Modernization of existing industrial furnace plants

by Peter Wendt, Friedrich Gerwin, Frank Maschler, Gregor Ferber, Hermann Meyer, Sascha Bothen

To date, the main priority for manufacturers of heat treatment plants has been to sell new plants. However, the modernization of an existing plant may often be considerably less expensive than an entirely new furnace. At any rate, this point requires detailed consideration. Especially where plant operators introduce new products or processes under their own responsibility or are aiming for performance improvements, modernization projects are becoming increasingly popular. These projects are frequently planned in close cooperation with plant suppliers. The operator has a specific objective in mind and the plant supplier knows a variety of ways in which this objective can be achieved. In this situation, cooperation on conceptual design is already called for before the contract is awarded.

In Europe and especially in Germany, very little has been invested in new reheating furnaces and heat treatment plants over the past decade. There is a growing demand for the modernization of the existing industrial furnace fleet with the following objectives:

- Quality assurance,
- Performance enhancement,
- Modified processes,
- Ensuring stable operation,
- Improved energy efficiency,
- Reduced emissions,
- Lower operating expenses.

LOI and its parent company Tenova have developed and implemented a wide variety of solutions for modernization projects.

REHEATING FURNACES

When planning a modernization project, it is initially necessary to review the entire reheating process. Following the completion of modernization, the energy required for the process must be used and transferred to the material to be reheated as efficiently as possible. In addition, the energy contained in flue gases must be returned to the process to the greatest possible extent.

Recuperator burners – for universal use

With no further changes in operation, energy consumption can be reduced by up to 25% if the existing heating system is replaced by modern recuperator burners. These advanced burners can be adapted to the flame characteristics and control parameters required for the process within very wide limits and can therefore be used in all existing heat treatment plants.

Regenerative burners – extremely low NOx values

A further development is the regenerative burner, which is increasingly being used in modernization and new furnace projects. LOI already installed the first walking beam furnace with a regenerative heating system for Hoesch Hohenlimburg GmbH in 2004. LOI had already converted existing rotary hearth furnaces to regenerative heating for the Austrian company voestalpine in Kindberg in 2002 and the German company Benteler in Paderborn in 2003.

A regenerative heating system operates in two alternating modes – burner operation and extraction. In burner operation, the cold combustion air is preheated in a regenerator unit and fed to the burners. In a counter-current configuration – in the extraction mode – flue gas from the furnace is fed to the second regenerator unit, which is heated up in the process. Although the temperature of the hot air in this unit often reaches more than 1,000 °C, the cooled flue gas discharged from the unit only has a temperature of about 200 to 250 °C. This flue gas is routed to the flue stack via piping and a flue gas fan. As flameless combustion is used, these burners have very low NOx emissions.
Heat Treatment

**Furnace geometry – higher performance with lower energy input**

Furnace geometry may be changed with a view to achieving several different objectives. The temperature distribution in the charge material may be made more homogeneous and optimized process control may allow lower specific energy consumption.

Furnace geometry changes include the dismantling of the ceramic soaking hearths in the case of pusher-type furnaces, followed by the extension of the skid system up to the exit door and the installation of additional burners. The shape of the furnace roof may also be changed to improve heat transfer to the material.

The optimization of furnace pressure control prevents the ingress of secondary air to the furnace, which can cause high heat losses. For this reason, the sealing of the furnace casing and all openings should be thoroughly analysed and improved where necessary. Door seals also represent an entry path for unwanted secondary air and should therefore be replaced by improved sealing systems.

**Extension of heating system – more capacity, less gas**

In order to increase the capacity of a furnace, it is sufficient in many cases to extend the existing heating system. Additional burners can be installed in zones which were previously not heated. In such cases, it is beneficial to use regenerative burners which are connected to the existing gas supply system. It is not normally necessary to increase the connection rating of the furnace as the new burners significantly reduce specific energy consumption.

