The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)

Volume 1, Pages 116-122

ICONTES2017: International Conference on Technology, Engineering and Science

DESIGN OF AN AUTOMATIC COIL LATH BONDING MACHINE FOR DISTRIBUTON TRANSFORMERS

Hakan Bicil
Kocaeli University

Tufan Polat
Kocaeli University

Ismail Malik Kundakci
Kocaeli University

Murat Ayaz
Kocaeli University

Huseyin Metin Ertunc
Kocaeli University

Abstract: It is desired that each product has the same quality and standard values in industrial production systems. Accordingly, it is aimed to reduce the use of human labor force in almost every industrial production line in order to increase the quality standards while reducing production costs. In today's developing technology, reduction of human labor is possible with industrial automation systems. This work deals with a machine design that automatically enables the bonding of lath used in high-power transformer coils. As known, lath bonding in transformers is mostly done by human power. Therefore, providing of the standard in production is becoming difficult and slow. With the designed machine, the production process is shortened and it is aimed that the process to be done is better quality and it is carried out in accordance with the standards.

Keywords: Industrial automation, distribution transformers, PLC, machine design

Introduction

Transformers are electric machines that are used to increase or reduce the voltage with fixed frequency and least power loss by magnetic induction in sinusoidal alternating current systems. Electricity can be transmitted with minimum loss at high voltage but it should be reduced again. So, transformers are generally used for electricity distribution and transmission. Transformers are mainly made of core, siliceous sheet and wire. There are two basic windings, primary and secondary. Voltage reduces or increases with number of turn rate. Transformers also heat up during operation like other electric machines. Heat is caused by losses in the core and the coils. Since transformers don't have the moving machine elements, the passive air cooling is not enough for them. For this reason, cooling fluid (oil, etc.) is used between the windings for most of them. The greater the change in voltage, the greater the warm-up. If the resultant heat is not blown out, the transformer becomes useless. For circulation of heat and for circulation of the fluid through the windings, the laths have great design when considering the conductivity coefficients. As stated in study conducted by Steurer and Frohlich (2002), they provide flow area for the cooling fluid.

- Selection and peer-review under responsibility of the Organizing Committee of the conference

*Corresponding author: Hakan Bicil- E-mail: hakanbicil@gmail.com

Figure 1. Transformer coil

In a study by Muhamad, Kamarden, Othman (2015), insulation materials are also exposed to high temperatures when transformers are heated. If the insulation materials are kept high temperature continuously, it accelerates the degeneration of the material. For this reason, the cable on the coil temperatures should not exceed the specified values. So, insulation materials continue without any damage a long time and ensure that the transformer works well. Coils and the laths between them can be seen in Figure 1. The laths allow the cooling fluid to flow between the coils, (oil, air, etc.) and ensure that the fluid insulation material remains intact much longer.

Lath bonding machines are used to produce KIT materials used in the transformer insulation sector, which provide insulation of the coils in the transformer. There are many established and big companies such as Astor (Özgüney), Best Transformer, Schneider, ABB, General Electric which manufacture KIT in Turkey and the world. The manufacture of the KIT takes place as follows. Paper pulp is dried and compressed by various methods under high pressure. These layers formed as a result of the process are driven towards the cylinders. These layers are glued with a special adhesive onto the lath produced in various sizes. Figure 4 shows the KIT manufacturing method. In order to manufacture the KIT in the direction of the request of the companies, lath bonding (KIT manufacturing) machines have been produced. There are several companies in Turkey and in the world, such as Stolberg, SEBA Makine, Transmek, which make lath bonding machines.

Figure 2. Stolberg winding machine

Figure 2 shows the Lath Bonding (KIT) machine produced by Stolberg. Laths are manually placed in standard production. As a result, KIT material cannot be produced properly. The spaces between the laths are different from each other. That means oil channels are different from each other. This means that the part of the transformer which is to be cooled with oil is cooled more or less than other parts. This can also lead to a major fault. In a study by Del Vecchio, Poulin, Feeney, Feghali, Shah, Ahuja (2001) in the end, the transformer will explode. The proposed machine in this study is designed to remove the human error in order to eliminate or minimize all these drawbacks.

