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Mechanical Drive Random Short Pattern Machine Prototype

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ABSTRACT

One of the important producers of the industrial industry in our country is the textile sector. The importance of the textile industry for our country is growing day by day with increasing production and employment. In order to keep up with this growth, manufacturers need to go beyond their existing systems, show their differences and make the right innovations in their production. Considering these values, changes to be made in the yarn structure or dyeing process come to the fore. In this study, the dyeing process is discussed. Weaving and home textiles, which are an important part of the textile industry, have a wide market. There are different dyeing systems that have an important market for the products made in these areas. Spaced and smart painting, which are among these painting systems, do not meet the needs in the desired direction. A new machine design is needed to provide the desired features. In the study conducted in this direction; A commercially unavailable machine has been implemented, designed and manufactured to generate random short patterns with mechanical drive. In project scope; First of all, the paint stand to be integrated into the system was designed . Different yarn lifters and godet systems have been designed. Paint container, drive system and electronic panel are also mounted on the system. In addition, new software has been developed within the scope of the project to provide automatic control of the system. Studies were carried out with PLC and Arduino electronic circuit board. In the first stage, motor driver circuits were designed with PLC and Arduino. Then, with the software loaded on the PLC and Arduino processor board, the frequency values to be given to the inverter were started by changing the threshold ranges we wanted. Lifters and painting cylinders are connected to each other so that the same sequence is not repeated. Thus, in this study carried out in line with the needs, both a new machine and a new textile product with different dye patterns emerged.

Mekanik Tahrikli Rastgele Kısa Desen Yapan Makine Prototipi

Araştırma Makalesi

ÖZ

Makale Tarihçesi:
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Tekstil
Akıllı boyama
İplik boyama

Ülkemizde sanayi endüstrisinin önemli üreticilerinden biri de tekstil sektörüdür. Ülkemiz için tekstil sektörünün önemi, artan üretim ve istihdam ile her geçen gün büyümektedir. Bu büyümeye ayak uydurabilmek için üreticilerin mevcut sistemlerinin dışına çıkarak farklılıklarını ortaya koyabilmeleri ve üretimlerinde doğru yenilikleri yapmaları gerekmektedir. Bu değerler göz önüne alındığında iplik yapısında veya boyama işleminde yapılacak değişiklikler ön plana çıkmaktadır. Bu çalışmada boyama işlemi ele alınmıştır. Tekstil sektörünün önemli bir parçası olan dokuma ve ev tekstili geniş bir pazara sahiptir. Bu alanlarda gerçekleştirilen ürünler için önemli bir pazara sahip olan farklı boyama sistemleri bulunmaktadır. Bu boyama sistemleri arasında yer alan degrade ve akıllı boyama, istenilen yönde ihtiyaçları karşılamamaktadır. İstenilen özellikleri sağlamak için yeni bir makine tasarımına ihtiyaç vardır. Bu doğrultuda yapılan çalışmada; Mekanik tahrikli rastgele kısa desenler oluşturacak şekilde tasarlanıp üretilmiş piyasada bulunmayan bir makine hayata geçirilmiştir. Proje kapsamında; Öncelikle sisteme entegre edilecek olan boya standının tasarımı yapılmıştır. Farklı iplik kaldırıcılar ve godet sistemleri tasarlanmıştır. Sisteme ayrıca boya kabı, tahrik sistemi ve elektronik pano montajı yapılmıştır. Ayrıca sistemin otomatik kontrolünü sağlamak için proje kapsamında yeni yazılım geliştirilmiştir. PLC ve Arduino elektronik devre kartı ile çalışmalar yapılmıştır. İlk aşamada PLC ve Arduino ile motor sürücü devreleri tasarlanmıştır. Ardından PLC ve Arduino işlemci kartına yüklenen yazılım ile invertere verilecek frekans değerleri, istediğimiz eşik aralıklarında değiştirilerek start verilmiştir. Lifterler ve boyama silindirleri birbirine bağlı hale getirilerek aynı sıranın tekrarlanmaması sağlanmıştır. Böylece ihtiyaçlar doğrultusunda gerçekleştirilen bu çalışmada hem yeni bir makine hem de farklı boya desenlerine sahip yeni bir tekstil ürünü ortaya çıkmıştır.

