Transformers

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DESIGN AWARD 2017

Shaping the future of transformers

▪ Winding machines ▪ Accuracy matters ▪ Bypassing a transformer ▪ Rugged fans ▪
▪ Smart maintenance ▪ Silent transformers ▪ CONNEX ▪ INSULutions® STRIP-Flex K ▪

Winding machines for Industry 4.0

Regional requirements for transformer design (Localized transformer design)

Looking at the global energy consumption map, the world could be divided into high energy consumption regions, such as Europe, North America, the Gulf Region, China and Russia, where energy consumption is very high, and low energy consumption regions such as Africa, where many do not even have access to electricity. Consequently, the transformer design requirements for these two types of the market are also different. Generally speaking, the technical specifications that are important for high consumption areas are high efficiency (low load- and no-load losses) and long service life (high quality) considering that low-loss and long-lasting transformers decrease the maintenance and reinvestment expenses of distribution utilities in these regions. This is reflected in the fact that a few years ago entire Europe shifted to Eco-Design Directive targeting to re-

With its latest-technology machinery designs, LAE is helping customers produce good and efficient transformers

Foil winding machine LAE BOB L 800

duce transformer losses across EU power systems by 20 %.

On the other hand, transformer design for low consumption regions focuses on long service life rather than low losses because their first priority is to provide access to electricity. In brief, the key design parameters for quality transformers around the globe are high efficiency and long service life.

In addition to these, over the past few years we have also seen an increased effect of local factors on technical specifications in different countries. For example, clients in northern Europe and countries such as Norway and Finland, which face severe thunderstorm seasons each year, request extra protection from lightning from their transformer suppliers. Another example are countries like Ireland, where thickness of paint is the most important specification due to high humidity level. On the other hand, in Palestine and some of the Middle East countries, where the power system quality is quite poor, high quality transformers are used in an attempt to compensate for the poor quality of the power system, which often lacks protection devices, so transformers themselves need to be sufficiently resistant. In particular, transformers there are required to have high quality insulation, so in design specifications attention is paid even to insulation distances inside the transformer.

In Palestine, for example, there are two key drivers for using safe transformers. Firstly, the case there is that the energy is provided to one side of the city for one half of the day and to the other for the other half. This means that the transformers are switched on and off more than two times a day and each time this happens they are subjected to impulse voltage stresses. Therefore, these transformers are required to have a sufficient insulation level. Secondly, there are certain local conditions which concern maintenance and service-life limitations, which further affect the design. For example, in their technical specifications they require that the transformers are of a

LAE's range of winding machines for manufacturing distribution transformers has been refreshed with BOB L 800 for foil winding and BOB FPN 08 for HV wire winding

specified height to be able to perform the maintenance locally and easily.

In some other countries, such as Pakistan, local conditions also dictate the technical requirements for transformer design because in case of a failure, they want to manage the maintenance locally with locally available material. Due to this, they impose certain limitations and include some parameters in their technical specifications. In the countries lacking raw materials for the local maintenance of transformers, such as transformer oil, enameled wires, etc., transformer suppliers are forced to make designs according to local technical specifications and local limitations.

The key to meeting these requirements and achieving efficient, long lasting and localized transformer designs is a combination of a good know-how, a well-organized production facility, a good design tools, good machines and equipment and finally a good manufacturing process.

In sum, the tendency around the world is to require low-loss and long service life transformers, and include local factors and conditions in specifications.

If all these conditions are met, the result will be a good transformer. In this regard, LAE is helping its customers reach good design results with its latest-technology machinery designs.

Importance of the winding machine for transformer design

Transformer designers always want to see the results after production to verify that it reflects what has been calculated in theory. Winding dimensions and tolerances are a critical part of the design. During the design process a certain winding diameter is expected. Based on the expectation, everything else is calculated – the insulation distances, tank dimensions, etc. If the winding machine delivers a good result, then every insulation distance will be correct and transformer will be safe. However, if the result yielded by the machine is not that good, the manufacturer will have to do one of the following: either keep the insulation distances low, which means that the transformer resistance to adverse conditions will also be lower; or increase the distances in order to achieve the desired safety margin, but this in turn increases the size of the transformer, adding an extra cost to transformer manufacturers. So, the machine can save costs to the manufacturers, and ensure a good, reliable product to the clients.

