ALUMINOTHERMIC HEATING OF STEEL IN A FLAT STEEL PRODUCING STEEL SHOP[1]

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Abstract

Objective : The enhanced requirements in steel quality and the multiplication of steel grades result in more complex and sometimes longer treatment processes in the secondary steelmaking line. Consequently there is an increasing need for heating steel to meet the temperature target at casting. Methodology : Chemical heating using aluminium and oxygen blown under a refractory bell is a flexible and efficient solution for heating, while the tight bell system guarantees efficient alloying conditions. Paul Wurth has supplied five aluminium heating stations to flat steel producers, in Europe, China, and recently in Brazil in partnership with VAI-Technometal. Conclusion: The paper describes the equipment supplied, and the main process performances of the last commissioned installation. The advantages of the process in heating speed and accuracy of alloying are highlighted, and a comparison with the electrical heating is proposed.

Key -words: Aluminotermia ; Refino; Aquecimento; Metalurgia Secundária

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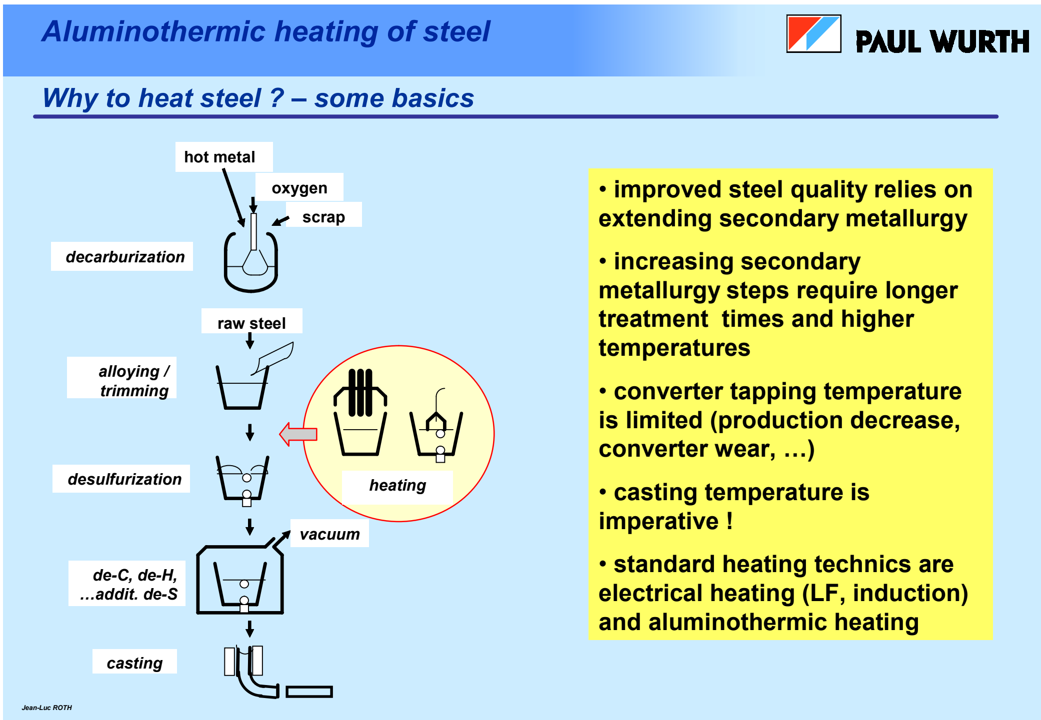
1. INTRODUCTION – WHY TO HEAT STEEL?

The development of secondary metallurgy has strongly contributed to the leap forward accomplished in steel quality during the two last decades, steel final properties being also improved by thermo mechanical processing and surface treatments.

The following slide (1) gives an overview of the main secondary metallurgy steps.