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Introduction

Since the formation of industrial sectors, people have aimed to obtain quality and more products in a short time. In the light of studies based on these reasons, the distribution of work between people and machines came to the fore and the basis of machine design studies was laid. Many improvements were made in textile machines under developing and changing conditions, new prototype studies were continued. Fancy yarn production and dyeing process in the field of textiles is quite detailed; The annual trend may change according to the need and demand. In this case, the role of innovation and R&D studies is of great importance in order to produce value-added products. Also, when we compare the production and dyeing of fancy yarn in small lots with large lots; We see that it is disadvantageous to a large extent in the fields of labor, production time, waste, waste and energy. Despite the high rate of textile exports, Turkey is heavily dependent on foreign sources for the supply of production machinery and chemicals. Lateness in production-oriented approaches and R&D activities and insufficient studies in this field are among the reasons for this foreign dependency. Although the textile industry is a labor-intensive industry, the labor costs in our country are below the European average. Turkey is in a disadvantageous position when compared to China and other rival Asian countries. In this process, where Turkey set out with the advantage of cheap labor, against China,

where it cannot compete in terms of cost ; It competes with flexible production, value-added product development, innovation and branding. When this situation we are in is considered on the basis of enterprises producing fancy yarn; It accelerates the studies on developing new products that will create added value, R&D studies carried out in environmentally friendly dyeing processes, process improvement studies, energy saving, producing more products in a short time, reducing the amount of waste generated and evaluating the waste in another area. Dyeing processes in the field of textiles are carried out by various methods. After the fibers are spun into yarn, dyeing before they are woven or knitted is called yarn dyeing. Yarn dyeing can be done in two different forms of yarn. First, the threads are made into bobbins and dyed in this form, or the threads are dyed by turning them into hanks. Apart from these, we call gradient painting; These are the processes that take place in the form of dyeing the yarn in bobbin or hank printing method and then end with spin and drying side processes. Although the yarns dyed with the spaced method are especially used in the field of hand knitting and carpet, spaced dyed yarns are preferred as an effect in weaving. In spaced dyeing, production is more difficult and less amount of production than flat dyeing. Also there are not standard processes such as spaced dyeing processes, flat dyeing processes, but there are many parameters controlled by humans during dyeing. Therefore, it is likely that there will be more tonal differences between batches than flat paint batches. Because more than one color is printed on the yarn at the same time and these colors nuance each other during the fixing, washing and softening stages. In spaced dyeing, chemical degradation events occur more frequently than in plain dyeing. Therefore, it is important to repare the mixture in the recipes in order to reduce the amount of waste material given to the environment. It is aimed to minimize the damage to the environment, while ensuring that the chemicals and dyestuffs in the recipes used with the correct dyeing method are used more effectively. The amount of waste given to the environment can be reduced by choosing the right chemical and dyestuff and dyeing in one go. In addition, the high number of parameters that must be controlled by humans in spaced dyeing leads to automation studies. Thanks to the spaced fancy yarn dyeing machine, yarn production can be made in many areas. The resulting products can be made in certain quantities from light to dark, from dark to light, or by choosing different color groups. This process is realized by means of painting stand, paint containers, pump, lifter, creel, passage ways washers, motors. In the current system, servo motors keep the lifter pressed as much as the quantities defined in the PLC software and adjust how many centimeters to paint.As a result of this system, which is repeated until the dyeing process is finished, it is seen that it repeats itself as a pattern when the yarns dyed from light colors to dark colors or from dark colors to light colors are weaving. With the new design, the random data generated in the PLC is sent to the inverters controlling the asynchronous motors as frequency information.In this way, the motors are randomly accelerated and decelerated. It is ensured that an image that does not repeat each other is created in the pattern that emerges as a result of the study (Mahmudova, 2018; Patnaik, 2018; Saggiomo, 2018; İlhan, 2019; Ku et al., 2020).

