Operating Experience with Regard to New Double P Radiant Tube Technology in a Vertical Galvanizing Line

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Abstract

Thyssen Krupp Steel started up a new 450,000 t/year (500,000 tons/year) galvanizing line in the fall of 2001 at their Dortmund, Germany plant.
The vertical annealing furnace is equipped with a total of 189 double-P-radiant tubes. This is the first time that a vertical annealing furnace was completely furnished with the new radiant tube design. The main motive to install new radiant tube technology was to improve tube life, due to better temperature uniformity of the tube. The presentation will describe the technology and will give a status report after five years of operation with special focus on::

- tube life
- energy efficiency
- reliability
- maintenance and
- emissions

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Introduction

Thyssen Krupp Steel started up a new 450,000 t/year (500,000 tons/year) galvanizing line in the fall of 2001. Special attention was paid to a friendly atmosphere within the production building. The light flooded structure was painted in certain colors and the cleanliness is remarkable for a steel plant operation. The line is designed for the production of high quality strip for exposed automotive body parts. The products include strip thickness of 0.3 to 1.5 mm (0.01 to 0.06 in) and strip width of 750 to 1650 mm (30 to 65 in). The maximum speed is 180 m/min (600 ft/min). The vertical annealing furnace from Andritz-Selas is equipped with a total of 189 double-P-radiant tubes with a total heat input of 27 MW (92 MMBTU/hr based on LHV). This is the first time that a vertical annealing furnace was completely furnished with the new radiant tube design.

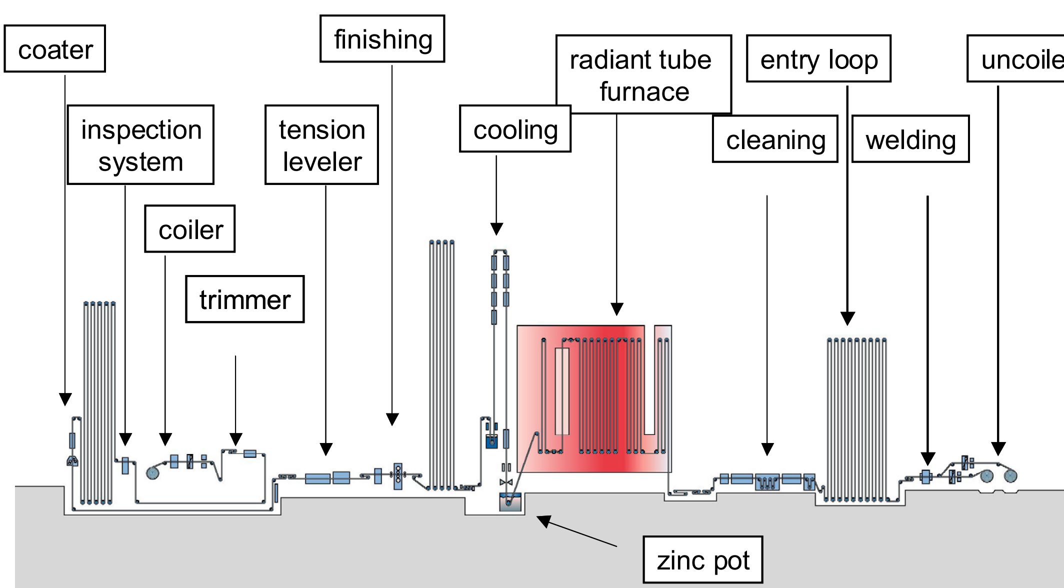

Figure 1: Galvanizing Line FBA8

The galvanizing line FBA8

The decision to build a new galvanizing line at the ThyssenKrupp Dortmund plant lead to the order of a new annealing furnace from the furnace company Andritz Selas in 2000. During the discussion about the radiant tube heating system, the decision was taken to use a new double-P radiant tube technology which had no reference in a vertical galvanizing line at that time with the exception of a few installation of test tubes and the application in other furnace types.
The motivation to use the new radiant tube technology for the first time was the expectation of improved:

- product quality
- energy efficiency
- furnace availability
- production rate
- exhaust emissions (NO_x, CO)
- tube life
- temperature uniformity
- and ease of maintenance

compared to the commonly used W-tube designs.