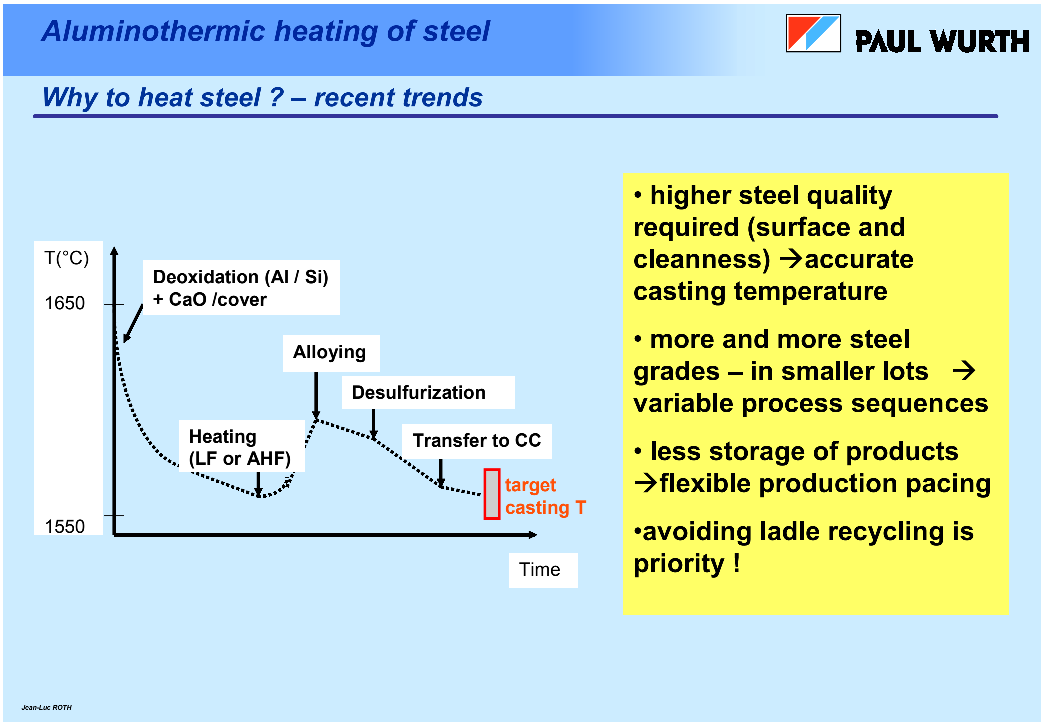
Slide 1. Secondary metallurgy steps – temperature requirements

It clearly suggests that applying more secondary metallurgy treatments requires an increased intermediate steel heating. This is because the in and out temperatures of the system are quite imposed:

- increasing the converter tapping temperature is detrimental for both productivity and refractory wear;
- the casting temperature cannot be decreased too close to the steel liquidus temperature.

Steel heating is mostly done electrically, by arc (in Ladle Furnace) or by induction; aluminothermic heating is less used up to now, but it will be considered more and more, due to new developments in steelmaking practice.

Important recent trends are listed on the next slide (2), which also shows a typical temperature evolution of a steel ladle from converter tapping to casting.



Slide 2. Temperature evolution on steel ladles

On the one hand, the increasing requirements in steel quality – regarding surface, structure and cleanness- will impose more and more accurate casting temperature.
On the other hand, the market asks for more steel grades, and at the same time optimizing WCR (working capital ratio) imposes to restrict the storage of semi-products; all this will increase the need for flexibility in production sequencing and pacing, thus requiring more and more thermal inputs.

Moreover, a flexible thermal source also provides the possibility of avoiding cold heats to be recycled in the converter, which is primordial in terms of cost and productivity.

2. HEATING STATIONS BUILT BY PW

Paul Wurth has built 5 aluminothermic heating stations in Europe (3), China (1) and Brazil (1).
Important figures of these plants are presented in the following table (1).

All stations presented were installed in steel shop producing high quality flat steels, and the last 3 are making an intensive use of the heating function - 33 to 70 % of the ladles being heated.

The situations of the steel shops and the reasons for considering aluminothermic heating were quite specific, a comparison giving all advantages in comparison with electrical heating being presented later, on this paper.

