Automatic core manufacturing

Automatic core cutting line TO 25 with core stacking robot IRE 25

Introduction

Manufacturing transformer cores includes two critical steps - cutting the steel sheets to the correct shape and stacking them to form the core according to the design. Core cutting is a technologically sensitive process but since it is suitable for automation, it was already earlier automated. Core stacking, however, is a much more delicate process, particularly for larger transformers. It involves a lot of precise and fine operations which used to be possible only for skilled workers to execute. So, the automation was later introduced into this process.
This article describes the automatic core cutting line TO 25 with an integrated automatic stacking robot IRE 25 from L.A.E.

Automatic core cutting line TO 25

The core cutting line model TO 25 is designed and built for the production of grain-oriented laminations suitable for the assembly of electric distribution transformer cores using the step lap system. Conforming to the transformer design, this machine is particularly suitable for the production of cores for transformer power ratings ranging from 50 to 2500 KVA.

Innovativeness

Developing the IRE 25 core stacking robot L.A.E. innovated the core manufacturing process. The IRE 25 is integrated in the core cutting line, so that now the line TO 25 integrates lamination cutting and assembling the core in a single process. This brings a big advantage to transformer OEMs because the robot relieves the need for manpower and core stacking is a very labour intensive part of manufacturing transformers.

Another big advantage is that the robot can simultaneously stack more than one core at the same time, enabling a greater flexibility in the production. The current version of the robot can simultaneously perform stacking of up to four cores, which can be of the same or different designs. Following the next R&D cycle, it will enable a higher degree of automation and assembling of even more cores at same time.

How the automatic manufacturing of cores works?

A very important feature of the process is the preparation and setting up of the robot. If it is complicated, the robot efficiency will be reduced. So, L.A.E. developed the solution paying a special attention to the preparation process that is required later for each individual batch of production. The machine has been developed so as to maximally simplify the preparation of stacking. The robot uses only one type of hand for the whole range of transformer ratings and the operator does not have to change it due to different dimensions of the lamination. All lamination cutting data can be downloaded to the cutting machine and the operator can see all of the information he needs to adjust the correct position of the assembling bench and correctly set up the position of the pins and the frames. This is the best support the operator can get for making all necessary arrangements before starting the production.

The operator is then required to enter the length of each lamination for limbs and yokes and the central position of the holes. This is standard for all cutting lines. He needs to provide the information about the batch of production, the number of cores to be manufactured, and core design types. Having received this input, the computer will organize the production and determine the sequence of different laminations on the cutting line according to the requirements of the design. All this ensures that a wrong sequence of lamination widths on the assembling bench is avoided.

Managing batches with cores of different designs is very important. If for example only two of four cores have the smallest lamination width of 60 mm, then the cutting machine will start with this width and the lamination will be put only on two assembling benches. If the next width of, for example, 80 mm is used in the second layer of the first two cores, which are already being stacked, and in the first layer of the other two cores, then the machine will manage the production properly. Getting the sequence of laminations right is a must in order to ensure correct stacking of the core and the machine performs this automatically.
guiding the operator through the loading sequence on the coiler.

The machine also performs cutting and punching of all round and oval holes in the lamination. Positioning of laminations on the assembling bench is done by pins, which requires laminations to have holes. The machine arranges the cutting of a complete step lap book, and when this is finished, the robot assembles the entire book at the same time. The step lap book is a sequence of four or five different step lap lengths of the laminations.

**Automatic stacker model IRE 25**

The stacker collects magnetic sheets cut by the core cutting line TO 25, forming from a minimum of 1 to a maximum of 4 three-phase cores, assembling each step-lap book according to a specified order. The figure represents a case of four cores being stacked. The core can be stacked as a “closed” core or with an “open” upper yoke.

The stacker will be equipped with four collection benches. Each bench is composed of a base fixed to the ground and of a movable structure, which the operator can use to set up the tools used to compose the core and manually adjust the pins used to position the sheets. The moving structure can be removed from the base by a forklift or an overhead crane. The robot can stack different types of step lap core.

When the line has finished the current sequence, the cutting machine stops automatically and the operator only has to pull out the last three meters of lamination between the coiler and the cutting machine, rewind it and replace the coil of the steel sheet with another coil of the right width according to the sequence list.

Our effort was also to reduce the time of moving the robot as much as possible.

