ROBOTIC SOLUTIONS FOR EAF – FIRST PERFORMANCE REVIEW[1]

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Abstract
The goal of the steel producers worldwide is to improve safety and performance in their production facilities. SIEMENS VAI made a step forward introducing to the industry the RCB-Temp and the LiquiRob@EAF as well as some semi-automatic devices like tap-hole scraper, slag door pusher and sampler. Having recently installed the RCB-Temp in various steel plants, the technology and performance results of these installations are being demonstrated. Also the LiquiRob robotic technology has been successfully introduced within the last years, not only at the Continuous Casters but also at the Converters for sublance probe handling. The benefits and results of such robotic systems are being presented in this paper.
Key words: Robotics; Liquirob; Contact-free; Temperature measurement; RCB.

Resumo
O objetivo dos produtores de aço no mundo inteiro e melhorar segurança e desempenho das unidades de produção. SIEMENS VAI fez um passo para frente introduzindo o RCB-Temp e LiquiRob@EAF e também equipamentos semi-automáticos como o “tap-hole scraper”, “slag-door pusher e sampler”. A tecnologia e o resultado de instalações recentes do RCB-Temp em varias aciarias estão sendo demonstrados. Também a tecnologia robótica LiquiRob foi introduzido com sucesso durante os últimos anos, não só no lingotamento continuo mas também no convertedor para manipulação das sondas da sublança. Os benefícios e resultados de sistemas robóticas estão sendo apresentados neste trabalho.
Palavras-chave: Robotics; Liquirob; Sem contato; Medição de temperatura; RCB.

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1 INTRODUCTION

The goal of the steel producers worldwide is to improve safety and performance of their production facilities. SIEMENS VAI made a step forward introducing the RCB-Temp and the LiquiRob for EAF as well as some semi-automatic devices like tap-hole scraper, slag door pusher and sampler to the industry.
Having installed the RCB-Temp in various steel plants recently - like in SAM Montereau - RIVA France as pilot installation and BOUS, Germany as second industrial installation with special mention to special steels production – the technology and performance results of these milestones installations will be discussed.
The LiquiRob robotic technology has been successfully introduced within the last few years in the field of the Continuous Caster for performing several tasks on the casting floor and in the field of the Converter for sublance probe handling. The LiquiRob is a six-axis industrial robot, which is being supplied in a foundry type to allow operations in hot and dusty environments. In January 2010, SIEMENS VAI installed and commissioned the first LiquiRob for EAF at SAM Neuves Maisons - RIVA France for fully automatic temperature and sampling through the slag door including change and check of cartridges.
The evaluated benefits of such performing systems will be presented.
Finally, it will be given an overview about new applications for both systems e.g. LiquiRob for LF, etc. as well as upcoming installations of SIEMENS VAI.

2 SIMETAL RCB TEMP

The innovation of the SIMETAL RCB Temp is to allow a contact-free temperature measurement of the liquid steel in steelmaking plants, using the supersonic oxygen injection technology of Siemens VAI – the RCB. The remarkable advantages of this reliable and accurate measurement increase productivity by lowering power on and power off times, reduce further operating costs by eliminating expensive cartridges and improve safety, avoiding hard physical and dangerous works.

Challenge:
Steel quality depends heavily on temperature control. That’s why the precise and reliable measurement of temperature is essential. Manual operations or manipulators are involved in nowadays temperature measurements by taking samples with conventional sensors to determine the tapping temperature. For optimum process control, it is necessary to shorten the time between measurements during power-on, just before the tapping temperature is reached, and to improve the measurement reliability and safety.

Solution:
The SIMETAL RCB Temp uses a combination of the supersonic oxygen injection technology – RCB - and an analyzing unit for performing a contact-free temperature measurement. This tool allows the temperature measurement of liquid steel inside the furnace during operation with closed door, so it offers major advantages over existing technologies. The results are far more accurate and reproducible, less sensitive,, with fully automatic operation.
The RCB Temp brings the steelmaker one step closer to automatic steelmaking under safe and reliable operating conditions.
Consequently, no further costs for cartridges being used for temperature measurements will arise.

