CONTINUOUS PICKLING LINE PROCESS EFFICIENCY ACHIEVEMENTS AT ARVEDI[1]

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Abstract
In 2010 Danieli & C. S.p.A. has put into operation a new Pickling Tandem Mill in Cremona (Italy) by Acciaieria Arvedi. The installation design was tailor made in order to suit the specific requirements of it customer, which is the ability of processing ultra thin hot band and also Advanced High Strenght Steel. The Danieli & C. S.p.A. Turboflow process was selected, based on its proven efficiency and ability to handle ultra thin gauges at speeds exceeding 400 mpm in the pickling tanks. This paper presents the engineering analysis done by Danieli & C. S.p.A. with the support of Arvedi in order to design the installation and optimize its operations.
Keywords: High speed pickling; PLTCM

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1 INTRODUCTION

The paper describes the activity performed in order to prepare the tuning of pickling section set-up, coil scheduling and optimization of pickling parameters. The tank design has proven to be effective and reliable in avoiding splashing of acid solution at high speed. Original minimum pickling time was 16 sec (at 400 mpm and with 85°C maximum acid temperature)) and there is margin to exploit the maximum line speed of 450 mpm, reducing the minimum pickling time to about 14 sec (at 85 °C acid temperature).

2 RESULTS AND DISCUSSION

The installation of PLTCM in Arvedi is quite not an ordinary one in the wordwide panorama of the existing pickling coupled to PLTCM, and the reason is due to high speed and relatively small reduction required in the rolling mill. A pickling speed of 400 mpm (with abot 10% reserve in the electro-mechanical design) was selected as the one able to achieve an annual output of 1.5 mio t/year, of which 30% only PO coils, that is one of the more successful of Arvedi on the market. The in-line tandem mill has a staged installation with 3 stand in phase1 and one additional stand 0 in phase 2. The mill design was 6-Hi with work and intermediate roll shifting in order to cope with future production of si-bearing steels. A pictorial representation of the shown on fig. 1

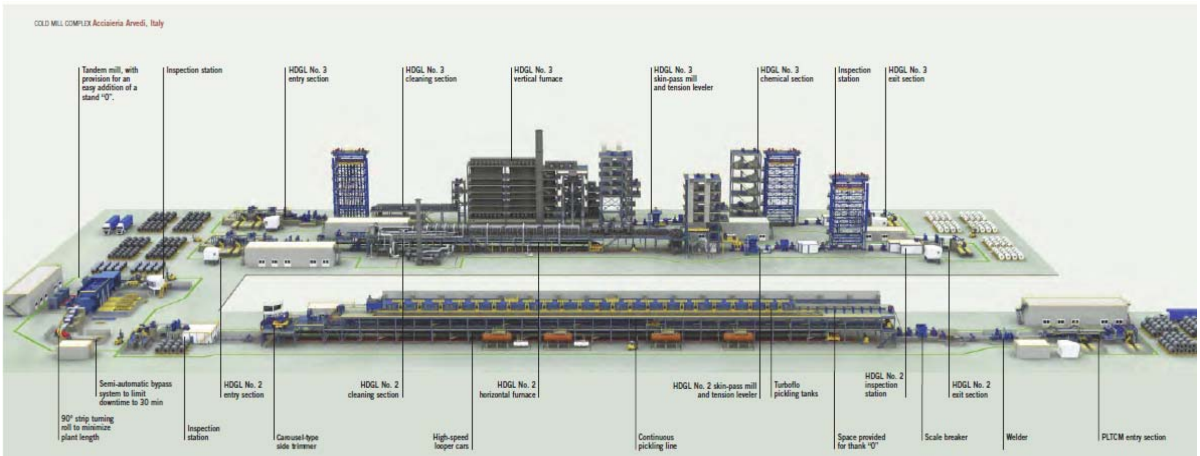


Figure 1. Acciaieria Arvedi, Italy

The expected average thickness to be produced by the plant was below 1.5 mm (in the pickling), with an average rolled thickness less than 0.5 mm.
It was selected to utilize 4 pickling tanks, each 28 m long. The tank design is patented by Danieli and trade mark under Turboflow. The tank design is a so called "turbulence", where the efficiency of pickling due to breakage of the laminar layer formed at the interface between the strip and the pickling medium is due both to the action of sprays located at the entry/exit and sides of each tank, and to the changes in the section of pickling channel (realized in practice by shaping both the bottom and the cover of the pickling tank).