In combination with the modernization of existing metering, instrumentation and control systems, LOI and Tenova have already achieved capacity improvements of more than 20%. For example, several rotary hearth furnaces at pipe production plants have been equipped with additional regenerative burners in convection zones which were previously not heated. In addition, LOI has significantly improved the energy balance of walking hearth and walking beam furnaces by installing additional regenerative burners.

**Hot strip rolling mill lines – 20% more capacity, 10% less energy**

An example of a modernization project currently in progress is the performance enhancement of an existing walking beam furnace for slabs on the hot strip rolling line of ArcelorMittal Eisenhüttenstadt GmbH. This project is being completed in cooperation between the two Tenova companies, Tenova LOI Thermprocess and Tenova Italimpianti.

In total, this project involves the installation of 28 regenerative burners in the walking beam furnace and the replacement of the existing hot air burners in the convection zone. Following the completion of the project, the capacity of the furnace will be increased by 20%; at the same time, the specific energy consumption will be reduced by about 10% (Fig. 1).

The modern regenerative burners developed and produced by Tenova Italimpianti will also reduce NOx emissions. The modernization work is due to be completed in December 2015.

**STAINLESS STEEL ANNEALING AND PICKLING LINES**

Until March 2007, ThyssenKrupp AST Terni operated a cold rolling mill for stainless steel strip at its Turin location. For the relocation of production to the new site at Terni, the existing annealing and pickling line LAC 2 in Turin was dismantled in 2009 and re-assembled as LAC 4 in Terni.

While the equipment was operated purely as a hot-rolled strip line in Turin, LOI modified the line now installed in Terni for operation as a combined hot-rolled and cold-rolled strip line. The general contractor for the relocation, modernization and re-assembly of the line was Tenova Strip Processing (TSP). This company supplied the mechanical systems for strip handling and the pickling unit while LOI supplied the furnace and the cooling section.

The furnace was extended to include an additional recuperative zone, new Up & Down furnace rollers were installed, the cooling section was completely redesigned and new instrumentation and control systems were installed. As a result, the company has now modernized the line to process both hot-rolled and cold-rolled strip. The new cooling section consists of three subsections. Subsection 1 operates with air cooling for cold-rolled strip and alternative water spray cooling for heavy-gauge hot-rolled strip. Subsection 2 features a combined cooling system with water and compressed air which is mainly used for cold-rolled strip. Subsection 3 is equipped with a water spray system for the final cooling of the strip.

LAC 4 has been in production operation since January 2010 and meets all the relevant quality requirements. In addition, LOI has increased the strip speed by 30%.

**ELECTRICAL STRIP PROCESS LINES**

Grain-oriented (GO) electrical strip is used as a core material for transformers. In this application, the magnetic properties of the strip are crucially important. The production process is complex and involves multi-stage heat treatment. Producers throughout the world are concentrating on the highest-quality material grades. Over the past 10 years alone, LOI has supplied 40 furnace plants for electrical strip production to customers throughout the world and has modernized or modified more than 10 plants.
New process technology – higher quality
Stalprodukt of Bochnia is Poland’s only grain-oriented strip producer. The strip, with a thickness of 0.50 to 0.65 mm, is decarburized by annealing between two cold rolling steps (Fig. 2). The existing decarburizing lines B1 and B2 had been in operation since the 1970s. The minimum electrical losses which could be achieved were of the order of 1.1 W/kg, while more modern plants reach values as low as 0.7 W/kg.

In the first stage of the project, LOI installed a modern annealing and pickling line for the hot-rolled strip. The main element in the modernization project for furnaces B1 and B2 was the nitriding of the strip by ammonia cracking following decarburizing. The nitrogen in the strip inhibits unwanted growth prior to grain orientation.

The contract mainly included:
- A new entry seal with process gas flare,
- Four new separators for the separation of furnace atmosphere gases,
- The installation of a separate dry reduction section in the soaking furnace,
- Two new furnace sections forming a nitriding zone, complete with process gas systems,
- New furnace rollers with graphite sleeves,
- Two new jet cooler units and an exit seal,
- The replacement of all valves and metering, instrumentation and control systems.