Designed Machine General Properties

All of the transformer lathing machines available in the market are based on hand work and require at least 2 staff to operate one machine. Figure 3 shows this situation.

Figure 3. Transformer winding process

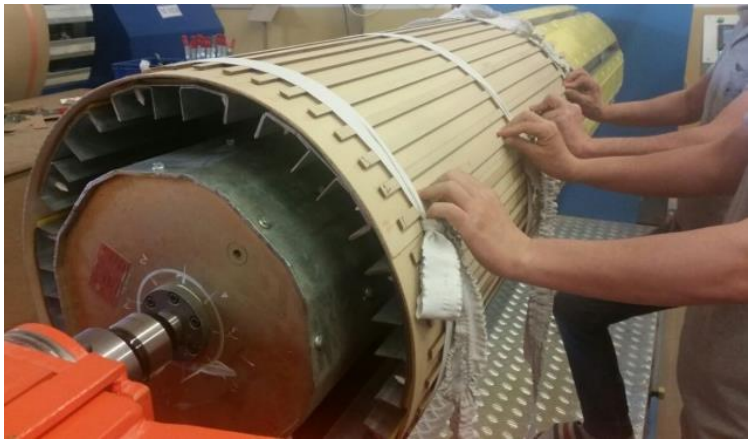

Figure 4. Lath bounding (KIT Manufacturing) (Manuel)

Figure 4 shows a lath bonding operation made by Star Energy Transformer. As seen in the figure, depending on the size of the material, two operators place the laths on the coil. During the lath bonding process, the cylinder is placed on the mold and the sticking process of the laths requires the two staff to work synchronously. It is mentioned that by Leijon, Dahlgren, Walfridsson, Ming, Jaksts (2001) both the quality of the product and the production capacity are not so high in manufacturing in this manner.

Considering these and similar situations, a system has been designed to automate the lath bonding process. The winding machines were combined with this system designed and the Automatic Lath Bonding Machine was removed. At the same time, this system can be integrated into the manual winding machines on the market. The system is highly demanded thanks to its innovations such as being automatic and being able to integrate with old machines at the same time.

Automatic Lath Bounding Machine Mechanical Design

The machine consists of three parts, the tray on which laths are placed, the lath conveying part and the lath bonding part. On the first part of the machine there is a tray on which the laths are placed. A motor is used to push the laths to the proper position. The task of this part is to ensure proper alignment of the laths. Figure 5 shows this part with green square.

