AN OPTIMIZATION OF KNITTING PARAMETER ON ANTIMICROBIAL TREATMENT BY USING BOX-BEHNKEN DESIGN

Dr.K.M.Patchiyappan[1], Dr.B.Senthil kumar[2],& R Divya[3]
1)Professor, Department of Costume and Fashion,PSG CAS
2)Asst.Professor ,Department of RIM,Gandhigram Rural University
3) Asst.Professor, Department of Costume and Fashion,PSG CAS

ABSTRACT:

A knitted fabric consist of forming yarn(s) into loops, each of which is typically only released after a succeeding loop has been formed and intermeshed with it so that a secure ground loop structure is achieved. In the knitted fabric, cotton single jersey knitted fabric is tested for anti microbial property. The researcher has selected Cotton knitted structure towards the optimization of knitting parameter. The process starts from the fiber yarn and converting it into single jersy fabric and finishing the fabric with an antimicrobial property..

Keywords: knitted,single jersy antimicrobial property.

INTRODUCTION

When textile materials assume an additional function over and above the conventional purpose, they are regarded as specialty or functional textiles. The Centre for Disease Control and Prevention, USA estimates that approximately 1.7 million Healthcare Associated Infections (HAIs) and 99,000 associated deaths occur each year on account of infection-causing bacteria. Hence, the control of infections has been identified as the most important target by the United States Department of Health and Human Services (Tomsic et al., 2008). Textile substrates have been implicated as one of the vectors of transmission of disease. Textile products particularly made from natural fibers have a serious problem of microorganism growth because of their surface area and ability to retain moisture (Aly et al.,2007). It is also pertinent to mention that other than the requirements of the healthcare facilities; the increase in consumer’s demand for comfort, hygiene and well-being has created a large and rapidly increasing market for antimicrobial textiles (Gao& Cranston 2008). As an example, the market for disinfectants and antimicrobial chemicals in the US is expected to rise by 5% annually (Freedonia Group 2009). As far as antimicrobial property is concerned, numerous antimicrobial agents are known and have already been tested in combination with many hydrocarbon and fluorochemical (Lee et al., 1999), and sol-gel based finishes (Mahltig et al., 2003; Mahltig et al., 2004; Mahltig et al., 2005). To develop weft knitted fabrics (Single Jersey-Plain, Rib and Interlock) using different liner density and different fibre composition through circular weft knitting machine. The prime objective of this research work was to study the effects of the fibre composition, yarn count and finishing add on percentage of single jersey knitted structure on the effectiveness of the finishing through experimental investigation of Box Behnken design.

MATERIALS AND METHODS

In this research work, the researcher has selected Cotton knitted structure towards the optimization of knitting parameter. The fibres are procured from ACME Fibre Ltd., Coimbatore. The yarn samples were prepared from this group of fibres such as 20's,30's,and 40's . The fibre details are listed in Table No.1

Table.1 Fibre Properties

Fibre Properties	Cotton
Fibre staple length (mm)	33.1
Linear density(dtex)	1.18
Strength(cN/Tex)	24.9
Breaking Elongation (%)	6.5
Moisture Regain (%)	8

These selected yarn counts are pre-dominantly used by the knitwear industry due to the better coverage of wide range of areal density in circular knitting machines.

YARN SPECIFICATIONS

Yarn samples of three different count levels were spun through M/s. ABC Spinning Unit, Tirupur such as 20's Ne . 30's Ne , 40's Ne 20 The three yarn samples were tested for their characteristics such as yarn count (ASTM D1907 –01), yarn strength (Lea Strength Tester) , yarn twist (ASTM D 1578-93) and yarn evenness (ASTM D1907-01).

The details of yarn characteristics of these yarns are given in Table No.2

Table.2 Yarn Properties

Yarn parameters	20's Ne Cotton	30's Ne Cotton	40's Ne Cotton
Actual count	19.45	19.45	40.13
Count CV%	1.49%	1.49%	1.79%
Lea strength (lbs)	106	106	65
Strength CV%	4.0%	4.0%	5.3%
Twist per inch	16.1	16.1	22.1
Twist multiplier	3.6	3.6	3.5
Yarn Unevenness%	9.0	9.0	10.2

Thick places/km	21	21	39
Thin places/km	9	9	10
Neps/km	34	34	43
Hairiness index	5.4	5.4	6.11

The grey yarn samples were used to develop three design structures such as plain, rib and interlock by using weft knitted circular machine.