Material and Methods

In the textile sector, especially in recent years, with the effect of Far Eastern companies, the sales prices of the products have decreased considerably and the competitive conditions have become more difficult, and it has become mandatory for the companies to work at lower costs without compromising on high quality in order to continue production. Improvement studies that will produce valuable new products have gained importance. Studies have been carried out to design a machine that will create a new product by changing certain parameters on the spaced Dyeing machine, which is considered within the scope of this study. Before the studies, the current situation was analyzed and the needs were determined. In the current system, the dyeing process is carried out by using viscose and polyester raw materials in the spaced dyeing machine as shown in Figure 1. Within the scope of this process, firstly, the raw materials in coil form are attached to the creel and passed through the yarn passageways. Before dyeing, the necessary washers and weights are placed to adjust the thread tensions. There are four painting boats and there are four cylinders where have been in painting boats.

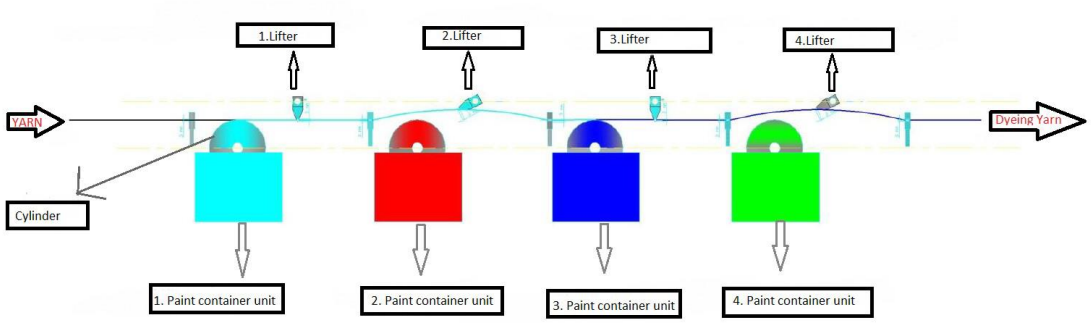

Figure 1. Painting machine autocad drawing

The dyeing process is realized by the servo motors controlled by PLC software moving the lifters. The quantities are entered manually. The drying process is carried out with the help of godets. For viscose yarns, the drying process is carried out at an average of 150-180 degrees with the help of 1 godet. For polyester yarns, there are 2 godets dry and one of them dries at 90 degrees and the other at 120 degrees. In some of the yarns produced according to the market needs, the centering process is performed and thus a knotty structure is provided to the yarn at certain intervals. After centering, the yarns are wrapped on perforated plastic bobbins and the winding process is carried out. As can be seen in Figure 2, in order to ensure that the process continues uninterrupted, the dyed mixture prepared in 50 kg barrels next to the machine is continuously circulated to the dye trough with an aquarium pump. In this way, the paint and chemicals in the barrels are mixed continuously to prevent collapse.

Figure 2. Spaced yarn dyeing machine

The yarns that emerge after dyeing are subjected to drying and fixing processes. Afterwards, puffs are taken from the bobbins selected by sampling method, as in Figure 3, in order to be able to control the color. Compliance approval is given by the quality control unit by comparing the master color with the puffs. All processes are repeated by preparing a new mixture in the barrels.

