OPERATIONAL BENEFITS DUE TO INSTALLATION OF DYNACON/LOMAS® TECHNOLOGY[1]

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Abstract

The described DYNACON/LOMAS® technology developed by VAI, a division of the Siemens Group Industrial Solutions and Services (I&S), enables the dynamic determination of the blowing end point in the converter process. It is thus possible – in a wide carbon range – to cut down on time-consuming and cost-intensive sample measurements that normally interrupt the blowing process. The implemented automation project at Maanshan Iron & Steel Co. Ltd. in PR China shows the great potential and operational benefits by usage of the DYNACON/LOMAS® technology. SIEMENS VAI's concept of complete monitoring of the state of the heat during BOF process with regard to steel temperature and steel analysis , including automatic blow end detection was implemented at MAANSHAN Iron & Steel Co. Ltd. (Masteel) for the first time in China.

Key words: LD(BOF) converter; Process optimization models; DYNACON/LOMAS®

BENEFÍCIOS OPERACIONAIS DEVIDO À INSTALAÇÃO DA TECNOLOGIA DYNACON/LOMAS®

Resumo

A tecnologia DYNACON/LOMAS® aqui descrita – desenvolvida pela VAI, uma divisão de Serviços e Soluções Industriais (I&S) do Grupo Siemens, - permite a determinação dinâmica do ponto de fim de sopro no processo de convertedor. Com isso, é possível – em uma ampla faixa de teor de carbono – reduzir o tempo e os custos envolvidos na tomada e análise de amostras, o que normalmente implica na interrupção do processo de sopro. O projeto de automação implementado na Maanshan Iron & Steel Co. Ltd. na República Popular da China mostra o grande potencial e os benefícios operacionais resultantes da utilização da tecnologia DYNACON/LOMAS®. O conceito SIEMENS VAI de monitoramento integral da condição da carga durante a operação do convertedor BOF em termos de temperatura e análise do aço, incluindo a detecção automática do fim de sopro, foi implementado pela primeira vez na China na MAANSHAN Iron & Steel Co. Ltd. (Masteel).

Palavras-chave: Convertedor LD(BOF); Modelos de otimização de processo; DYNACON/LOMAS®

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1 INTRODUCTION

Based on the experience of numerous successfully realized LD(BOF) converter automation projects the primary objective during the recent years was to improve the process models with respect to optimized production guidance and dynamic process control. A very promising and meanwhile tested approach is to use the converter offgas analysis as significant input for the calculations.

In the following SIEMENS VAI's LD(BOF) automation system, including process models for optimized raw material input as well as the dynamic off-gas model DYNACON is described.

DYNACON permits - in connection with the gas analyzing system LOMAS® - to dynamically determine the blowing end point in the converter process. It is thus possible to cut down on time-consuming and cost-intensive samples that normally interrupt the blowing process.

The recent implementation at Maanshan Iron & Steel Co. Ltd. in PR China is described and results are presented.

2 PRINCIPLES OF DYNACON/LOMAS®

Following scheme shows the basic architecture of the DYNACON / LOMAS® package.