ANTI-MICROBIAL AGENT

The **quaternary ammonium Compound (QAC)** based antimicrobial agent was based on 3-Trimethoxysilypropyldimethyloctadecyl ammonium chloride ($C_{26}H_{58}ClNO_3Si$) (Simoncic&Tomsic, 2010).

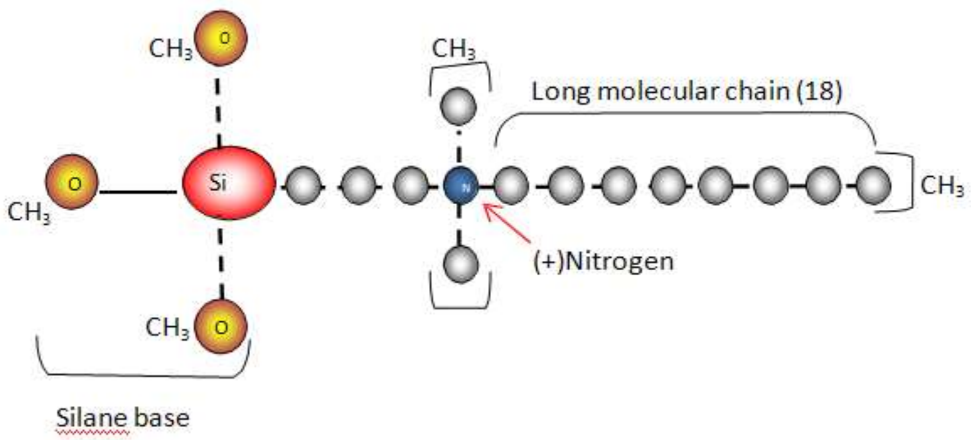

Fig. 1 Chemical structure of quaternary ammonium Compound

In this research work the researcher has chosen this QAC as anti- microbial agent for different fabric composition. The fabrics were finished with the 1:1,1:1.25 and 1:1.5 dilution of the antimicrobial agent, AM 1000 (quaternary ammonium compound) with water by Dip dry method (Temperature - 25 °C, Time - 30 minutes). The treatment was started with the required amount of distilled water calculated as per 1:10 MLR

Experimental design for optimization of ZOI level on Cotton Single jersey fabrics

Table 3 Process variables and their actual values for the coded values in the experimental design for Cotton with S/Js

Factors	**-1 level**	**0 level**	**+1 level**
Count	20	30	40
Loop length in mm	2.5	2.75	3.0

Finishing %	1	1.25	1.5

Table .4 Three Factor Box-Behnken design experiment with predicted response of dependent variable (Zone of Inhibition against E. coli and S.Aureus)

Runs	Factors						Zone of Inhibition (ZOI)E.coli
	Coded			Actual			
	X1	X2	X3	X1	X2	X3	
1	0	0	0	30	2.75	1.25	24
2	-1	-1	0	20	2.5	1.25	25
3	1	-1	0	40	2.5	1.25	22
4	-1	0	1	20	2.75	1.5	25
5	0	0	0	30	2.75	1.25	22
6	0	0	0	30	2.75	1.25	23
7	0	1	-1	30	3	1	23
8	0	-1	-1	30	2.5	1	22
9	-1	1	0	20	3	1.25	24
10	1	1	0	40	3	1.25	22
11	-1	0	-1	20	2.75	1	23
12	0	-1	1	30	2.5	1.5	22
13	1	0	-1	40	2.75	1.25	22
14	1	0	1	40	2.75	1.5	23
15	0	1	1	30	3	1.5	23

EXPERIMENTAL RESULTS AND DISCUSSION

Optimization of ZOI level on Cotton SJ fabric against E.Coli using contour analysis

In order to optimize the variables that influence the Zone of Inhibition (ZOI) against E.coli of the coated fabrics, the response surface plots were generated from the regression model. The three dimensional plots were generated by keeping one variable as constant at the centre point and varying the other variables within the experimental range. The resulting response surface showed the effects of yarn count, loop length and percentage of finishing on zone of inhibition against microbes.

