



RF Stalam Drying Automation

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ABSTRACT

The basis of the textile industry is yarn production. Many processes are applied to the yarn during the production phase. The last and most important of these processes is the drying process. There are various drying methods for the drying process and RF-Satalam dryers are discussed in this study. There are electrodes above and below the conveyor belt in these dryers. With the help of these electrodes, the water in the wet bobbin is evaporated by friction force and removed from the yarn. All process steps such as belt speed, drying parameters, electrode position of the machine determined by the machine operator have been automated with the developed system. With the barcode read to the system, it brings the data from the ERP database to the PLC system, where the raw weight of the wet coil is calculated and the tape speed and electrode level are determined.

RF Stalam Kurutma Otomasyonu

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ÖZET

Tekstil sektörünün temelini iplik üretimi oluşturmaktadır. İpliğe, üretim aşamasında birçok işlem uygulanmaktadır. Bu işlemlerden sonuncusu ve en önemlisi kurutma işlemidir. Kurutma işlemi için çeşitli kurutma yöntemleri olup bu çalışmada RF-Satalam kurutma makineleri ele alınmıştır. Bu kurutma makinelerinde yer alan taşıyıcı bandın altında ve üstünde elektrodlar yer almaktadır. Bu elektrodlar yardımıyla ıslak bobin içindeki su, sürtünme kuvveti ile buharlaştırılarak iplikten uzaklaştırılır. Makine operatörü tarafından belirlenen makinenin bant hızı, kurutma parametreleri, elektrot konumu gibi tüm işlem adımları geliştirilen sistem ile otomatik hale getirilmiştir. Sisteme okutulan barkod ile ERP veri tabanındaki verileri PLC sistemine getirir ve burada ıslak bobinin ham ağırlığının hesaplanması sağlanarak bant hızı ve elektrod seviyesi belirlenir. Böylece yapılan yanlış hesaplamaların önüne geçilerek yangın riski ortadan kaldırılmış, makinede oluşabilecek elektrik hasarlarının önüne geçilmiş ve sistem daha verimli hale getirilmiştir.

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Introduction

The textile sector, which is one of the oldest branches of industry in our country, also constitutes an important part of exports. Turkey ranks sixth in the world in terms of installed capacity and number of spindles in the textile industry. This production capacity has made our country the largest textile producer in Europe. In this respect, it provides important gains to the country's economy. The increase in the production volume with each passing day brings about an increase in employment opportunities. The responsibilities of the textile companies in our country are increasing in order to ensure the continuity of the increase in this field and to continue to have a say in the textile sector in the world. In this context, textile companies in their production; they should be based on quality, correct production, sustainability and efficient energy use. While it has become inevitable for companies to produce new products / machines in line with these foundations, the improvements they will make have revealed their R&D activities.

Yarn production constitutes the basis of all activities of the textile sector. Therefore, yarn production constitutes the priority area in innovation studies. Yarns are materials that have a certain length, number of twists, fineness and can be dyed. The fibers that make up the threads are called fibers. The yarn industry has many processes and steps in the production phase. In the period until the final product is obtained, yarn; It is subjected to processes such as dyeing, printing, coloring and drying. The final stage, drying, is a process that requires significant energy and cost. In this process, which is carried out to remove moisture from the yarn, first of all, mechanical processes are applied. However, since mechanical methods alone are not sufficient, full drying is carried out by applying secondary methods (Ribeiro, 1995; Akarsalan, 2002; Akyol, 2007).

The quality of the yarn depends on the dyestuff and chemicals used in the dyeing of the yarn, the fixation process and drying as the last step. While a correct drying method makes the yarn higher quality, incorrect drying can cause the yarn to be of second quality, to be wasted or even to burn. Therefore, the drying process is a very costly and time-consuming process. Therefore, the possible ratio of the amount of water in the yarn should be removed by mechanical means. In addition, determining the state of the water contained in the yarn is an important parameter in the effectiveness of the drying method to be applied. Water can be found on textile products as indicated in Table 1. (Le, 1995; Güneban, 2005; Akyol, 2010; Akyol, 2011)