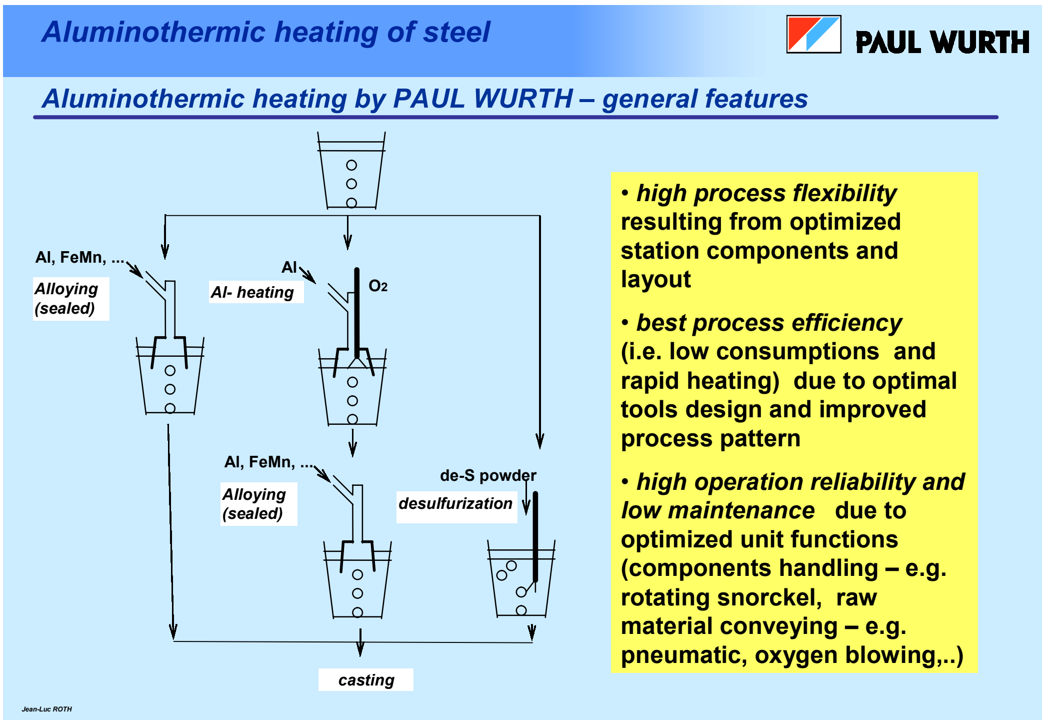
Table 1. Figures of Heating stations built by Paul Wurth

COMPANY steelwork	raw steel production (Mio t / year)	ladle size (t)	oxygen blowing rate (Nm3 O2/h)	proportion of ladles heated (%)
KRUPP-HOESCH Dortmund	4,5 (closed ’99)	190	3000	15
BENXI Steel* Benxi	4,0	155	3000	n.g.
THYSSEN-KRUPP Beckerwerth	5,0	260	4500	33
ILVA Taranto	7,0 (2 steel shops)	370	4800	70
COSIPA* Cubatão	2,7→ 4,5 (2 steel shops)	160	4000	50

** stations built within VAI-Technometal general contracts*

But the three following requirements were of highest importance in all cases:

- <u>high process flexibility, i.e. ability to realize a wide range of metallurgical functions, in different combinations</u>:
  this is illustrated in the following slide (3) showing three important metallurgical sequences to be achieved.



Slide 3. Possible metallurgical steps in Paul Wurth heating station

In Paul Wurth’s stations this ability is ensured by optimized station components and layout, as shown for the station presented hereafter.

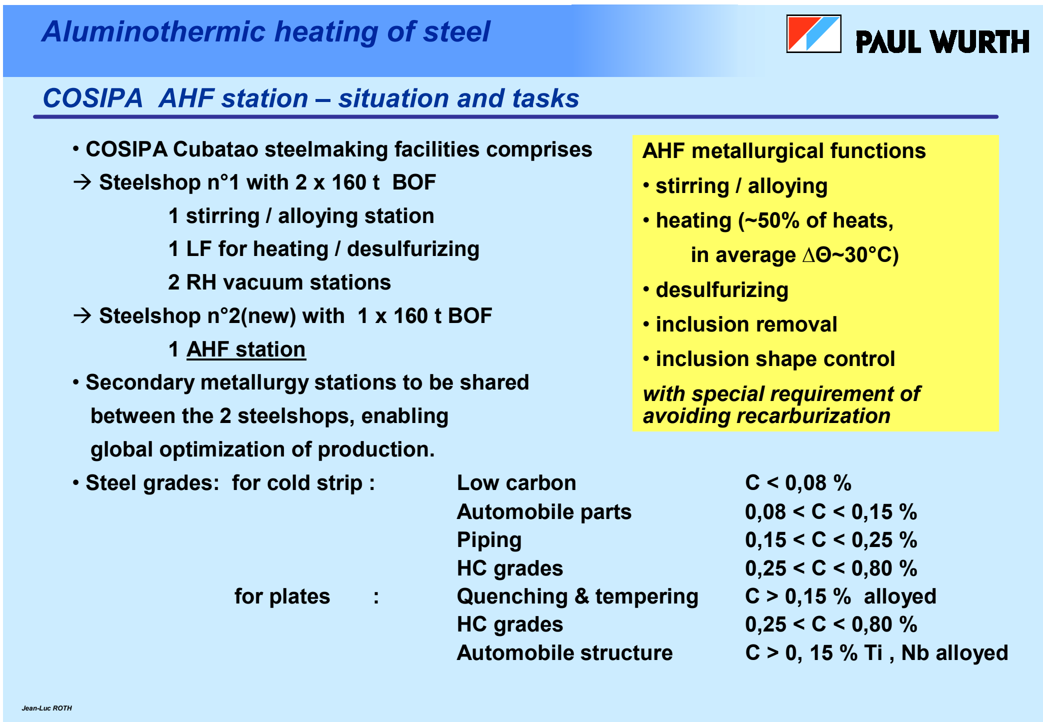
- best process efficiency, i.e. low consumptions and rapid heating:
  these performance figures are guaranteed by Paul Wurth, based on optimal tools design and proved process pattern.

