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Investigation of the Effect of Raising and Finishing Process on the Phycysical Performance of 3-Thread Fleece Fabric

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ABSTRACT

Within the scope of the study, pre-softening, raising and final softening processes were applied to 2 fleece fabrics under different conditions. The raising fastness, air permeability and bursting strength tests were performed on the samples obtained after the processes, and the effect of the process conditions on the researched performance values was examined. This paper is also detailed by statistical analysis. When the results were examined, it was seen that the best result in terms of raising fastness was the fabric with 50% waste + 50% PES back yarn. As a process, it was determined that the best result was obtained after a single passage with micro silicon pre-softening and raising at a speed of 15m / min, and then a low concentration softening process with a polyvinyl acetate-based binder and softener mixture.

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KEYWORDS

3-thread, fleecy fabric, rasing process, raising fastness, softener, binder

1. INTRODUCTION

Knitted fabrics, which are called three threads, are fabrics that are knitted on special plain circular knitting machines equipped with different cam sets, special sinker structures and thread guides from three different ways. In 3 thread fleece fabrics, one of the two yarns that are mostly used in the same count or thickness is the face yarn that forms the ground, and the other is the binding yarn that acts as a filler. The third yarn is the back (fleece) yarn, which is thicker than these two yarns. The front of these structures looks like a plain knit. On the reverse, there are yarn floatings in the course direction [1].

The raising process plays an important role in obtaining thermal comfort in the production of three thread fleece fabrics. In this type of fabric, raising is applied to the back surface of the fabric that skin-contact. The raising process is a mechanical finishing process based on the physical pulling out of the fibers from the yarns of the fabric. As a result of this process, a fiber layer is formed on the surface of the fabric. The thickness and effect of this layer vary depending on the length of the fibers, how they pile and counter-pile, and the number of passages. Thanks to this layer, the fabric turns into a bulkier structure and the existing air in the fabric pores is trapped, giving it a feature like an airbag. Thus, the heat retention ability of the fabric is also increased. In the raising process, rollers covered with pointed metallic wires are used to pull the fibers mechanically. While the hooks in one of the rollers pull the fiber from the fabric (pile roller), the hooks that mounted with reverse angel in the other roller comb the fibers (counter-pile roller) [3].

The softening process also has an important role in the production of three yarn fabrics. Softening application is used in two separate stages in the production processes of three thread fleece fabrics. The first of these is the pre-softening applied before raising and providing easy raising of the fabric, and the other is the 2nd softening aplied after raising and improving the touch of the fabric. Silicone-based softeners are generally used in both processes. Silicone-based softeners are softeners that are mostly produced as oil-in-water emulsions (O/W), which are used to give textile products not only better softness, brightness, and lubricity, but also flexibility, bulkiness (fullness), easy sewing, and tear strength [4].

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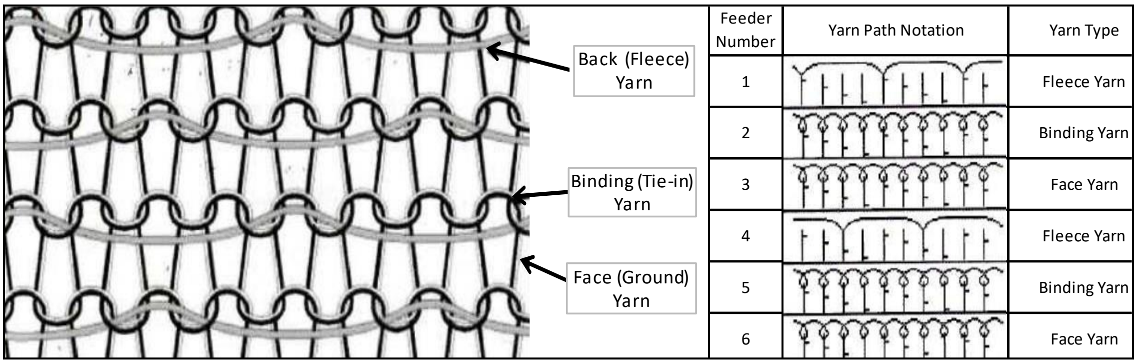

Figure 1. Structure of 3 thread fleece fabric and dyagram of needdle notation [2]

In this way, while the touch, bulkiness, and comfort features of knitted fabric exposed to raising and softening processes come to the fore in a positive sense, it has been determined that fiber loss occurs on the back of the fabric depending on the process and fabric conditions, and many important global brands, high amounts of customer complaints and negative returns were reflected on the manufacturer/seller. When garments made from these fabrics are used, fiber loss causes adhesion to the body or stains on other garments. Raising fastness is the resistance of the raising faces of three yarn futter fabrics to the adhesion of the fibers to the human body or to the garment they come into contact with when exposed to mechanical/chemical effects. The raising fastness test is an analysis designed by LC Waikiki to measure and rate this performance and applied with the "in house" method. Determining the root cause of this problem constitutes the main purpose of the study. Therefore, the research focused on the investigation of the relationship between raising fastness (fiber loss), bursting strength, air permeability performances of three thread fleece knitted fabrics, and the raising process and softening application.