Production with line B2 started in June 2013, followed by line B1 in February 2015. The customer can now produce top-quality grain-oriented strip from low-cost hot-rolled strip. Aperam Inox America do Sul in Brazil has adopted a similar approach. At the end of 2014, several Tenova companies under the leadership of LOI received a contract for the process engineering modernization of the existing facilities.

The modernization project includes an annealing and pickling line and a decarburizing line with downstream MgO dryer as well as the refurbishment of the rolling stand by Tenova I2S. Following completion in the spring of 2016, the customer will have a plant which will meet the quality requirements of the electrical strip market.

Modernization with minimal production downtimes
ThyssenKrupp Electrical Steel (TKES) produces grain-oriented electrical strip at its Gelsenkirchen plant. Flattening and coating lines S1 and S2 were commissioned in the early 1970s. In contrast with the current state of the art, an oxidizing atmosphere was used throughout the entire process. Gradually, the surface quality obtained fell below customers’ expectations. As a result, the operator decided to convert both the lines to operation with a protective controlled atmosphere.

In 2012, LOI replaced all the components of line S2 downstream from the straightening rolls. The strip now runs through to the exit seal at the end of the jet cooling section in a controlled atmosphere (Fig. 3). The new electrically heated soaking furnace is equipped with a bottom heating system comprising strip heating elements. In the slow cooling section, the strip is cooled to about 600 °C at a rate of around 15 K/s. This section is equipped with radiant tubes with internal air cooling. The strip then passes through the new jet cooling section, where it is cooled to below 500 °C. The exit seal with seal rolls and double fibre curtains is also new.

To keep production downtime to a minimum, LOI planned the modifications in such a way that the line could already be recommissioned 21 days after the start of dismantling work. Initially, the line was recommissioned without atmosphere gas operation; in other words the operating mode was equivalent to that used prior to the modernization. LOI then completed all further installation and commissioning work with the line in operation. The project was completed to schedule and line S 2 was recommissioned with atmosphere gas.
operation in March 2013. All the quality targets which had been set were achieved (Fig. 3).

For the S2 furnace line, the operator had specified an atmosphere gas mixture with up to 10% hydrogen, which called for considerably more complex safety engineering compared with the preliminary planning stage. However, experience from production indicated that a hydrogen content in excess of 4% would not be required. For this reason, it was possible to simplify the modifications to line S1, which were completed to schedule at the end of March 2015.

**BELL-TYPE ANNEALING PLANTS**

Considerable improvements in energy efficiency, performance and quality can be obtained by modernizing old bell-type annealing plants. The following modifications have been tried and tested in practice and represent the state of the art:

- Older HNX plants can be changed over to advanced HPH® technology with a controlled atmosphere of 100% hydrogen, combined with high convection.
- Older recirculation fan motors can normally be replaced by modern frequency-controlled motors with fan speeds of up to 2,500 rpm without any problems. Apart from the possible performance improvement and the longer service lives of these fans thanks to their reinforced bearings, this modification normally also results in cost savings because the new standard motors are less costly than the old motors which are now only available to special order.
- New fan impellers with a weight saving of about 30 kg (based on a steel strip impeller with a diameter of 950 mm) can also be installed at existing plants without any problems. Apart from the cost saving, these impellers have higher critical speeds as a result of lower loads on bearings or may be operated at higher speeds in order to improve performance.
- For old and new plants, LOI has developed a base seal which can even out irregularities in the base or inner cover flange up to a limit which is twice as high as with conventional base seals.
- Gas injection optimized for individual stacks and controlled by special software with a view to reducing nitrogen and hydrogen consumption is now a state-of-the-art solution.

In the search for further savings potential in bell-type annealing plant operation, it becomes evident that about 56% of the energy input is needed for heating the coils. Flue gas losses account for about 28%, while 12% of the energy input is used for heating ancillary equipment (convector plates, inner cover, annealing base). Energy losses through the wall of the heating hood or the cooling water system are relatively low, at about 2% in each case.