- high operation reliability and low maintenance:
  these essential features rely on optimized unit functions, like components handling and raw material conveying.

Paul Wurth supplies original and proven solutions for automatic lance handling, for uniform bell wear (patented rotating bell), as well as for the pneumatic conveying of solids (world leadership).

3. MAIN FEATURES OF COSIPA AHF STATION

Paul Wurth supplied his last aluminothermic heating station to COSIPA, in a new steel shop built in Cubatão works by VAI.
Main features of the steel shop and the steel qualities produced are seen in slide (4).

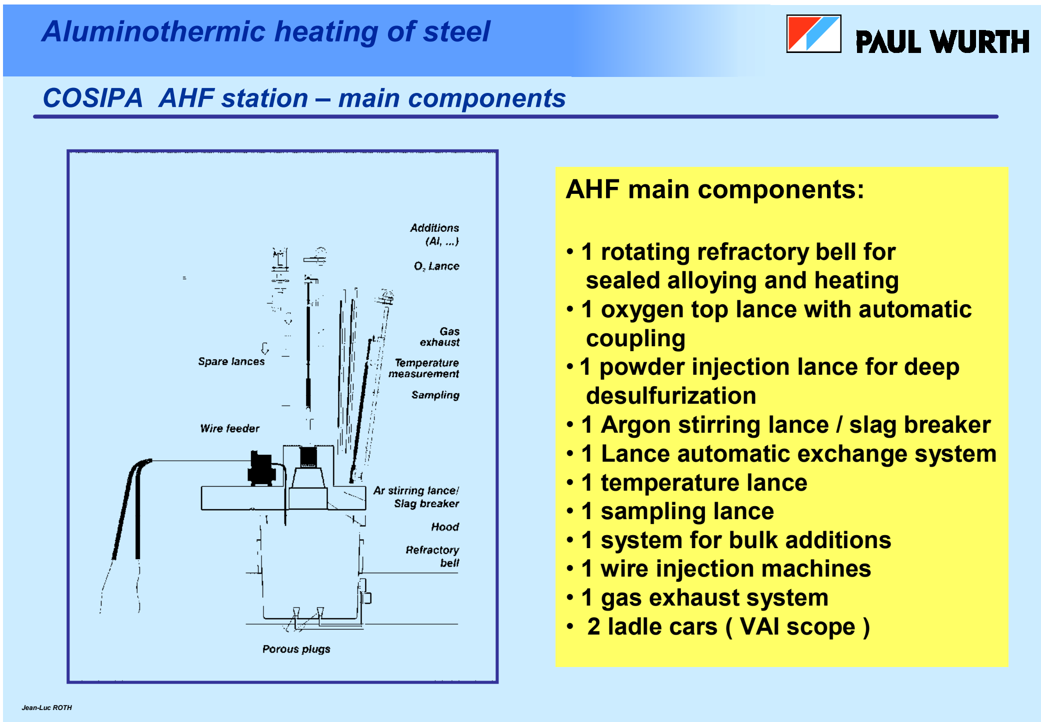


Slide 4. Characteristics of Cosipa steelshop and AHF tasks

COSIPA's AHF station (Aluminum Heating Furnace) was started in December 2001, with the following functions:

- stirring / alloying
- heating (~50% of heats, average temperature increase $\Delta\Theta$~30°C)
- desulfurizing
- inclusion removal
- inclusion shape control

To realize these functions in different sequences, the equipment supplied comprised the components presented in the next slide (5).



Slide 5. Main components of Cosipa's AHF station

The sketch suggests a very complete and flexible installation, which will be shared between the two steel shops.

Figure 1 & 2 shows some views of COSIPA AHF station.