When the literature is examined, the increase in the demands of knitted fabrics in recent years has also shown itself in studies related to these fabrics, and many studies have been carried out on the dimensional behavior of knitting especially in jersey, interlock, lacoste and futter fabrics. In all of these studies, knitted fabric properties are affected by all operating parameters, starting from the fiber properties used, to yarn, knitted surface properties, and finishing processes. It was stated that the desired properties of knitted fabrics at the place of use should be determined and the appropriate fiber, yarn, knitting surface and finishing processes should be selected [5-17]. It is seen that these studies are more limited in the 3 thread fleece fabrics, which are mostly referred to with the raising process. In studies conducted for this type of fabric, it has been observed that research on thermal comfort and thermal insulation have come to the fore. As a result of these studies, it was stated that the thickness of futter fabrics and especially the presence of the raising process increased the heat retention ability [18-19]. In another study, it was concluded that the front yarn should be knitted tightly, the rear yarn height should be kept short, and a separate study should be done for raising fabric in order to have a lower combustion value of three yarns without raising [20]. Balcı et al., In their studies, found that the quality of the back yarn of the two yarn futter fabric loses weight as a result of the cellulase enzyme application and raising process and therefore increases the waste rate so that the waste rate in the back yarn should not exceed 50% [21]. In a study on 3-yarn fabrics knitted with different front and back yarn combinations, water vapor and air permeability of knitted fabrics with tencel yarn gave the best results, while cotton fabrics remained worse [22]. As can be understood from all these previous studies, the relationship between three yarn knitted fabric, raising, and softening was examined experimentally and statistically within the scope of this research.

In this context, the knitted fabric with two different constructions which was determined according to the results of their experimental study before this study was presented, was selected to be used within the scope of this research by Asker and et al [23]. 192 finishing processes were applied to these two selected fabrics under various softening and raising process conditions within the ÖZEN MENSUCAT R&D Center. In this context, 7 different softeners were used in the study. The type of pre-softening and 2nd softening chemical (applied before and after raising), the number of raising passages, the speed of the raising machine, and the concentration of 2nd softener agent were selected as varied. In addition, 9 more trials were carried out to examine if the use of binder affected the performance of the second softening process. In the laboratories of LC Waikiki Stores, all samples were tested for raising fastness, bursting strength, and air permeability. One-way analysis of variance (ANOVA) was performed on the results, and evaluation of the effects of the selected input parameters on the outputs was presented.

2. MATERIAL AND METHOD

2.1 Material

Within the scope of this study, three thread fleece fabrics of two different constructions were used (Fabric 1 and Fabric 2). The variability in Fabric 1 and Fabric 2 being different is due to the back yarn blend. Open-end yarns defined as Type 1 (50% cotton-50% polyester) and Type 2 (50%

Waste cotton + 50% Polyester) were used for the back yarn. The cotton used in the back yarn defined as Type 1 and preferred for Fabric 1 is the original Turkmenistan blend, and the cotton defined as Type 2 and selected in Fabric 2 is the waste of the same blend.

In the previously published study of the researchers (Asker et al.) were applied 18 different finishing process combinations to three thread fleece knitted fabrics developed in 32 different constructions (as structural parameters, two different front yarns, four different back yarn fiber contents, two different back-yarn pile lengths pile and two different number of back-yarn floating were used), and as a result of this study, they determined that two constructions had the best results in terms of the raising fastness. Since the main subject of the study is fiber loss, it has been prioritized to make the first evaluation directly on the raising fastness. [23]. Accordingly, Ne 30/1 combed ring for face yarns, 70 denier filament polyester for binding yarns, and Ne 14/1 open-end yarns for back yarns were used in both fabrics. In these constructions, yarn lengths in 100 needles are 44/28/17 cm, and their weight is 295 g / m2.

USTER and Tensorapid results of the back yarn (Type 1 and Type 2), which cause the differentiation of the two fabrics, are given in Table 1 and Table 2.

7 different softeners and 3 different binders were used within the scope of the study. 5 of these softeners were specially prepared for this research, and commercial samples were used for 2 of them. Information on softeners and binders is given below.

Softener 1: It is an amino-functional micro silicone emulsion. It is prepared to contain 15% silicone oil. 15% oil, 9% tridecyl alcohol 6 ethoxylate based emulsifier is used in its recipe. The particle size of this developed product was determined as 80 nm.

Softener 2: It is an amino- functional macro silicone emulsion. It was provided from VESKIM as ready, with 15%. The particle size of this developed product was determined as 145 nm.

Softener 3: It is a hydrophilic macro silicone emulsion. It is prepared to contain 15% silicone oil. Quarterner ammonium modified silicone oil is prepared according to the oil in water emulsion principle. 15% oil, 1.5% tridecyl alcohol 6 ethoxylate-based emulsifier is used in its recipe. The particle size of this developed product was determined as 100 nm.

Softener 4: It is the mixed emulsion obtained by mixing the macro emulsions provided with the prepared micro silicones emulsions in equal proportions. The particle size of this developed product was determined as 80 nm.

Softener 5: It is a hydrophilic micro silicone emulsion prepared to contain 15% silicone oil. Quarterner ammonium modified silicone oil is prepared according to the oil in water emulsion principle. 15% oil, 3% tridecyl alcohol 6 ethoxylate-based emulsifier is used in its recipe. The particle size of this developed product was determined as 50 nm.

Softener 6: It was obtained from FOURKIM as commercial product. It is a mixed emulsion formed by hydrophilic macro and micro silicone emulsions in equal proportions. Hydrophilic macro emulsion produced by quarterner modified silicone oil while micro emulsion produced by amino-functional silicone oil.