Wire winding machine LAE BOB FPN 08

LAE's winding machines

LAE's range of winding machines for manufacturing distribution transformers has been refreshed with BOB L 800 for foil winding and BOB FPN 08 for HV wire winding. For the machines to meet the expectations of manufacturers and ensure that the winding process is performed to the expected standard, the control of the tension of what is being wound is crucial: this means the precise control of the tension of the foil for foil winding, and of the wire and the strip for progressive insulation used in wire windings.

Our machines are designed in a modular way, using the same solution on different sizes with an option to add or remove the accessories to accommodate different client requirements. This enables us to adapt the machine to the customer needs without redesigning it every time.

Foil winding machines

About three years ago, we introduced a new generation of foil winding machines. At that time, our best seller was BOB L 600. However, the new rules on low-loss design, together with the use of aluminum, required the use of conductors of larger dimensions, which results in the bigger overall size of the winding. So, we re-designed and enlarged the machine to be able to wind bigger foils.

We changed the control system of the entire machine, both hardware and software, as well as the design of the decoiler, which is the core of the machine. We introduced the servo motor for purposes of braking and alignment of the foil as well as decoiler expansion, so that we could eliminate the hydraulic units from the machine. So, where there is small movement, pneumatic units are used, but for the main task – braking the foil, providing tension and moving the foil sideways to guarantee the correct alignment during winding – we use the servo motor, which is much more precise and more reactive. This is important because to control the foil tension there are also load cells on board of the machine, so that the real tension can be measured during winding. In addition, we have developed a special algorithm which controls the speed of the winding in order to reduce the effect of inertia that occurs when winding non-round coils. There is a tendency to use oval coils, rectangular coils, octagonal coils, etc., and winding of such shapes implies continuous change of speed, so the algorithm is used to control the speed of the windings and reduce the effect of inertia. This is one of the characteristics of LAE technology that makes us stand out. Applying these three components – the algorithm, the load cells to measure the real tension, and the servo motor to brake the coil, which is also able to change the braking torque very quickly – we have reached a very good control of the tension and can guarantee a variation within approx. 5 % of the set value for tension. This and, obviously, the control of the alignment are key to guaranteeing the winding dimensions and tolerances are as per design requirements, which is another feature making our machines stand out.

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Wire winding machines

In case of the wire winding machine for HV coil, to control the tension for both the wire and the strip the tendency is to use one or two strips to build the interlayered insulation. While this is not a new technology, there are many manufacturers who still do not use it. So, when a new machine, LAE's **BOB FPN 08**, is installed in a factory that never used progressive insulation in coil winding, there is an immediate reduction of the final dimension of the coil.

Winding of the HV coil using round wire requires certain layers of insulation. However, the insulation is required only at the end of the layer, when the two turns that must be kept isolated have a bigger voltage difference. The traditional system is to put paper sheets between the layers of the thickness calculated so as to withstand the voltage difference. Considering that at the beginning of the layer there is no need for big thickness of the insulation, by using one strip and winding it on the coil together with the wire, then by overlapping the strip to create insulation and finally by changing the pitch of this overlapping, we can create interlayer insulation with gradual thickness. This brings another advantage of using the same strip for building the coil end insulation.

Having been in use in Europe for about 20 years, this technology is not new, but it is important because it ensures a good control of the tension, which allows winding at high speed. With more non-circular windings in use, such as oval, rectangular, etc., modern winding machines are required to ensure fast winding. This, in turn, for the oval shape requires a very accurate control of the tension of both the wire and the strip. Machine manufacturers use a dancer to control the tension and compensate for the speed variation, however, LAE uses a dancer which has carefully calculated dimensions, weight and positions in order to minimize the tension variation. This makes a difference, and the feedback from our customers about the result has always been very good. For example, a good control of the tension helps in making the winding more compact, minimizing the gaps between the conductors, which results in a more stiff winding with a better short-circuit withstand capability.