3.1.1 Influence of ZOI on yarn count and finishing%

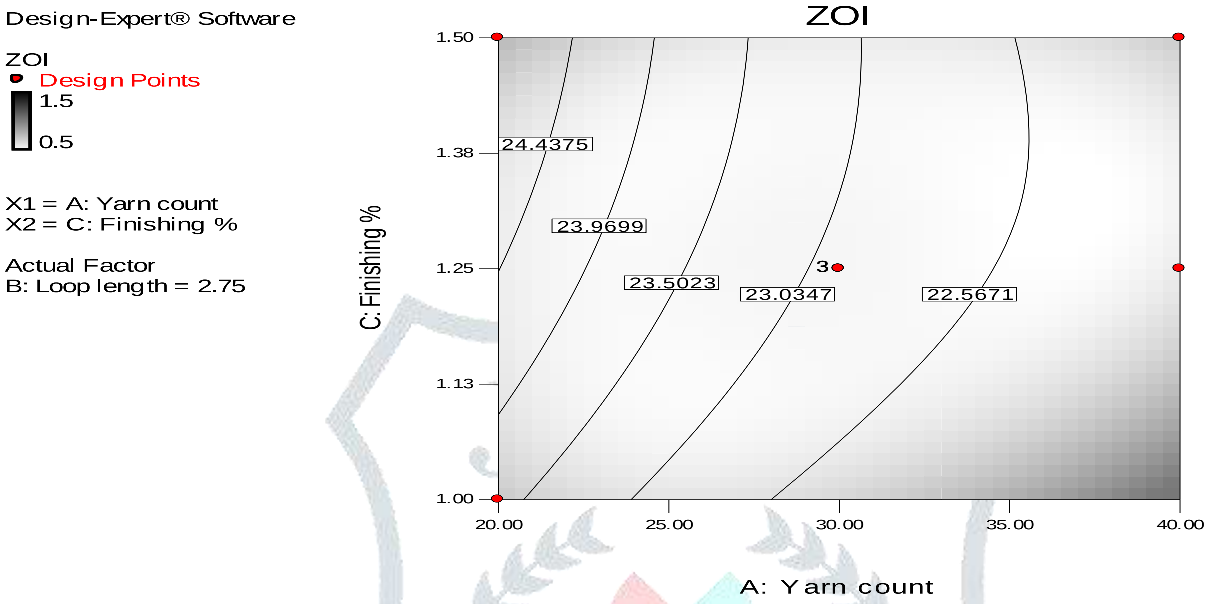

Fig. 2 Response and contour plots for ZOI for function of yarn count and finishing%

The above graph shows that the response and corresponding contour plots for ZOI as a function of yarn count and finishing %. An decreasing in yarn count with an accompanying increase in finishing percentage resulted in increase in ZOI value from 22.57mm to 24.4 mm at yarn count of 22's Ne and finishing percentage of 1.40%.