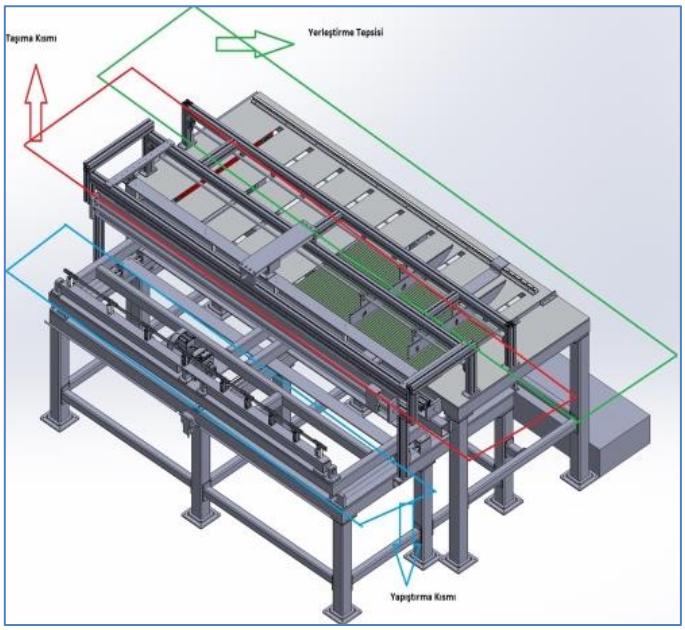

Figure 5. Structure of the proposed mechanical

In second part, the conveyor part is operated by pneumatic valves and servo motors. The servomotor in this part is set to the proper position and picks up the first lath and leaves it at the adhesive section. The gripping of the lath is provided by pneumatic vacuums. Figure 5 shows this part with red square. In the third part, the laths are inserted into the grippers and the glue is spread to the lath by a servo motor. By means of an asynchronous motor, the lath is turned and bonded to the coil. Figure 5 shows this part with blue squares. In Figure 6, the automatic lath bonding machine is shown with the winding machine. As you can see in the Figure 6, the lath on the sealing part will stick the coil on the bonding machine. Thus, only one operator is able to carry out gluing process.

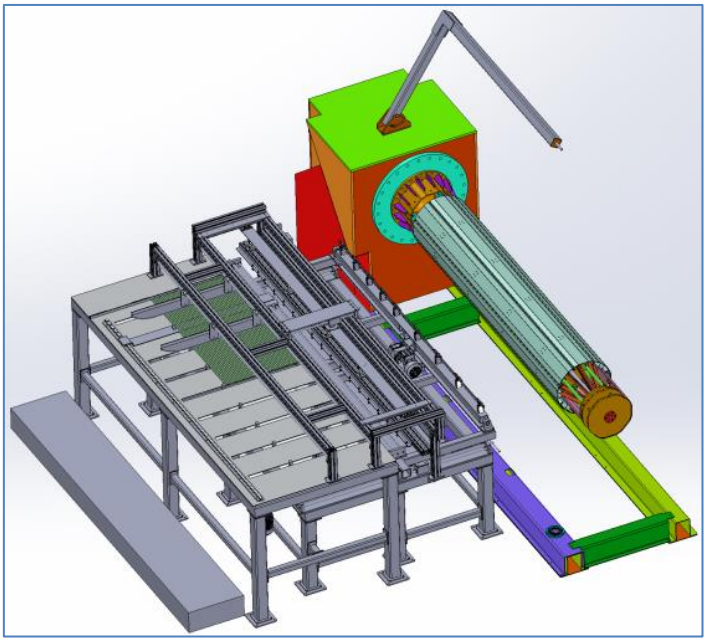

Figure 6. Carrier part of the proposed machine

Algorithm of Machine, Electronic and Software Design

Operation of machine actualizes with the following steps. The machine control algorithm is given in the figure 7. First, the operator needs to line up the laths in the chamber and then enter the prescription from the control panel. In the prescription:

- Lath Width
- Lath Length /Depth
- Lath Height

- Coil Diameter
- Number of laths
- Glue Application Method (continuous, point, Method)

Knowledge must be entered. If the operator chooses the method glue application, he/she enters the value that how much glue need to be and how many mm gap will be. This application intermittently refers to gluing process. Firstly, with the start command, the height adjustment servo will take position and the laths will be align with the side reference. Secondly, the mold is opened to the desired diameter by means of AC motor (mold opening-closing motor) in the direction of information entered by the operator. The pitch adjusters will be pushed towards the front by means of the fingers connected to the AC motor (lathing motor). The AC motor will stop when the lath contacts the switch on the front. Thirdly, Vacuum servo will be launched and will take the position so that the center of the vacuum pad will be at the center of the lath according to the switch on the front. Fourthly, the vacuum pads will move down, contact to lath and vacuum. The Laths, which is vacuumed by pistons, will be moved up and vacuum servo will return to the home position. These parts are shown in figure 8.