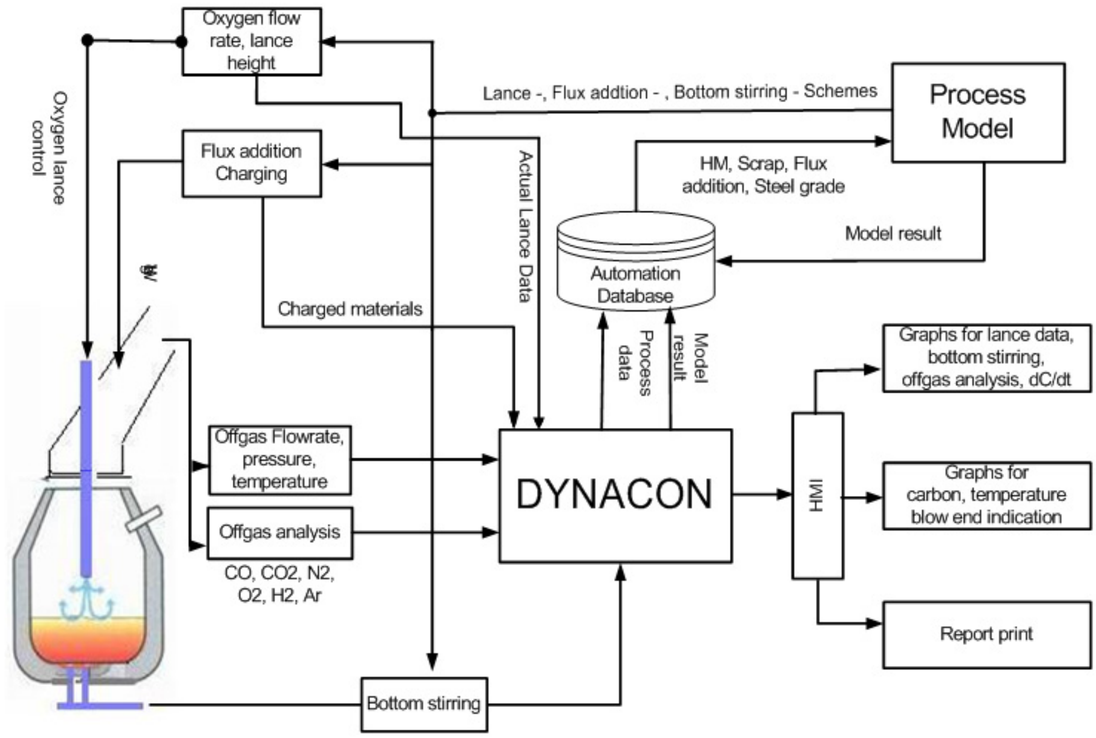

Figure 1. DYNACON/LOMAS® architecture

2.1 LOMAS® (LOw Maintenance Analyzing System) Off-gas Sampling and Analyzing

LOMAS® carries out continuous gas analyzing during combustion process at high temperatures (up to 1800 °C), dust loads up to 2000g/Nm3 and in corrosive and reducing environment conditions.
In case of converter off-gas analysis the result is transmitted in 2 seconds intervals and directly utilized for the dynamic process control system DYNACON.
LOMAS® is characterized by

- Alternating 2-probe operation for continuous, redundant gas tapping
- High temperature- and corrosion resistant probes
- Special gas treatment system for automatic gas preparation
- Off-gas analysis information (CO, CO_2, H_2, O_2, N_2, Ar) available at Level 2 in less than 15 seconds after gas tapping
- High accuracy in data measurement and data evaluation
- High availability, even under extremely hot (up to 1800°C), heavily dust-laden (up to 1000 g/Nm3) and corrosive / toxic process and waste gas conditions

Approximately 1200 – 1300 l/h of gas are drawn off by one of the two redundancy compressors through one of the probes, out of which about 60 l/h are used by the mass-spectrometer. The remaining gas is back-washed through the other probe for regeneration and cleaning of filter and sampling tubes. Tapping of this large amount of gas flow reduces the response time and thus provides quicker analysis results.
The individual operational cycles (gas sampling / back-washing / filter and jet cleaning with nitrogen) for the two different probes are initiated by a programmable logic controller. The system is operated automatically and thus guarantees continuous measurement.
For gas analyzing a magnetic sector mass spectrometer is installed, including analyzing and diagnostics software.

3 VAI PROCESS MODELS

LD(BOF) process models cover the production from ordering of hot metal and scrap until alloying during tapping. The purpose of the models is to calculate the amount of charging materials and the volume of oxygen to be blown in order to produce a heat according to the schedule and matching the planned steel grade.
The process optimization system includes the models as shown in the figure below. The most important process models are shortly described in the following.