Table 1. Uster values of back yarn type 1 and type 2

Fleece yarns type	Type 1			Type 2		
	Mean	CV	S	Mean	CV	S
U %	8,92	3,3	0,29	10,91	3	0,33
CVm %	11,28	3,3	0,37	13,84	3	0,41
Thin -40 % /km	14,00	81,9	12	103	27,7	28
Thick + 35% /km	101,00	23,7	24	510	19,7	100
Thick +50% /km	13,00	97,6	13	63	23,3	15
Neps +140% /km	397,00	29,1	116	3014	18,4	555
Neps +200% /km	31	52,7	16	555	22,7	126
Neps +280% /km	8	105	9	82	25,1	21
Neps +400% /km	2	202,4	4	11	33,5	4
H	5,94	2,8	0,17	6,01	2	0,12
S3u /100m	1582	16,6	263	1510	9	136

Table 2. Tensorapid test results of back yarn type 1 and type 2

Fleece yarns type		Time to break (s)	B-Force (cN)	Elongation (%)	Tenacity (cN/tex)	B-Work (N.cm)
Type 1	Mean	0,56	579,4	9,27	13,74	15,00
	S	0,05	35,76	0,75	0,85	1,88
	CV	8,09	6,17	8,07	6,17	12,55
Type 2	Mean	0,60	608,4	9,88	14,42	16,22
	S	0,04	81,39	0,69	1,93	2,50
	CV	6,95	13,38	7,03	13,38	15,42

Softener 7: Softener 6 was mixed with commercially available Binder (polyvinyl acrylate) and a special mixture was obtained. Binder was used in the softener at a concentration of 50 g / L.

In the experimental study, the effect of the chemical properties of the binder on the performance properties of futter fabrics was also investigated. In this context, 3 different commercial binders are used. These; Binder 1: Ferane NGU - Cationic Quaternary Amidation (A), Binder 2: Ruco-Plast EPG 18803 - Polyvinylacetate (B), Binder 3: Ruco-Plast PSM - Polyacrylate dispersion (C).

2.2. Method

According to the research published previously, it has been observed that the softener used in pre-softening and second softening processes is effective in fiber loss of fabrics. It has been seen that the 2nd softening has a negative effect on raising fastness whereas pre-softening reduces this negativity [23]. Based on these findings, within the scope of the research, the type of the softening chemical applied to facilitate the raising process (4 levels) before the raising process, the type and concentration of the softener used to improve the touch after the raising (4 levels), and the number of raising passages (2 levels) and the speed of the raising machine (2 levels) were selected as process parameters. The experiment plan created with these parameters was applied to Fabric 1 and Fabric 2, whose structural features were specified above, in a stenter machine under operating conditions.

In the second part of the study, three different binders were applied only to Fabric 2 in three different concentrations of 2nd softening chemicals. Experiment plans are given in Table 3 and Table 4.

In this study, all sampless were prepared under the same conditions until the pre-softening stage. The machines and process conditions after this stage are given in Table 5.

The samples were subjected to raising fastness, bursting strength, and air permeability tests as per the test plans in Tables 3 and 4.

The process flow chart was carried out as Figure 2.

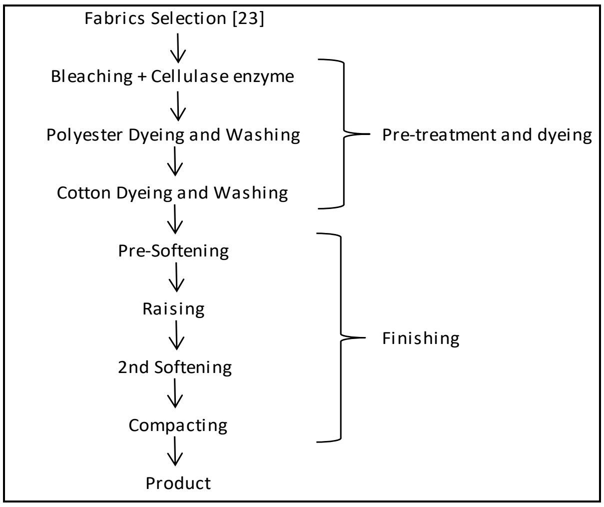

Figure 2. Experimental flow chart of the study

The raising fastness test was made to measure the fiber loss of the fabric, and LC Waikiki KMS05 standard was used for this test. According to this method, first of all, samples are cut from 4 different parts of the fabric to be tested. Optical white, carbon brush fabric (40/1-40/1 poplin 52/48, 100% cotton), is used as the top cloth in the test as reference. Then, the raised fabric to be tested and the reference fabric is tested in 5 rounds in the Martindale Pilling Tester. Finally, samples are evaluated by using scale. If the score is 3 or more over the 4-point scale, the test is considered as passed

The bursting strength test is carried out in James H. Heal brand Truburst2 device according to the Bursting Strength (ISO 13938-2) ISO 13938-2 standard. According to the standard 50 cm2 (79.8 mm diameter) fabric is tested. The KPa value at the moment of explosion refers to the strength.