Table 1. Types of water on textile products

Dripping water	It is water that can flow down the product with its own weight by not making bonds with the fibers, which can be completely removed by mechanical drying methods.
Surface water	It is water that can bond on the surface of the product with its adhesion force, but only a certain part of it can be removed by mechanical methods.
Capillary water	It is water that binds to the surface of the fibers forming the threads by adhesion forces. However, some of them can be removed by mechanical means.
Inflatable water	It is the water that binds to the fiber molecules forming the yarn with dipole forces and causes the fiber to swell, but is removed from the product by thermal methods.
Hydroscopic moisture (crystal water)	A well-applied drying method is water, which must be present in a textile product at the end. If this amount of water is removed from the product, the hold of the product will deteriorate and it will not be possible to reintroduce it into the product at the same rate.

Drying in the yarn is the method of removing these amounts of water in the yarn from the yarn by means of heat transfer. This process has become the most important step of the yarn production stage in terms of cost, quality and efficiency. There are various drying methods and machines used in the textile industry to perform this process (Jhanji et al. 2015; Gallopi et al. 2017). In addition, there is a pre-drying process applied before the drying method. The purpose of this process is to save energy by reducing the amount of energy to be used in the drying process.

The pre-drying process is carried out with three different methods. These methods are as follows: Spinning is the method performed by passing the wet textile product between rollers with a certain speed. In this method, the amount of water contained in the product is removed by vacuuming. Centrifugation is a method in which surface water is removed from the wet product by utilizing centrifugal force. After one of these methods for pre-drying is applied to the yarn, for the actual drying; convection drying, conduction drying, infrared (infrared) drying or radiofrequency dryers are preferred.

In the drying method, in which air and other gases are used as the heat source, the heated and dehumidified air comes into direct contact with the textile product, allowing the water in the product to evaporate. Hot air or other gases used are passed over and between the product to be dried. Due to this feature, it is also known as the hot air drying technique (Akyol, 2011). These dryers; they are tensioned, conveyor belt and air cushioned, hot-fluelar, perforated drum dryers (Karakoca, 2017).

In these drying machines, the yarn bobbins placed for the machine are exposed to air at a certain temperature and pressure, first from the outside to the inside, and then from the inside to the outside, and the drying process is carried out.

In the conduction drying method, firstly, the rollers are heated with hot steam or oil, then the textile product to be dried is directly contacted with the surface of the roller and the drying process is performed. However, in this process, since the product directly contacts the surface of the heated roller, it may cause overheating (Karakoca, 2017). Therefore, necessary precautions should be taken to ensure that the heating before drying is homogeneous. It is not preferred due to the need to develop unique control methods and high investment costs.

Infrared drying method, also known as radiation drying, is a heat transfer method that takes place in the form of electromagnetic waves from a high-temperature surface. In this method, which is used in cases where it is desired to reduce the amount of water in the product below 25%, the temperature can rise above 500 °C. Therefore, the risk of over-drying is very high (Karakoca, 2017).

In radio frequency dryers, no heat is taken from the outside for the drying process. The water molecules on the product passing between two capacitor plates connected to the alternating current are in constant motion thanks to the high frequency. The heat energy generated by this movement causes the evaporation of the water molecules and ensures the drying of the product.

They are drying machines that are widely used for drying open fiber, tops, hank, bobbin and ready-made clothing products. In order for the drying to be economical, the free water on the product is removed by pre-drying and subjected to the main drying process in the radiofrequency (RF) dryer. Although the initial setup cost is high, it provides an important advantage by providing a fast and effective drying opportunity (Karakoca, 2017).

Material and Methods

In the textile sector, the fibers are dyed after being turned into yarn. After the dyeing process, the yarn is dried in order to give the yarn its final shape and to ensure the permanence of its colour and to remove the water in it. The main logic of the drying process is to remove the water in the solid. In this process, it is very important to create the most suitable method that will make the right drying without compromising the yarn structure, colour and quality by consuming minimum energy. Improvement studies were carried out on the RF-Stalam dryer, which is considered within the scope of this study, for a more accurate and efficient operation. The current situation was analysed and the needs were determined before the studies. In a standard yarn bobbin drying process, the bobbins are first placed in

centrifugal machines where centrifugal force is used to remove excess water on them. In these machines, excess water is removed by rotating the coils at 1500 rpm for an average of 3 to 6 minutes.