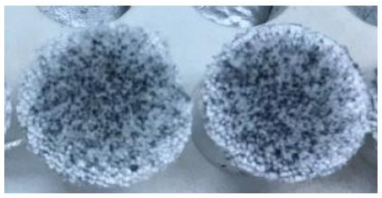

Figure 3. Selected examples

The pattern that emerged after weaving with the existing yarns was examined. It was determined that there were repeating images in this pattern.In order to create a new trend and to use the yarns in different markets, research and analysis were carried out. In this direction, mechanical and software improvement and revision studies of the existing machine were started. Unlike computers, PLCs are devices used for programming complex systems, thanks to its microprocessor, which has many inputs and outputs.When examined in terms of PLC operating systems, it consists of 3 steps. The first of these is "testing the input status." In this step, the on / off states of the switches and sensors in the PLC are checked. In the second step, the "programming execution process" is done. In this step, the data stored in the previous step is checked. appropriate operation is performed. In the third step, it controls the output signals and adjusts them as needed. After the third step, the system returns to the beginning and is repeated continuously. Before PLCs, relay cards were used for automation processes. Thanks to PLC, special designs were developed for the electromechanical control of machines such as conveyor belts, pneumatic equipment, robots etc. that make up the production lines. There are microcontroller boards on them, as in Arduino, and there are input and output connections. In this way, reading data from various sensors, controlling various output units (actuators such as motor drivers, solenoid valves, etc.) according to the created program scenario, and other input and output and monitoring

(SCADA) takes part in ensuring communication with the units. The biggest difference of PLCs from microcontroller cards as we know them is that they are designed to operate in much heavier physical conditions (high or low temperature, dust and humidity, mechanical vibration and impact, electronic interference and noise, etc.) while maintaining their stability. There are many studies about PLC, some of them are as follows; Brindha et al. realized the color acquisition system fully automated by using PLC, SCADA and Arduino. They obtained the color mixes they wanted in their study as a result of the color choices they assigned, thanks to the MATLAB GUI. They created other colors based on the primary colors yellow, red and blue. The authors used Arduino to control the process and aimed to increase efficiency, reduce cost and profit (Brindha, 2018). Becerikli conducted a study that he addressed the problems arising in PLC and SCADA based weighing and dosing systems. In this study, he aimed to find solutions by addressing external factors affecting weighing quality. In this system, three different chambers are compared with pneumatically controlled weighing, pneumatically controlled weighing using manual correction coefficients and proportional pneumatic valve using PID controller (Becerikli, 2013).

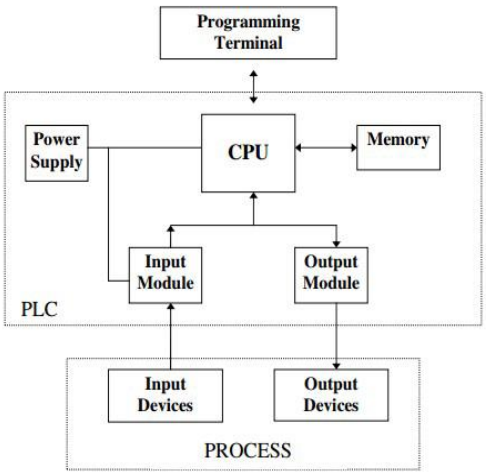

Figure 4. PLC structure

Ahvad et al. used the PLC system to mix green and blue colors and obtain the Cyan color. They have integrated a photoelectric sensor that can detect bottles on a conveyor belt powered by an AC motor. They used a color level sensing sensor to produce the same amount of product each time. The commands are created in the PLC and visualized the color production with SCADA on the computer screen (Avhad et al. 2017). The most important factor that enables the formation of different yarn pattern lengths is the motors that enable the lifter and dye rollers to move. Within the scope of the development of the prototype, the working principle of the currently used servo motors has been examined. A servo motor is any motor with feedback, closed loop control and is only part of a servo mechanism where negative feedback is used to control the performance of the motor. However, the commonly used industrial servo motors are regular AC induction motors with additional features such

as a low inertia rotor, high torque braking, and a built-in encoder for speed and position feedback. All these components come together to work with the servo drive. In the new design, asynchronous motors were preferred instead of servo motors. Asynchronous motors have many advantages in order to realize the desired process. Considering the general working principle, asynchronous motors are the most used electrical machines in the industry. In terms of working principle, asynchronous motors are also called induction motors. No electric arc occurs during the operation of asynchronous motors. They are also cheaper than other electrical machines and require less maintenance. These features have caused induction motors to be the most widely used motors in the industry.

