Improved lance injection process for hot metal desulphurisation

A PC-based system has been designed by Polysius to optimise dip-lance injection through automatic selection of the injection reagents, calculation of process parameters and plant scheduling requirements for each hot metal treatment. It is easily integrated into the automation systems of both new and existing plants. Following installation in a European steel plant, desulphurisation plant operating costs were reduced by 15% and capacity increased by 10%.

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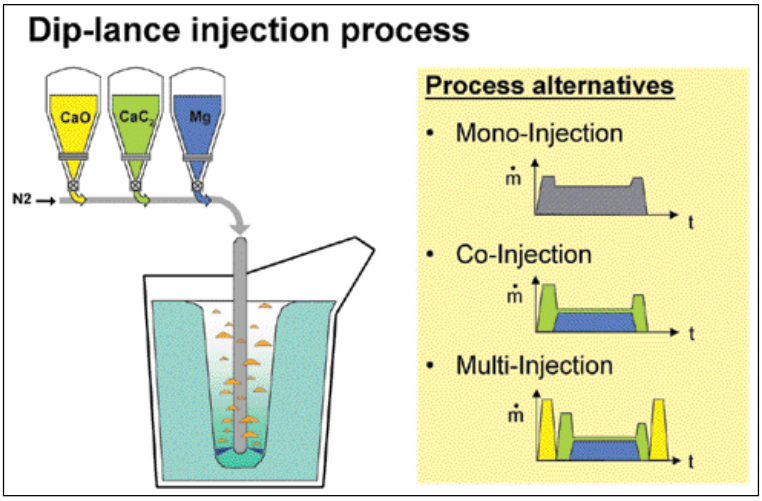


● **Figure 1** *Desulphurisation reagents and process types*

Today, many hot metal desulphurisation plants are still not equipped with technology that enables them to take full advantage of the economic potential of the dip-lance injection process through optimisation of plant capacity, operating costs and achievement of target final sulphur contents. As it is a very flexible process with regard to its ability to use different reagents, operating methods and process parameters, the dip-lance injection process offers many options for optimisation.

Polysius AG has developed a metallurgical PC which allows integration of the hot metal desulphurisation process into the steelmaking process schedule, which selects the optimum process for each hot metal treatment, calculates process parameters, and which easily integrates into the automation systems of both new and existing plants. Following installation of a metallurgical PC from Polysius in a European steel plant, desulphurisation plant operating costs were reduced by 15% and the plant capacity increased by 10%.

Metallurgical PC

The hot metal desulphurisation process is located between the blast furnace process and the basic oxygen process. This means that variations in hot metal quantities, temperature and sulphur level, and in the target steel sulphur level, result in variations in the demands on the desulphurisation process.

Despite this, many hot metal desulphurisation plants are still operated with a single desulphurisation process with constant process parameters, hence they cannot take full advantage of the flexibility of the dip-lance injection process to optimise operating costs and plant capacities. To do this it is necessary to operate each hot metal treatment individually, involving the appropriate selection of the reagents, process type, and process parameters.

The dip-lance injection process offers many options for the selection of the optimum process for every treatment; for example, with different desulphurisation reagents, process types and operating parameters (see *Figure 1*). Lime, calcium carbide, magnesium or lime/magnesium and calcium carbide/magnesium mixtures can be used as reagents either singly or serially during one treatment. The process also allows wide variation of the process parameters, such as injection rate and transport gas rate.

To ensure maximum optimisation of the process, Polysius conducted extensive studies of the

thermodynamics and kinetics for several desulphurisation reagents and process types, and developed a mathematical model which includes the parameters influencing process efficiency so that target final sulphur content is achieved independently of the type of desulphurisation reagent and injection process type. For instance, it is well known that the hot metal temperature has an influence on the desulphurisation efficiency. High temperatures increase the efficiency of lime and calcium carbide but reduce that of magnesium. Temperature must therefore be included in the mathematical model to enable accurate adjustments of the target final sulphur contents and selection of the most efficient process and reagent combinations (see *Figure 2*).