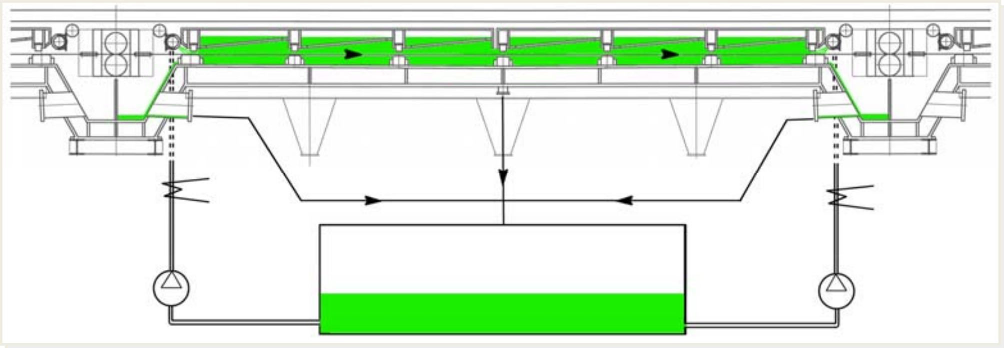


Figure 2. schematic representation of Turboflow tank with shaped bottom and cover.

Figure 3. Picture of the tank bottom and cover.

Acid is heated by steam in carbon fiber heat exchanger located in the main pipe-line between the recirculation tank and the in-line tank. This system allows a fast control of acid temperature, and also allows achieving a high heating power to be transmitted to the acid also at low strip speed, where the highest tonnage per hour of the line is realized.

Ahead of the plant commissioning, a number of samples taken from the hot strip mill were analyzed in the research and development center of Danieli, and tested for pickle ability, in order to prepare a steel grade pickle ability curve (based on lab tests under specified free acid and temperature concentration)). See Fig. 4 and 5

In order to estimate more correctly the pickling time according to line speed and grade, the above mentioned data are utilized in a pickling model that takes into consideration the amount of iron in each pickling tank.

This measurement is performed automatically by an on-line sampling and analyzing system supplied together with the pickling section.

The aim of this work was to prepare the further tuning of pickling prediction model and of the in-line lev2 scheduling control.

Figure 4. Example of pickled samples at different pickling time.