When winding non-round windings with constant angular speed, the line speed variation is compensated by using the dancer. Because the speed variation is of a very high frequency – two times the frequency of rotation for the oval winding, or four times for the rectangular winding – the design of the dancer must be adequate. For the same reason, a servo motor is used to feed the wire by feeder.

The combination of flattening the wire and using progressive insulation will reduce the coil dimension and thus result in cost saving for transformer manufacturers of up to 6 %

We support our customers from four service centres, covering the entire world 24 hours a day, and solving their problems by remote assistance

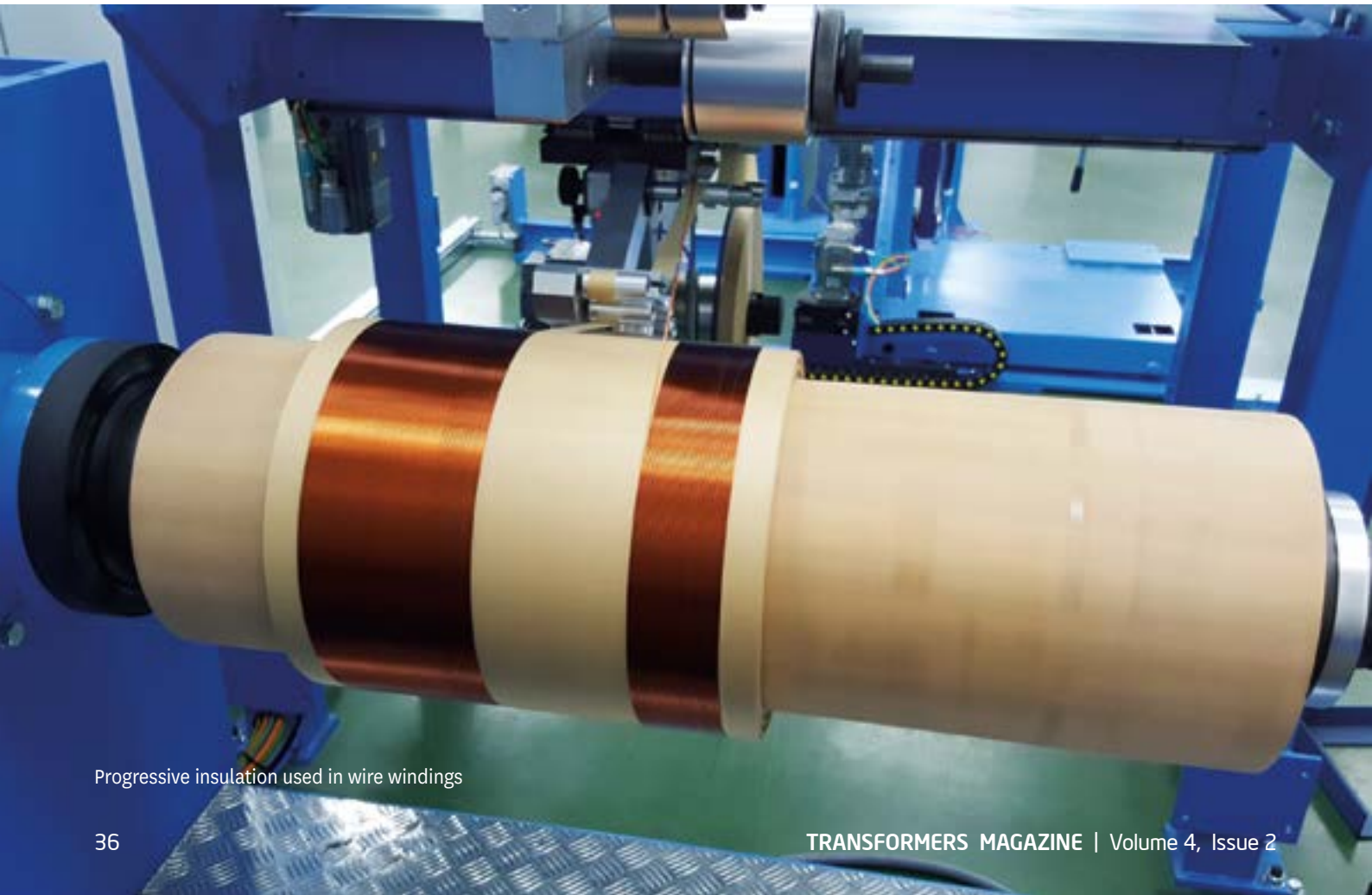
The force, i.e. the tension of the wire is provided by a spring located on the dancer. The spring is preloaded according to the required tension. The machine features a kit of springs to be able to provide a wide range of tension values required by different types of winding, for wires from 0.4 or 0.5 mm diameter to up to 5 mm aluminum or copper wire. Again, the use of the spring has been carefully evaluated, differently from other winding machine manufacturers, who use other systems such as pneumatic cylinders.