To be prepared for future stricter emission limits, it was to decided to equip 30 out of the 189 radiant tubes with FLOX® low NOx technology.

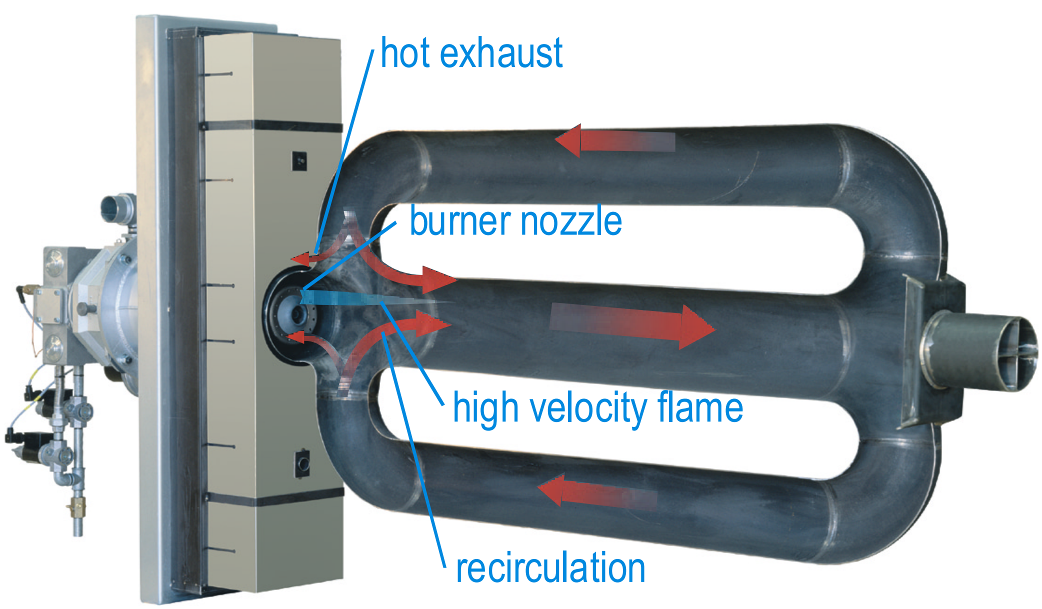

Figure 2: Double-P radiant tube

Figure 3: Top view into the furnace

Radiant tube technology

The most prominent features of the double-P design are a different tube design which is used in combination with a self recuperative high velocity burner.
The double P tube consist of one center leg and two symmetrically arranged return legs with a smaller tube diameter compared to the center leg. The combustion products are feed back into the center leg. The two internal recirculation loops are driven by the high velocity flame of the burner. The flow velocity at the burner is typically in a range of 100 m/s (330 ft/s). To maintain the optimized flow condition the burner is operated on/off in a pulse firing mode. To assure a negative tube pressure and proper burner adjustment, the radiant tubes are operated with a push-pull system. The exhaust gas leaves the tube through the burner leg, passing through a finned counter flow heat exchanger and thereby preheating the combustion air to about 700°C (1300°F). The double P tubes are made out of sheet metal (Inconell 601) with pressed bends and branches.