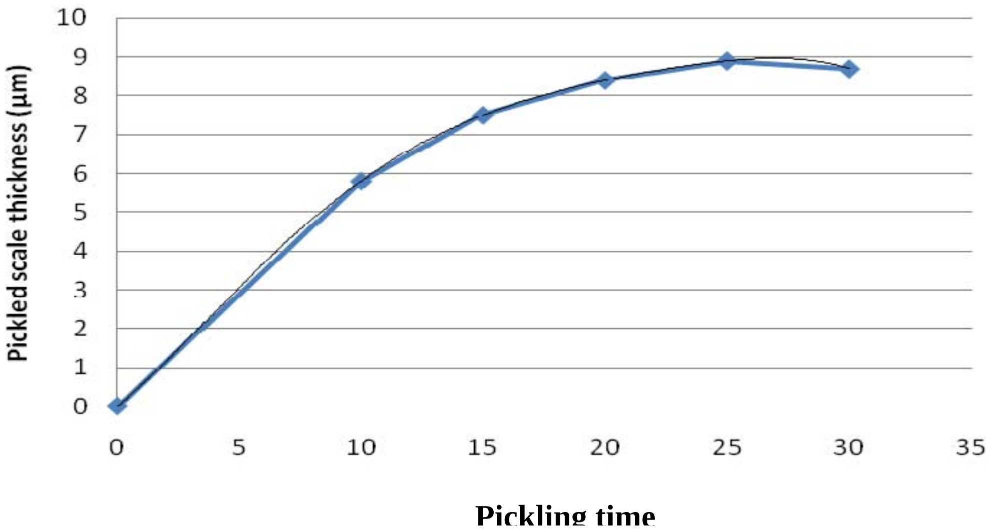


Figure 5. Typical pickleability curve

When analyzing the samples, also the scale morphology was verified by SEM analysis (i.e. composition in terms of magnetite, wustite and hematite), in order not to rely only on the scale thickness and steel grade to justify the difference in pickling time (Fig. 6).

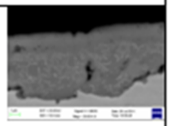
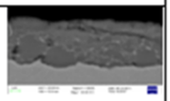
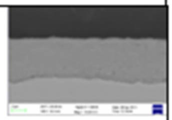
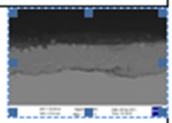
Sample	Position	Strip thickness	Oxide thickness	Description	Pickability	Image
1-End of the coil	Edge of the strip	1.00	6÷8	Mixed phase: hematite, magnetite, decomposed wüstite and retained wüstite	Actual pickling time @ 70°C: 17" Minimum pickling time@ 70°C : 12"	
2-End of the coil	Centre of the strip	1.00	6÷7	Mixed phase: hematite, magnetite and low fraction of decomposed wüstite.	Actual pickling time @ 70°C: 17" Minimum pickling time @ 70°C: 12"	
3- Head of the coil	Edge of the strip	1.50	7÷8	Mixed phase: hematite, magnetite, decomposed wüstite and retained wüstite	Actual pickling time @ 70°C: 22" Minimum pickling time @ 70°C: 17"	
4- Head of the coil	Centre of the strip	1.50	6÷7	Mainly magnetite and decomposed wüstite. Little retained wüstite. No hematite.	Actual pickling time @ 70°C: 22" Minimum pickling time @ 70°C: 17"	

Figure 6. Mapping of coil scale thickness, morphology and pickling time.

The results of pickling test in the laboratory are of course not a very trustworthy source of the true pickling time. This is known from past research activities and tests. First because it is difficult to replicate exactly the actual mass-transfer conditions of the full scale plant, secondly because in the real pickling line all coils undergo scale breaking during tension leveling process. This operation is known to affect the total amount of scale entering the pickling tank, and also to expose areas of bare steel to acid, which condition is known to enhance the overall pickling process.
Nevertheless once the limits are known, the lab test of pickling can be used to compared pickling time vs temperature and scale thicknesses in order to deduct trend values to be finally tuned by on-line data into more exact pickle ability curves.
The analysis performed was mainly confirming our knowledge of the scale morphology as function of the upstream processing conditions, it was never the less a constructive exercise for both us and the final customer that had the possibility of gather a complete confirmation of the operating practice of the hot strip mill and their effects on the downstream pickling.
In order to further characterize the effect on Turbulence itself as a function of the line speed in the designed pickling tank, a number of numerical simulation were also performed, in order to estimate the thickness of boundary layer during the pickling process.
As Danieli already did this exercise in the past, but with simulation tools that are now obsolete, and the results of this number of analysis has shown rather clearly the fact that at low speed most of the turbulence is created by the acid sprays where as the line speed increases the effect of "self induced" turbulence is predominant Fig. 7