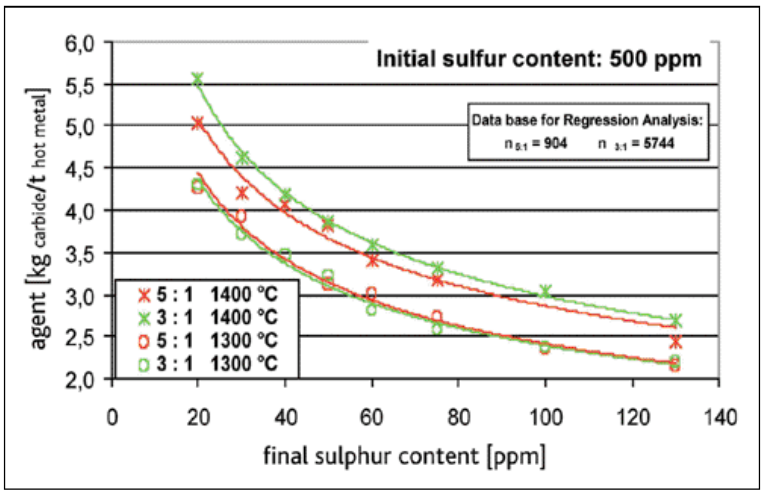
An important precondition for optimisation is to maximise the available injection time because the lower the reagent injection rate, the higher the reagent efficiency. Thus, the injection plant has to be integrated into the overall time schedule of both the blast furnace and the basic oxygen furnace so that the desulphurised hot metal is supplied to the basic oxygen furnace just in time and with the minimum operating costs. Such a scheduling program is included in the metallurgical PC and, depending on the actual production conditions, it selects high reagent injection rates if the time window for the process is narrow, and low reagent injection rates if the time window is wide (see *Figure 3*). If the time available is too short to meet both aims and vessel charge time, the metallurgical PC selects the process with the shortest injection time, independently of cost.

The metallurgical PC is designed for simple integration into the automation systems of both new and existing hot metal desulphurisation plants. Until today, one of the main problems was the fact that different steel plants use different automation environments with different bus systems, databases and control systems, so that new systems could not be integrated without extensive reprogramming.

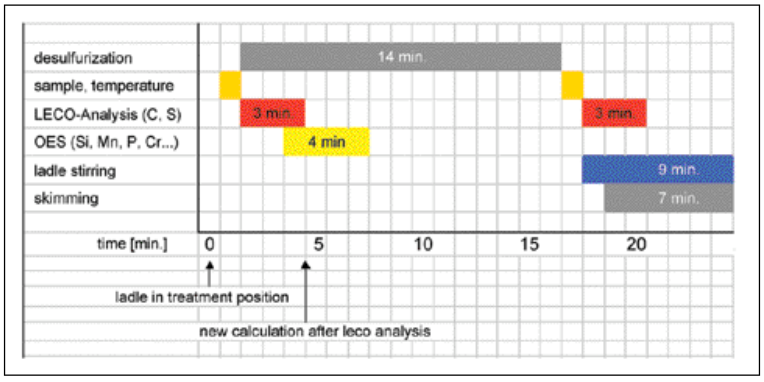
The target was to find a solution which can be integrated into a multitude of possible constellations, which can operate with different languages and which still offers the necessary user friendliness.

Metallurgical PC standard configuration The Polysius metallurgical PC (MPC) is a Windows 2000/XP PC system that is integrated into the automation network via Ethernet (see *Figure 4*). In its standard configuration, it is pre-configured as a separate PC and all the programs relevant to the calculation and operation run on this computer, namely:

- OPC (OLE for Process Control) server for data exchange with the control system. (Communication standard based on Microsoft's OLE [Object Link and Embedding])



● **Figure 2** ***Reagent consumption for CaC_2/Mg – Mixing ratios as a function of hot metal temperature***

