

DFI oxyfuel solution boost galvanizing capacity at ThyssenKrupp Steel

H. Eichelkraut, H-J. Heiler, W. Högner, (ThyssenKrupp Steel), R. Paul (Linde), Germany, O. Ritzén, P. Vesterberg (Linde), Sweden

INTRODUCTION

ThyssenKrupp Steel has been searching for a both straightforward and effective solution in order to increase the galvanizing capacity of an existing production line at the Fintentrop works. In discussion with Linde, having extensive experience of oxyfuel solutions, a Direct Flame Impingement (DFI) oxyfuel boosting unit was installed beginning of 2006 at the entry side of the existing furnace. The paper will present project background, the DFI oxyfuel technology, its application and important results.

CLEAN STRIP & MORE GALVANIZING CAPACITY

The galvanizing line at TKS Fintentrop (FBA 3), processes both hot and cold rolled strip with a width of 650-1550 mm and thicknesses of 0.3-3.25 mm for both automotive and construction applications. The total furnace length is 130 m, whereof 67 m is airfuel fired. The highest strip speed is 180 m/min and the maximum output was limited to 82 tons/hour, Fig 1.



Fig 1 TKS set the target to increase galvanizing capacity, at the same time removing pre-cleaning.

TKS had identified that by increased strip heating the line could reach 105 ton/h. The appropriate heating solution should also free the strip surface from

unwanted contaminants, such as emulsions, oils, grease and particles, which origin from the upstream strip production process. TKS had experience of electrical strip pre-heaters, typically with poor thermal efficiency, low reliability with too much maintenance. The required boosting unit must also allow for strict control of the required surface properties needed for a successful galvanizing of the strip. With this specification TKS met with Linde in the end of 2004 to discuss the possibilities of applying oxyfuel in galvanizing lines.

DIRECT FLAME IMPINGEMENT OXYFUEL

Direct Flame Impingement oxyfuel is based on Linde's vast experience of oxyfuel combustion and its application in steel heating processes as well of the process to torch prior to welding. This was adapted to continuous and large-scale use in reheating and annealing furnaces. In DFI technology with controlled oxyfuel firing directly onto the moving metal, the heat transfer properties are drastically promoted. Fig 2.

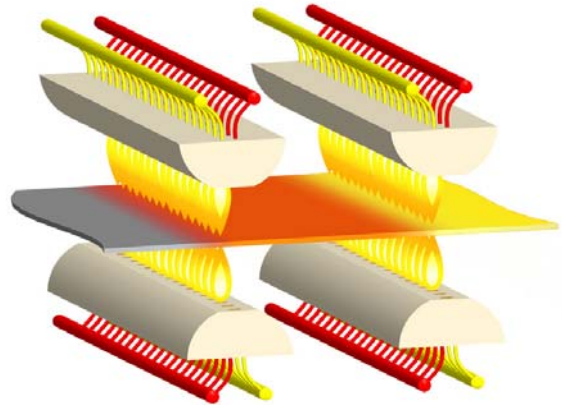


Fig 2 Firing with oxyfuel flames directly onto the material results in a highly effective heat transfer for increased furnace throughput.

Tests have verified the higher level of local heat flux for the DFI oxyfuel technology, reaching levels of 800-1000 kW/m², Fig 3.

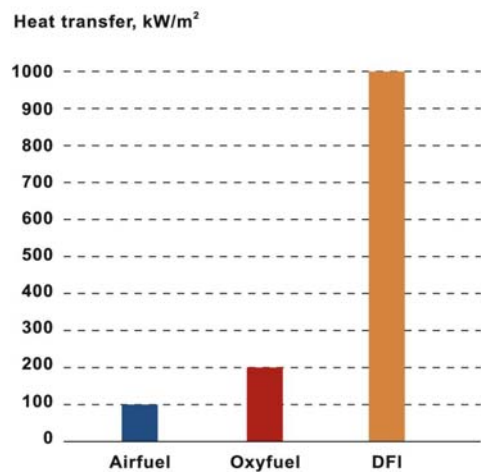


Fig 3 Heat transfer of DFI oxyfuel is drastically higher as compared to air- or oxyfuel combustion.

The first DFI installation was employed in 2002 at a stainless strip annealing and pickling line at Outokumpu Stainless, Nyby works, Sweden. The line was already completely converted to all oxyfuel combustion and with DFI the furnace capacity was further increased, from 23 to 35 ton/h.

APPLICATION OF DFI IN EXISTING FURNACE

TKS conducted several tests together with Linde at its laboratory facilities in Sweden. The studies aimed to determine exactly what levels of preheating could be achieved with DFI oxyfuel for the particular steel grades and thicknesses conditions at Fintentrop, also looking at impact on surface. These data were used in the engineering phase of designing the DFI oxyfuel boosting unit. To minimize line downtime, concerns were taken to find a solution for easy integration with the existing furnace.