Figure 1. Yarn bobbin centrifugal dryer

Afterwards, while the yarn bobbins dyed in the current system are dried, the bobbins are placed on the tape on the RF-Stalam dryer. The operator calculates the raw product kilogram and wet product kilogram by taking the work orders of the yarn bobbins coming out of the dyeing process. The belt speed of the dryer is calculated and adjusted according to the wet coil kilogram.

Belt Speed Calculation is done with the following formula.

$$V_{belt\ speed} (m/h) = (kW \times I,2) / (B \times S)$$

B: Number of coils per meter (pcs)

Q: Amount of water in a coil (kg)

Except for these formulas based on, all hank dryers are dried at a constant speed of 40 kW and 4.5 m/h. 16 hanks are placed on a one meter long tape, 4 side by side, in 4 layers, and the electrode is adjusted to the highest level by the operator.

According to the values in Table 1, the tape speed is calculated and the sequence is made.

No cloth is placed on the tape for muff dyeing. However, in all other viscose blended dyeing's, a dry and clean polyester cloth should be placed on the tape. In the 10" stalam, the electrode is used at the upper level for 10" bobbins and at the lower level for 6" bobbins. In this calculation made manually by the operator in line with all this information, if the tape speed is faster than it should be, the bobbins can come out of the drying process moist before they dry, or if the tape speed is slower than it should be, the yarn bobbins. It may ignite inside the machine and cause a fire. In such a case, the process will start again and the yarns obtained from the new products will be dyed and dried again.

Table 2. RF-Stalam band velocity calculation table

FIBER	10" STALAM			
	kW	Bobbin per 1 meter	Electrode Level	Speed of Band (mt/h)
2x78/68 dtex/Nylon Half Matt	40	11x5=55	Low Level	12
Acrylic (10")	40	28		
Acrylic (6")	60	28		
Acrylic / Nylon (Light Color)	55	28		
Acrylic / Nylon (Middle-Dark Color)	55	28		
Acrylic / Cotton	60	28		
Acrylic / Polyester	40	28		
Acrylic / Wool	60	28		
B438 Vis / Nyl	55	21	Low Level	4,5
B438 Vis / Nyl (optical)	40	21	Low Level	4,5
Nylon	40	28		
Cotton (except for softening and optical stanining)	40	>1200 gr:28, <1200 gr:36		
Cotton or Viscon (softening and optical stanining)	40	28		
Cotton / Polyester	55	28		
Polyester	30	28		
Polyester / Viscon	55	28		
Viscon (except for softening and optical staining)	70	>1200 gr:28 <1200 gr:36		
Wool	60	28		
Nylon (Kod1569-Kod2079-Kod2153) 8"	40	28		
Polyester / Viscon (C92)	55	28		
Polyester (K2056)	30	28		
KOD3196 PES	30	18 Hank		

**Figure 2. RF-Stalam drying**

This results in extra costs and loss of time. Considering all these problems that may arise, it has become necessary to make an improvement on the system and to minimize the errors that may arise from the operator or the machine. In line with these needs, a new system has been developed in the study. Thanks to this system, an automation system has been introduced that automatically determines the operating rules of the machine according to the raw material. For this, first of all, the inputs and outputs needed in the hardware were evaluated within the scope of the study. Electrical, electronic and mechanical equipment has been determined. As shown in Figure 3, necessary electronic circuit designs have been made in accordance with the system and data.