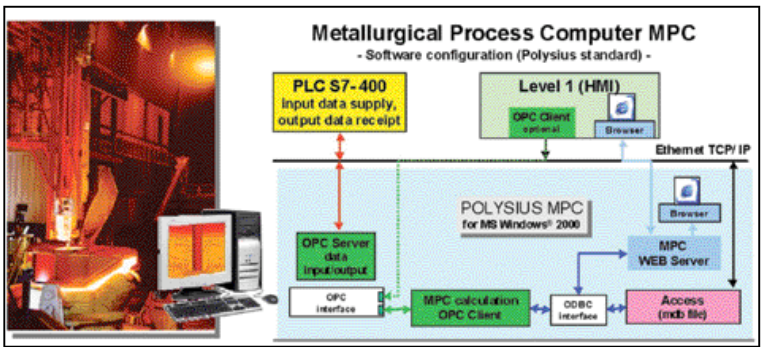


● **Figure 3** ***Time sheet of hot metal desulphurisation treatment***

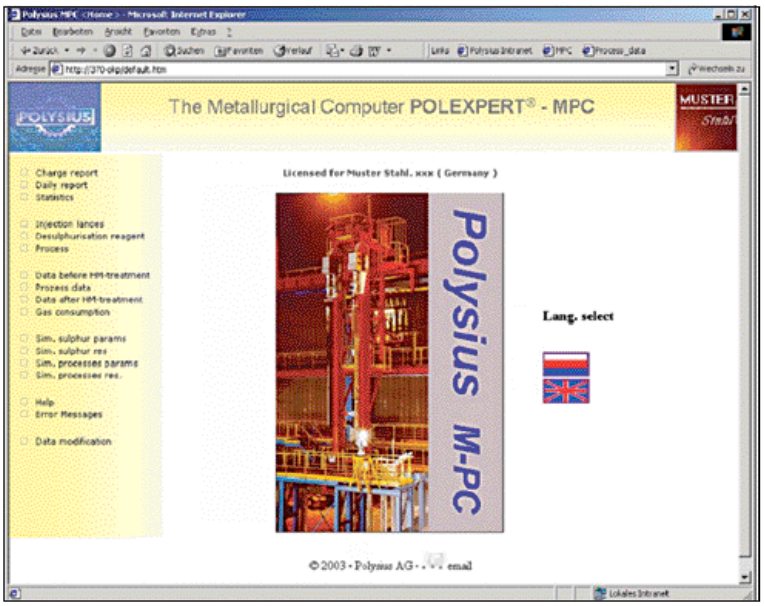
- MPC calculation program (as OPC client)
- Web server for allocation of the operator interface
- Database – archiving the process data

This standard version is a solution that does not require any additional software to be installed on any of the steel works computers, but nevertheless permits a number of these computers to access the MPC and the desulphurisation data. The user is also able to access the PLC data from any computer in his network, for instance in order to display them on the control panel (provided that the master control system is OPC client-capable).

It is also conceivable that the metallurgical calculation program could be installed on one of the steel works computers, provided that a network link to an OPC server is assured. Within the framework of this concept it is also possible to incorporate an existing process database. This would mean that all the process values and configuration data that are read or written by the MPC are stored in the steel works database (eg,



● **Figure 4** ***The metallurgical PC***



● **Figure 5** ***Start display of the MPC operator interface***

Oracle). This information is then displayed by means of the database's own report tools or via a web browser.

Communication concept

The Polysius MPC makes use of three different standardised communication mechanisms in its various functions:

OPC – data transfer with the control system and master control system The OPC communication concept is based on an OPC data server, which makes the data available for an exchange with other communication partners. The communication partner (OPC client) establishes a link to the server and determines what data should be exchanged between the server and the client. After the link has been established, both the server and the client can access the common data for reading and writing. The server and client do not necessarily have to run on the same computer.

The data exchange between server and client can take place in the same way via the network if the two processes run on different computers.

ODBC - database linking In its Windows systems Microsoft provides a standardised interface for data accessing (ODBC). This interface permits uniform accessing of different file formats and databases. The Windows user interface is used to define whether the data should be stored in a Microsoft Access database file or, for instance, in an Oracle database already existing at the steel works plant. As standard, the MPC writes to an ACCESS mdb file which the user can access as required with his ACCESS application, in order to conduct his special evaluations on the basis of the process and desulphurisation data.

HTTP – user interface The HTTP is the Internet protocol. It enables data exchange within the plant' s own Intranet, almost independently of the employed Windows NT operating system. Access to the metallurgical PC is displayed in a similar layout, even though different computer platforms may be used (see *Figure 5*) .

