EcoTransFlux™

Demonstrating unit for heating strips with Transverse Flux Induction (TFIH)

A technology limiting CO_2 emissions & acid wastes in the Steel industry

The project

BACKGROUND

The steel industry is an important contributor to the Europan economy. Steel manufacturers are generally conscious of the need to be environmentally responsible and have already made breakthroughs in developing low carbon emissions technologies. One example of this is ULCOS, a consortium of 48 European companies and organisations from 15 European countries researching ultra low CO_2 steelmaking.

As part of the axis of research that need to be considered, the cold rolling process represents a source of potential progress. Indeed, cold rolling impacts on the environment in several ways, particularly due to the generation of acidic wastes, degreaser fumes, oil emissions, wastewater, dust and nitrogen oxides (NOx).

Continuous annealing of strip gauge steels using high-density electrical induction is known to provide technical and environmental improvements in cold-rolling processes. This technology, known as Transverse Flux Induction Heating (TFIH), overcomes the higher costs and inflexibility of earlier continuous annealing processes, but take-up is still limited.

Cold rolled steel after continuous Annealed process

OBJECTIVES

The EcoTransFlux™ project aims to demonstrate that the TFIH technology is mature and can be implemented on new processing lines of steel cold-rolling plants to reduce greenhouse gas (GHG) emissions and acid waste, whilst meeting quality, economic and capacity criteria.

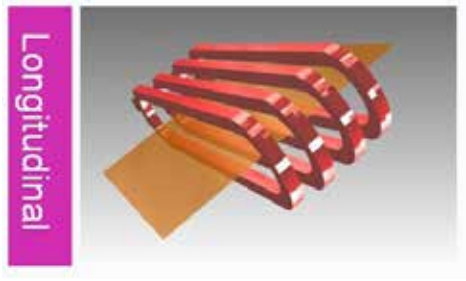
The project has implemented a pilot Induction Bright Annealing Line (iBAL), consisting of a heating section, cooling section and temperature control system - including EcoTransFlux™ high-density inductors. It should demonstrate quick heating cycles and a positive impact on the metallurgic charcteristics of the final product.

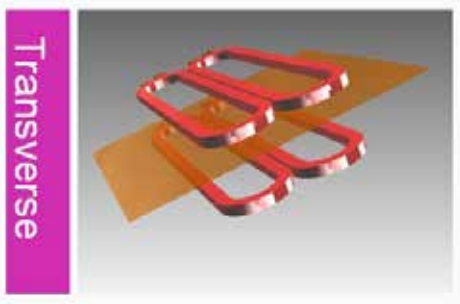
The expected benefit is to convince steelmakers that this technology is an innovative solution that meets their technical, economic and capacity requirements, with a reduced environmental impact. The final objective it to see TFIH being used in new annealing lines for stainless and carbon steel.

The technology

WHAT IS TRANSVERSE FLUX INDUCTION HEATING?

In the case of Longitudinal Flux Induction, the strip to be heated passes through several induction windings, creating a magnetic field. The Transverse Flux Induction sees the strip passing between pairs of induction windings located on both sides of the strip.





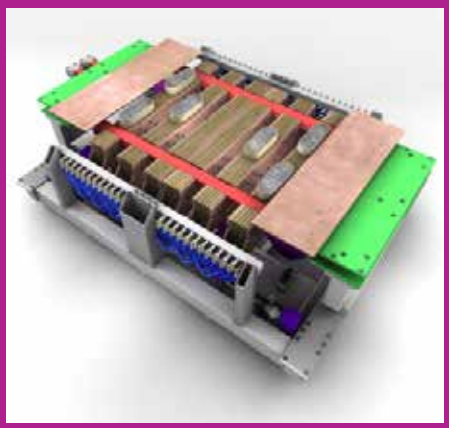
MAIN ADVANTAGES

Transverse Flux Induction Heating is a technology that is able to heat thin amagnetic steel strips above Curie point up to 1200°C, with a constant high ratio efficiency over the complete temperature range, regardless of the strip format.