This shows that significant energy savings at modern bell-type annealing plants can only be achieved by making more efficient use of energy for charge heating and by reducing flue gas losses.

**HPH Flameless technology**

For bell-type annealing furnaces, LOI has developed a new generation of heating hoods that use flameless oxidation. The objective of development was to reduce energy consumption by at least 10% at the same time as significantly lowering NOx emissions.

Normally, flue gas temperatures downstream from the recuperator in the recrystallization of cold-rolled steel strip are of the order of 450°C, resulting in flue gas losses of 25% or more referred to the entire energy input. One possibility of reducing energy consumption is to increase the combustion air preheating temperature. However, this results in higher NOx formation at temperature peaks. LOI adopted the flameless oxidation approach in order to resolve this conflict.
In the course of development, Hoesch Hohenlimburg GmbH provided intensive support for the construction of a pilot plant. An HPH® bell type annealing plant supplied by LOI with eight annealing bases had already been in operation at the company’s Hagen-Hohenlimburg facility for several years. The pilot plant was commissioned in May 2011. In production operation for more than one year, it was shown that the process allowed energy savings of 12 % combined with extremely low NOₓ emissions. Flameless oxidation has therefore been proved to be suitable for bell-type annealing furnaces at soaking temperatures of about 700 °C.

The heating hood is heated by six burners (Fig. 4) installed on two levels of three burners each; each burner has a thermal rating of up to 240 kW. Although energy is now transferred by six burners instead of 12, the maximum temperature on the inner cover is 50 K lower than with a conventional heating hood (Fig. 5).

In order to increase the hot air temperature to at least 550 °C, LOI increased the recuperator exchange surface to about triple the usual value. The heat transfer surface of the two recuperators totals about 42 m².

At the beginning of a typical annealing cycle, the plant operates in the flame mode. After less than one hour of operation, the temperature near to the burners already exceeds 830 °C and the burners are then switched to flameless operation. After 12.5 hours, the temperature falls below 830 °C and the burners are then switched back to the flame mode.

In comparison measurements, energy consumption with the conventional heating hood was 221.4 kWh/t. Under identical conditions, energy consumption with the HPH® Flameless heating hood was 194.5 kWh/t, corresponding to a reduction of more than 12 % in energy consumption.

For a typical recrystallizing cycle for cold-rolled strip with a core temperature of 680 °C and a duration of 17.5 hours, the energy consumption of the HPH® Flameless heating hood was 173 kWh/t. Assuming an energy price of 0.033 €/kWh, this would correspond to an energy saving per heating hood of € 33,000 per year in normal recrystallizing operation.

All in all, the average NOₓ emissions over the annealing cycle, with reference to the fuel gas flow, are about 70 mg/m³ (Fig. 6). In both modes, CO emissions always remain below 10 ppm. This plant therefore ensures compliance with the world’s most stringent NOₓ emission limit of 100 mg/m³ – which applies for example in the Netherlands and in parts of the USA.

This new technology will have consequences for the approval of new plants. Although TA Luft (the German Clean Air Regulation) allows emissions of up to 500 mg/m³ for rolling mill furnaces and states a general limit of 250 mg/m³ for bell-type annealing plants with natural gas firing systems, the environmental protection authorities are always called upon to take the state of the art into account.
In effect, HPH® Flameless technology has now redefined the state of the art.

Flameless oxidation also lays the foundation for a drastic reduction in flue gas losses. However, the cost of larger recuperators and modifications to hot air piping and burners needs to be recouped. With current natural gas prices and a reduction of 12 % in gas consumption, the additional cost can be recouped in about three years. In analyses of this type, expected increases in natural gas prices should be taken into consideration. Trading with CO₂ certificates may also provide additional motivation for investments.

