the research realized.

In particular the activity is devoted to develop control strategies to combine both necessities:

- To enable optimal liquid steel treatment to support metallurgical process for final product
- To enable to maintain optimal slag condition for subsequent reuse avoiding improper conditions

The main principle driving this developments are:

- Necessity to support the Steelmaking treatments with knowledge about real status of slag conditions as parameter to evaluate the real effectiveness of the process targets
- To combine the evaluations about slag conditions as waste for their reuse with the steelmaking treatment necessary for steel production in a single evaluation making evidence to their interdependency
- The necessity to support the knowledge of the status of the process with mathematical modelling as necessary to predict the parameters describing phenomena occurring on the process when not measured.
- The necessity to maintain internally the know-how about mathematical modelling in order to gain deeper process knowledge and maintain capability of continuous applications functions and their use on the production practices.

Taking into account these development needs long time having as preconditions the development of internal skills and structures and the application both on conventional steel for civil construction and special steel for automotive.

DESCRIPTION

General approach / Scheme

Following the general scheme of the systems developed are described (Figure 1), in particular the main scope is to describe in a same view the 2 route of steel treatment in different positions of the ladle and for subsequent yard disposal.

In particular the steel tratment in ladle is followed along the production route from the EAF process including following steps :

- EAF scrap Charge
- EAF melting and refining process
- Steel taping in ladle and ladle positions
- LF treatment and additions
- Steel in tundish till casting

The evolution of steel conditions in different ladle positions are followed in order to estimate and detect the slag conditions during interaction with steel and the conditions when taken for yard disposal.

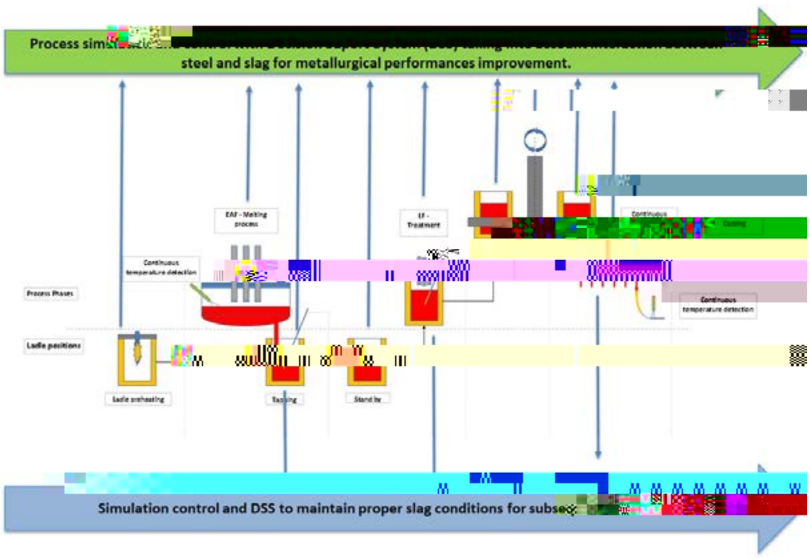

Fig.1 - General scheme of the parallel view of metallurgical treatment and slag conditions for reuse.

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Input	Output
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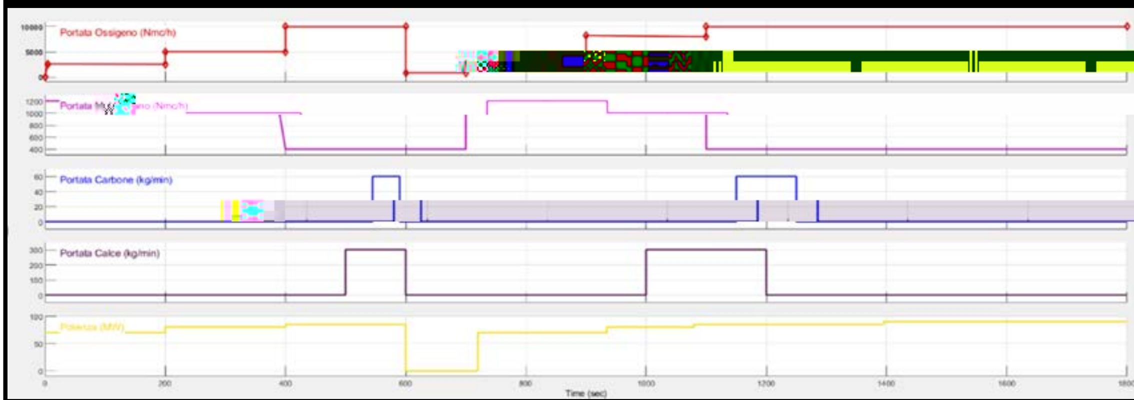