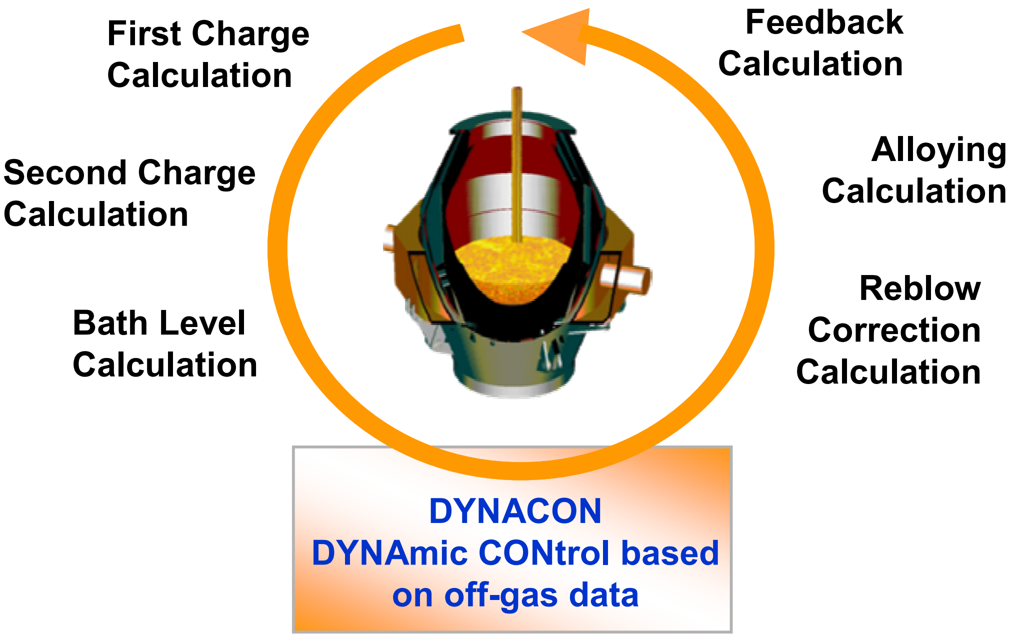

Figure 2. BOF process models

The classical VAI BOF model package - aiming at achieving a defined weight, temperature and chemical composition of the steel bath as well as a defined slag basicity - comprises:

First and **Second Charge Calculation** (FCC and SCC): The two models together determine the entire scale of materials to be charged into the converter, performing a complete precalculation of the blowing process. Whereas FCC is started timely before blowing start and calculates the appropriate hot metal and scrap amount, based on the schedule and steel grade definitions, SCC subsequently determines the required amount of oxygen, slag builders, and heating/cooling agents taking the prepared/charged scrap and hot metal into account.

Bath Level Calculation: One part of the bath level calculation determines the actual surface position of the steel bath based on the converter geometry. It is started automatically for each heat to ensure a perfect adjustment of the lance height. On the other hand a feedback calculation of the converter lining status is performed whenever a measurement of the bath level is available.

The **Tapping Alloying Model** calculates the necessary amount of alloying materials to be added into the tapping ladle. Material prices are considered and a cost-efficient material combination is determined.

The **Feedback Calculation** is the online adaptation of process model parameters that describe slowly changing processes during a converter campaign. It is started automatically as soon as the end of blow- or the tapping-analysis of the steel is available.

In addition a dynamic process model based on off gas measurement was developed and recently enhanced by VAI:

3.1 DYNACON Model

The DYNACON model is working in combination with the measurement of converter off-gas. Off-gas flow rate as well as at least CO, CO_2, O_2 and N_2 content are required

as measured values (Ar and H_2 are additionally measured to serve as important process information but not directly used by the DYNACON model).
During blowing the model cyclically calculates the actual carbon content in the steel bath and the decarburization rate. A significant change in the off-gas composition near the end of the refining process allows the model to determine the end of blow point. Thereby oxygen blowing can be stopped automatically, in order to reach the target carbon content of steel exactly.
The precisely stopped blowing process saves valuable minutes in the BOF process and - together with optimized raw material input – provides a stable basis for competitive steel production.