Waste heat utilization and power generation

LOI has adopted a new approach at the plant of Bilstein GmbH & Co. KG in Hagen-Hohenlimburg (Fig. 7); the energy balance of the annealing plant is not considered in isolation but the entire production facility is included. The fundamentally new approach that has been adopted is to extract excess heat generated during coil cooling within a comprehensive energy management system and to make it available to other users in the form of electric power or heat.

Energy from the cooling process is recycled in two stages. Initially, hydrogen at temperatures between 700 and 350 °C is extracted from the hood and used to heat transfer oil to a temperature of up to 270 °C in a special bypass cooler (gas/oil heat exchanger). The heated oil is fed through a ring main. The ethanol is evaporated in a downstream Organic Rankine Cycle (ORC) process, driving a reciprocating piston expander (Fig. 8) that powers an electric generator.

When the gas temperature during the cooling process falls below 350 °C, water is fed via a second bypass cooler (gas/water heat exchanger) and through a secondary cycle at a temperature of about 80 °C. This cycle supplies heat via a ring main system to high shelving units, air curtains at the hall doors and emulsion tanks which must be maintained at a constant temperature of about 50 °C.

As LOI preheats the combustion air to up to 650 °C, the fuel consumption of the bell-type annealing plant is about 11 % lower than in conventional operation. 3 % of the recycled energy is converted into electric power and 55 % into heat for users throughout the plant. The recycling rate is 58 %, corresponding to an improvement of 39 % in energy efficiency. Per charge, the ORC system generates about 300 kWh of electric power and a total of 5,300 kWh of heat energy is recovered. Since the installation of the system, Bilstein has saved about € 350,000 per year as a result of reduced power and natural gas costs.

An evaluation of the meters installed showed that Bilstein had recovered about 1.5 million kWh of energy in 2014 as a result of waste heat recovery alone.

Bilstein’s bell-type annealing plant is not only the most efficient annealing plant in the world but the only plant
equipped with fully automated crane operation system. The entire plant with 12 annealing bases is controlled and monitored by only one person.

**HOT DIP GALVANIZING OF STEEL STRIP**
The FBA7 galvanizing line of TKSE Bochum is a vertical unit with annual capacity of about 540,000 t mainly used for the production of outer-skin and dual-phase steels for the automobile industry. The line was commissioned at the beginning of the 1990s and the operator planned to modernize it to ensure better use of energy in the preheating furnace; the plant was also to be upgraded for the production of improved multi-phase steel grades.

LOI modernized the preheating furnace, installed a pre-oxidation unit, modified the rapid cooling system and installed a reheating unit with electrically heated radiant tubes in the original over-aging section (Fig. 9). The modernization project for the preheating furnace included (Fig. 10):

- New flue gas and atmosphere gas flow systems to ensure intensive counter flow of flue gas and strip with new gas ducts and new high-efficiency flue gas/atmosphere gas heat exchangers.
- The installation of two additional fans for atmosphere gas recirculation.
- The replacement of the existing recirculation fans by fans with double the volume flow rate.

The project was to be completed during the planned summer shutdown in August/September 2014 when other major repairs were also scheduled. LOI completed the project within the time schedule and the line was recommissioned as planned. The performance of the preheating furnace, the pre-oxidation unit and the reheating system was demonstrated. In addition, LOI significantly improved the efficiency of strip preheating. The heat extracted from the system was increased from about 900 kW to 1,650 kW at reference conditions.

The FBA 7 line is currently successfully producing improved multi-phase concept grades with low strip thickness. The experience gained in the first stage of the project is now to be used for further modernization of the plant in a second stage in order to extend the possible applications for these new steel grades.

**ROLLER HEARTH FURNACES – 150 % EFFICIENCY IMPROVEMENT**
Over the past few decades, the modernization of many of the 350 roller hearth furnaces built by LOI has become increasingly important in addition to the construction of new furnaces (Fig. 11a, b).

The main factors which make the modernization of these furnaces especially attractive for customers are shorter downtimes and the partial reuse of existing infrastructure.

