weaving, RPM= PPM= Picks per minute)
Then, Production capacity per loom per day	= (550 x 60 x24)/ (72 x 36)
	= 306 yards
Here, 60, 24 and 36 are constant.	
Loom production (per day) found	= 280 yards
Then, production efficiency	= (280/ 306) x 100
	= 91.5 % (efficiency expressed as percentage)

3. Data Analysis

3.1 Cost of sizing of different construction for winter, standard temp. and summer

Sizing Chemicals name, price and origin

1) Plystran H-MV (Modified Starch) = 84.00 Tk./kg
2) SEYCOFILM A1 (Acrylic Binder) = 68.25 Tk./kg
3) Accurosize (PVA) = 241.50 Tk./kg
4) SICO 12 (Softener / Wax) = 78.75 Tk./kg

Country of origin (all chemical): INDIA

Sizing recipe for Case-1

Warp yarn Count – 30/1 Ne
Total Ends – 8232

Table 1. Sizing recipe and cost for Case-1

Chemical Name	For Summer (30~45) degree Celsius		For Standard Temperature (24~28) degree Celsius)		For Winter (10~20) degree Celsius)	
	Quantity	Total Price	Quantity	Total Price	Quantity	Total Price
Plystran H-MV (Modified Starch)	50 kg	4200 Tk.	55 kg	4620 Tk.	60 kg	5040 Tk.
SEYCOFIM A1 (Acrylic Binder)	35 kg	2388.75 Tk.	38 kg	2593.50 Tk.	42 kg	2866.25 Tk.
Accurosize (PVA)	12 kg	2898 Tk.	13 kg	3139.50 Tk.	14 kg	3381 Tk.
SICO 12 (Softener/ Wax)	4 kg	315 Tk.	4 kg	315 Tk.	4 kg	315 Tk.
Total Cost	9801.75 Tk.		10668.00 Tk.		11602.25 Tk.	

Table 2. Sizing cost summary for case – 1

	Sizing cost per pound (Tk.)	Cost Difference based on STD Temp. (Tk.)	Cost Difference based on STD Temp. (%)
Standard Temperature	7.52		
Summer	6.86	0.66	8.78%
Winter	8.12	(0.60)	-7.98%

Sizing recipe for Case-2
Warp yarn Count –30/1 Ne
Total Ends – 6500

Table 3. Sizing recipe and cost for Case-2

Chemical Name	For Summer (30~45) degree Celsius		For Standard Temperature (24~28) degree Celsius)		For Winter (10~20) degree Celsius)	
	Quantity	Total Price	Quantity	Total Price	Quantity	Total Price
Plystran H-MV (Modified Starch)	50 kg	4200 Tk.	55 kg	4620 Tk.	60 kg	5040 Tk.
SEYCOFIM A1 (Acrylic Binder)	20 kg	2388.75 Tk.	22 kg	1501.50 Tk..	24kg	1638 Tk.
Accurosize (PVA)	8 kg	2898 Tk.	8 kg	1932 Tk..	9 kg	2173.5 Tk..
SICO 12 (Softener/ Wax)	4 kg	315 Tk.	4 kg	315 Tk.	4 kg	315 Tk.
Total Cost	7812 Tk.		8368.50 Tk.		9166.5 Tk.	

Table 4. Sizing cost summary for case – 2

	Sizing cost per pound (Tk.)	Cost Difference based on STD Temp. (Tk.)	Cost Difference based on STD Temp. (%)
Standard Temperature	5.93		
Summer	5.54	0.39	6.58%
Winter	6.5	(0.57)	-9.61%

Sizing recipe for Case-3
Warp yarn Count – 20/1 Ne
Total Ends – 6500

Table 5. Sizing recipe and cost for Case-3

Chemical Name	For Summer (30~45) degree Celsius		For Standard Temperature (24~28) degree Celsius)		For Winter (10~20) degree Celsius)	
	Quantity	Total Price	Quantity	Total Price	Quantity	Total Price
Plystran H-MV (Modified Starch)	50 kg	4200 Tk.	55 kg	4620 Tk.	60 kg	5040 Tk.
SEYCOFIM A1 (Acrylic Binder)	25 kg	1706.25 Tk..	27 kg	1842.75 Tk..	30 kg	2047.5 Tk.
Accurosize (PVA)	10 kg	2415 Tk.	11 kg	2656.5 Tk..	12kg	2898 Tk.
SICO 12 (Softener/ Wax)	4 kg	315 Tk.	4 kg	315 Tk.	4 kg	315 Tk.
Total Cost	8636.25 Tk.		9434.25 Tk.		10300.5 Tk.	