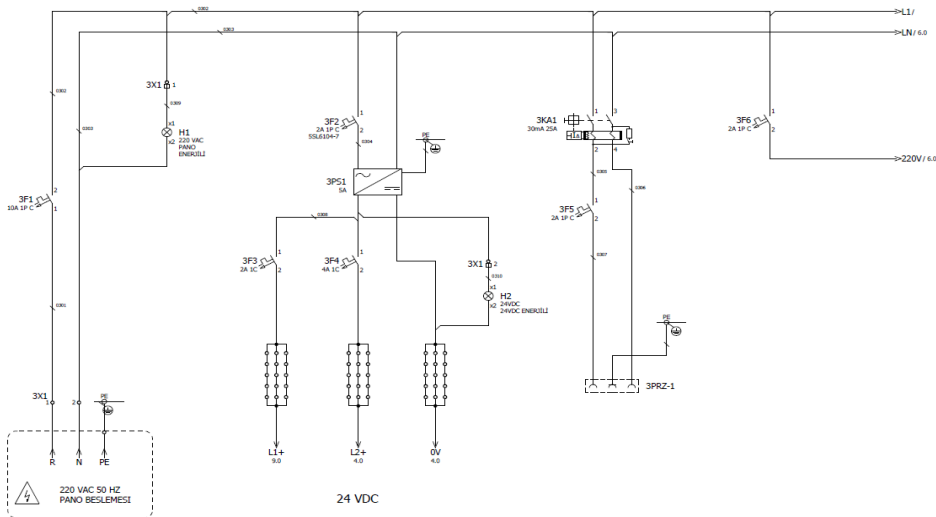


Figure 3. RF-Stalam Board Supply Line

In addition to the electronic circuit designs made, the system digital average was poured and the software system was developed. While developing the software, first of all, the parameters affecting the drying process were determined. These; raw material, bobbin weight, bobbin height. Thanks to the software developed as shown in Figure 4, all yarn types, their weights and the amount of water they contain are introduced to the system.

```

1 ALTER PROCEDURE SP01_KurutmaUrunOzellikGetir_Esas
2 AS
3 DECLARE @IthostName VARCHAR(150) = dbo.IthostName();
4
5 DELETE TMP01_KurutmaUrunOzellikleri
6 WHERE IthostName = @IthostName;
7
8 INSERT INTO TMP01_KurutmaUrunOzellikleri
9 (
10 KurutmaID,
11 UrunNo,
12 Kilowatt,
13 ElektrodBoyuu,
14 Katsayi,
15 Ortalama_Su_Cekme,
16 Metreye_Bobin_Sayisi,
17 IsFarkliHesap,
18 BantHizi,
19 IsStalam,
20 IthostName
21 )
22 SELECT OzellikID,
23 UrunNo,
24 Kilowatt,
25 ElektrodBoyuu,
26 Katsayi,
27 Ortalama_Su_Cekme,
28 Metreye_Bobin_Sayisi,
29 IsFarkliHesap,
30 BantHizi,
31 IsStalam,
32 @IthostName
33 FROM KURUTMA_Ulusoy.dbo.UrunOzellikleri
34 ORDER BY UrunNo;
35
36 GO
37

```

Figure 4. Software that introduces the drying features to the system

Thus, it has become sufficient to read the lot numbers of the bobbin yarns into the system. The system automatically sends drying instructions to the dryer in line with the batch numbers read into the system.

Product No	Product	Kilowatt	Electrode Size	Coefficient	Average Water Content	Bobbin per Square Metre	Different Account?	Speed of Band	Stalam?
218	Ne 24/1-ACRYLIC-RING-251-560 Z TM	40	45	1,7	10	28			
218	Ne 24/1-ACRYLIC-RING-251-560 Z TM	60	1	1,2	10	28			✓
219	Ne 20/1-ACRYLIC-RING-251-590 Z TM	60	1	1,2	15	28			✓
219	Ne 20/1-ACRYLIC-RING-251-590 Z TM	40	45	1,7	15	28			
984	Ne 16/1-ACRYLIC-RING-251-440 Z TM	40	45	1,7	10	28			
984	Ne 16/1-ACRYLIC-RING-251-440 Z TM	60	1	1,2	10	28			✓
1012	C000042-Nm 4.50-VISKON%70+COTTON%30-880 S TM	60	0	1,2	65	21			✓
1018	C000050-Nm 8-POLYESTER-1000 S TM-0.70	30	0	1,2	15	28			✓
1040	C000029-Nm 8-ACRYLIC-1000 S TM-0.70	40	0	1,2	10	28			✓
1054	FETTUCCIA-Nm 2.40-ACRYLIC	40	0	1,2	10	28			✓
1623	Ne 30/1-VISKON-RING-690 Z TM	40	60	1,5	65	21			
1623	Ne 30/1-VISKON-RING-690 Z TM	70	1	1,2	65	21			✓
1859	M01380A-Nm 23-FLOŞ%65+NAYLON%35-500 Z TM	55	1	1,2	50	28			✓
1859	M01380A-Nm 23-FLOŞ%65+NAYLON%35-500 Z TM	40	45	1,5	50	28			
1895	CORESPUN-Ne 30/2-VISKON%72+ELASTAN%28-330 S	30	1	1,2	50	9			✓