Figure 1: Modified RCB Lance pipe for RCB Temp.

Figure 2: RCB Temp installed.

The RCB technology itself is a technology from the late nineties, which represents the combination of a conventional gas/oxy burner and a supersonic oxygen injection lance installed in the water-cooled sidewall of an EAF. Since then, up to 100 furnaces worldwide – conventional EAFs and shaft furnaces, both AC and DC EAFs, for the production of carbon steel, stainless steel or specialty steels – were equipped with the RCB technology, achieving excellent results.

RCB Temp operation

The RCB Temp consists of a burner with an integrated oxygen lance. The lance injects oxygen at a special angle and with a supersonic laminar jet. To protect the central laminar oxygen stream, the shrouding burner function is maintained during the refining process. Switching the RCB Temp from lance to temperature mode, allows contact-free temperature measurement.

Temperature measurement process with RCB Temp

The RCB Temp is characterized by three main functions: burner mode, lance mode and temperature mode.
1. Burner mode
During power-on time and after scrap charging, the RCB Temp is used as a burner for preheating and melting the scrap. This is resulting in a more homogenous melting process and therefore increases the productivity.
2. Lance mode
As soon as a liquid pool is formed in front of the RCB, the system switches to lance mode to provide a supersonic oxygen stream.

3. Temperature mode

Temperature measurement mode is ready to be used when a defined homogenization of the liquid phase occurs. The system switches from oxygen to measuring gas and the temperature signal is transmitted.

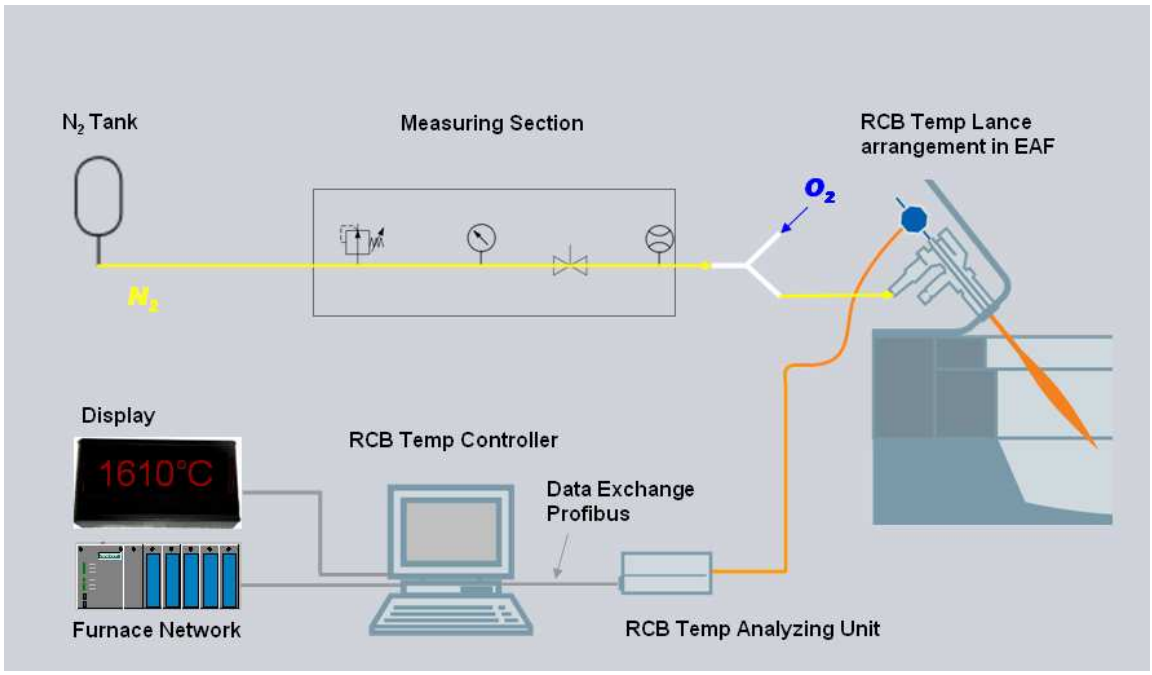

Figure 3: RCB Temp system.