Table 3. Experiment plan 1

The type of fabric	The type of presoftening agent	The number of passages	The speed of raising	The type of 2nd softening agent	The concentration of 2nd softenening agent
Fabric 1	Softener 1	Single Pass	S1-10 m/dk.	Softener 1	Low-5 g/l
Fabric 2	Softener 2	Double Pass	S2-15 m/dk.	Softener 5	Medium-15 g/l
__	Softener 3	__	__	Softener 6	Normal-30 g/l
	Softener 4	__	__	Softener 7	__

Table 4. Experiment plan 2

Trial no	Binder type	Amount (g/l)	Trial no	Binder type	Amount (g/l)	Trial no	Binder type	Amount (g/l)
1	A	10	4	B	10	7	C	10
2	A	30	5	B	30	8	C	30
3	A	50	6	B	50	9	C	50
Original (Without Binder)								

Table 5. Processes parameters and working conditions

Parameters	Pre-softening	Raising	2nd Softening	Compacting
Used Machines (Trademark)	8 Chambers Stenter (Effe)	2 Drums Raising Machine (Has Group)	8 Chambers Stenter (Effe)	Sanfor Machine (Ferraro)
Application Method	wet on wet impregnation. Pick -up % 20-30	-	impregnation Pick-up %80-100	-
Amount of Softener (g/L)	125	-	50	-
Application pH	4.5-5.5	-	4.5-5.5	-
Drying Temperature (°C)	130	-	130	-
Machine Speed (m/min)	15	10-15	15	20

The air permeability test was made according to the standard of GOST 12088-77 / ISO 9237. The test was carried out under the conditions of 100 Pa test pressure and 5 cm² surface area, and the air permeability value is shown in l / min unit.

The relationship between fabric type and selected process parameters, and tested performance values was statistically analyzed using variance analysis with 95 percent confidence limits on the results obtained from the trials and tests. Input parameters in all variance analysis; A- Fabric Type, B- Pre-softening Softener Type, C-Number of Passages, D-Raising Speed, E- The Type of 2nd Softening Agent, F- The Concentration of 2nd Softener Agent. F and p values were used in the evaluation. For an investigated main factor or interaction to be statistically significant, the p value must be less than 0.005. In addition, it can be said that the larger the F value, the greater the significance state of the parameter examined and its effect on the variability.

3. RESULTS AND DISCUSSION

3.1 Evaluation of Raising Fastness

The raising fastness test was performed on 384 samples collected in accordance with Table 3's experiment plan, and the results of the variance analysis are shown in Table 6. Figure 2 depicts the normal distribution curve used to assess the reliability of these test results. The distribution has a normal distribution character, as shown in Figure 3.

Table 6. Raising fastness variance analysis results

Parameters	F Value	p-value	Significance level
Model	55,39	< 0.0001	**significant**
A- Fabric Type	449,67	< 0.0001	**significant**
B- Pre-softening Softener Type	6,70	0.0002	**significant**
C- Number of Passages	30,76	< 0.0001	**significant**
D- Raising Speed	2,94	0.0873	insignificant
E- 2nd Softining Softener Type	33,58	< 0.0001	**significant**
F- 2nd Softining Softener Concentration	2,56	0.0785	insignificant

As seen in Table 6, it was determined that the model established was statistically significant. However, of the main parameters selected as an input, A parameter (fabric type), B parameter (Pre-softening softener type), C parameter (number of passages), and E parameter (The Type of 2nd Softening Agent) are significant on the output. On the other hand, it was determined that D parameter (raising speed) and F parameter (The Concentration of 2nd Softener Agent) had no effect on raising fastness.

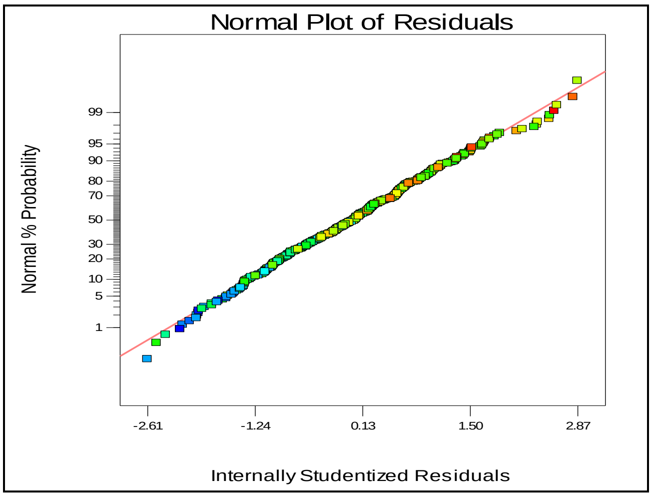

Figure 3. Normal distribution curve for raising fastness results

In Figure 4, raising fastness test results drawn depending on Parameters A and B are shown.