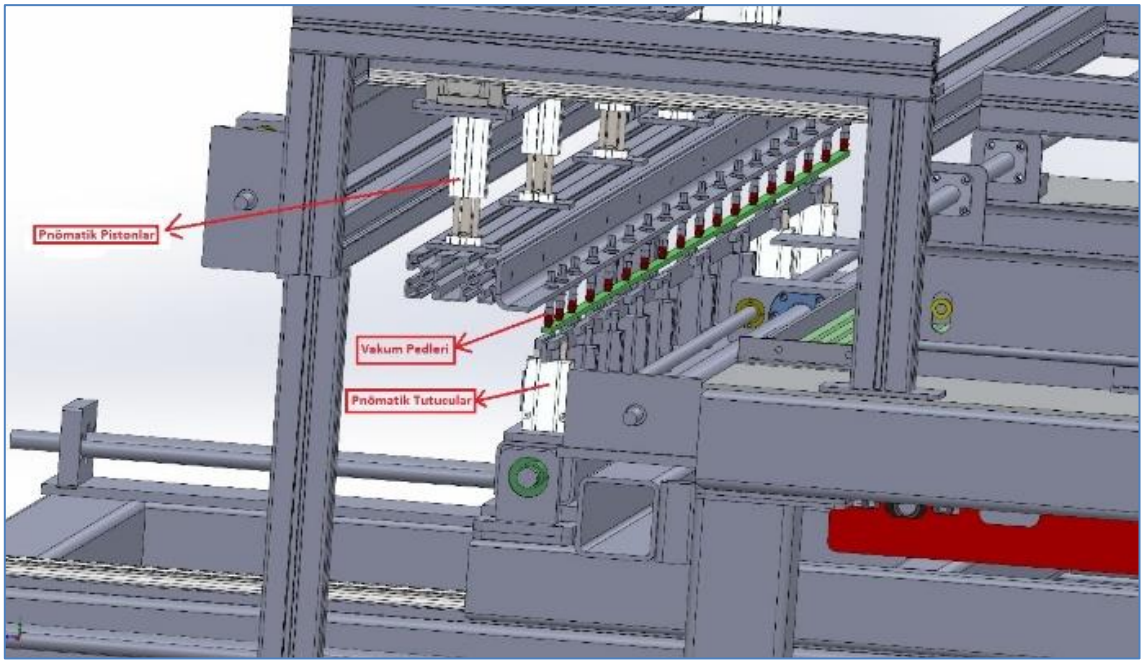

Figure 8. Parts location on the machine

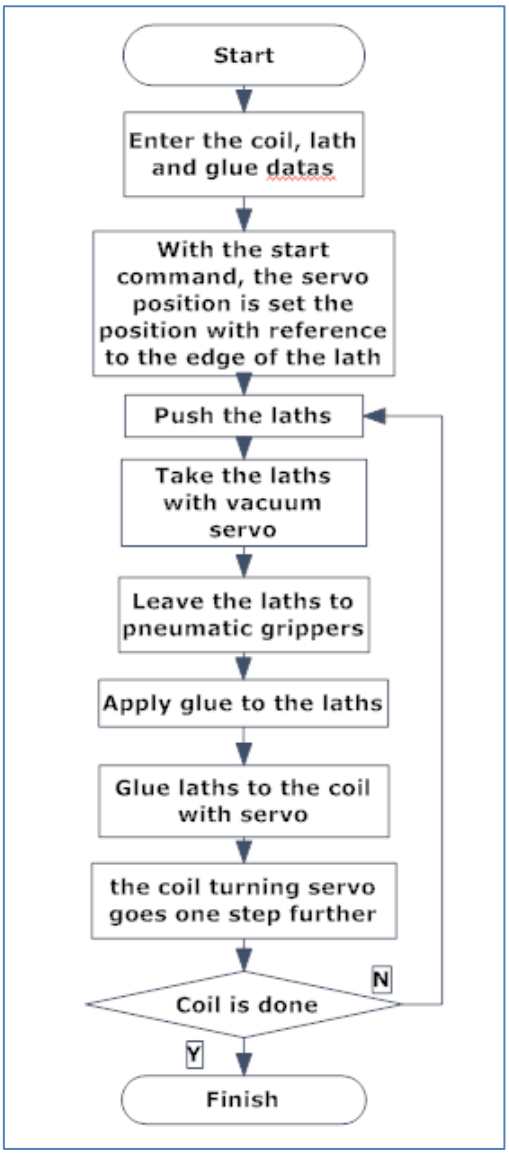

Figure 7. Flow chart of the proposed machine

The home position of the gluing servo with the pneumatic grippers and the home position of the vacuum servo will remain at the same point and the vertical axis. After vacuum servo arrives to home position, piston valve will open and lath will be left on the pneumatic gripper. Once pneumatic holders close and squeeze the lath, Pneumatic vacuum pads stop vacuuming and pistons move up. After that the glue servo will move and stand in the same vertical axis with the glue nozzle. At this situation, gluing process will be launched. Glue nozzle is located on the threaded shaft that is attached to glue servo. In the next step, the glue-applied lath will be moved towards the body by the gluing servo. It will stand at a distance of about 100 mm from the body. When the stopping operation is performed, the AC motor (rotating motor), which is connected to the pneumatic holders, will be actuated and it will rotate 90 ° the pneumatic holders which are standing in the vertical axis. After the AC motor completes the spinning process, the gluing servo will re-engage and stick the lath with the pressure on the coil. System will keep waiting a little time at the pressure position. After gluing, the coil spinner servo will move one step forward for every time relative to the number of laths. Eventually, the system will return to start position. S7-1200 is used as controller and KTP600 is u sed as HMI panel. The operator information interface is shown in Figure 9.

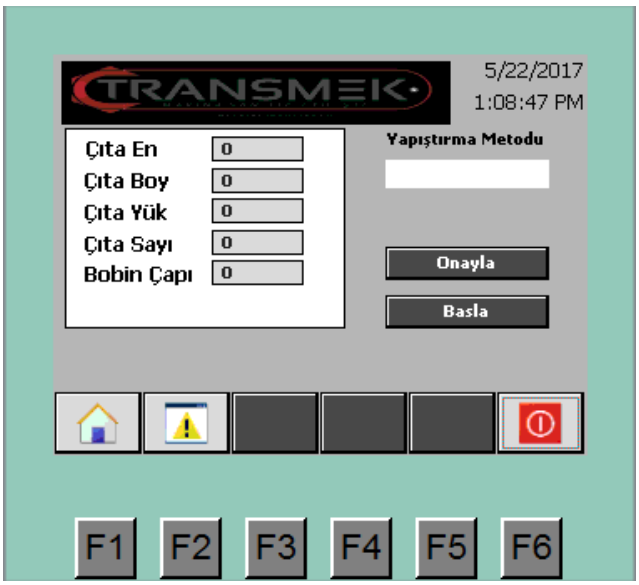

Figure 9. Interface screen

Conclusions