The EcoTransFlux™ inductor

EcoTransFlux™ is the result of a decade of development activities and the consequent patent applications. This transverse flux induction heating technology enables to heat up steel strips and to reach high temperature levels, even beyond the Curie Point (760°C), while maintaining very high efficiency rates (> 70%).

One or several 3,5 MW nominal each modules can ensure 1,200°C heating on the strip, with heating gradiants up to 300°C/s, thus offering multiple possibilities on steel processing lines.



Its power capacity and compactness make EcoTransFlux™ an appropriate solution for optimization of new or existing processing lines, over the 900°C - 1,500°C strip width range, as long as one of the following requirements are of essence:

- Fast heating
- Compactness
- Process flexibility

The demonstrating unit in Lautenbach

PURPOSE OF THE UNIT

A scale 1 induction heating demonstrating unit has been installed in Fives Celes premises, readily available for steelmakers to carry out fast heating tests with 900-1,550mm width strips, for process qualification purposes.

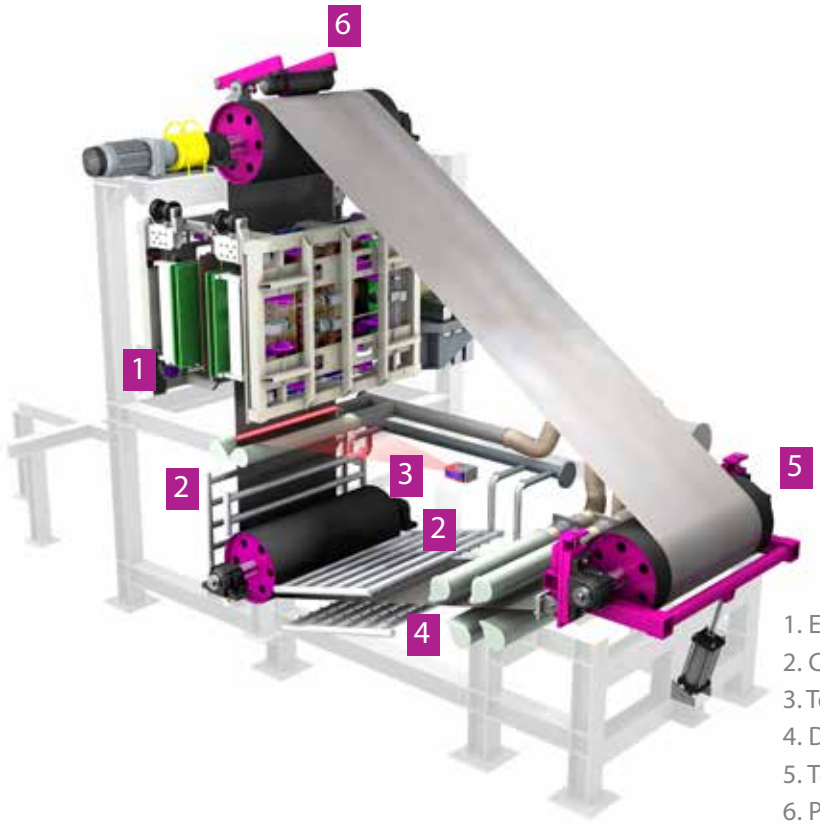
The demonstrating unit was designed, built and erected prior to the project during 2010. The project started with tests and demonstrations in September 2010.

The temperature of the strip can reach up to 800°C, with a speed range from 5 to 150 m/min, depending on the temperature and the strip's width and thickness.

INDUSTRIAL SIMULATION OF A CONTINUOUS INDUSTRIAL LINE

The simulation is obtained by using a close loop strip: the temperature of the full width of the strip is measured at the exit of the inductor (1) with a scanner (3). The strip is then immediately cooled with water nozzles (2) and dried pressure air (4).

The strip is permanently dry and at room temperature when it enters the inductor and a continuous recording of temperature is thus obtained at the exit.



1. EcoTransFlux™ inductor
2. Cooling of the strip with water nozzles
3. Temperature measurement with scanner
4. Drying with high velocity air gaps
5. Tension roller
6. Pinch and motorization

Obtained results

The demonstration program has been fully assessed after consolidation and compilation of data obtained on different types of materials and formats during tests and demonstrations.