Precise control of the tension gives you compact coils, more precise final dimension and allows to wind at high speed.

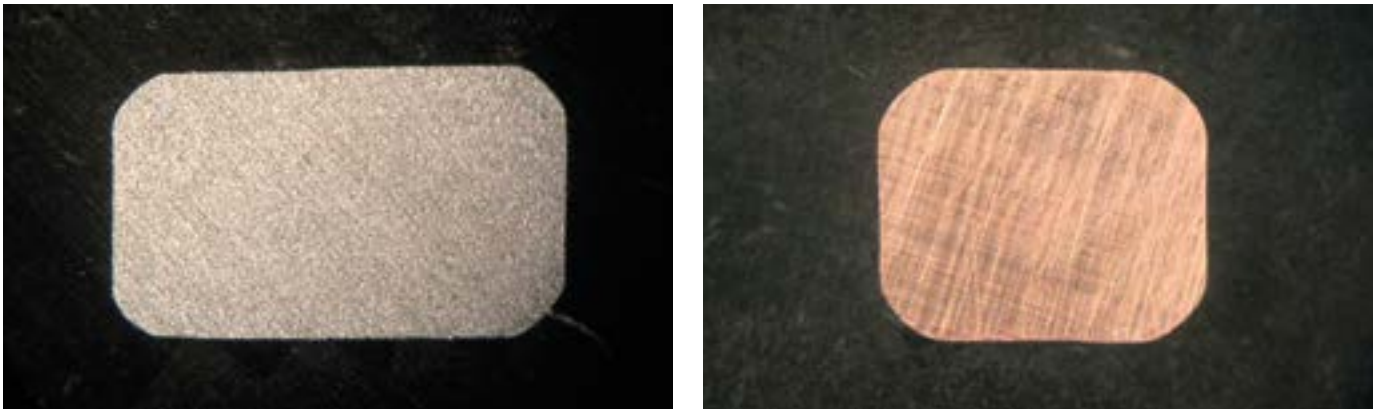
The machine can be equipped with the wire flattener, allowing the customer to save material and bring down the cost of the transformer. There are two versions of the wire flattener. A simple one only flattens the wire in the radial dimension, so during the winding process the wire goes inside this unit which squeezes it and makes it oval. This improves the winding fill factor. Due to a slight increase of the axial dimension of the wire, the number of layers may increase as well, depending on the design. However, by flattening the wire, the final diameter of the coil will not increase; it may only be reduced. This is a benefit for the customer. By changing the percentage of flattening, the customer can adjust the design. The next step is to control the axial dimension of the winding made of the flattened wire. So, the machine can flatten the wire in both radial and axial dimensions – the customer starts with a round wire and at the output of the flattening machine winds the rectangular wire with custom-set dimensions because they are adjustable.