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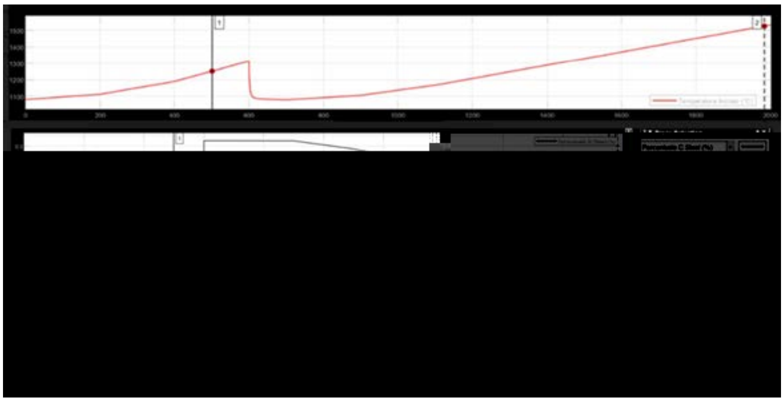

Fig.4 - Simulation heat results in terms of steel temperatures and compositions evolutions.

Thanks to this system the prediction of final results and performances of EAF process can be predicted taking into account the charge mix and operating practice adopted in order to evaluate efectivene of operating practice setting choices.

This approach is presently used to evaluate comparison between effectiveness of different practices and as base to optimization of the on-line EAFProcess control system that is based on EAF process simulation and for this reason external off-line calibration of calculation is needed.

Off-Line modelling for prediction of LF treatment

The simulator is focusing on the treatment of the secondary metallurgy of the steel, staring from tapping in EAF and finish in tundish of continuous casting.

The practical use of the simulator is to find out the best operative practice to treat the steel in terms of time of treatment and the optimal amount of ferro-alloys to add to steel.

In this way, thanks to the software is possible to have an improved view of the process and act on different input data, is possible to have different operative practice to treat the steel.

Model Architecture

The main input data for liquid steel treatment include (Figure 5) condition of steel coming from EAF Tapping, Tapping and ladle additions, dynamical input as ferroalloy additions, electrical power used and stirring gases adopted. The model is able to simulate the treatment of secondary metallurgy over time in particular to obtain:

1. Estimation of the temperature trend over time
2. Estimation of the trend over time of the level of Sulfur (Desulphurization Process)
3. Estimation of the trend over time of the oxygen level (Deoxidation Process)
4. Estimation of the trend over time of the main elements of steel
5. Estimation of the trend over time of the main elements of the slag

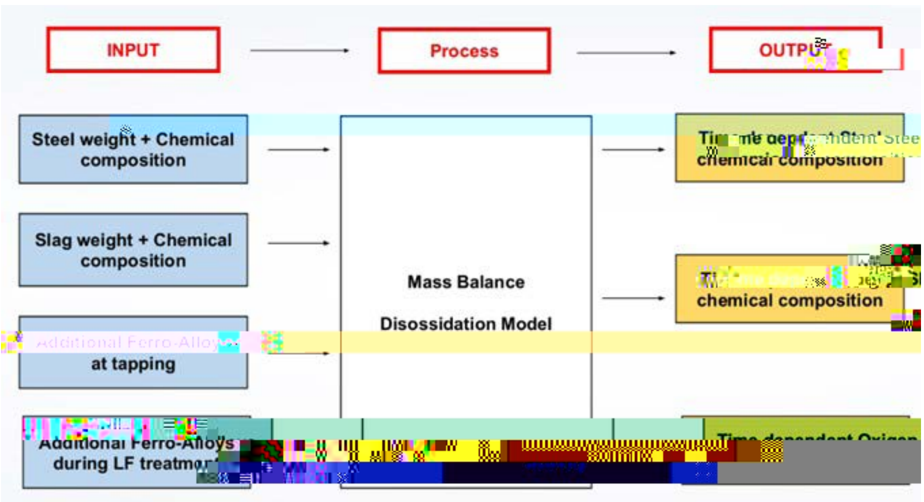

Fig.5 - General architecture of LF process simulatore and input / output data adopted.