Table 6. Sizing cost summary for case – 3

	Sizing cost per pound (Tk.)	Cost Difference based on STD Temp. (Tk.)	Cost Difference based on STD Temp. (%)
Standard Temperature	8.11		
Summer	7.42	0.69	8.51%
Winter	8.85	(0.74)	-9.12%

From above data we have found that, sizing recipe as well as cost is changing with temperature change to avoid production loss and maintain fabric quality. For all cases sizing cost of winter is higher than standard temperature and of summer is less than standard temperature. It will found the production change according to this sizing recipe in the next part of this study.

3.2 Impact of Temperature on Weaving Production

Weaving production efficiency can be increased by reducing the machine idle time which can be controlled by

- Reduce warp yarn breakage by proper sizing depends on the temperature.
- Reduce weft yarn breakage by proper mechanical and electrical setting.
- By proper controlling the working environment i.e. human comfort temperature and Relative humidity

Production data for Case-1

Construction – 30 x 20+70D/160x72
Warp yarn Count – 30/s
Total Ends – 8232
Weft yarn Count – 20 + 70D
Ends per Inch – 160
Picks per Inch – 72
Weave – 3/1 Left hand Twill (LHT)

Table 7. Production summary for case – 1

SL	Brand	Origin	Model	RPM	Capacity (Yds)	Production (Yds)			Total	Eff %	Temp.
						A	B	C			
1	Itema	Italy	2018	**550**	306	92	90	91	273	89%	10~15
2	Itema	Italy	2018	**550**	306	97	95	92	284	93%	15~20
3	Itema	Italy	2018	520	289	86	81	88	255	88%	24~28
4	Itema	Italy	2018	520	289	83	83	87	253	88%	30~40
5	Itema	Italy	2018	520	289	83	83	83	249	86%	40~45

Production data for Case-2

Construction – 30 x 14 Linen/114x62
Warp yarn Count – 30/s
Total Ends – 6500
Weft yarn Count – 14 linen
Ends per Inch – 114
Picks per Inch – 62
Weave – 2/1 LHT

Table 8. Production summary for case – 2

SL	Brand	Origin	Model	RPM	Capacity (Yds)	Production (Yds)			Total	Eff %	Temp.
						A	B	C			
1	Vamatex	Italy	2002	400	258	69	67	69	205	79%	10~15
2	Vamatex	Italy	2002	400	258	72	72	69	213	83%	15~20
3	Vamatex	Italy	2002	400	258	68	65	70	203	79%	24~28
4	Vamatex	Italy	2002	400	258	69	66	71	206	80%	30~40
5	Vamatex	Italy	2002	400	258	66	64	70	200	78%	40~45

Production data for Case-3

Construction – 20 x 20+70D/130x68
Warp yarn Count – 20/s
Total Ends – 6500
Weft yarn Count – 20 + 70D

Ends per Inch – 130
Picks per Inch – 68
Weave – 3/1 LHT

Table 9. Production summary for case – 3

SL	Brand	Origin	Model	RPM	Capacity (Yds)	Production (Yds)			Total	Eff %	Temp.
						A	B	C			
1	Vamatex	Italy	2002	400	235	67	66	64	197	84%	10~15
2	Vamatex	Italy	2002	400	235	67	67	65	199	85%	15~20
3	Vamatex	Italy	2002	400	235	68	66	70	204	87%	24~28
4	Vamatex	Italy	2002	400	235	67	64	70	201	86%	30~40
5	Vamatex	Italy	2002	400	235	66	63	68	197	84%	40~45

From above tables of all cases we are found that, production efficiencies are almost similar (variation only 2~3%) but temperature difference range 10 ~45 degree Celsius. We got this production due to change the sizing recipe for different temperature. So, it is clear that, change of temperature have a remarkable effect on sizing recipe as well as cost.