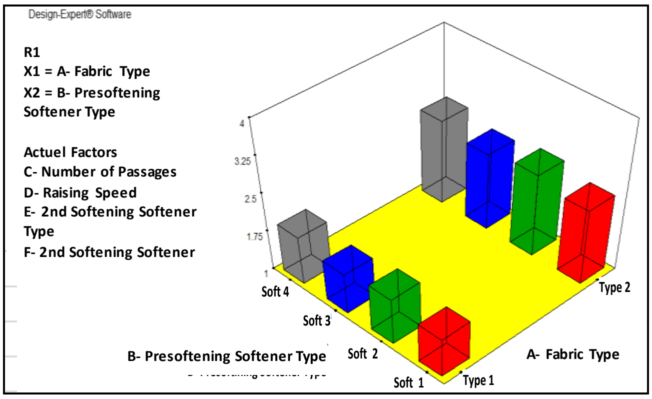

Figure 4. Model chart for raising fastness according to A and B parameters

It has been determined that the most important parameter affecting raising fastness is fabric type. The only difference between fabrics (Fabric 1-Fabric 2), which is the biggest cause of variability, is the cotton blend used in spinning the back yarn. In Type 1 (Fabric 1) Cotton (50%) + Polyester (50%) was used in the back yarn blend, while in Type 2 Waste Cotton (50%) + Polyester (50%) was used. Therefore, the most important difference affecting raising fastness is the use of waste cotton instead of cotton at 50%. As seen in Figure 4, the results of raising fastness were higher in Type 2, that is, the fabric knitted from the back yarn with waste (Fabric 2). This result is thought to be due to the fact that the waste fibers in the back yarn are shed more during the raising process and are transferred with less waste to the finished product stage. Thus, there is little or no residual back yarn fiber to adhere to the reference fabric during the test. It is also thought that there is a relationship between the raising fastness performance and the USTER results of the yarns. It is thought that the type 1 yarn which has less thin / thick place amount and is smoother (see table 1), breaks more because it is raising harder and breaking harder, thus increasing the fiber loss and the raising fastness is lower.

In Figure 5, raising fastness test results drawn depending on C and E parameters are shown.

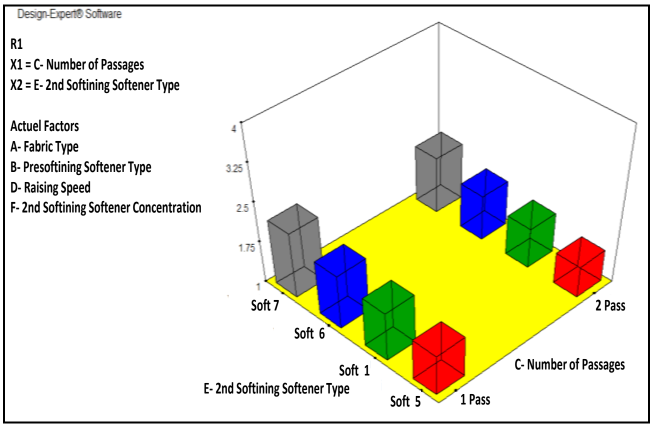

Figure 5. Model graph for raising fastness according to C and E parameters

As seen in Figure 5, The E parameter (The Type of 2nd Softening Agent) has the second greatest effect on raising fastness. The best result, namely the lowest fiber loss, has been obtained in applications where Softener 7 is used. On the other hand, the lowest result was found in applications where micro silicones (Softener 1 and Softener 5) are used. When the results are evaluated in terms of the number of passages, it is seen that fabrics applied with a single passage have better results than double passages. The reason for this is that the single passage raising application causes less damage to the fiber than the double passage and as a result, the fiber loss occurs less.

In Figure 6, raising fastness test results drawn depending on A and E parameters are shown. As can be seen from Figure 6, Softener 7 gave better raising fastness results, while Softener 5 gave the lowest values in the 2nd softening stage for both fabric types.

3.2. Evaluation of Bursting Strength Results

Variance analysis results on bursting strength test results are shown in Table 7. The normal distribution plotted to analyze the reliability of these test results is provided in Figure 7. As seen in Figure 7, the curve shows a normal distribution character.

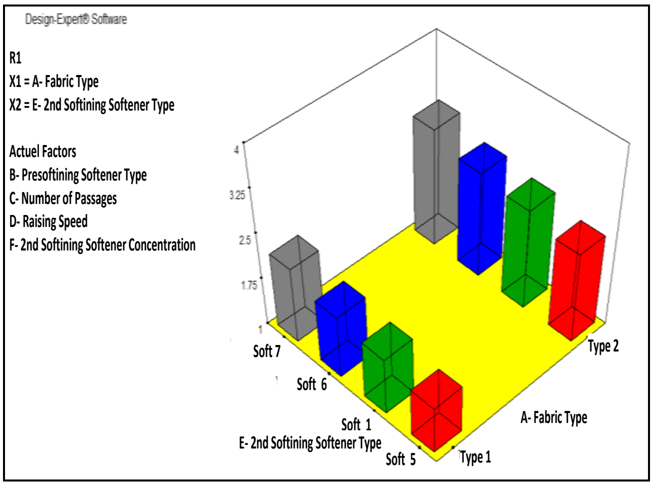

Figure 6. Model graph for raising fastness according to A and E parameters

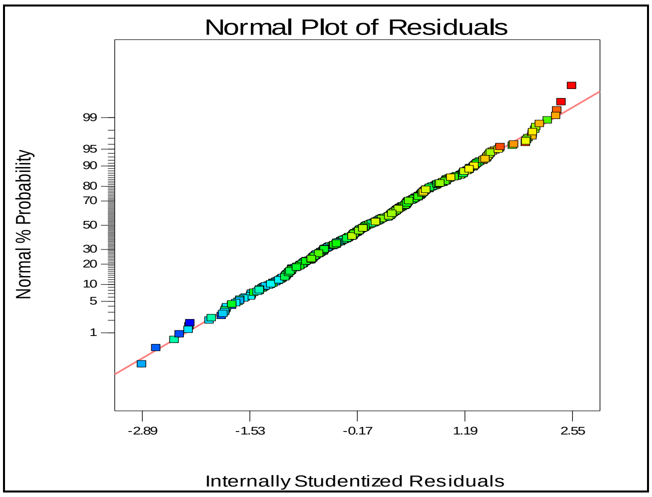

Figure 7. Normal distribution curve for burst strength

When examined in Table 7, it was found that the model established was statistically significant. Besides this, it was determined that the parameters A (fabric type), C (passage number), and E (The Type of 2nd Softening Agent), which are among the main parameters selected as the input, are significant on the output. On the other hand, B (Pre-softening softener type), D (raising speed) and F (The Concentration of 2nd Softener Agent) parameters did not affect the change in bursting strength at a statistically significant level.