The modernization of a plant operated by Jansen GmbH in Dingelstädt, a long-standing customer of Nassheuer, illustrates this development. In 2014, Jansen awarded LOI a contract to increase the capacity of an existing roller hearth furnace used to heat treat steel tubes.

The decision to modernize the existing plant instead of purchasing a new heat treatment furnace was taken following a thorough analysis. The key factors in the decision were the shorter downtime as a result of modernization and the possibility of making optimum use of the surface available.

In the first stage of the project, annealing capacity is to be increased by a factor of 2.5. An optional expansion stage which has already been planned will allow a threefold capacity increase to as much as 6,000 kg/h. For this reason, a new heating section will be preassembled on the existing line.

The new equipment is to be integrated in the line during a plant shutdown with a duration of only six or seven weeks. In addition to increasing the annealing capacity, the use of the latest technology will improve plant availability, operational safety, product quality and, last but not least, energy efficiency.

With modern, high-performance recuperator burner systems in ceramic radiant tubes, Jansen will also reduce pollutant emissions following the expansion.

In addition, heat losses are to be further reduced by the use of microporous insulation and the replacement of refractory materials. New cooling section segments in the high-temperature and low-temperature sections will also allow significant heat recovery.

Finally, a further key aspect needs to be taken into consideration for the modernization of heat treatment plants – the increasingly demanding requirements of the final customer. A particularly significant example is the continuous improvement of quality in accordance with document CQI-9 (Continuous Quality Improvement) for products to be used in the automobile industry. This specification states stringent requirements for the pyrometric equipment of heat treatment plants and must also be taken into consideration for the modernization of existing plants.

**LINES FOR MELTING, RECYCLING AND HEAT TREATMENT OF ALUMINIUM**
In general, the modernization possibilities mentioned above are also available for the melting and heat treatment of aluminium.

**Age hardening furnaces**
In the case of heat treatment lines consisting of solution annealing and elevated-temperature age hardening furnaces, flue gas from the solution annealing furnace can be fed to the age hardening furnace instead of being released directly via the flue stack, which is normally the...
Heat treatment case. The age hardening furnace operates at a temperature of 200 °C, a much lower temperature level than that of the solution annealing furnace (500 °C). As result, the flue gas can be routed to the heating-up zone and the waste heat contained in the flue gas can be used up to the temperature level of the low-temperature age hardening furnace (Fig. 12).

**Quench tanks**
Waste heat from the flue gas of heat treatment processes can be used to maintain the temperature of quench tanks. For this purpose, a gas/water heat exchanger is installed in the flue duct. Depending on the quench medium required, this heat exchanger may be used directly for the heating of the quench medium or it may form part of an intermediate loop.

**Melting and recycling plants**
In the case of melting furnaces, the replacement of existing cold air or recuperator burners by regenerative burners can always be recommended as significant energy savings and performance improvements can be achieved. As a result of the flame configuration of a regenerative burner, the furnace can be used more effectively for heat transfer to the melting bath and production capacity can be increased.

**Casting furnaces**
Regenerative burners can also be recommended for casting furnaces, especially if alloying elements are added in the furnace. The small size of modern regenerative burners means that they can also be installed in existing casting furnaces. As the flame is distributed more evenly over the melting bath, overheating during the soaking and melting process is avoided.

With regenerative burners, it is normally possible to continue to use the existing flue gas treatment systems; as a result of waste heat recovery, the flue gas volume is not increased.

**Recycling furnaces**
Furnaces used for melting aluminium scrap may be equipped with LOI’s CCR central regenerator (Fig. 13). This unit allows the entire flue gas flow to be routed via the regenerator, where it is rapidly cooled, thus preventing the recombination of harmful components following combustion. The regenerator is installed on the side of the furnace and connected to the furnace or the burners by hot gas piping. The central configuration means that hot combustion air may be supplied to any number of burners which may be required.