3.3 Impact of temperature on maintenance cost

The term "maintenance" refers to the sequential or systematic actions taken to maintain the temperature necessary for the proper operation or operation of machinery or other equipment. The longevity of the durability and attractiveness of textile machinery depends on proper care and maintenance.

Effects of Maintenance:

1) Due to proper maintenance reduce undue worn out of different parts and equipment as well as corrosion of the items and increase the machines life (these are the result of routine cleaning, lubricating, repairing, replacement, fitting, and refitting etc.).
2) For sound or congenial operation of machinery, it is required the proper lubrication, fitting, repairing, and replacement (as per necessity).
3) By the continuous operation of the machinery reduces stoppages time resulting better quality and less wastage.

Good maintenance helps to increase the machine performance and its lifetime. In general, 3 types of maintenance are doing in most of the weaving industry. These are:

1) Schedule maintenance (gear oil, oil filter etc. change after specific period of time)
2) Preventive maintenance (Oiling, greasing etc. on daily basis)
3) Breakdown maintenance. (repair or replace parts when breaks)

Table 10. Month wise Spare Parts (Electrical + Mechanical) expense of ITEMA looms for 2022

Month	Spare Parts Expense	Unit
January-2022	43984	Tk.
February-2022	14128	Tk.
March-2022	34793	Tk.
April-2022	24122	Tk.
May-2022	35741	Tk.
June-2022	87092	Tk.
July-2022	159904	Tk.
August-2022	76300	Tk.
September-2022	149930	Tk.
October-2022	67778	Tk.
November-2022	101971	Tk.
December-2022	104862	Tk.
TOTAL	**900605**	**Tk.**

In Bangladeshi weather, June; July; August and September – in these four months we feel too hot. And from the above table we can see that, spare parts costs are higher in those four months than other months. Due to frequent quality change, spare parts cost for the month of November and December are showing higher than August and October. Spare parts costs are more in summer/higher temperature than winter /cold temperature.

Table 11. Month wise Spare Parts (Electrical + Mechanical) expense of VAMATEX looms for 2022

Month	Spare Parts Expense	Unit
January-2022	118779	Tk.
February-2022	82953	Tk.
March-2022	82328	Tk.
April-2022	69329	Tk.
May-2022	53134	Tk.
June-2022	120058	Tk.
July-2022	78828	Tk.
August-2022	246392	Tk.
September-2022	108771	Tk.
October-2022	166311	Tk.
November-2022	151550	Tk.
December-2022	113631	Tk.
TOTAL	**1392064**	**Tk.**

From the above table we can see that, spare parts costs are higher in August and October months than other months. Due to frequent quality change, spare parts cost for the month of November are showing high amount.

4. Results and Discussion

4.1 Impact of temperature on different steps of weaving

During this study it has found many impact of temperature on different steps of weaving during this research work. Research results and findings are discussing below:

Relation between sizing cost and production efficiency

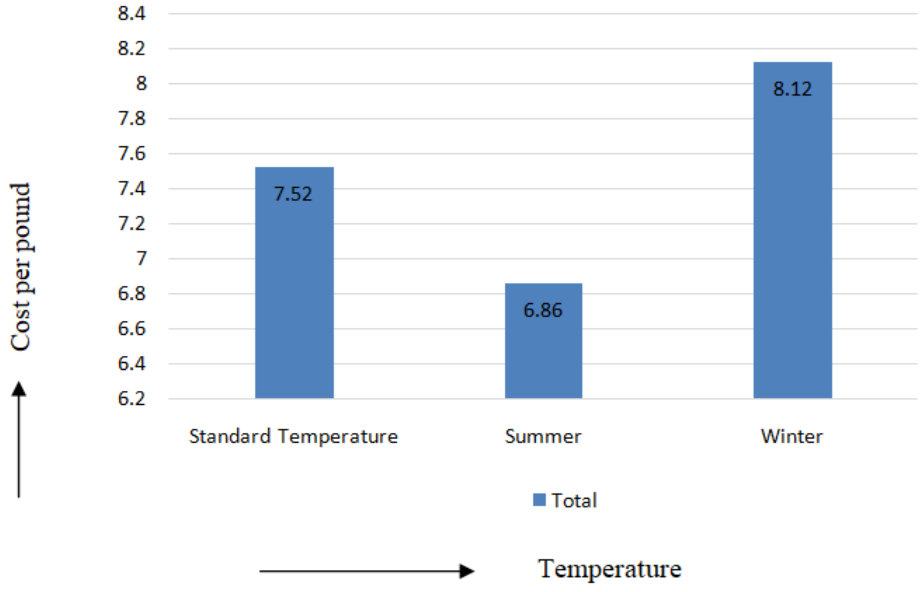

Fig. 1. Sizing cost summary for case – 1.