The signal is then processed and intensified within the analyzing unit. The control unit filters the signal and evaluates it based on an algorithm, especially developed for this application by Siemens VAI. The RCB Temp follows the condition of the melt by measuring the temperature of the liquid steel more frequently until the tapping temperature is reached. Temperature measurements can be started manually or automatically.

Benefits

- Thanks to contact-free measurement, no pieces are in movement to perform the measurement, resulting in a long service life. Also wrong temperature measurements are reduced as the measurement is always done on the same spot in the furnace and under exactly defined conditions in the measurement spot.
- The RCB Temp is a highly economically solution thanks to the elimination of temperature cartridges, the reduction of personnel costs and considerable time and energy savings.
- The RCB Temp eliminates the risks for personnel during temperature measuring, as the slag door is closed.
- The right time for tapping can be determined more precisely. Faster temperature measurements results are achieved.

Profitable investment

Not limited to RCB installations, the technology can be implemented in a short stoppage like a regular maintenance shutdown. Installation costs are low, and leading to a short return of invest.

3 RESULTS ACHIEVED

In figure 4, the development of the temperature in front of the RCB and at the slag door can be seen. The door as a cold spot of the furnace is shown clearly, whereas in the finally homogenized steel bath, the temperature measurements via RCB and through the door are showing nearly same results. The difference can vary in a range of +- 10°.
The results of the installations are showing that savings of more than 1$/t can be achieved, even considering the amount of process gas consumed during the measurement cycle.

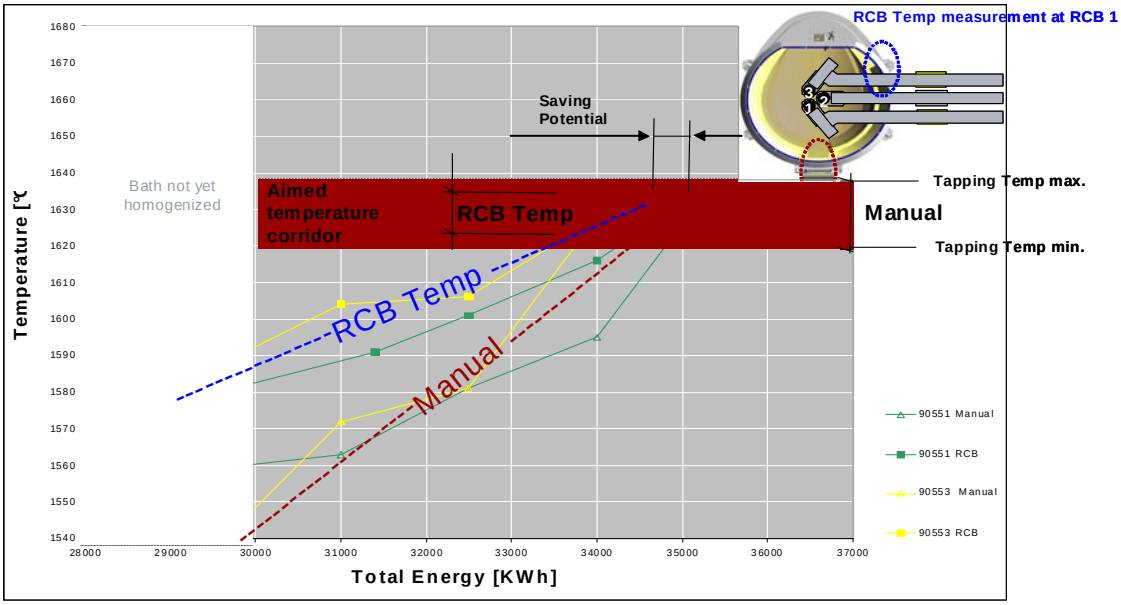

Figure 4: Typical temperature measurement curve of RCB temp.