Program flow

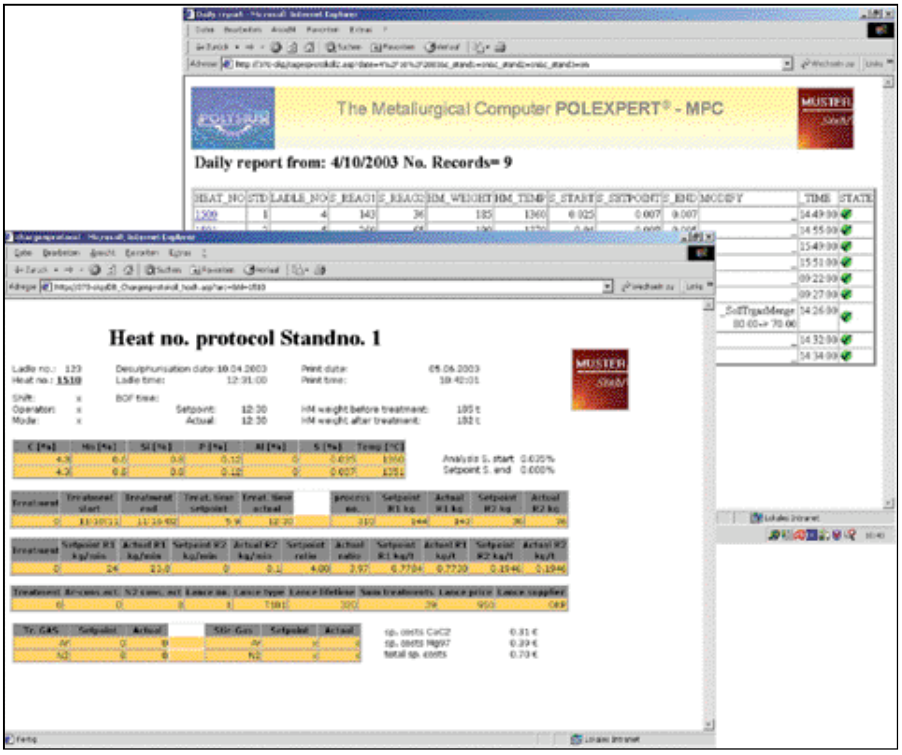
When the hot metal ladle arrives at the desulphurisation stand, the heat is assigned an explicit identification number. In the control system, further material data is allocated to this ID (for example, hot metal temperature, hot metal weight, chemical analysis, final sulphur content). Data transfer between the control system and the MPC takes place via an OPC interface and the OPC server makes these data available on the PC. Based on these initial values, the MPC calculation program generates target process data such as desulphurisation reagent quantities and injection rates for all the processes enabled in the process file. It then selects the optimum process on the basis of the injection time and operating costs. These settings are returned to the control system by the OPC server. Following confirmation by the operator the desulphurisation process starts automatically with the setpoint values calculated by the MPC. After treatment, the control system transfers the actual process data, such as injected reagent quantities, to the MPC calculation program via OPC. All the relevant process data are stored by the MPC calculation program in a database table and are then available to the user for more detailed statistical evaluation.

The user operates and configures the metallurgical PC via Internet Explorer. It is thus possible to access logs, process data and configuration information from any computer in the network without any additional software installations. This also includes accessing the desulphurisation database via a modem.

Statistics

Day or heat reports are generated as required. The user selects data on which he requires a print out of detailed information, and when a heat number is selected, the heat report is displayed on the screen.

The user can also preselect a date for which the processed heats are to be displayed. If desired, these can even be filtered by stand number. Following the database query, a daily report showing the basic information on the individual treatments is displayed. By selecting the heat number, the user returns to the more detailed heat report (see *Figure 6*).



● **Figure 6** ***Examples of a daily and heat reports***

Plant example

At the end of 2001, a new hot metal desulphurisation plant in a European steel works built by Polysius, went into operation. Treatment takes place in two stands, each consisting of two injection dispensers, two daily silos, one protection hood, one injection lance travelling device, one temperature measuring and sampling device, and one deslagging machine which is operated from the control room.

Three silos are used for storing the desulphurisation reagents, and pneumatic transport to the daily silos is undertaken by three dispensers located under the silos. On average, 130t of hot metal are desulphurised per heat. The initial sulphur content varies from 0.025% to 0.170% and the hot metal temperature from 1290°C to 1415°C. Target final S contents are in the range 0.003%–0.010.%. Calcium carbide and magnesium were selected as desulphurisation reagents for the mono-injection and the co-injection process. The reagent injection rates vary between 20 and 50kg/min for calcium carbide and 5–10kg/min for magnesium (see *Figure 7*). The metallurgical PC is connected with the steel plant master PLC and calculates the process data and selects the optimum process depending on the blast furnace output and basic oxygen furnace requirement.