Sizing cost per pound for case-1 is decreasing with increasing temperature. It is lowest for summer and highest for winter. Compared with standard temperature cost is 7.98% less for summer and 8.78% higher for winter.

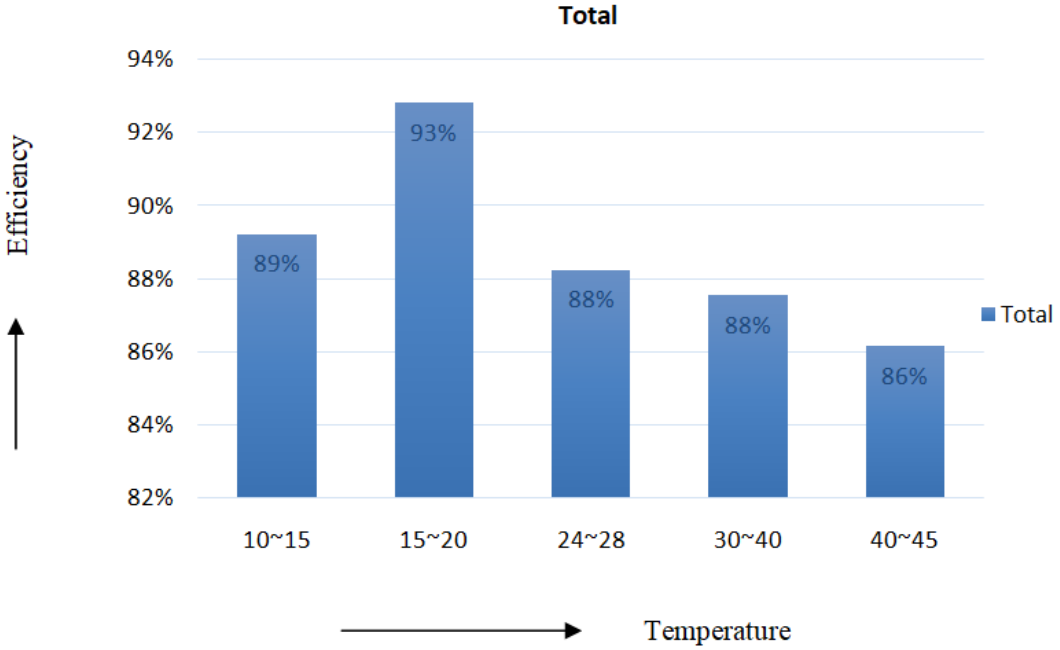

Fig. 2. Production summary for case – 1.

For case-1, from above data, we are found that production efficiencies are very closer for different temperature except temperature 15~20 degree Celsius which is 4~5% higher than standard temperature but machine RPM are decreasing with increasing the temperature. Due to different sizing recipe we get this closer efficiency. Itema is one of the modern automatic looms which are equipped with maximum electronic device. To save the electronic parts RPM is decreasing with increasing the temperature.