The design resulted in a 3-meter long DFI unit equipped with 4 burner ramps, having totally 120 oxyfuel flames and 5 MW installed power, with an option of 2 more ramps for an additional 2.5 MW. The number of ramps and burners employed depend on set preheating temperatures and the actual strip width, Fig 3. At 105 ton/h, the DFI oxyfuel results in an immediate steel strip surface temperature (ΔT) increase of 200°C

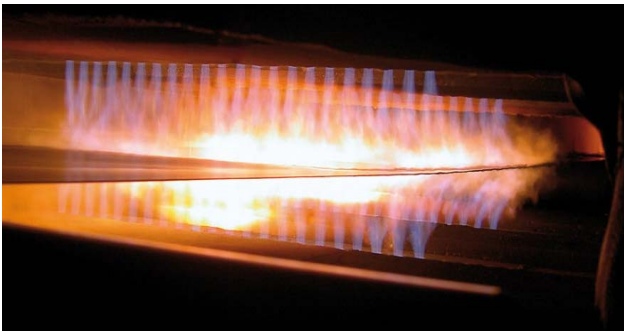


Fig 3 In the photo, 4 oxyfuel burner ramps are seen directly firing onto the steel strip, for a ΔT of 200°C.

A traditional heating furnace solution to reach the requested capacity increase would have extended the furnace an extra 10 meter, a length which is not normally available in existing galvanizing lines. For the installation of DFI, 3 meter of the existing recuperative entry section was removed to fit the compact and powerful DFI oxyfuel unit, Fig 4.

After a 12-day line stop to fit the DFI unit, galvanizing production could be resumed. With initial tuning and subsequent optimization of the DFI unit and the total line, capacity evolved from 82 to 109 ton/h. The DFI oxyfuel unit also manages to burn off residues, particles, grease and oil from the strip rolling process, providing a cleaner strip than the, 25 meter long, electrolytic and brush strip pre-cleaning section; which has now been removed.

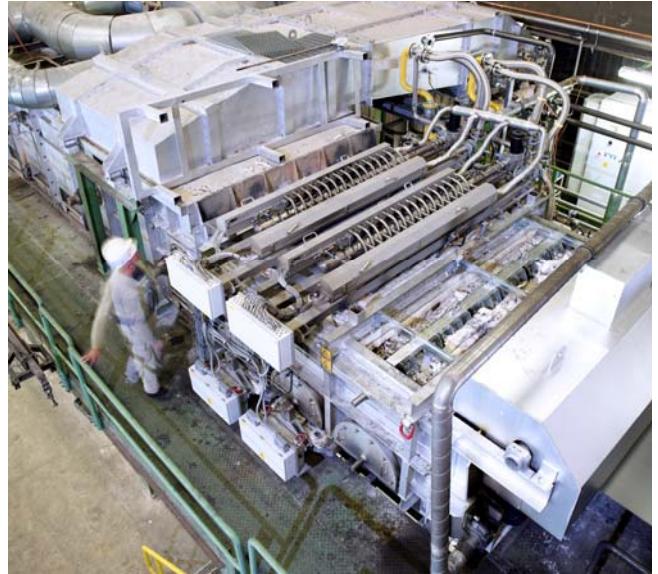


Fig 4 The 3 meter long DFI oxyfuel boosting unit integrated with existing furnace at TKS Fintentrop.

30% MORE CAPACITY WITHOUT ANY EXTENSION

The DFI oxyfuel unit has a thermal efficiency of 80-90%, higher as compared to electrical pre-heaters, which reduces the specific fuel consumption while delivering a powerful 30% capacity increase in an existing galvanizing line, Table 1.

Table 1 A 30% raise in galvanizing capacity was possible while lowering the specific fuel consumption.

		Without DFI	With DFI	Change
Capacity	ton/h	82	109	+ 32%
NG volume/ton	m3/ton	20.6	19.4	- 6%
O₂ volume/ton	m3/ton	0	8	
Energy input/ton	GJ/ton	0.792	0.746	- 6%

Zinc adhesion and surface appearance improved due to DFI's effective pre-cleaning properties, leaving both strip and furnace rolls cleaner than before. It also provides more uniform heating over the strip width for improved annealing properties. Precise and controlled pre-oxidation of strip is also possible with the DFI unit.

SUMMARY

The DFI oxyfuel-boosting solution has effectively demonstrated to boost galvanizing line capacity without extending any furnace or line length. It also cleans the strip for better quality without any need for a separate pre-cleaning section. The compactness and fast installation time of the DFI unit allows for a powerful and cost effective solution, also applicable in galvanizing lines with vertical furnaces.

TKS and Linde have decided to cooperate and jointly develop the application of DFI oxyfuel for use in galvanizing lines.