- Servo motor has closed loop negative feedback system while general induction motor has feedback mechanisms in internal encoder.
- Servo motor speed and position can be more precisely adjusted and controlled, while induction motors can only be speed adjusted.
- The inertia of the servo motors is low, while the inertia of the rotor of the asynchronous motor is higher.

In the exist system, servo motors communicated with PLC as line with the created recipe and determined the holding time and order of the lifters. Thanks to the prototype developed, servo motors were replaced by asynchronous motors. Asynchronous motors send random frequency information to the PLC system and adjust the holding time of the lifter and paint roller motor. The frequency range sent changes by accelerating and decelerating in the range of 20-50 hz. In this way, the dyeing process is done in different pattern lengths without writing a prescription to the asynchronous motor. Therefore, the pattern lengths formed do not repeat each other. To create a mechanically driven random short pattern; dye stand, creel, dye trough and cylinders, various yarn lifters and godet system were designed and controlled by PLC (Sener, 2020; Mammadli, 2020; Vadi, 2021).

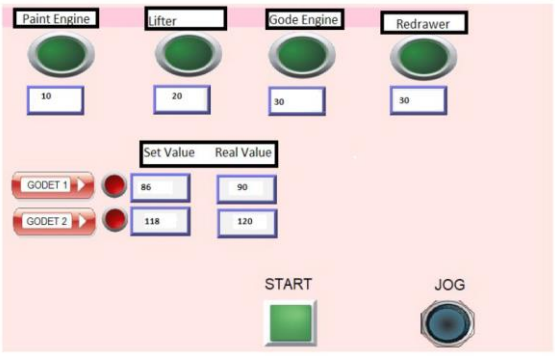

Figure 5. Prototype machinworking screen

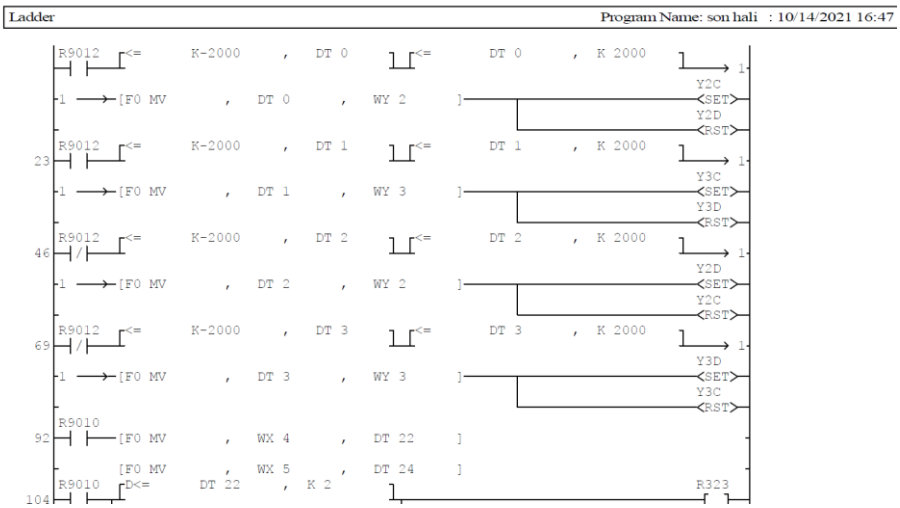

Figure 6. Ladder diagram

In addition, paint container, drive system and electronic panel design were also made. Motor drive circuits were designed with PLC. Then, with the software loaded, the values to be given to the inverter were tried to start by changing the frequency values within the threshold ranges we wanted. A connection was provided between lifters and painting rollers. Thus, the same pattern is prevented from repeating.The range that can generate random numbers written to the PLC system is in the range of 20-50 Hz, and the painting quantity is adjusted by speeding up and slowing down. The main purpose of the system; It is to design a prototype machine that can produce original products by changing the outer appearance of yarn structures, which have a high demand in low-quantity lots in the domestic and foreign markets. At the same time, considering low energy, time and labor issues, improvement studies have been carried out. The technical structure of the painting section of the system developed in this context will create minimum paint waste, which will benefit environmentally friendly production.