3.1.2 Influence of ZOI on yarn count and Loop length

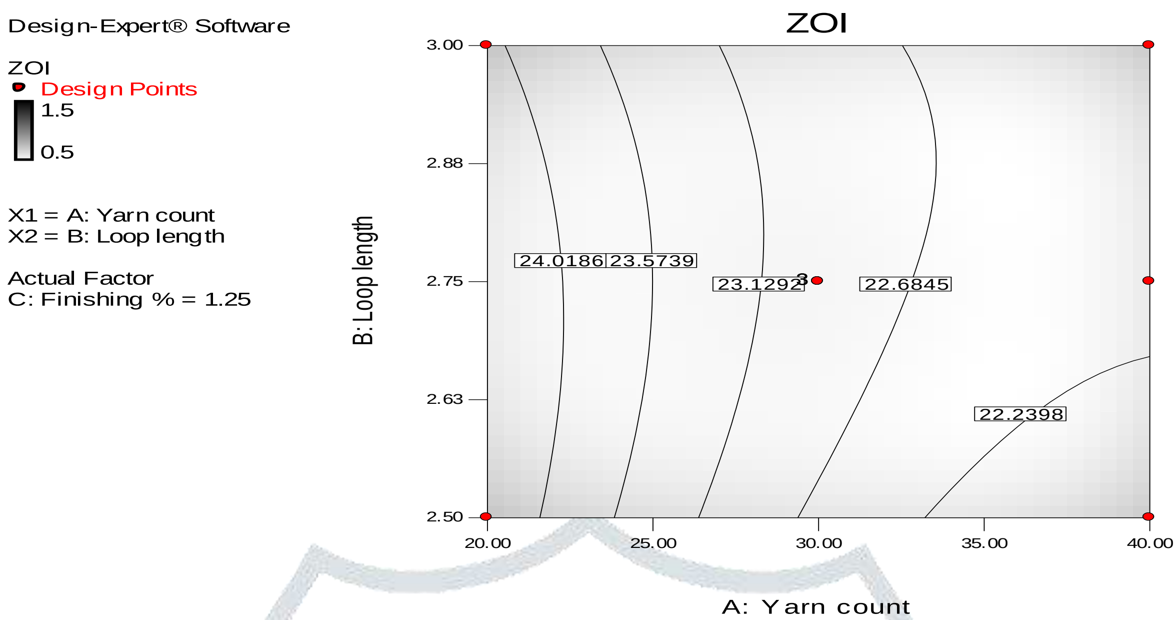

Fig. 3 Response and contour plots for ZOI for function of yarn count and Loop length

Influence of ZOI on finishing% for constant yarn count

The effect of yarn count and loop length on ZOI against microbes while keeping finishing percentage as constant is presented in Figure 4. The trend observed that decease in yarn count with the slight increase in loop length combination results optimum ZOI value of 24.0 mm.

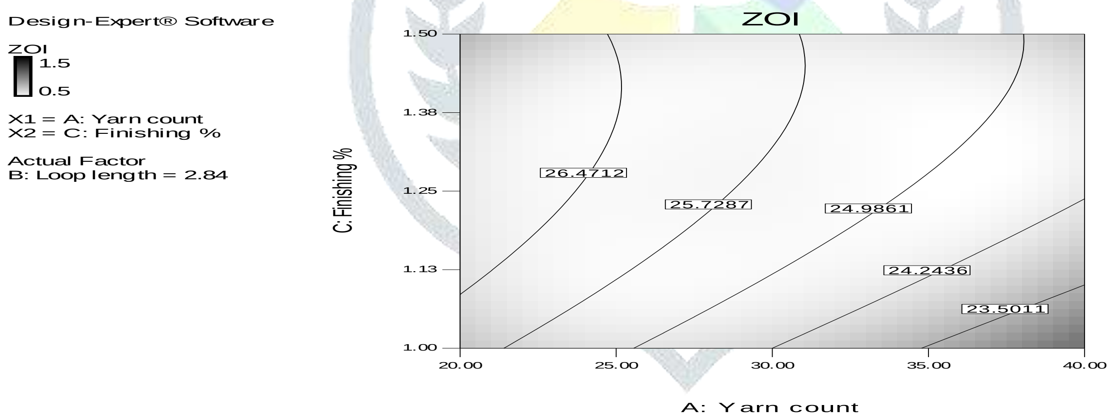

Fig. 4 Response and contour plots for ZOI for function of yarn count and Loop length

The above graph shows that the response and corresponding contour plots for ZOI as a function of yarn count and finishing %. A decrease in yarn count with an accompanying increase in finishing percentage results an increase ZOI value of 26.4 mm

Analysis of Variance

This section, discusses the experimental findings using the main effect of the process parameters on response and interaction effects, contour analysis, analysis of variance (ANOVA) to estimate the effect of parameter on ZOI value of antimicrobial treated knitted fabrics. Based on the contour analysis optimal combination of process parameters has been arrived. Furthermore, the variation of ZOI of finished fabric with process parameters is modelled mathematically using the multiple linear regression analysis method