The evaluation was carried out through several rounds of testing products with potential clients between 2011 and 2012. A technical presentation concerning the transverse flux inductor (TFIH) has been developed and consolidated thanks to the demonstration.

The operation of the machine has been demonstrated in automatic mode, with excellent stability in response to disturbances encountered classically on a production line : Steel strip alignment, speed variation, change of format width or temperature setpoint, etc.

The limits of the strip format for this inductor have been confirmed for widths between 900mm and 1,550mm and thicknesses from 0.35mm to 2mm. Some evolutions are being considered to increase the limits of these formats, including the maximum width heated.

Customers' strips heated at temperatures up to 800°C with the demonstrating unit

Data collection, thermal and metallurgical were made on steels and alloys from our customers. Collection targets have been achieved with a wide range of products: stainless steel (austenitics & ferritics), carbon steel and aluminium alloys.

Homogeneity now reaches the required value at 800°C

The objectives of the demonstrations on Austenitic stainless steels were largely fulfilled: the machine is operating in manual and automatic mode to temperatures up to 800°C, from ambiant temperatures of 20°C.

Temperature profiles in the cross direction +/-1.2% have been obtained, compared to the initial objective of +/-3%.

New design of the muffle certified

The realisation of a full scale model, made with definitive materials and components, was followed by certification tests relative to the hydrogen proof capability. The program has widely contributed to certify the muffle of second generation.

The technical specifications of the various constituants of the industrial muffle were made during the program. The muffle and our patented heat shield was presented to potential customers in the second semester of 2012.

Patented Muffle allows heating above 760°C in H_2 atmosphere with induction.

The muffle is an enclosure used in the real industrial application to achieve the containment anti oxidant atmosphere.

It makes it possible to heat steel strips at the requires 1,200°C while preventing oxidation by the oxygen of the ambiant air at high temperature.

The muffle must meet three main technical requirements:

- Transparency to the magnetic field
- Tightness hydrogen H_2
- High temperature performance of the containment structure

Expected benefits for the environment

The use of induction can generate energy saving and also limit the impact on the environment in the process of the annealing of steels (bright annealing, annealing and pickling, carbon steel annealing).

ENERGY SAVINGS & LIMITATION OF GAS EMISSIONS

The replacement of natural gas furnaces by induction furnaces contributes to reduce the emission of gases such as NOx, CO_2, etc. It is recognized that 10 kWh saved correspond to 1m3 of CO_2 and 50mg of NOx that are not then emitted into the atmosphere.

Energy gains expected in bright annealing and annealing and pickling are 70 kWh/T, based on heating between 20°C and 1,150°C. The expected gains in annealing of carbon steel are 23 kWh/T, based on heating between 700°C and 800°C.

Energy savings expected in France (year 2000), based on a yearly production of 500kT (bright annealing) and 700kT (annealing and pickling) for stainless steel and 6,000kT for carbon steel lead to a saving of 20 GWh, that is PET 1680, on the basis of a technological substitution of 20% on stainless steel and 2% on carbon steel production.

REDUCED USE OF ACID BATH FOR ANNEALING AND PICKLING OF STAINLESS STEEL

In the annealing-pickling process of stainless steel, annealed strip passes through a pickling bath to remove all traces of oxidation. Pickling baths contain acids such as $H2SO_4$, HNO_3, HF and molten salts (Na_2SO_4).

The formation of the oxide on the metal sheet depends on the residence time of the strip in the oven. In the current lines (heating gas furnaces), the residence time of the strip is about 2 minutes; in a new line, where the strip is heated by induction, the residence time is about 10 seconds. It is believed that the formation of oxide formed is divided by 5 when the residence time decreases from 120 to 10 seconds, which also involves a strong decrease in the consumption of acid.

The bright annealing process, for which any single contact with the strip is prohibited, the EcoTransFlux™ technology fulfills its definitive implementation as a heater under H_2 atmosphere antioxidant, thus avoiding the use of any acid products.