It has been determined that E (The Type of 2nd Softening Agent) applied after raising along with the A parameter (the fabric type) was the most important variable, among the significant parameters. The number of passages (C parameter) applied to the back of the fabric followed these 2 variables. The type of softener (A parameter) applied before the raising process did not affect the bursting strength. The fact that the 2nd softening material (E parameter) increased the lubricity of the yarns while improving the handle, reduced the yarn-yarn friction, and this decrease caused the strength value to decrease. The different particle sizes and chemical structures of the selected softeners caused the change in bursting strength to differ depending on the type of softener. However, the amount of use of these softeners did not change the bursting strength performance.

Table 7. Burst strength variance analysis results

Parameters	F Value	p-value	Significance level
Model	26,70	< 0.0001	**significant**
A- Fabric Type	53,92	< 0.0001	**significant**
B- Pre-softening Softener Type	1,14	0.3321	insignificant
C- Number of Passages	14,98	0.0001	**significant**
D- Raising Speed	0,00	0.9492	insignificant
E- 2nd Softining Softener Type	73,24	< 0.0001	**significant**
F- 2nd Softining Softener Concentration	1,25	0.2866	insignificant

3D model graphs showing the interactions of these parameters (A-C, A-E and C-E) are shown in Figure 8, Figure 9 and Figure 10.

As seen in Figure 8-10, the strength values were higher in samples exposed to single passage raising process. In other words, the strength performances of the samples that were mechanically less exposed to the raising hooks over the raising machine were measured higher. This is a result of the direct break-off effect of the raising process on the fibers and the resulting fiber damage. Although there is no direct decrease after the first passage, the performance is lower after the second passage.

When examined in terms of softening at the end of raising, it shows that the fabrics to which Softener 7 is applied have higher strength performance and from here, the binder chemical in it has a positive contribution to the strength. When other softeners are examined, it has been determined that those with microparticle size show lower strength performance.