Results and Discussion

Coloring is done to give the yarn an attractive appearance or to give it a different style. Coloring is done by dyeing or printing method. These dyeing methods are listed as bobbin dye, hank dye and spaced dye.

Bobbin paint; it is the most preferred dyeing technique due to its low production cost, ease of use and high quality dyeing feature. In this method, first of all, preparation is done before dyeing. In the preparation process, the diameters of the bobbins are equalized in the soft winding machine and they are wound on perforated plastic bobbins of suitable softness for homogeneous spreading of the dye. The prepared bobbins are transferred to the carrier and taken to the boilers for dyeing and dyeing is performed.In this method, the yarns are dyed in a single selected color.

In hank dyeing, which is one of the oldest methods, hanks are formed by wrapping the threads in a circular fashion in a wide and loose manner. These hanks are made ready for the dyeing process by

attaching them to the parallel bars and adjusting the appropriate tension.Hank dyeing method; It is preferred for dyeing sensitive, high bulk yarns that are suitable for stretching.

Spaced dyeing method, on the other hand, emerges by dyeing the determined colors with different colors along a certain length. Spaced dyeing also has more than one method in itself. These are hank gradient dyeing, fiber gradient dyeing, coil gradient dyeing, fabric gradient dyeing. The product that emerges in this dyeing method repeats itself after a certain period of time. For example, the continuous repetition of 4 color tones of the same color from dark to light in equal length or the continuous repetition of 4 different colors in order.

Considering the trend that changes every year, new products that will create added value are more common in gradient dyed yarns than plain dyed yarns. In the production of intermittent (transitional) dyed fancy yarn, low lot yarns are needed because of the high variety and the use of dyed fancy yarn at certain points of the final product to be woven.

Considering all these dyeing methods, it is not possible to dye yarn in non-repeating random lengths in existing systems. With the new machine design made in this study, a new spaced dyeing method has been developed. In this way, the design of gradient dyeing machines, which can produce new products with high added value, is discussed. Especially in the intermittent dyed yarns used in carpet and home textiles, new yarns have emerged that are dyed in a way that does not repeat each other in the pattern formed after weaving.For this, production solutions including new process structures, paint stand, engine, PLC software and innovative technologies were redesigned.With the new product that emerged as a result, the amount of sales was increased and the existing market network was expanded.

Conclusion

Textile industry; it is one of the locomotive sectors of Turkey with the employment it creates, current investments and high export rate. Therefore, every innovation and development is needed. One of the most important issues for factories producing fancy yarn is to produce new products with high added value in accordance with the changing trend. A new dyeing type has been developed. Thus, product variety has been increased with innovative studies in the textile dyeing process. The resulting spaced dye yarn is mainly; It has started to be used in the field of carpet and home textiles. Since this study is enlightening and guiding, it has a potential to guide for other studies that will take place in the literature.

Acknowledgment

Operating in Adana Organized Industrial Zone, Ulusoy Tekstil San. ve Tic. A.Ş. carries out production in the carpet, home textile, hand knitting and knitwear markets, and a total of 3.5 million kg of yarn is dyed annually. Approximately 100 tons of these yarns are spaced dyeing. The studies on increasing the amount of dyeing and diversifying the dyeing method within the scope of this study have been realized thanks to the infrastructure and facilities of Ulusoy Tekstil, and I thank them for their help in

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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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