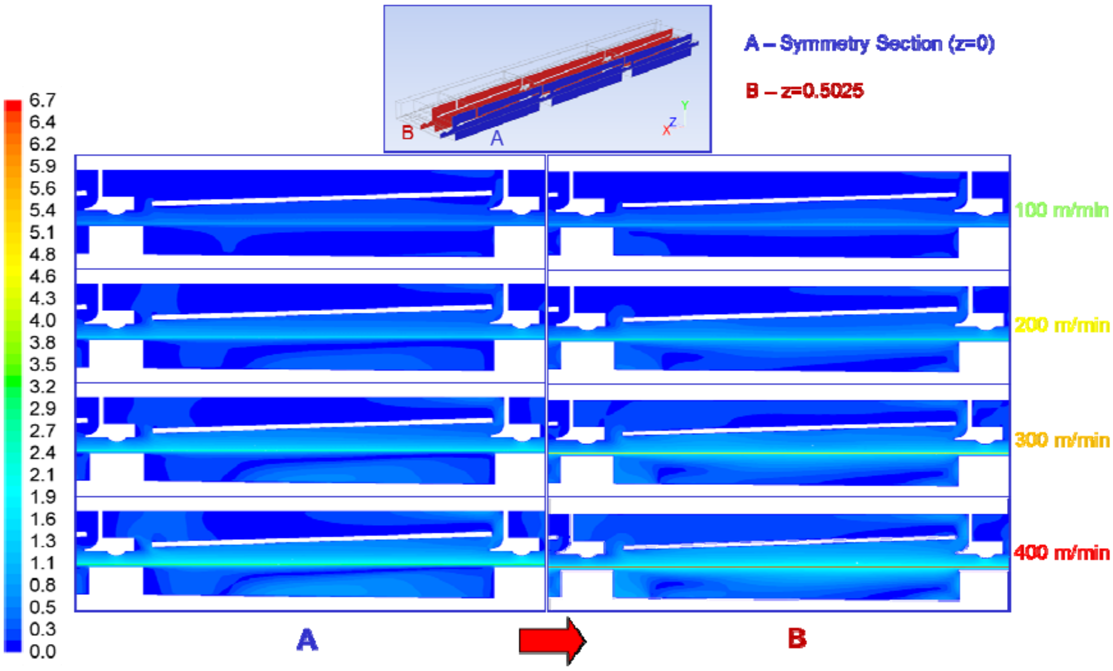


Figure 7. Contour of Velocity [m/s] in the pickling cell at different line speed. Component due to sprays is disregarded.

It can be seen by the results shown in Fig.7 that the effect of the strip speed is to enhance the value of velocity of fluid in the boundary region. This is likely to increase the turbulence level and the heat/mass transfer between the pickling medium and the surface of the strip.
A further analysis that was performed in order to validate the estimation of thermal losses in the pickling system, and in case of wish, to identify the major sources of losses and possible remedy, was a thermal mapping of the recirculation system components, as shown in the pictures 8,9 and 10.
As some what expected, but confirmed by this analysis, was that the major source of dispersion is the fume exhaust system, the acid piping and the off-line tanks. So far this has improved the losses estimation, but no modification in the system was made following the discussion of results.