4 SIMETAL LIQUIROB FOR EAF

Robots are commonly used in high productive, reproducible and flexible industries, as for example in car assembling manufactures. Now, Siemens VAI, as a pioneer in innovating processes, technologies and automation in steel plants, introduces a robot suitable for the harsh operation conditions and rough environment at casters, secondary metallurgical plants, converters and also EAFs. In January 2010, the first SIMETAL LiquiRob for EAF was put in operation in the steel plant SAM Neuves-Maisons - RIVA France.

Challenge:

Personnel health and safety when working in the vicinity of liquid steel, slag and extremely hot environment is a major concern. The steel plant managers take full responsibility regarding health and safety of their employees. A further issue is accuracy and reliability in performing measurement and taking samples during production, having direct influence on the quality of the produced steel and on productivity thanks to faster cycle times and less measurement errors.

Solution:
With the SIMETAL LiquiRob for EAF, Siemens VAI provides a highly flexible robot-aided measuring and sampling solution that gives the steel maker the flexibility and reliability needed to ensure uninterrupted, fail-safe and controlled EAF steel production. It can perform fully automatic temperature and sample measurement cycles including cartridge replacement, so that manual and even manipulator measurement are obsolete. In many cases it will prevent operators from making temperature / celox measurements or taking samples. Thanks to the LiquiRob, work in hazardous areas is largely eliminated.

Figure 5: LiquiRob foundry type.

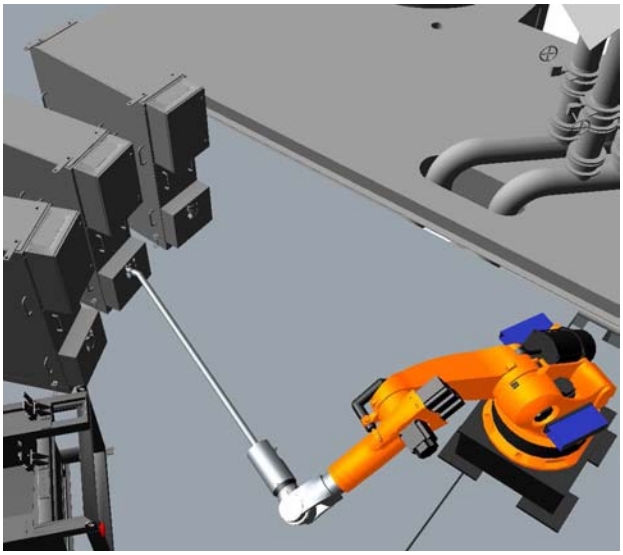

Figure 6: LiquiRob receiving cartridge.

Additionally, the LiquiRob recognizes defective cartridges and sorts them out before carrying out any measurement, thus avoiding time-consuming measurement errors. Furthermore, it is also possible to check the contact rod position, so the availability of the system is guaranteed.
To protect it from dust and heat, the robot is covered with a special heat cloth, as can be seen in fig. 5.

Flexibility:

- With its 6-axis movement, the LiquiRob may be used even under extremely tight space conditions. Consequently, very short cycle times can be achieved.
- Furthermore, the LiquiRob is a perfect upgrade solution for existing plants with limited available space.

Due to its high degree of flexibility, the LiquiRob can be used for handling various kinds of cartridges, without any major modifications.

Benefits

- Low maintenance costs compared to those of conventional manipulators as the LiquiRob is a proven, matured system and is virtually maintenance-free.
- Ease of use: During most of its operating time, the LiquiRob needs no operator interaction because the system is controlled by a state-of-the-art automation system.
- Significant increase of health and safety conditions by keeping the workers away from dangerous areas.
- Higher reproducibility of measurements and availability of the used equipment

Results

Commissioned in January 2010 at SAM Neuves-Maisons - RIVA France, the LiquiRob showed reliable operation performing up to 75 Celox-measurements until end of January. In the commissioning phase, adjustments have been made to improve tip cooling and robot kinematics. As result, an excellent availability and shortest cycle times from pick up of new cartridge via check of cartridge and measuring cycle until drop of used cartridge could easily be demonstrated.