Obviously, there are some limitations to the sides, shapes and modifications provided by the flattener. Flattening slightly reduces the thickness of enamel; however, if the wire is of good quality, then there is no issue. Therefore, we do not provide any specific requirements for enamel. This technology is used by many transformer manufacturers, so it is a well-proven system.

The combination of flattening the wire and using progressive insulation will significantly reduce the coil dimension and thus result in cost saving for transformer manufacturers. Compared to a traditional transformer manufactured with a round wire and standard insulation, the use of flattened wire and progressive insulation can lead to approximately 6 % saving on the material and total weight of the transformer. In other words, because of the smaller size of the coils, transformer manufacture will require fewer conductors, less lamination, smaller size of the core, smaller tank and a smaller quantity of transformer oil. The more traditional the technology currently used by the customer, the more benefits there will be by switching to the new technology offered by our machines.



Progressive insulation used in wire windings



Flattened aluminum and copper wire

Integration into the manufacturing process

All our machines are able to talk to the customer design program. Winding programs can be loaded through the network and the customer can choose between producing a file to be loaded to the machine by using their own program or by using an application that we can provide so that engineering department can create the design and create programs for the machines. The machines also provide feedback on some parameters. For example, they are able to give a log file after the customer registers and enters the parameters of importance, such as the tension, the time needed to make the coils, how often the operator needs to stop the operation for any reason and so on.

Industry 4.0 ensures unparalleled service

Staying close to our customers is very important to LAE. We have good technical staff in our after-sale office and we support our customers from four service centres in the world. From Italy, where we are headquartered, we coordinate the Local Service Centres, which are our assistance points placed in strategic geographic areas. Then there is local service in India, one in Joinville (Santa Caterina) in Brazil, and one in Turkey. With this model we are able cover the entire world 24 hours a day. The customer can contact LAE at any moment of the day through either the local service or our after-sales office.

Once the customer contacts the service center, the service center will immediately contact our staff in the office and serve the ticket for the issue. LAE then continues to solve the problem directly with the customer. The customer can contact LAE by web portal, which is a quick and efficient means of contact, particularly in case of emergency. The customer can come to our web portal, select the machine, and report the problem. In this model, the Local Service Centre at our office receives the email with the issue and can quickly contact the customer to solve the problem.

Local service is important for customers because it makes service assistance available all over the world at a lower cost. Local services centres can also provide their expertise and training directly at the customer's plant, for example train the technician and pass on the knowledge requisite to respond to a situation when there is a problem. Expertise is key to reducing the time to solve the problem. In addition, we can solve the problem on the machine by remote assistance provided there is an internet connection. Connecting to the machine, we can verify its status online and identify the type of the problem – for example, whether it is a software problem or a failed part which needs replacement, and help the customer to solve it quickly.

Also available for the machines BOB L 800 and BOB FPN are video manuals. Video manuals are very important as they improve the customer support and offer an alternative solution for assistance.

For example, video manuals can be used by customers to train their staff, as a guide and support in placement of spare parts, or as a support in sending the technical data in some situations. There is another advantage to this in the countries where winders frequently change companies. Our technicians will visit the customer to install the machine and train the staff, but then perhaps a year later, the customer's personnel will be changed completely. So, the customer will have to share the know-how on how to use the machine and this is not always done properly. This is where video manuals are very helpful, assisting customers to solve problems at hand.

Additionally, video manuals are very user-friendly. The manual can be installed on the machine and when the customer encounters a problem, he can consult the video manual, understand the issue and solve it.

Finally, to stay close to our customers, we propose scheduled maintenance contracts, which can yield best results in the period of three years. For annual ordinary scheduled maintenance, we offer assistance via telephone, email or Skype. The contracts also offer a discount for non-scheduled maintenance and special discount on spare parts.

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