Figure 1. AHF station at Cosipa

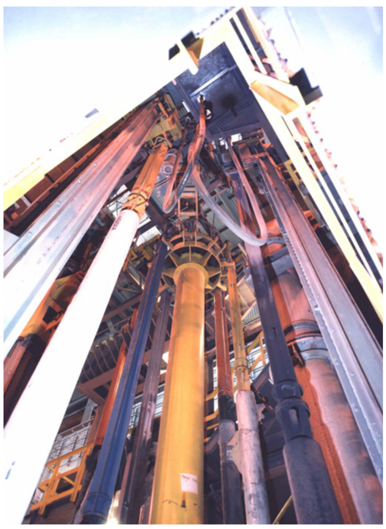


Figure 2. Automatic lance exchange

4. RESULTS – MAIN PROCESS PERFORMANCES

All aluminium heating stations built by Paul Wurth have realized the tasks assigned with excellent metallurgical performances; among them, typical figures for steel heating must be pointed out:

- the temperature increase figures range from 0 to 120°C (realized in 2 phases for $\Delta\Theta$ exceeding 60°C)
- typical heating rates are 10 to 12°C / min
- consumptions for 10°C temperature increase are in the following ranges

→ Aluminium 0,3 to 0,4 kg / t
→ Oxygen 0,22 to 0,3 Nm3 / t
→ Exact figures depending on local process requirements.

A cost item to keep under control is the refractory wear, since it represents both a consumable and an item for maintenance work.
Typical figures are the following:

- the wear of the oxygen lance is proportional to the heating amplitude: it represents ~1 mm / °C temperature increase
- the wear of the bell refractory amounts to ~10 mm per charge (heating), which normally leads to repair it every 50 heats; this wear is reduced with an accurate bell positioning system, and with the Paul Wurth patented rotating bell, which enables an uniform wear over the bell circumference.

When evaluating an overall refractory cost of the aluminium heating station substituting another station, one must consider a reduced wear of the ladle slag line, since the bell protects the ladle refractory from direct thermal solicitation.

5 DISCUSSION – COMPARISON WITH ELECTRICAL HEATING

Electrical heating is mostly realized by free arcs, in the ladle furnace, which is also used in a multi-function station.
A comparison of aluminum heating with the ladle furnace must therefore consider the main tasks done, namely

- heating itself, but also
- deoxidation / alloying
- desulfurization

and finally it must assess the positive or negative effects of the treatment on steel quality.

This qualitative evaluation can be summarized as follows:

- heating with aluminum enables doubled heating rates compared with LF

(roughly 10°C / min versus 5 °C / min), and the comparison of the heating costs only depends on local conditions (i.e. compared unit prices of aluminum/oxygen and electricity)
- deoxidation and alloying are more efficient in the aluminum heating station, thanks to the sealed conditions for adding the alloying materials; this advantage concerning practically all the heats treated in the station;
- desulfurization can be done efficiently in both configurations
- detrimental effects on steel quality are well identified for the LF, which definitely causes carbon pick-up from electrodes, and nitrogen pick-up over arcs; aluminium heating clearly produces additional alumina, which potentially could generate more inclusions – however experience shows that adequate stirring for inclusion removal efficiently avoids problems of steel cleanness, even for sensible steel grades.

Finally a comparison of the investment cost clearly shows an advantage for aluminium heating, mainly due to the costly high power supply of the LF.

Of course a quantitative assessment has to be made for each industrial situation, considering local metallurgical requirements and economics.

6 CONCLUSION

With the increasing role of secondary metallurgy in steelmaking, steel heating is becoming a key process for improving steel quality, productivity and production costs.
Thanks to recent progress in efficiency and reliability, aluminothermic heating shows highest process flexibility and is best suited for variable process requirements – especially for the task of "saving" cold ladles.
Aluminium heating stations built by Paul Wurth feature key points in design and operation – including patented features – which enable

→ high efficiency alloying
→ fast steel heating
→ flexible process metallurgy

The stations presented concern flat steel producing steel shops in integrated works; but no doubt that this technology will be more and more considered in the development of electrical steel shops.

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AQUECIMENTO DO AÇO POR ALUMINOTERMIA EM UMA ACIARIA DE AÇOS PLANOS

Resumo

Objetivo: O aumento dos requisitos na qualidade dos aços e a multiplicação dos graus produzidos, resultam em processos de tratamentos, algumas vezes mais longos e complexos, na linha da Metalurgia secundária. Conseqüentemente, há uma demanda por reaquecimentos do aço sendo produzido para se atingir as temperaturas objetivadas no lingotamento continuo. Metodologia: O aquecimento químico usando alumínio e sopro de oxigênio sob um sino refratário, é uma solução flexível e eficiente para aquecimento do aço, enquanto a atmosfera inerte sob o sino refratário assegura condições para um refino eficiente. Conclusão:O trabalho descreve os equipamentos envolvidos, e a performance do processo na última estação de aquecimento e refino instalada. As vantagens do processo em velocidade de aquecimento e precisão de ajuste químico são salientadas, e uma comparação com o aquecimento elétrico é proposta.

Palvras-chave: Aluminotermia ; Refino; Aquecimento; Metalurgia Secundária