In order to evaluate the reliability, tests have been made during commissioning putting thermal loads onto the LiquiRob. The position of the LiquiRob during measurement can be seen in Figure 7.

Figure 7: LiquiRob during measurement.

5 OVERVIEW

Awarded contracts and references for LiquiRob systems:

- LiquiRob for EAF for cartridge manipulation (T, S, O); SAM Neuves-Maisons - RIVA France
- 2 LiquiRob for BOF sublance probe manipulation (T, TSO & TSC probes); Thyssen Krupp CSA, Brazil
- 2 LiquiRob for BOF sublance probe manipulation (T, TSO & TSC probes); JSC ZAPOROZHSTAL, Ukraine
- LiquiRob for CCM; COMPANHIA SIDERURGICA PAULISTA, COSIPA No 3, Brazil
- LiquiRob for CCM; POSCO, CCM2-CCM3 in Gwangyang,South Korea
- LiquiRob for CCM; voestalpine Stahl GmbH, CC7 in Linz, Austria

Further developments:

Robots are very beneficial for fast operations in dangerous areas, where several different jobs have to be done. The LiquiRob for EAF will soon be installed for performing different jobs around the tap-hole, such as oxygen burning, inspection,

etc. Also in other areas of a steel plant, where a LiquiRob is not yet used like the ladle furnace or vacuum degassing units, it is beneficial to install such a system when several different jobs have to be carried out under conditions being dangerous for human beings.

6 MANIPULATOR SYSTEMS

In a steel plant, there are also individual applications, where a robot would be “bored” or it just does not fit in the concept of the steel plant. Therefore SIEMENS VAI developed several manipulator systems for performing individual jobs in a semi-automatic way.
SIMETAL Scraper, SIMETAL Pusher and SIMETAL Sampler are further special solutions for tap-hole cleaning, slag door cleaning and temperature and probe sampling.

- The Scraper (figure 8) is a device designed to automatically remove the crown on the tap-hole with a special cutter. Furthermore, it uses a camera system for tap-hole observation. The steelmaker gets knowledge about whether or not the tap-hole is blocked by slag or scrap from remote pulpit and about tap-hole wear and prediction for next tap-hole sleeve exchange or safe sand filling.
- The Pusher (figure 9), fully integrated into the working platform, provides semi-automatic slag door cleaning and repeatable results for sill management and deslagging operation.
- The Sampler (figure 10) provides trouble free temperature measuring and sampling under power-on in less than one minute. Based on proven, simple and flexible technology and a maximum range of 5.8 meters, the system can be installed in any kind of furnace area.

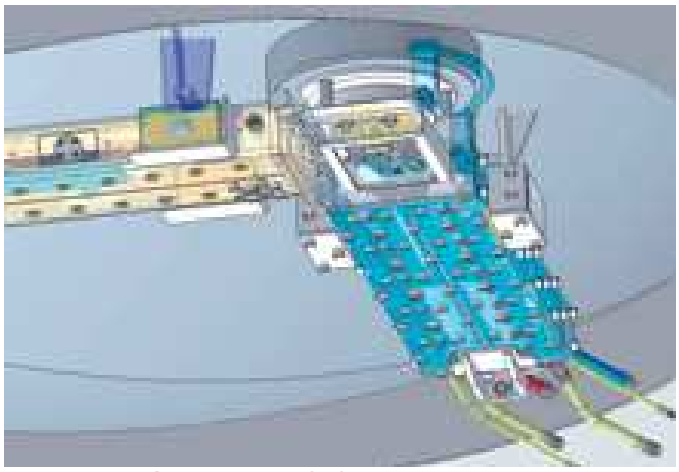

Figure 8. Tap hole scraper.

Figure 9: Pusher.

Figure 10: Sampler.

7 CONCLUSION

Introducing developments, ranging from RCB Temp, LiquiRob to manipulator systems, such as sampler, pusher and scraper for EAF, Siemens VAI Metals Technologies is in the position to offer High-End solutions to meet the steel makers' demands for improved safety, increased efficiency and lower operating costs.