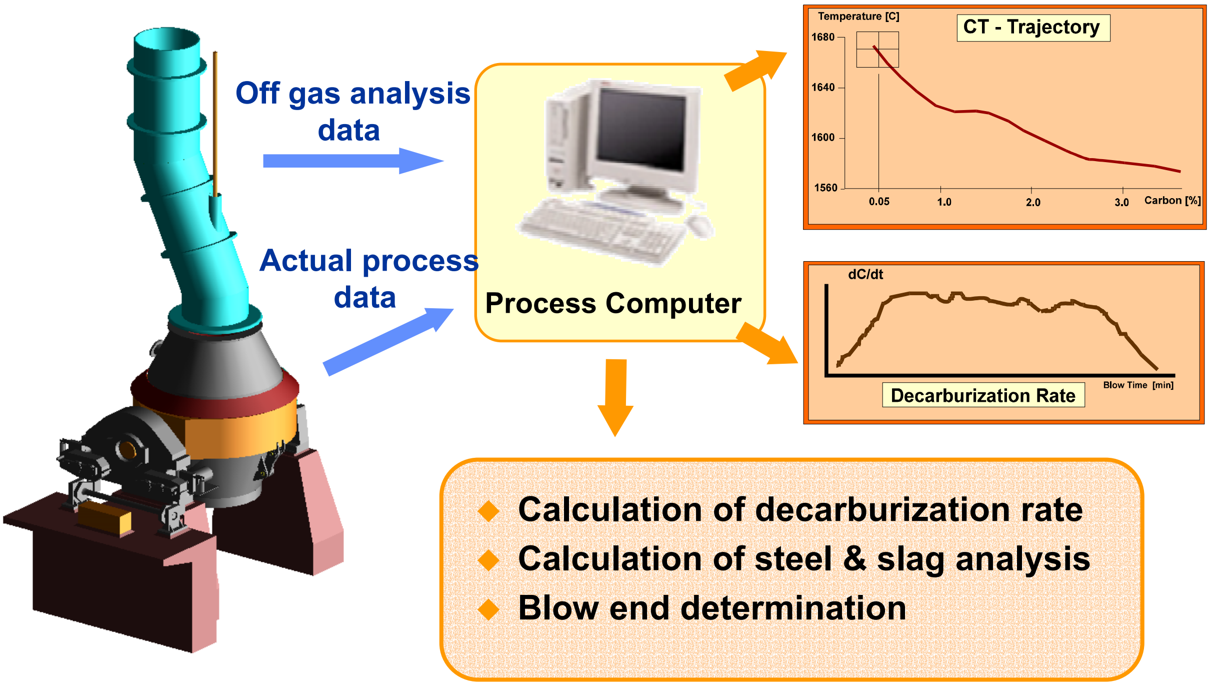

Figure 3. LD process control with DYNACON

4 OPERATOR GUIDANCE

The BOF process supervision and control is done using HMI process monitor window. The following activities are included:

- Activation of charge calculation, confirmation of results and downloading of production pattern set-points
- Graphical display of heat status information: C,T – trajectory, dC/dT
- Display of predicted final steel- and slag properties
- Visualization of production pattern
- Display of process event log and alarms
- Slopping indication
- Activation of automatic blow end control