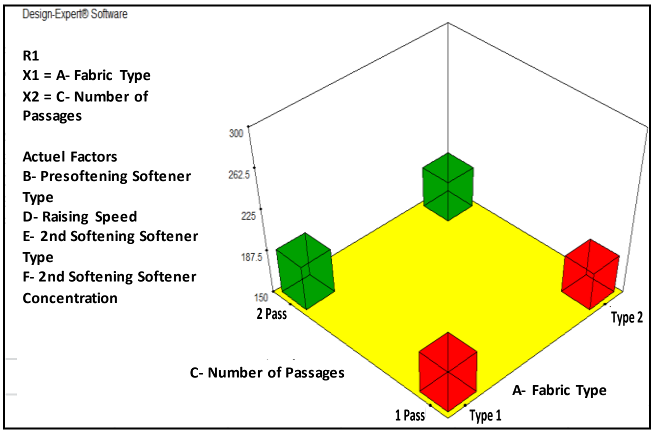

Figure 8. Model graph for bursting strength according to parameters A and C

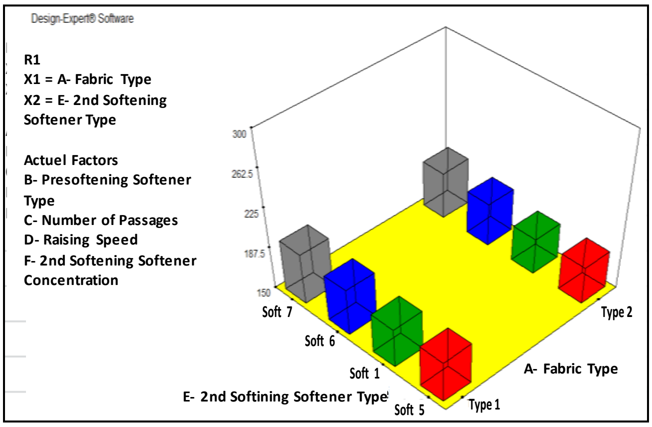

Figure 9. Model graph for bursting strength according to parameters A and E

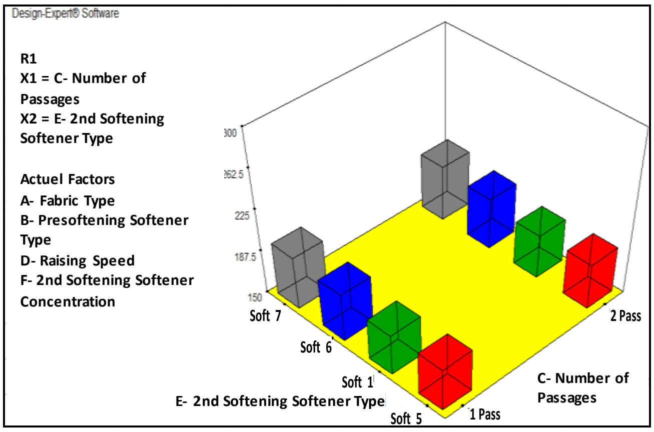

Figure 9. Model chart for bursting strength according to parameters C and E

3.3 Evaluation of the Air Permeability

One-way variance analysis results on air permeability test results are shown in Table 8. The normal distribution curve drawn to analyze the reliability of these test results is given in Figure 11. As seen in Figure 11, the curve shows a normal distribution character. When Table 8 is examined, it is seen that the model established is statistically significant. However, it was determined that C (passage number) and E parameters (The Type of 2nd Softening Agent), which are the main parameters selected as an input, are also significant on the output. However, it was determined that the parameters A (fabric type), B (Pre-softening softener type), D (raising speed) and F parameters (The Concentration of 2nd Softener Agent) had no effect on air permeability. It was determined that the most important factor on the change in air permeability performance is the number of raising passages. The difference in the air permeability value depending on the number of passages can be explained by the change in the surface hairiness after raising.

Table 8. The ANOVA results of Air Permeability Data

Parameters	**F Value**	**p-value**	**Significance Level**
Model	23,62	< 0.0001	**significant**
A- Fabric Type	0,22	0.6399	insignificant
B- Pre-softening Softener Type	0,52	0.6676	insignificant
C- Number of Passages	87,82	< 0.0001	**significant**
D- Raising Speed	7,62	0.0061	insignificant
E- 2nd Softining Softener Type	52,92	< 0.0001	**significant**
F- 2nd Softining Softener Concentration	1,15	0.3164	insignificant

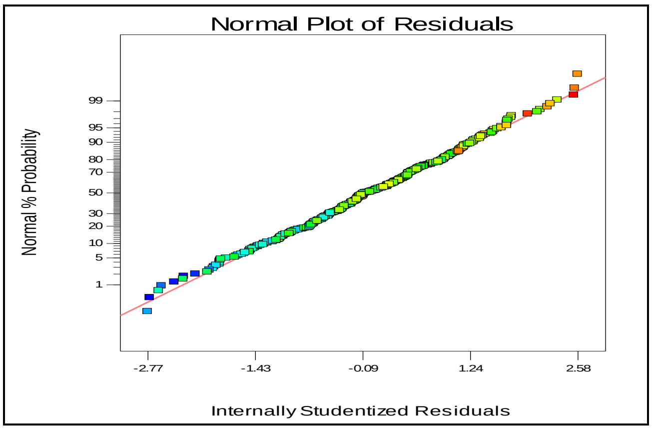

Figure 11. Air permeability normal distribution curve

The 3D model graph of parameter C (passage number) and parameter E (The Type of 2nd Softening Agent), among themselves is given in Figure 12.

As can be seen in Figure 12, the air permeability of the fabrics treated with softening agent 7 was higher. It can be concluded that, with the binder effect used in the recipe, the adhesion of the fibers in the fabric pores to each other and to the yarns on the surface creates a channel and increases the pore passage with the vacuum effect created by the channel. With the number of passages, one more combing was made. In this combing, fibers emerging in the first combing and physically weakly attached to the surface will fall off the surface. Thus, these fibers that reduce the permeability on the fabric surface will fall off and disappear. So that the fabric surface will be eliminated which reduces the permeability decreased in those fibers. The disappearance of these fibers was also proven in the test of raising fastness, in this respect there is a correlation between the results. Air permeability has increased due to the falling of these fibers from the surface. In addition, with the second passage raising process, the smoothing of the fibers on the surface and the raising effect can be counted among the reasons that cause this situation.

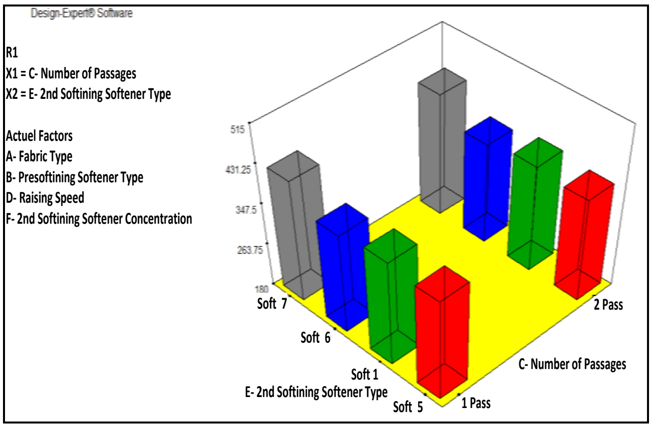

Figure 12. Model graph for air permeability according to C and E parameters

3.4 Test Results and Evaluation of Binder Applications

In the first part of the study, it has been seen that the use of binders (samples using Softener 7) improved raising fastness and other measured performance properties. Hereupon, it was decided to conduct a more detailed study on the use of binders and the study was deepened with 3 binders and 3 different concentrations. Accordingly, applications were made to Type 2 Fabric. In Table 9, the results of the tests (raising fastness, air permeability, and bursting strength) made on the samples obtained with the trial plan and planned trials using binder are given. Table 9 also shows the performance data of the reference fabric..