Following the curves of estimation of different steel temperature along the steel treatments in ladels are shown In particular also comparison with real steel temperature detection is reported in order to evaluate and improve estimation of steel temperature

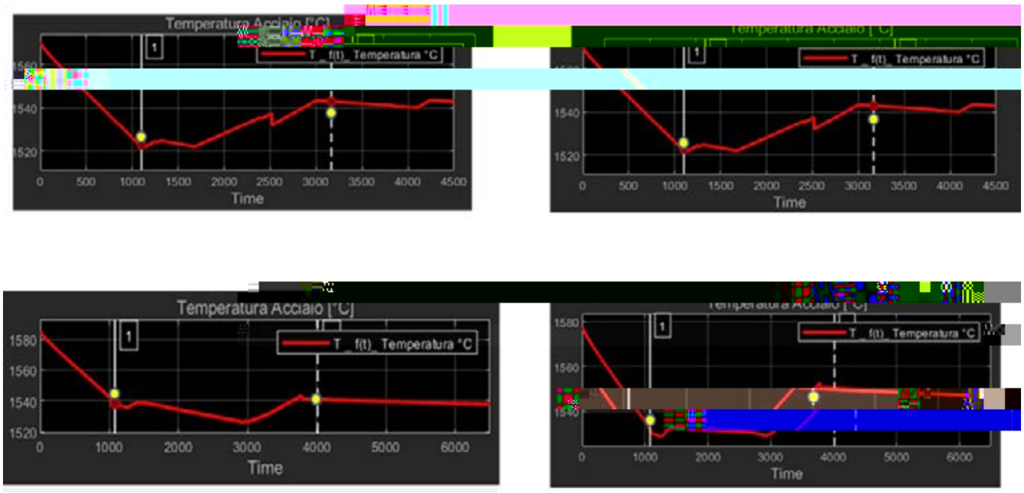

Fig.8 - Exemplary curves of prediction of EAF performances.

Tuning of the LF simulator and sesitivity analysis has been ealize in order to evaluate and improve continuously its accuracy in determination Steel and slag composition in LF exit (Figure 9, 10) and to evaluate the effectiveness on prediction of results for tratment management variations.

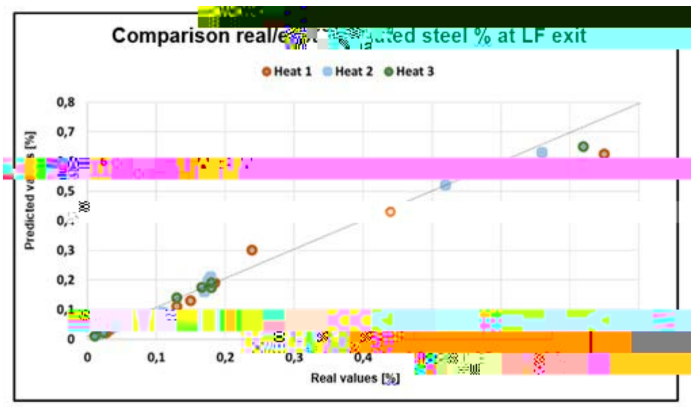

Fig.9 - Comparison of estimations and samplings for steel composition.

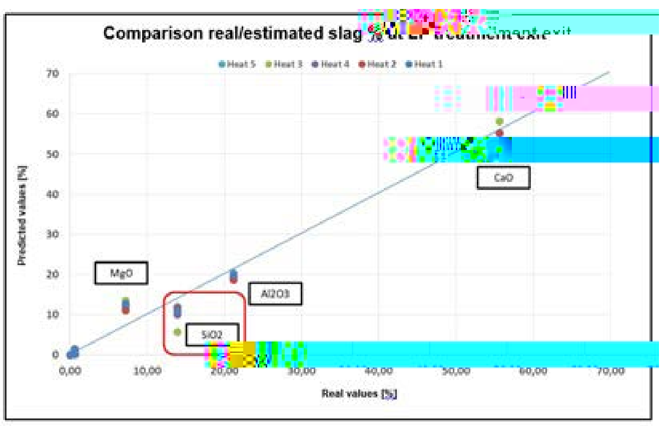

Fig.10 - Comparison of estimations and samplings for slag composition.