These design features have the following effects on the radiant tube performance. One important point is the improved temperature uniformity for a longer tube life, due to the internal flue gas recirculation. Additionally, the internal flue gas recirculation reduces NOx formation despite the high air preheat temperatures. A further drastic reduction of NOx emissions is possible the FLOX® combustion technology. The heat exchanger and the burner are one compact unit, so that no external hot air piping is required. The burners can be prepiped and packaged to reduce on site work during furnace construction phase. The on/off operation allows for individual burner adjustment which eases start up and burner maintenance. In this project, the more lightweight sheet metal tubes were preferred to improve the response time of the furnace at product changes. In other applications, it could be beneficial

to use cast tubes.
The tube placement and the number of radiant tubes in the furnace is similar to a W-tube installation. A difference exists in the piping of the furnace. The pulse firing system requires a constant air and fuel gas pressure at all locations and over time but there is no requirement for a zoning defined by the piping. Zoning is solely done electrically. Therefore, the air, fuel gas and exhaust manifolds can be arranged horizontally across the vertically running zones. Attention should be paid to the diameter of the manifolds to avoid pressure drops. Also, the combustion and exhaust blower as well as the fuel gas pressure control should be dimensioned accordingly.

Operating experience

The installation of the double-P tubes was not different compared to W-tubes. Final piping and start up was speedy since all the burners and controls were pre-assembled, tested and fired in advance at the burner manufacturing site.
Emissions of NO_x and CO were within the legal limits after the pressure control of the main natural gas train was properly adjusted.
The produced strips reached their quality goals much faster than stipulated (see Figure 4). A few technical changes were made to the burner and the radiant tube support after installation. All these improvements could be carried out while the furnace was in production, during the scheduled outages or by taking advantage of outages caused by strip breakage or other reasons. So far, no production loss was caused by the new double-P radiant tubes.

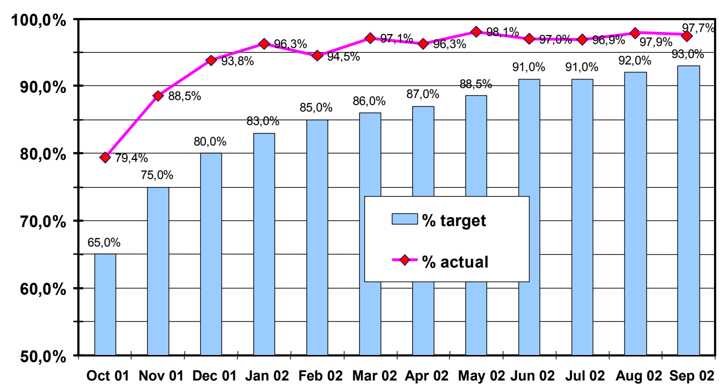

Figure 4: Target versus actual product quality

After five years of continuous operation, the tubes show no sign of sagging or deformation. The tubes with FLOX technology showed no difference in operating behavior except lower NOx emissions.

Having no hot air piping outside the furnace in combination with good airing of the furnace decks through grates led to very pleasant temperatures on the decks. The temperatures are acceptable even on the upper decks during production on a hot summer day.

The energy efficiency gained importance in the last years since energy prices have been rising drastically. The energy consumption was validated to be in the range of 0.8 to 0.85GJ/t LHV (0.8 to 0.85 MMBTU/ton HHV).

Outlook

The positive results of the FBA8 installation led to several new installations and to the consideration of this technology for new projects worldwide.

Two of the FLOX® double-P radiant tubes in the FBA8 were modified for further NOx reduction and delivered NOx emissions of less than 20 ppm (0.025 #/MMBTU) which represents a reduction of about 90% compared to conventional systems. These figures were not achievable in the past without exhaust gas treatment in a deNOx-plant.

The energy efficiency will gain further importance in the future. Besides that, the usage of substitute fuel gases for natural gas will be considered in many projects. The high velocity combustion in combination with double-P radiant tubes are perfectly suited for burning substitute gases as long as the gas shut off valves can handle the impurities in the fuel.

The successful introduction of the new radiant tube design to vertical galvanizing lines would not have been possible without the excellent cooperation between end user, furnace maker and equipment supplier. Technical difficulties, which are inevitable with the introduction of new technology were eliminated with minimal suffering for all related parties. It was clear at all times, that safe operation, product quality and production levels were of particular importance.