Acid waste savings during the annealing process with EcoTransFlux™

A 20% substitution of the current stainless steel processing lines with the demonstrated technology would avoid the yearly consumption of 12,000 tonnes of nitric acid (HNO_3) and 4,000 tonnes of hydrofluoric acid and associated sludge. It would also avoid the emission of 50,000 tonnes of CO_2, 3.2 tonnes of HF (hydrogen fluoride gas) and 4,000 tonnes of NOx.

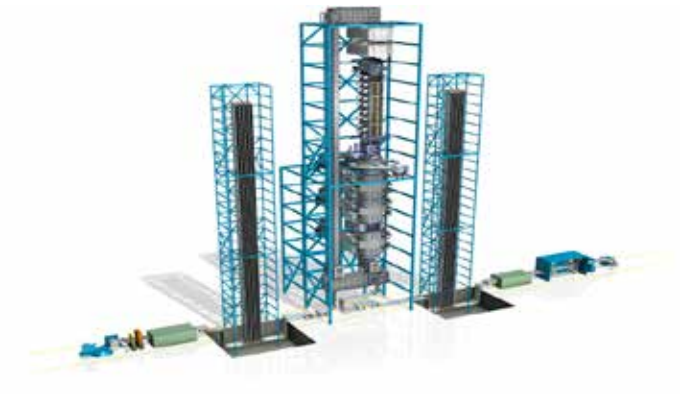
In the carbon steel industry, penetration of only 2% of the world capacity would save 75,000 tonnes of CO_2 annually.

Applicability of the technology

STEEL APPLICATIONS

Stainless steel applications

In the iBAL (Induction Bright Annealing Line) system, the EcoTransFlux™ inductors can replace gas-heated furnaces of the Bright Annealing lines (BAL) and CAPL lines. The steel is heated up to 1,200°C by induction in a non-oxidant atmosphere, and the new technology enables a drastic reduction, even elimination of acids and effluents, thanks to the ability to operate in non-oxidizing atmospheres.



Combining Fives Celes' transverse flux induction technology EcoTransFlux™ with Fives Stein's FlashCooling rapid cooling technology, the iBAL systems allows the annual processing of as much as 350,000 tonnes of bright annealing strainless strips of BA quality.

Carbon steel applications

In partnership with ADEME and INSA Lyon University, Fives participated to a PhD thesis outlining the benefits of the rapid heating cycles on carbon steel (200-400°C/sec). EcoTransFlux™ makes the implementation of such a new process now possible on an industrial scale.

Benefits

> Mechanical resistance of the steel improved by 5 to 10%
> Preservation of elongation capacity

THE OUTCOMES OF THE PROJECT

The successful demonstration of the EcoTransFlux™ inductor showed that it has a real impact on the carbon footprint of the steelmakers. This was achieved with an equipment able to be connected to sources of 3MW per unit, performing the heating of steel strips with a homogeneity of +/-3%.

The outcomes of this demonstration will be disseminated to industrials, universities, research institutes, etc.

This technology is expected to be used by international steelmakers, and especially Europeans.

In the long term, the expected result is the application process for stainless steel in particular. After a period of 5 to 10 years, it is estimated that 20% of annealing lines will be replaced by stainless steel bright annealing lines (iBAL-Induction Bright Annealing Line), integrating EcoTransFlux™ inductors.

Through the Life+ programme, the European Union tends to create an environment favourable to initiative, development of companies, industrial cooperation and improved utilisation of the industrial potential of the innovation, research and technological development policies.

Within the scope of the third call for proposals for the Life+ programme (2007-2013), Fives Celes submitted a financing file to the European Commission, with the help of the Regional Agency for Innovation in Alsace and presented its innovation of steel strip heating by transverse flux: the EcoTransFlux™ project.

This project aims at demonstrating that the technology of transverse flux and high power induction heating can be applied to new processing lines in cold rolling mills in order to decrease the emission of greenhouse effect gases and acid waste while meeting economic, quality and capacity requirements.

Project beginning: the project was approved on September 1st, 2010
Project end: 30/09/2012

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