Figure 8 illustrates final sulphur distribution for an aim S range of 30–60ppm (0.003–0.006%). Compared with the former desulphurisation plant, operating costs were reduced by 15%, plant capacity was increased by 10% and a target final sulphur hitting rate of more than 97% was achieved. Operating data before and after installation of metallurgical PC are shown in *Table 1*.

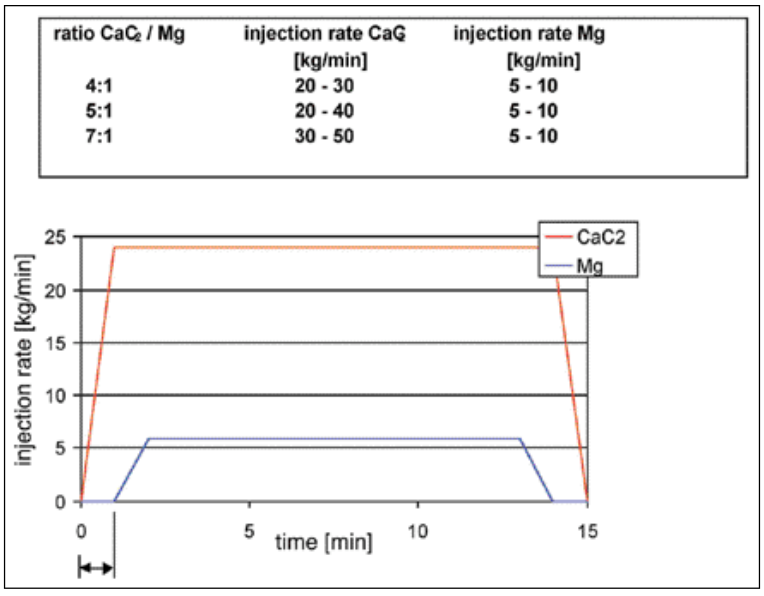


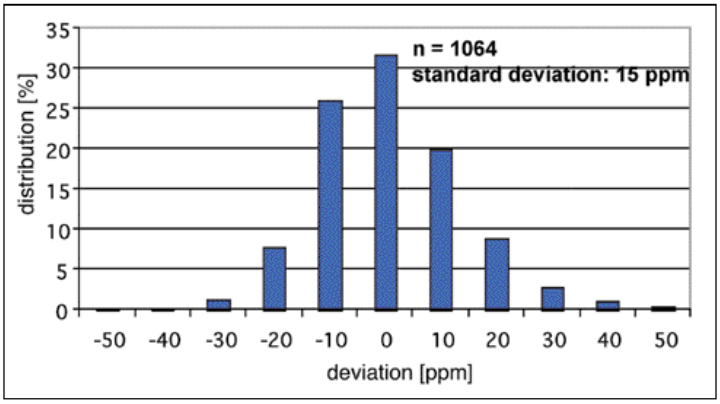
Figure 7 ***Process sheet for co-injection with CaC_2/Mg***

Summary

Polysius has developed a new metallurgical PC for the economic optimisation of hot metal desulphurisation plants, which calculates the process requirements and selects the optimum process for every treatment, ensuring a high final sulphur target attainment rate. Integration of hot metal desulphurisation into the overall steelmaking process leads to optimisation of operating costs

	Old HMD plant without MPC	New HMD plant with MPC
Desulphurisationreagent	CaC_2	CaC_2 + Mg, ratio 5:1
Hot metal weight, t	220	130
Initial sulphur content, %	0.068	0.068
Final sulphur content, %	< 0.005	< 0.005
Reagent consumption, kg/t hm	7.2	2.9
Final sulphur hitting rate, %	< 90	> 95
Injection time, min	32	11
Hot metal temp. loss, °C/min	1.0	0.9

● **Table 1** ***Comparison of process details before and after use of Metallurgical PC***



● **Figure 8** ***Final sulphur distribution***

and plant capacities by maximising available treatment time.

The metallurgical PC is designed with standardised communication mechanisms which allow integration into the automation systems of new and existing plants. Data exchange with the metallurgical PC takes place within the plant's own Intranet.

The operating data in a European steel works show that the operating costs were reduced by 15% and the plant capacity was increased by 10%, thanks to metallurgical PC.

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