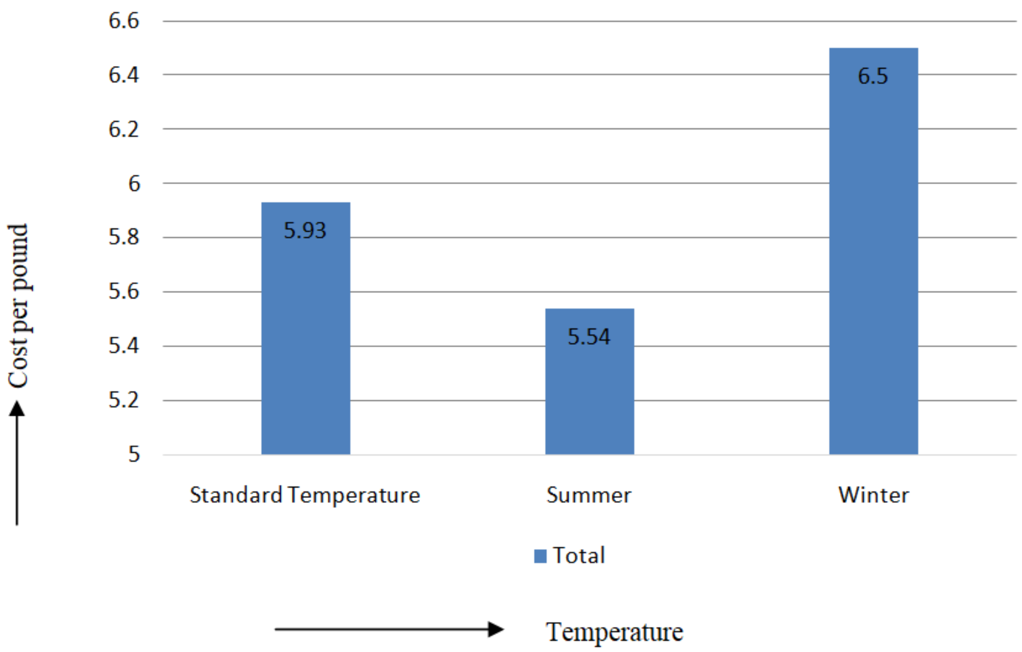

Fig. 3. Sizing cost summary for case – 2.

Sizing cost per pound for case-2 is decreasing with increasing temperature. It is lowest for summer and highest for winter. Compared with standard temperature cost is 9.61% less for summer and 6.58% higher for winter.

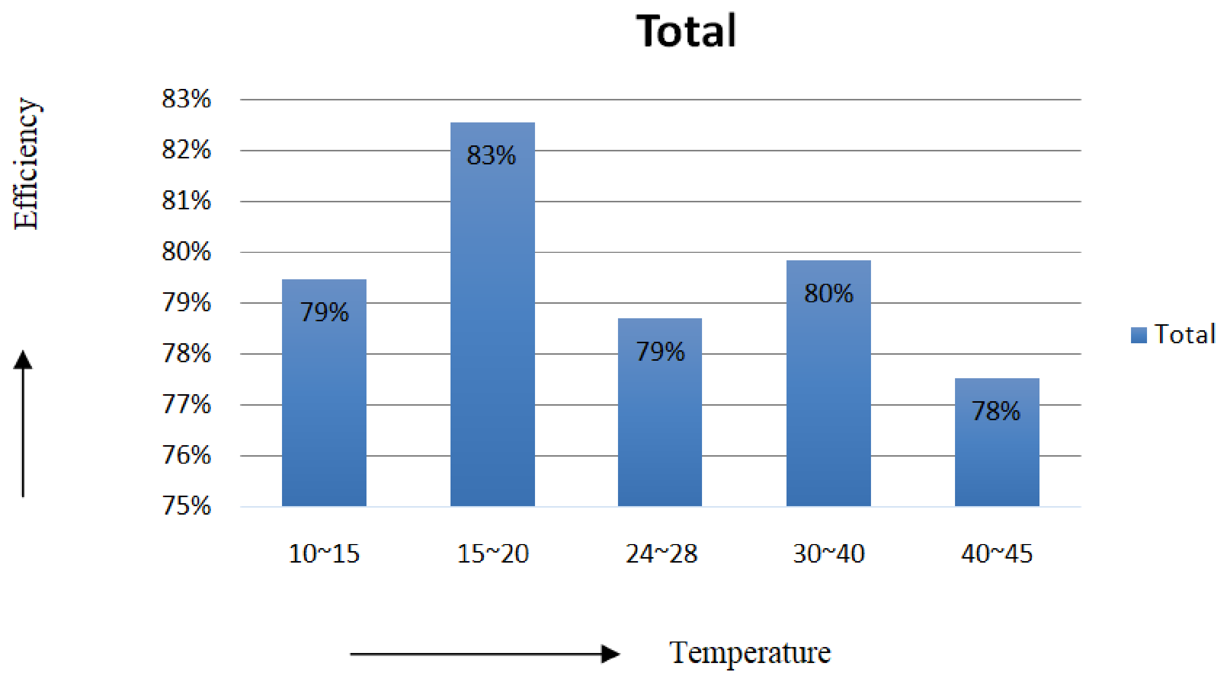

Fig. 4. Production summary for case – 2.