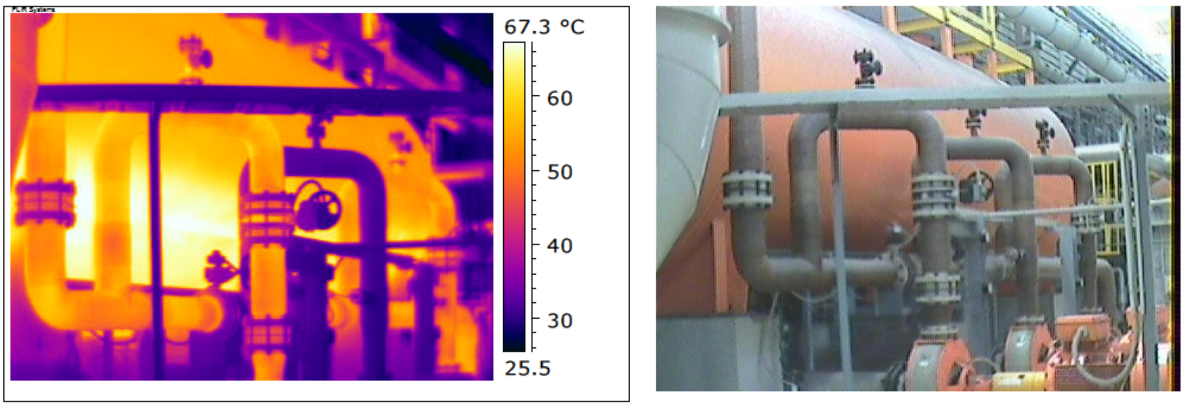


Figure 8. thermal map of off-line recirculation tank

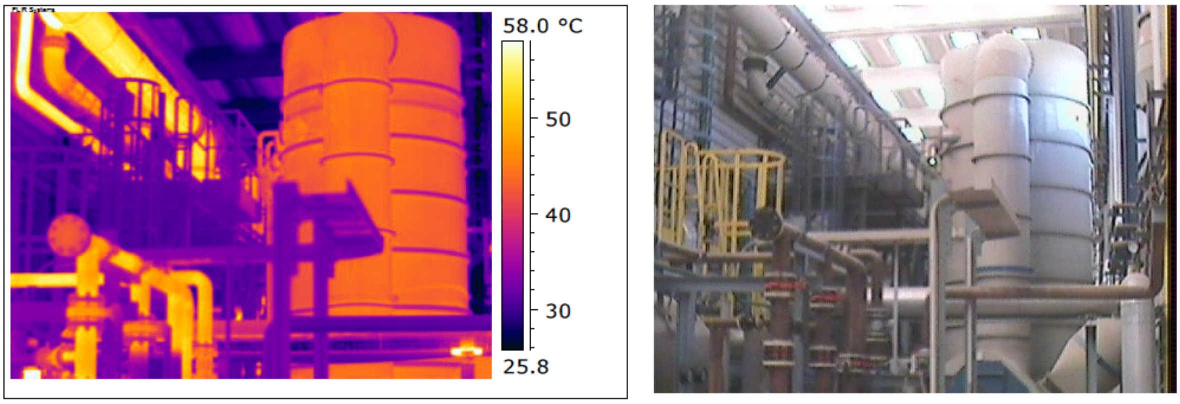


Figure 9. Thermal map of fume exhaust system

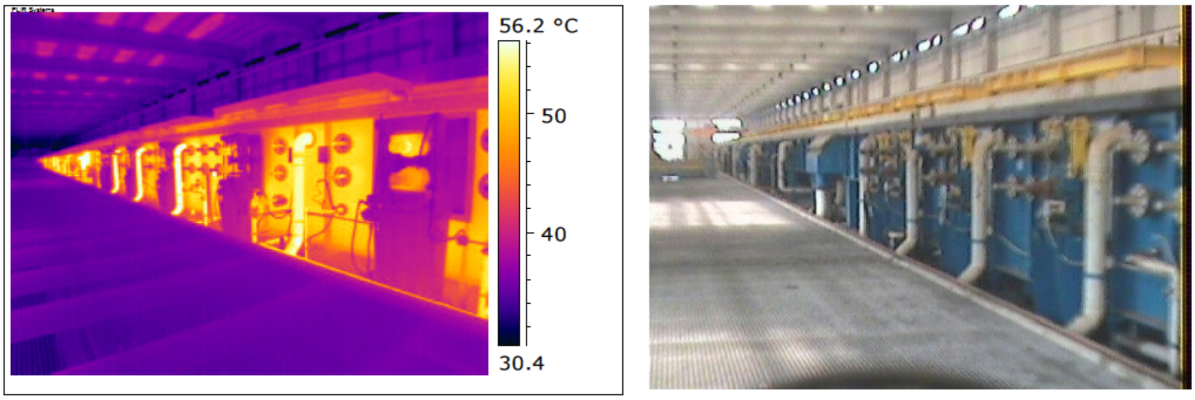


Figure 10. Thermal map of in.line tanks (operator side)

3 CONCLUSIONS

A very detailed examination of the factors influencing the working conditions of the pickling system was done. This resulted in a very smooth start up of the plant and optimization of the process section.
The analysis gave several indication on the major factor influencing efficiency of pickling and actual source of energy losses.

Acknowledgements

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