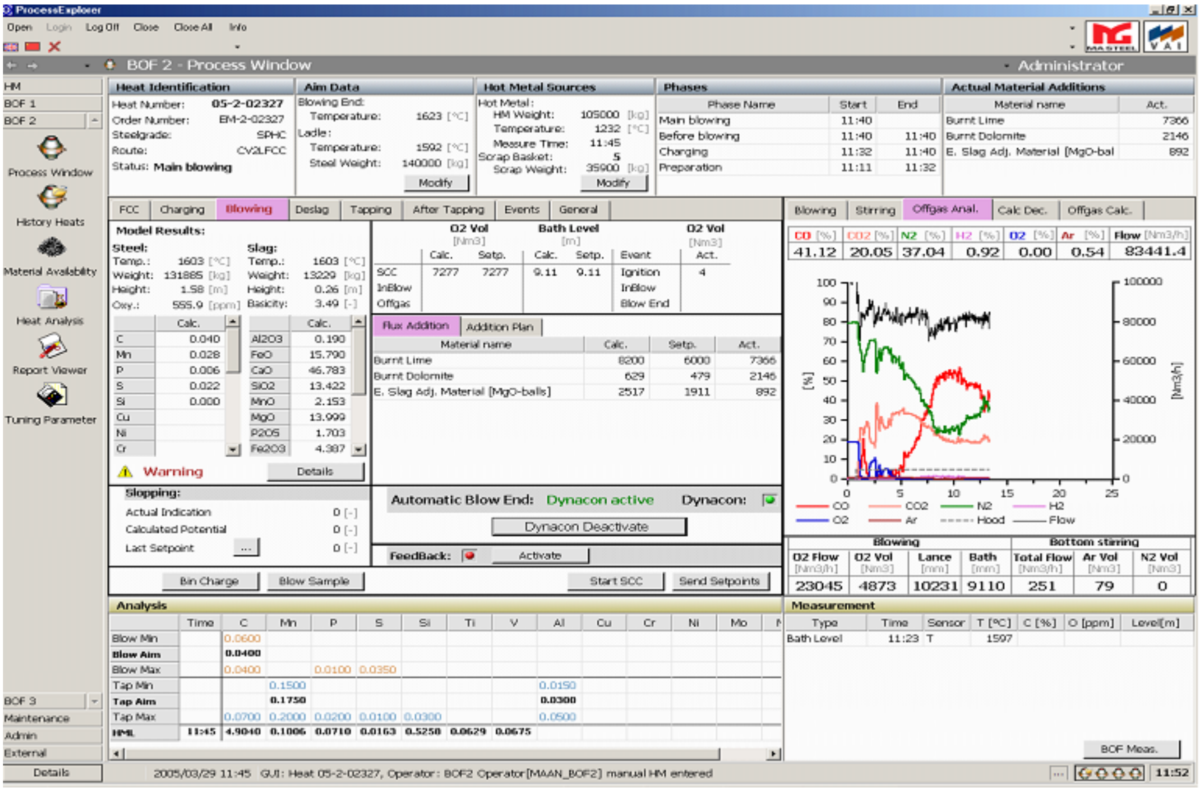

Figure 4. LD process window

5 RESULTS AT MAANSHAN

5.1 Project Introduction

In 2003 MAANSHAN Iron & Steel Co. Ltd. (Masteel) awarded SIEMENS VAI, a division of the Siemens Group Industrial Solutions and Services (I&S), with the order for a new process optimization system for one 90-ton and two 120-ton converters in the existing No.1 steelworks. The annual liquid steel production of this works amounts to 3 mio t/year of steel grades with carbon contents ranging from 0.04 – 0.12% [C] are produced.

Scope of the VAI contract was the implementation and commissioning of DYNACON - the dynamic LD (BOF) process model utilizing the LOMAS® gas analyzing package - for all three converters.

Following dates summarize the project schedule:

Order placement by Masteel	January 2003
Start up date BOF 2	April 2004
Start up date BOF 1&3	November 2004
Final Acceptance Certificate for BOF 1, 2 & 3	March 16, 2005

For a successful application of the process models significant modifications of process guidance and stabilization of measurement equipment were required according to suggestions by the VAI experts.

5.1 Project Results

The implementation of the VAI LD(BOF) Process Models yielded the following general improvement:

Automatic selection of production pattern based on hot metal conditions to achieve following targets:
- Optimized slag development for effective de-phosphorization
- Avoidance of slopping
- Reduction of lime and dolomite consumption

The following figures show the reduction of slopping for heats with high hot metal silicon input and the reduction in lime consumption.

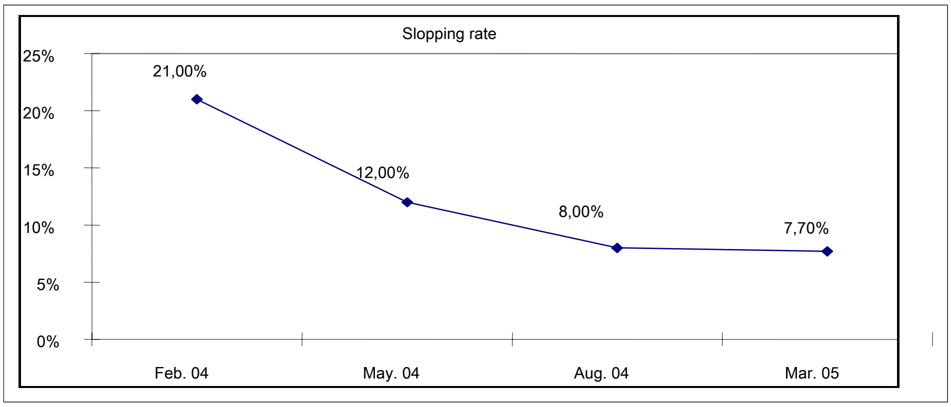

Figure 5. Slopping rate reduction.

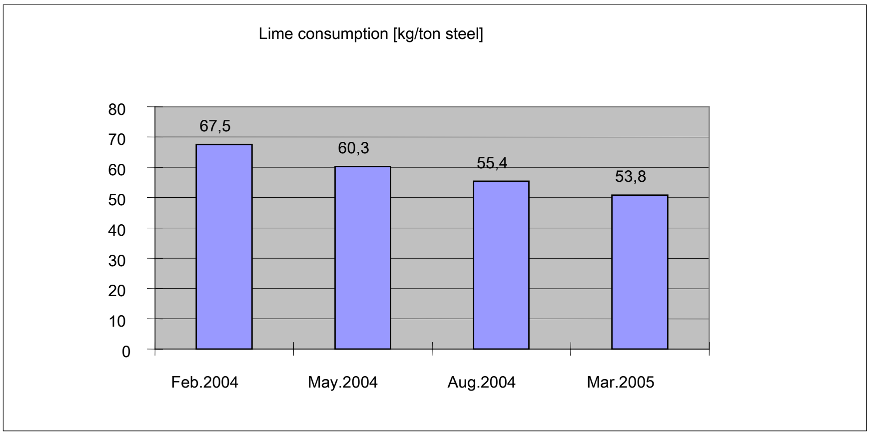

Figure 6. Lime consumption.