For case-2, from above data we are seeing that in production summery efficiency are very closer for different temperature except temperature 15~20 degree Celsius which is 3~4 % higher than others. Due to different sizing recipe we get this closer efficiency.

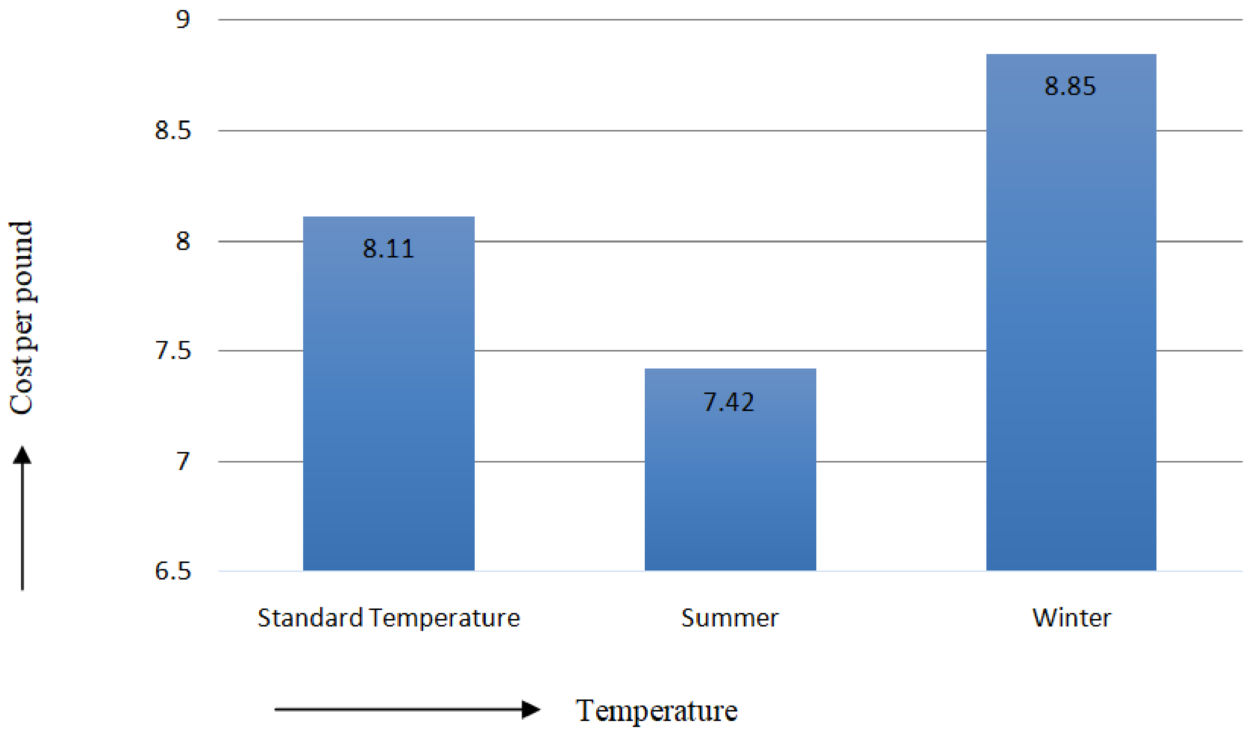

Fig. 5. Sizing cost summary for case – 3.

Sizing cost per pound for case-3 is decreasing with increasing temperature. It is lowest for summer and highest for winter. Compared with standard temperature cost is 9.12% less for summer and 8.51% higher for winter.