Figure 5. Yarn grades introduced into the system

According to the system, the operator only reads the work order of the dyed yarn with a barcode reader, thanks to the barcode in the work order, the necessary data from the ERP database comes to the PLC and the PLC calculates the average raw weight of a bobbin, thanks to the bobbins placed in the weighing unit, the wet bobbin average is calculated on the PLC, and amount of water is found. The system calculates the belt speed according to the number of coils to be placed on the belt.

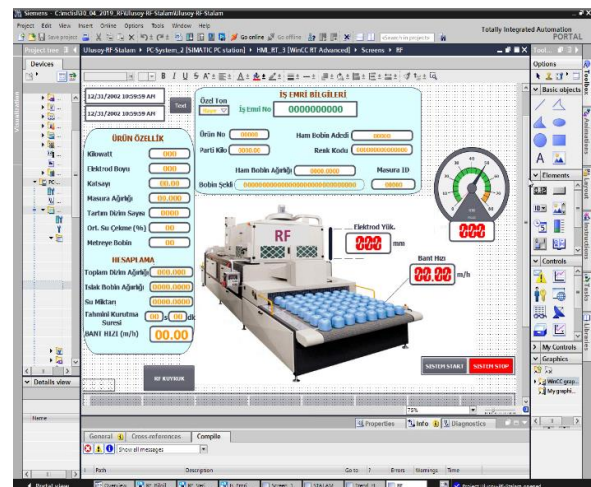
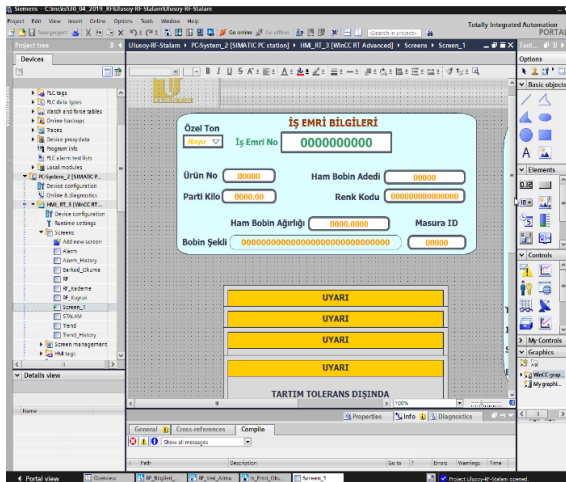


Figure 6. The screen of the developed system available to personnel

Thus, human errors arising from incorrect drying times calculation have been eliminated. Correct drying was ensured in one go, excess energy consumption was prevented and the cost per unit product was reduced.

Results and Discussion

Radiofrequency dryers are drying machines that are widely used in drying open fiber, tops, hank, bobbin and ready-made clothing products, where bulky textile products can be dried uniformly in a short time and in accordance with the desired humidity rate. Therefore, within the scope of this study, radiofrequency (RF) dryers are discussed in order to make drying economical.

Since the calculations are made and controlled by the system, the possibility of error is eliminated. Since the machine speed and drying power settings are automatically taken from the system, problems such as incomplete drying of the yarns or melting and burning of acrylic yarns are eliminated. The smoke produced by the combustion of acrylic yarns is toxic. Therefore, the system has become safer in terms of occupational safety and environment. The workload has been lightened and the system has been made independent from the personnel. Thus, the need for qualified personnel was eliminated. A waste-free and uninterrupted process was ensured. As a result, drying processes that make up 0.3% of the monthly total drying and result in burning were not seen after the field implementation of the project.

Conclusion

Since the calculations are made and controlled by the system, the probability of error has approached 0. Since the machine speed and drying power settings are automatically taken from the system, problems such as incomplete drying of the yarns or melting and burning of acrylic yarns are eliminated. Also the smoke produced by the combustion of acrylic yarns is toxic. Therefore, the system has become more secure in terms of occupational safety. The workload has been lightened. The need for qualified personnel has disappeared. A waste-free and uninterrupted process is provided.

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Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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