**Quality of robot stacking**

The space gap between laminations in the area of connection of lateral limbs and yokes and the central limb and yokes is very important for the electromagnetic efficiency of the core. When the operator stacks the core manually he can do a lot for final adjustment, hitting the laminations laterally by a small hammer in order to close the gap as much as possible. Such operations for final adjustments cannot be performed by a robot, but the robot can help in correct positioning of the pins and correct lamination cutting. This was taken into account while developing the robot and practical measurements showed that there are not any differences in the core efficiency, i.e. the stacking quality.

What is expected from the IRE 25 is an increased reliability of stacking because the machine can be connected with the factory design office to directly receive the input data, which will maximize their reliability.

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**Figure 1. Cutting sequences performed by the core cutting line TO 25**
Customers generally store all information related to the lamination cutting for the core design in the machine's memory. The machine enables retrieval of information already available in its memory, which additionally helps in avoiding mistakes and increases the reliability and the quality of the core manufacturing process.

**The machine equipment**

The basic machine will be equipped with the following components:

- **Decoiler** (consisting of a basement resting on the ground, housing - inside - the hydraulic unit and an upper body housing the mandrel for lamination coil. The opening and closing of the four mandrel jaws are ensured by two hydraulic cylinders which are controlled by a manual hydraulic valve. The mandrel unwinding speed in operation is constantly controlled by the computer, according to the size of the loop on the slide at the beginning of the cutting machine)

- **Entry lamination slide with control and electronic lamination feeder** (a structure consisting of machined steel walls and housing – inside – a lower roll which is driven by an electric motor, an upper idle roll and a pair of idle wheels. This control system ensures the best feeding accuracy)

- **Centering guides** (necessary to constantly keep the sheet on the central axis of the machine; they consist of steel coated in chromium rods on which a set of bearings coated with a ring of widia are mounted)

- **Punching unit** (necessary to make holes along the longitudinal axis of the laminations. The cutting command is provided through an electric motor controlled by the machine computer. This unit allows the replacement of punching tools in order to obtain holes of different diameters)

- **V-notch cutting unit** (necessary to make the V-notch for the yoke and to partially perform the cutting of the central legs. A computer-controlled motor moves the whole unit transversally on precision ball guides in order to cut sets of laminations with varying displacements according to the step lap sequence)

**Main features**

The cutting line is made of machines whose co-ordination is managed by control software. A high performance and reliability of the line ensure a high output productivity. The line automates the functions necessary for the processing of laminations, namely:

- Unwinding from the coil
- Admeasurement of the shapes
- Conveying and cutting of the sheet
- Stacking of the finished products

**The main advantages of this line are:**

- Compactness
- Low power consumption
- Direct decoiler control without loop pit
- New electronic cutting system
- Silent operation
- Self-commissionable machine
Swinging cutting shear 45°+ 45°- (a shear cutting at three different angles: -45°, 90° and +45°, and turning by means of a high precision gear motor in the longitudinal direction. It performs the necessary cuts to form the different laminations)

Transport unit (consisting of a motorized belt sliding on permanent magnets and located after the cutting unit. Its function is to collect the lamination and to convey it to the stacker)

Manual stacking unit (which can be replaced by an optional AUTOMATIC stacking unit)

Controls by computer & touch-screen

Internet tele-assistance

Safety systems

In addition to the above mentioned components, the machine can be equipped with optional items, such as a quick set-up unit and an automatic stacker. The latter one can be a stacker model IRE 25.

L.A.E. LUGHESE ATTREZZATURE PER L’ELETTROMECCANICA S.r.l.

Since 1978, L.A.E. Lughese Attrezzature per l’Elettromeccanica S.r.l. has been producing and manufacturing automatic equipment for the electromechanical industry, through the expertise of highly skilled designers and technicians who have also gained hands-on experience in the transformer manufacturing field.

The product range includes coil winding machines for transformer windings - including foil winding machines, wire winding machines and strip winding machines; core cutting lines for magnetic cores, featuring step-lap technology and equipped with manual and automatic stackers; and fin folding machines for transformer tanks.

As a result of constant technological innovation, L.A.E. has played an active role in the evolution of the market: the plants and equipment designed and manufactured by L.A.E. operating at transformer manufacturers worldwide, are proof of this approach.

ABOUT TRAFOGRID ALLIANCE

TRAFOGRID Alliance is formed by a group of companies with extensive experience in the field of transformers. Thanks to their specialist input from different areas in the transformer sector, TRAFOGRID can provide added value in consultancy, comparison and training. These services are particularly useful in new turn-key projects or where increased production capacity or new implementations are required.

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