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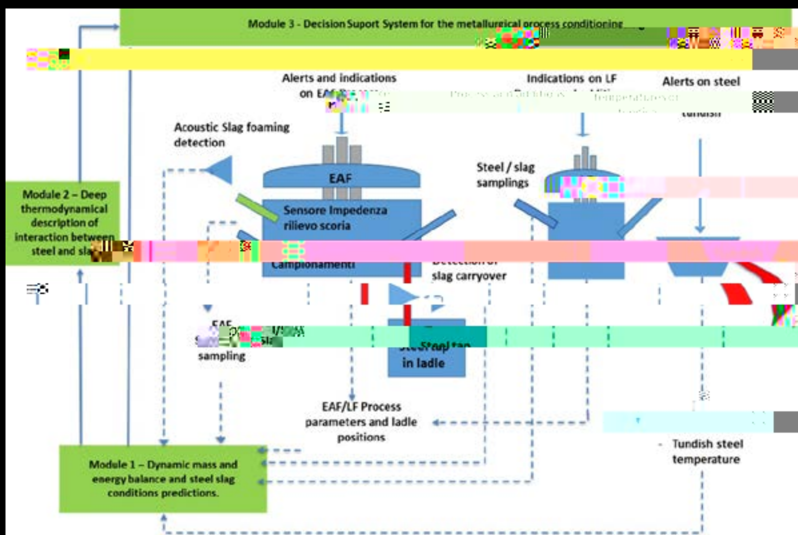

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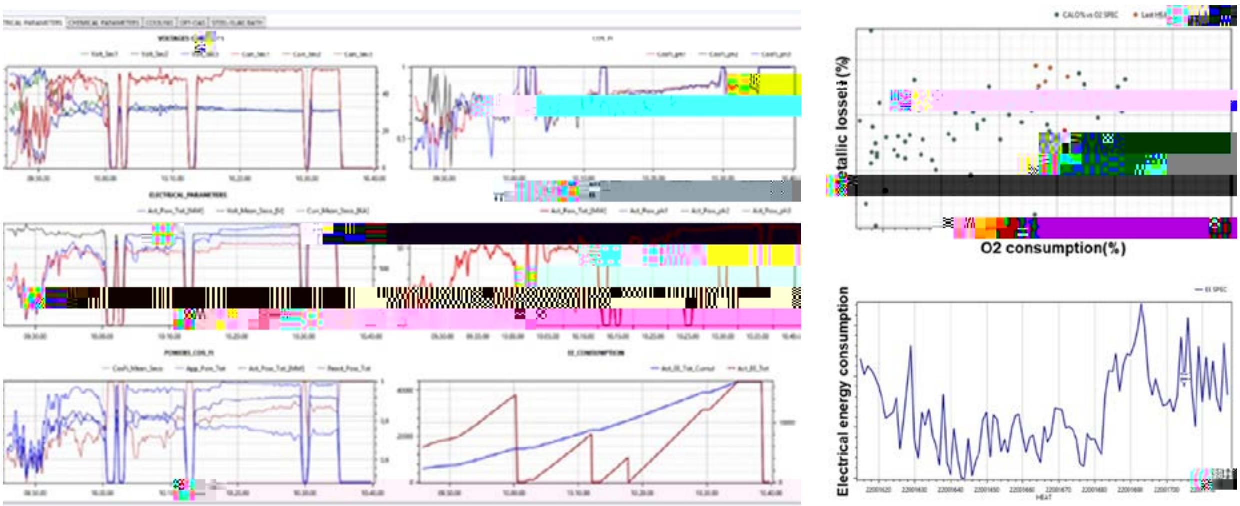


Fig.12 - Main view on-line available for monitoring of EAF process and heat summary results.