When the values in Table 10 are examined in terms of raising fastness, it has been determined that the reference sample with a performance of 3 showed an improvement of 0.5 - 1 points after binder applications. It was observed that the binder concentration was not an important variable, but the best results were measured after polyacrylate-derived binder application (Experiments 8 and 9). This situation led us to conclude that the active substance forming the chemical structure of the binder material adheres the raising fibers to the fabric surface better than the others.

Table 9. Test results for binder trials

Trial number	**The type of binder**	**The concentration of binder (g/l)**	**Raising fastness**	**Air permability (l/min)**	**Bursting streng (kpa)**
1	A	10	3/4	192	207
2	A	30	3	179	206
3	A	50	3/4	181	207
4	B	10	3	203	215
5	B	30	3	189	213
6	B	50	3	195	211
7	C	10	3	192	215
8	C	30	4	195	223
9	C	50	4	181	221
Original Sample (without binder)			3	218	218

When evaluated in terms of bursting strength, it was seen that the strength of the reference sample was 218 kPa, while all other trials were almost the same. It has been determined that these tests have no effect on bursting strength.

When the data shown in Table 10 are examined in terms of air permeability, it was determined after the measurements that all trials were at least 10% lower than the air permeability of the reference 218.78 l / min in the same table. Here, it has been determined that the layer formed by the polymeric binder chemical reduces the permeability and thus the comfort of use. However, it has been observed that there is no significant difference between polymer concentrations or types, they all cause a similar decrease.

4. CONCLUSION

3 thread futter knitted fabrics are fabrics known for raising the back side and napping the yarns on this side. This back surface napping is an application that improve the touch, bulk, and comfort properties of the fabric. However, when the back yarn is raising, the fibers in its structure cannot be attached to the fibers located in the yarn, its weak adhesion on the surface causes these fibers to form debris with mechanical effect. Then these rashes stick to their clothes or body in a way that disturbs the consumer. This negativity is recorded as the most important quality and reason for return by the consumer for the garments made of 3 thread fabrics. Within the context of the study, it is aimed to determine the changes over the physical performance properties of the fabric such as raising fast ness, air permeability, and bursting strength of some chemicals (silicone softeners, binders, etc.) which are used before and after the raising process and minimize the problem of raising fastness performance and therefore the problem of fiber shedding due to raising for 3-yarn fabrics. In order to make this evaluation, the results of the burst strength and air permeability tests, both of which are important for this type of knitted fabrics, were also examined in addition to the fiber loss performance, which is described as raising fastness.

In terms of raising fastness, performance, and product cost evaluation of all examined parameters for both fabrics (Fabric 1 and Fabric 2) was made. As a result, Type 2 fabric, which is single passage raising with Softener 7, gave the best performance. It can be emphasized that Pre-softening and raising speed do not affect the fastness of raising in terms of performance, but considering the cost factor, it can be emphasized that working with speed 2 and Softener 1 will be more economical because fast working will directly contribute to production. While the end of raising softener type is very effective, it has been determined that the amount of use has no statistically significant effect. Accordingly, it can be said that using softener 7 at a low rate (5 g / L) would be more optimal. A comparison of parameters in terms of rasing fastness can be seen in Table 10. According to table 10, the most suitable parameters in terms of raising fastness can be listed as follows; Type 2 fabric, Pre-softening softener 1, 15 m/min raising speed, single passage, and low concentration (5 g/l) with 2nd softening softener 7.

In terms of bursting strength, the strength values were higher in knitted samples with a single passage raising. Likewise, it was determined that the fabrics in which the softener 7 substance was applied in the softening at the end of the raising showed higher strength and from this, the binder in the Softener 7 made a positive contribution to the strength. It is thought that the other three parameters (Pre-softening Softener Type, Raising Speed and The Concentration of 2nd Softener Agent) do not have statistically significant effects and it will be sufficient to evaluate them only in terms of cost. As a result of the evaluations made in terms of performance and cost for bursting strength, suitable working conditions; It was determined that it is similar to the process sequence specified in raising fastness.

As a result of the performance evaluation for both fabrics in terms of air permeability, it was determined that all parameters were very close to each other, and fabrics treated with Softener 7 only after raising were more permeable.

The high performance demonstrated by the application of Softener 7 in 3 thread futter fabrics created the need for a more detailed study of the studies on the binder. As a result of the experiments conducted to examine the use of binder in raising fabrics, it was determined that the use of binder improves the fiber loss performance after raising regardless of the concentration but does not change the burst strength. However, it has been observed that it harms air permeability and touch. It has been determined that polyacrylate-based binders improve the fastness of raising, but together with it increase the hardness of the fabric.

Table 10. Comparison of parameters in terms of rasing fastness

Parameters	**The type of fabric**	**The type of pre-softening agent**	**The number of passages**	**The speed of raising**	**The type of 2nd softener agent**	**The concentration of 2nd softener agent**
Level	Fabric 2 Type 2	Softener 1	Single Passage	S2-15 m/dk.	Softener 7	**Low-5 g/l**
Technical Results	Better performance	No matter	Better performance	Better performance	Better performance	No matter
Economical Results	More economical	No matter	More economical	More economical	No matter	More economical

It was seen that the best result in terms of raising fastness was the fabric with 50% waste + 50% Polyester back yarn. As a process, it was determined that the best result was obtained after a single passage with micro silicon pre-softening and raising at a speed of 15m / min, and then a low concentration 2nd softening process with a polyvinyl acetate-based binder and softener mixture. It has been observed that the binder additive also increases the bursting strength and air permeability.

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