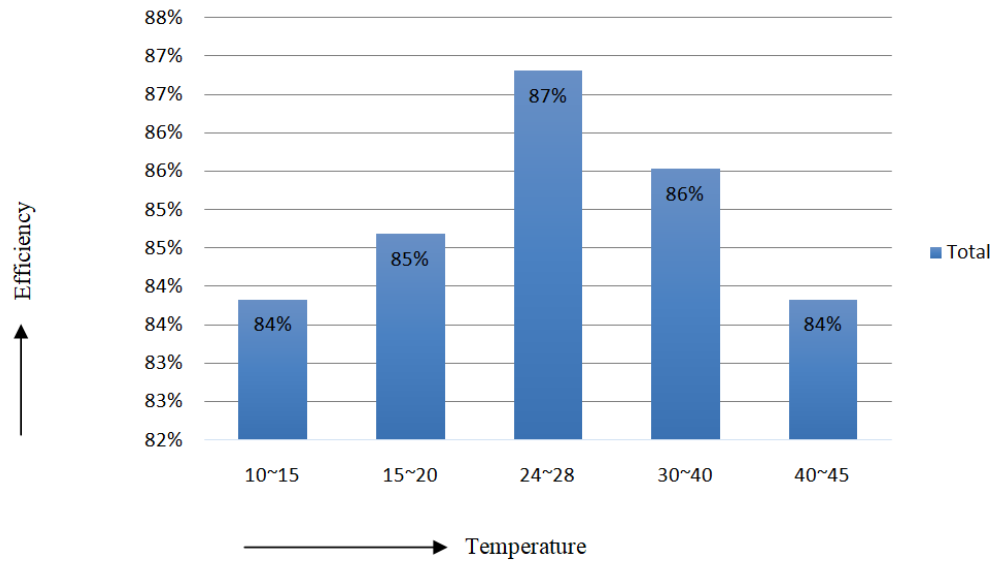

Fig. 6. Production summary for case – 3.

For case-3, from above data we are seeing that in production efficiency are very closer for different temperature except temperature 24~28 degree Celsius which is little bit higher (2~3%) than other. Here also, due to different sizing recipe we get this closer efficiency. Vamatex is also automatic loom but it is older version than ITEMA and also RPM changing is more difficult and time consuming than ITEMA. That's why RPM remain same for all season.

Temperature control is one of the most important ways to minimize the sizing cost and production variation. Chiller is best solution to control the weaving production floor temperature.

4.2 Impact of temperature on maintenance cost

The maintenance costs are varying depends on temperature for different type of maintenance. Each part (electrical and mechanical) has a temperature range to work properly. When temperature exceeds the maximum level, mechanical parts become wither more quickly than its actual lifetime and electrical/electronic parts are not working properly or become damage.

Most parts of modern looms are not available in local market. Many cases it needs to purchase from machine manufacturer which is too much expensive and time consuming.

So, temperature control by chiller is the best way to reduce the maintenance cost.

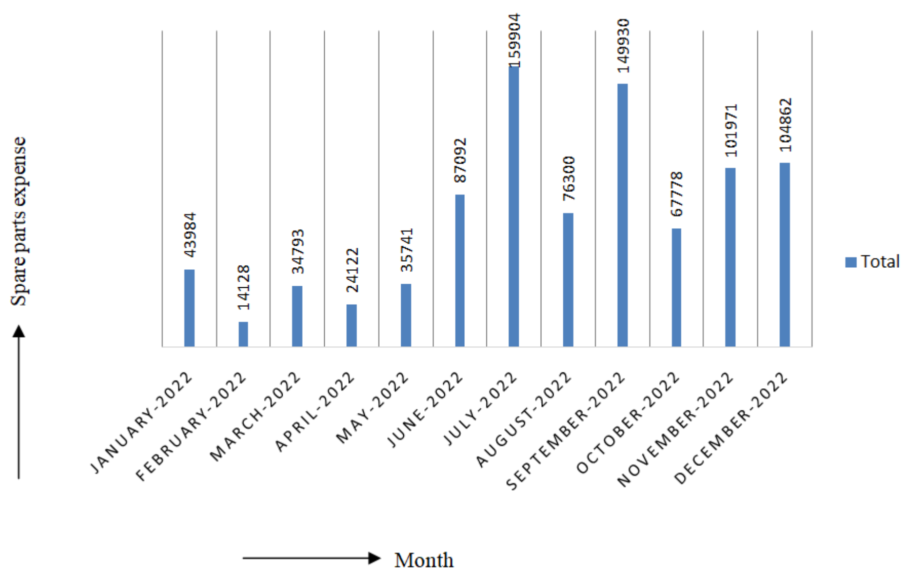

Fig. 7. Month wise Spare Parts (Electrical + Mechanical) expense of ITEMA looms for 2022.