Result of dynamic mass and energy balance in EAF:

- Steel and slag masses
- Evolution of %C and steel composition during the process
- Steel temperature evolution

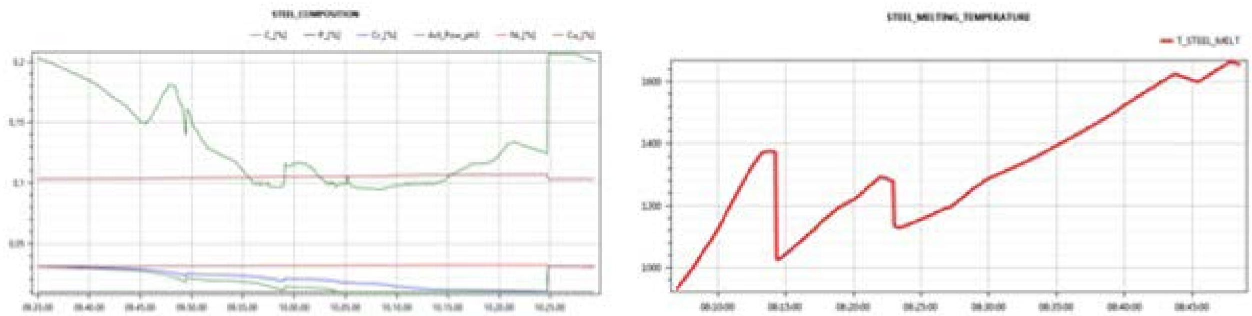


Fig.13 - Steel composition and temperature on-line by dynamic mass and energy balance.

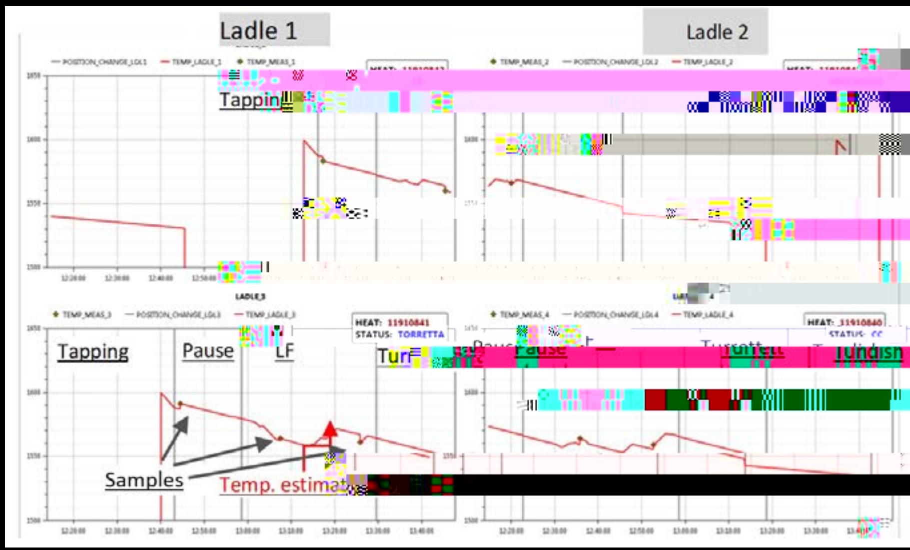
<u>On-line simulation application for LF process</u>

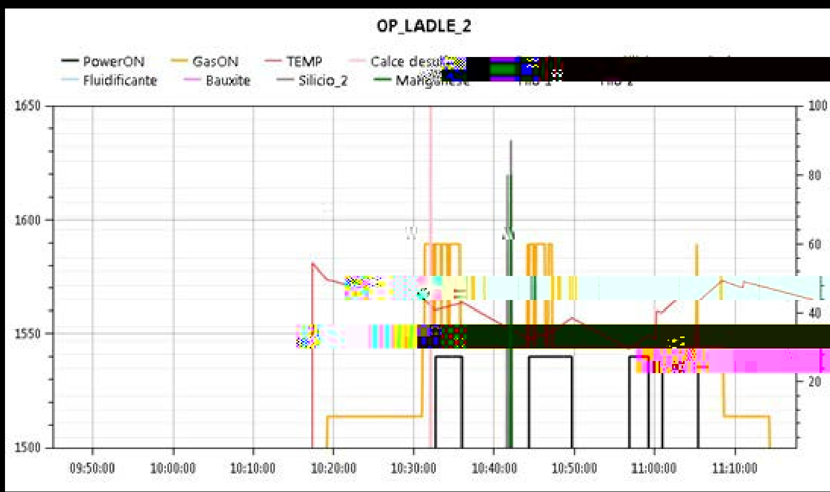
The on-line ladle treatment is followed ladle by ladle and represented in site views.