Manually working lath bonding machines, two staff working together two or maximum three KITs can be manufactured per day. This number means maximum 100 laths can be glued. In the automatic lath bonding machine, one lath can be glued in two minutes. This means that the production of six or seven KITs per day can be done very easily. The automatic machine has also reduced work-related production. In the case of manual production, it is possible to operate two personnel in one machine. But in the automatic production, one operator might operate two machines at the same time. It is the first in the world thanks to its features such as precise, fast production, high quality product and most importantly automatized lath bonding (KIT manufacturing) process. For this reason, patent and registration studies have also started.

References

Del Vecchio R. M., Poulin B., Feeney M. E. F., Feghali P. T., Shah D. M., Ahuja R., & Shah D. M. (2001). Transformer design principles: with applications to core-form power transformers. *CRC press.*

Leijon M., Dahlgren M., Walfridsson L., Ming L., & Jaksts A. (2001). A recent development in the electrical insulation systems of generators and transformers. *IEEE Electrical Insulation Magazine*, 17(3), 10-15.

Muhamad N. A., Kamarden H., & Othman, N. A. (2015, July). Heat distribution pattern of oil-filled transformer at different hottest spot temperature locations. *In Properties and Applications of Dielectric Materials (ICPADM), 2015 IEEE 11th International Conference,* pp. 979-982.

Steurer M., & Frohlich K. (2002). The impact of inrush currents on the mechanical stress of high voltage power transformer coils. *IEEE Transactions on power delivery*, 17(1), 155-160.