Table 5.ANOVA for Response Surface Quadratic Model

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob> F	
Model	11.08	9	1.23	1.25	0.4237	not significant
A-Yarn count	*7.13*	*1*	*7.13*	*7.24*	*0.0433*	
B-Loop length	*0.13*	*1*	*0.13*	*0.13*	*0.7362*	
C-Finishing %	*0.73*	*1*	*0.73*	*0.74*	*0.4292*	
AB	*0.25*	*1*	*0.25*	*0.25*	*0.6358*	
AC	*0.17*	*1*	*0.17*	*0.17*	*0.6952*	
BC	*0*	*1*	*0*	*0*	*1*	
A2	*0.75*	*1*	*0.75*	*0.76*	*0.4228*	
B2	*0.15*	*1*	*0.15*	*0.15*	*0.7104*	
C2	*0.097*	*1*	*0.097*	*0.098*	*0.7665*	
Residual	4.92	5	0.98			
Lack of Fit	*2.92*	*3*	*0.97*	*0.97*	*0.5423*	*not significant*
Pure Error	*2*	*2*	*1*			
Cor Total	16	14				

The "Model F-value" of 1.25 implies the model is not significant relative to the noise. There is a42.37 % chance that a "Model F-value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case yarn count value is significant with the response.

Percentage contribution

Percent contribution to the total sum of square can be used to evaluate the importance of a change in the process parameter on these quality characteristics.

Percent contribution is calculated by the following equation:

Percent contribution (P) = (SS'A / SST) *100

Table 6 shows individual % contribution of parameters under study.

TABLE 6 PERCENTAGE CONTRIBUTION

S.No	Parameter	Rank	Percentage Contribution
1	A-Yarn count	1	44.5625
2	B-Loop length	3	0.8125
3	C-Finishing %	2	4.5625

REGRESSION ANALYSIS

The results obtained from the 15 experimental runs carried out according to the Box- Behnken design are summarised in Table 4. The proposed second degree polynomial was fitted to the data presented in Table 5 using multiple linear regressions to determine the optimum fermentation conditions that resulted in the maximum ZOI value .The effects of Yarn count, loop length and Finishing percentage on ZOI of the antimicrobial treated fabrics were quantitatively evaluated using response surface curves. By applying multiple regression analysis on the experimental data, the following second degree polynomial was.

ZOI =22.94-1.03 * A+0.13 * B+0.36 * C+0.25 * A * B-0.28 * A * C+0.000 * B * C+0.48 * A^2-0.21 * B^2-0.18 * C^2.

Conclusion

The following conclusions have been derived and studied from the research work.

- The effects of process parameters such as yarn count, loop length and finishing percentage on the ZOI against the E.coli microbes on cotton single jersey knitted fabric have carried out. It is observed that the optimized ZOI from contour analysis is from 25 to 27 mm. The optimized process value falls in the following manner, such as yarn count value range from 22Ne to 25Ne; Finishing percentage value from 1.0% to 1.25% and similarly the loop length range from 2.6 mm to 2.75mm.
- ANOVA table shows that except yarn count other parameters are not significant towards the ZOI against microbes. Subsequent to that the percentage analysis has been done to measure the contribution of individual process parameter on the outcome .In this case the yarn count contributes highest level such as 44.5% on the result, subsequent to that finishing add on percentage contributes second level.

REFERENCES

1. Aly, AS, Mostafa, ABE, Ramadan, MA, & Hebeish, A 2007, 'Innovative Dual Antimicrobial & Anticrease Finishing of Cotton Fabric', Polymer-Plastics Technology and Engineering, vol. 46, no. 7, pp. 703-707.
2. Freedonia Group, Dinsinfectant & Antimicrobial Chemicals, November 2009.
3. Gao Y, Cranston R. 2008, 'Recent Advances in Antimicrobial Treatments of Textiles', Textile Research Journal,vol. 87,pp.60-72.
4. Lee, S, Cho, J, Cho, G 1999, 'Antimicrobial and blood repellent finishes for cotton and nonwoven fabrics based on chitosan and fluoropolymers', Textile Research Journal, vol. 69,no.2,pp. 104-112.
5. Mahltig, B, Bottcher, H 2003, 'Modified silica sol coatings for water-repellent textiles', Journal of Sol-Gel Science and Technology, vol.27,no.1, pp 43-52.
6. Mahltig, B, Fiedler, D, Bottcher, H 2004, 'Antimicrobial sol-gel coatings', Journal of Sol-Gel Science and Technology, vol.32,no.1,pp. 219-222.