Furthermore the implementation and usage of the DYNACON/LOMAS® package resulted in following benefits:

- **Slopping detection during blow process**
- **Continuous calculation of steel- and slag properties**
- **Automatic blow end control**
- **Increase of Hitting ratio of carbon and temperature at blow end**
- **Increase of heats without reblow from 10% to 92%**

Figure 7. Project results using DYNACON/LOMAS®

- **Slopping detection during blow process**
  Based on hot metal conditions and the decarburization process derived from off-gas analysis measurement, the slopping probability is calculated and displayed as a warning to the operator.

- **Continuous calculation of steel and slag properties**
  Beginning from blow start the DYNACON process model calculates cyclically
  - Steel-analysis, -weight and -temperature
  - Slag-composition and – weight
  - Decarburization rate, carbon content and temperature of steel (graphically displayed)

- **Automatic blow end control**
  At the final decarburization phase DYNACON process model predicts the actual carbon content in steel derived from a significant change in the offgas component proportions. In case of activation the blow process is terminated automatically when the calculated carbon reaches the target value.

- **Increase of hitting ratio of carbon and temperature at blow end**
  The carbon hitting ratio reached over 90 % for low carbon steel grades (0.03%-0.07% aim [C]) and defined carbon window (+/- 0.01%[C]).
  The temperature hitting ratio reached also over 90 % for carbon steel grades up to 0.12% aim [C] content and defined temperature window(+/- 16 degree C).

- **Increase of heats without reblow from 10% to 92%**
  The percentage of heats with no reblows could be increased dramatically as shown in the figure below.

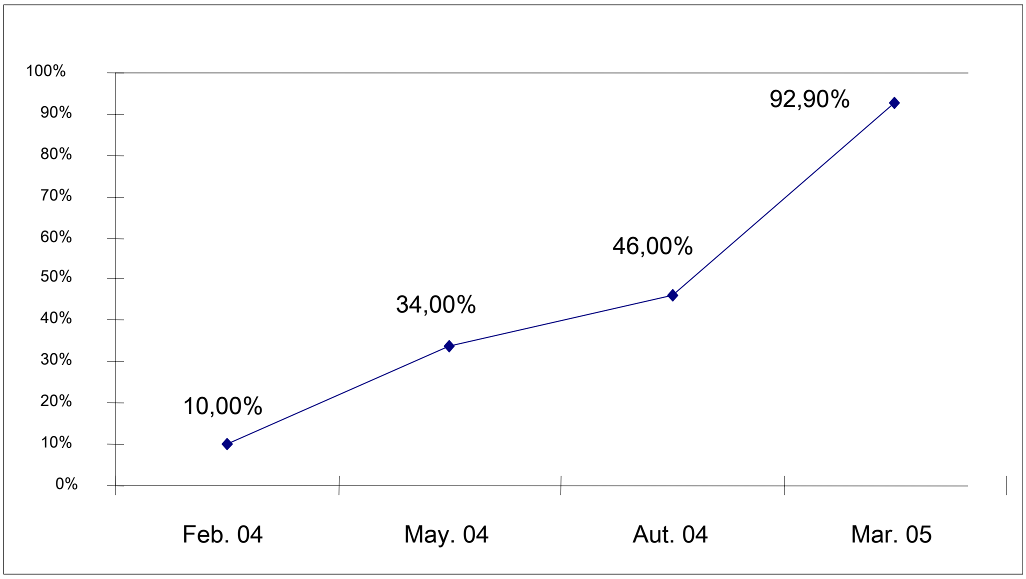

Figure 8. Percentage of heats without reblow.

6 OUTLOOK

VAI has just made an innovative step towards new process models for the LD (BOF) steel production. The development was done in close cooperation with VAI metallurgists and will be installed in the actual and upcoming LD (BOF) automation projects.
The main advantages of the new approach are:

- Simulation of a complete heat
- On-line calculation of steel- and slag- analysis & weight & temperature during the entire blowing process
- Enhancement of standard blowing practice by introduction of metallurgical aims per production step
- Modelling and automation of variant BOF practices (e.g. intermediate deslagging)
- Simulation tool for metallurgist to improve the production practice

7 CONCLUSIONS

The implementation of DYNACON/LOMAS® has proven to meet the requirements for a stable and efficient production.
DYNACON process control enables continuous monitoring of the current heat state and leads to more transparency of the BOF process.
Several benefits have been achieved and the direct tapping method can be applied for defined steel grades.
These features lead to increased productivity and product quality.