**Molten metal recirculation systems**
Another approach which can optimize production capacity and the energy consumption of melting furnaces is the use of molten metal recirculation systems. These include electromagnetic stirrers positioned under the furnace, electromagnetic pumps located on the sides of the furnace, mechanical rotor pumps and permanent magnet units. These systems mix the metal bath internally or extract molten metal via an opening in the side wall of the melting bath and pump it back to the bath at a different point. This results in mixing...
Heat Treatment

of the molten metal, homogenizing the temperature in the bath and avoiding temperature peaks on the bath surface. This approach improves heat transfer in the melting bath and the quality of melting. In addition, recirculation systems make the molten metal more homogeneous.

CONTROL SYSTEM SOLUTIONS

At many furnace plants which have been in operation for many years, the original control systems are still in use. Over the past few years, manufacturers of control hardware have launched new product families and discontinued production of the old hardware. It is only possible to service or repair old modules to a limited extent. This also applies to the modular control systems supplied by LOI, some of which have already been in service since 1984.

In the meantime, the customers of plant operators have posed increasingly stringent requirements for the documentation of production processes. It would be impossible or costly and time-consuming to meet these documentation requirements using the old control systems which are installed.

The modernization of furnace control systems that have already been in operation for many years has a number of benefits:

- Use of the latest control hardware with long-term availability.
- Use of modern programming languages for control solutions.
- Process documentation using up-to-date data logging systems.
- Central operation and control with modern user interfaces (Fig. 14).
- Integration of control solutions into production planning systems.
- Links to production, process and performance optimization systems.

Replacement of S5 control systems by S7 equipment

One of the old control system families that is still in use at many plants is the Siemens Simatic S5 series of PLCs. Although these systems are still fully functional, many components are no longer available from the manufacturer. If a component needs to be replaced at short notice, plant operators are often forced to purchase used equipment.

Upgrading to a modern PLC family also allows additional safety functions to be implemented. There are a wide variety of possibilities. In the case of old furnace plants approved under former legislation, the replacement of control systems is normally possible without any problems if the replacement results in a reduction of the risk connected with plant operation. When an old control system is replaced by a new system, it is generally assumed that this risk is reduced if the original control functions are maintained. Further safety functions combined with additional instrumentation – for example the use of safety relays or failsafe controllers – are also possible.

CONCLUSION

In a large number of projects, LOI has demonstrated that the performance of existing heat treatment plants can be significantly improved by modernization at considerably lower cost than with the construction of a new plant. All the modernization projects completed have resulted in an improvement in energy efficiency leading to considerable reductions in operating expenses in combination with intensive energy recovery. In addition, advanced technologies such as flameless oxidation help protect the environment. Plants equipped with systems of this type meet the world’s most stringent environmental protection requirements.
The approach adopted at a cold rolling plant points the way to the future. Here, individual heat treatment units were no longer considered in isolation; instead, an energy management system was realized throughout the plant. This allows the energy recovered to be used at a number of different levels.

**AUTHORS**

Dr. Peter Wendt  
LOI Thermprocess GmbH  
Essen, Germany  
Tel.: +49 (0) 201 / 1891-236  
peter.wendt@tenova.com

Friedrich Gerwin  
LOI Thermprocess GmbH  
Essen, Germany  
Tel.: +49 (0) 201 / 1891-492  
friedrich.gerwin@tenova.com

Frank Maschler  
LOI Thermprocess GmbH  
Essen, Germany  
Tel.: +49 (0) 201 / 1891-308  
frank.maschler@tenova.com

Gregor Ferber  
LOI Thermprocess GmbH  
Essen, Germany  
Tel.: +49 (0) 201 / 1891-608  
gregor.ferber@tenova.com

Hermann Meyer  
LOI Thermprocess GmbH  
Essen, Germany  
Tel.: +49 (0) 201 / 1891-855  
hermann.meyer@tenova.com

Sascha Bothen  
LOI Thermprocess GmbH  
Essen, Germany  
Tel.: +49 (0) 201 / 1891-645  
service-loi@tenova.com