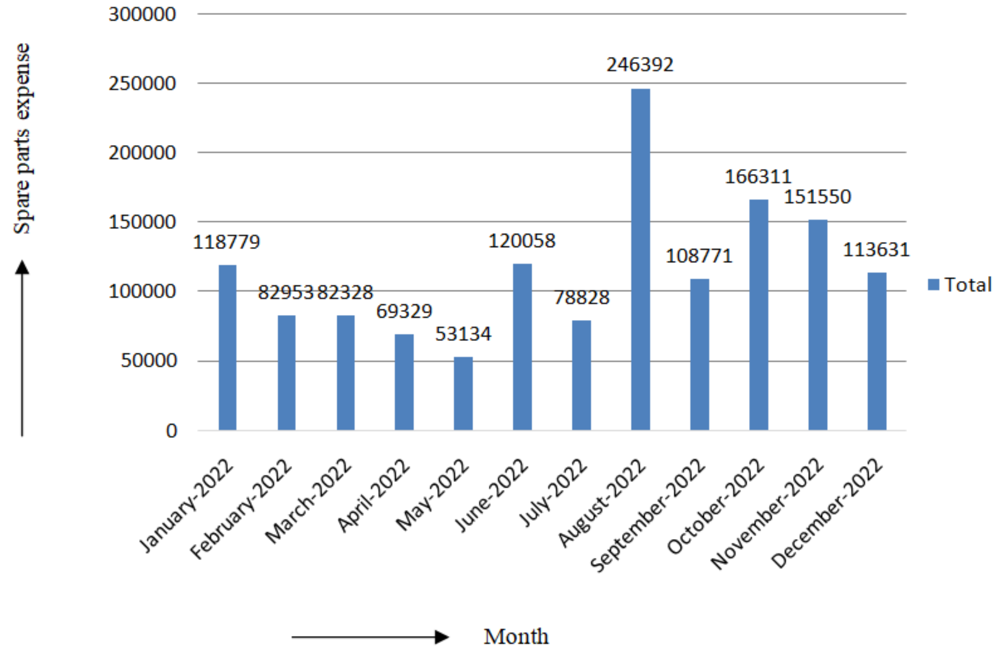

Fig. 8. Month wise Spare Parts (Electrical + Mechanical) expense of VAMATEX looms for 2022.

From above two figures, it is seeing that maintenance cost is higher at July & September than other months for ITEMA looms and August & October for Vamatex looms. These four months are remaining hot weather than other months.

4.3 Result Summery

Result summary for impact of temperature increase on different steps of weaving are found from this study are as follows.

Table 12. Result summery

Area	Impact
Sizing Cost	Decrease
Production	Similar (but sizing cost change)
Maintenance Cost	Increase
Machine Life Time	Decrease

5. Conclusion

Temperature effects on each step of weaving process were found in this study. Two sets of yarn are needed for weaving process which is known as warp and weft. For warp yarn, it is needed some preparation for both conventional and modern looms before looming. Warping, sizing, drawing-in or knotting is mandatory. Warping has little influence on temperature. But for sizing, it has remarkable impact on temperature. Though it is a wastage process, cause during dyeing preparatory size chemical fully remove by de-sizing, sizing is the heart of weaving. Because without proper sizing (depends on temperature) weaving is not possible. In this study it has shown that, to keep the similar productivity for different temperature sizing cost is decreasing with increasing temperature. Machine lifetime and fabric quality also decrease in higher temperature compare with lower temperature. Working environment become more uncomfortable with temperature increase. Better working environment helps to improve the human productivity. Fabrics rejection percentage, maintenance cost and voltage drop are increase with temperature increase. Cost minimization, increase productivity, reduce wastage/rejection, improve quality is the key factor that plays a vital role to sustain in today's competitive market. Though initial investment for chiller and voltage stabilizer setup are costly, but for long run it will be benefited. This high investment amount will return within 2~3 years by reducing sizing cost, increase productivity, improve fabric quality, reduce wastage, minimize maintenance cost, better working environment and increase machine lifetime.

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