In particular following steel temperature are estimated depending by steel treatment followed including: treatment time, ladle position, electrical energy provided, stirring gas activation, ladle additions real temperature detection.

In this way the main functions on-line available are:

- Temperature estimation on-line for each ladle
- Auto tuning depending by real temperature samplings
- Prediction of temperature estimated at ladle arrival to further process phases
- Alerts function in case of abnormal temperature predicted





Following s

	AVG Err.	Dev STD Err.	% Err <10°C	% Case Out of tolerance

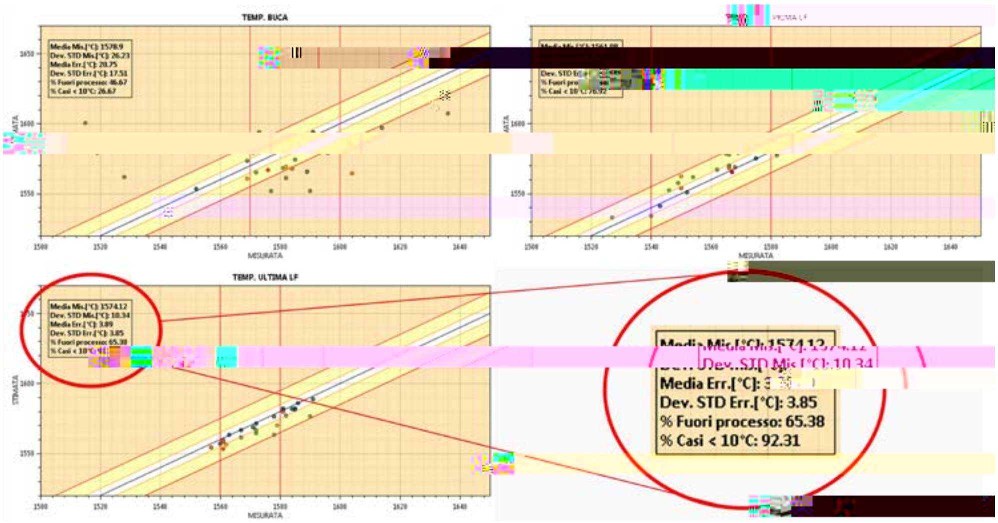


Fig.16 - On-line accuracy monitoring of steel temperature estimation for different positions.

Based on steel temperature predicted alert functions are active to support the operators to evaluate if uncorrect steel temperatures are coming for subsequent process steps in LF from EAF and in continuous casting from LF (Figure 16) In particular depending by actual temperature estimated and production cicle conditions are predicted:

- Time remining to reach the next process step (to LF from EAF, To CC from LF)
- Temperature predicted of arrival to next process step (To LF, To CC)
- Indications in terms of alerts for abnormal temperature or heating necessity are shown

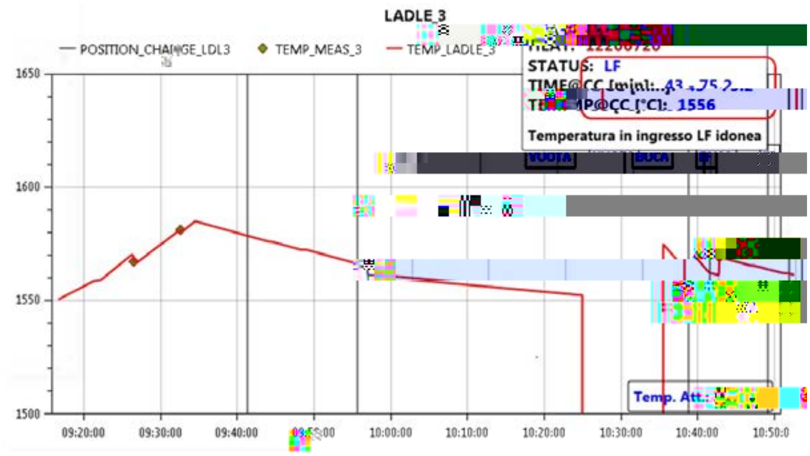


Fig.17 - Steel temperature prediction for next process steps and alerts available on-line.

CONCLUSIONS

The status of process study and meathematical representation in EAF and LF process prediction became now a relevant task in Feralpi and this enable the Feralpi technical group to support internal automation developer and as in this case also external software developers as

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