

# BOF Calculator

The BOF Calculator is a ready-to-use converter process model which you can fully customize to your specific needs. It is the perfect tool to develop and adapt steel grade recipes, in line with your specific knowledge.

It supports all common calculation scenarios, from scrap order calculation, additions calculation to actual heat calculation with fixed weights for all charge materials. It also includes subroutines for specific targets e.g. tapping temperature and slag basicity.

All process related knowhow included in this model is accessible by the user. You can directly implement the results of your own statistical findings in the model without losing any functionality. The know how stays comprehensible for anybody/colleagues and is well documented. This enables the continuous improvement of the model.

## Features:

- **Heat calculation** for end of blow carbon in steel
- **Automatic energy balancing** with coolant weight, tapping temperature and more
- Sub routine calculations for **target Basicity, MgO** in slag or **Minimum Slag Amount**
- **Equation editor** to **customize** the process model
- **Export** heat **data** to MS-Excel or print as PDF
- Detailed flow balances/**Sankey diagrams** for all chemical elements and energy balance
- **30 elements considered** in calculation including all commonly found **tramp elements**

The software runs on any modern windows based desktop PC by a simple installation. Updates are frequently issued implemented to improve calculation performance and add new functionality. Upcoming features are:

- Calculation of multiple scenarios
- Connection to user database
- Charge cost optimization
- Monte-Carlo simulation

## Technology:

The BOF Calculator is a static converter process model, which solves the mass and heat balance between the start and the end of a converter heat.

The heat balance is based on the energy content of each raw material and process product in respect to their chemical analysis and temperature. For each material the specific heat, the enthalpy of formation and solution are considered. Based on the vessel's inner volume, tapping weight, steel temperature and tap to tap time the energy losses of the converter are estimated. The user chooses the target variable to automatically balance the energy of the heat. This is either the weight of charged coolant (e.g. scrap), the steel temperature at temperature or the energy losses term. The balance is solved iteratively by finding the correct value for the target variable previously defined by the user.

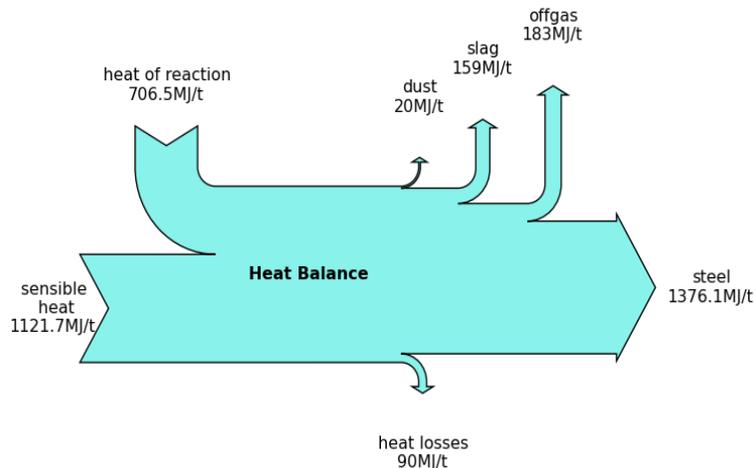


Figure 1: Result of heat balance

The mass balance considers 30 chemical elements, each of it having a set of possible reactions to chemical products. The specific quantity of how much of an element is reacting to a certain product is defined by functions and values derived from empirical data. During the heat calculation these functions are updated according to the actual process conditions and parameters. All functions are easy comprehensible and can be simply adapted to a specific converter metallurgy by editing them in the equation editor.

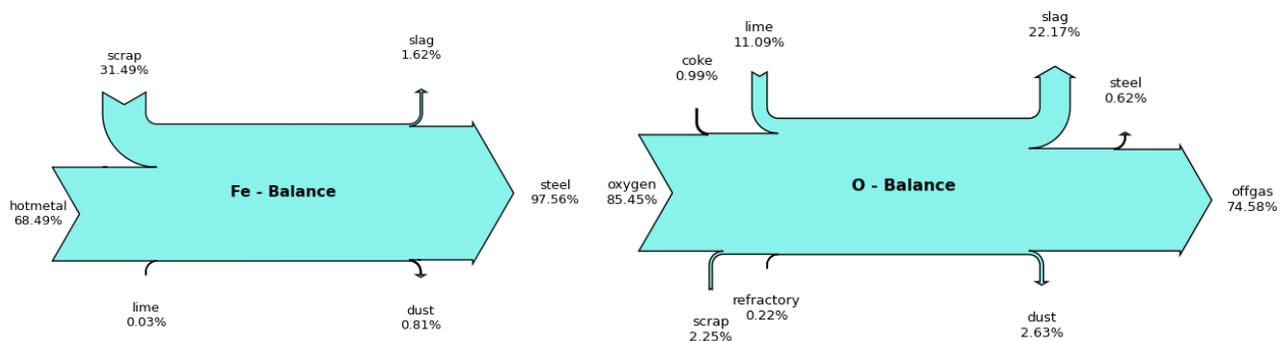


Figure 2: For all 30 elements a mass balance is calculated. Exemplary balance here for Fe and O.

## Empirical functions and Customization:

The BOF Calculator relies on empirical data und functions. Many equations for distribution/(partition) ratios of elements between slag and steel, the CxO product or the FeO content have been published in literature over the time. Those are mainly statistically derived from process data and measurements and therefore vary from plant to plant. As for the example of phosphorus, an overview of different functions are published (Urban, et al., 2014)<sup>1</sup>. Examples are:

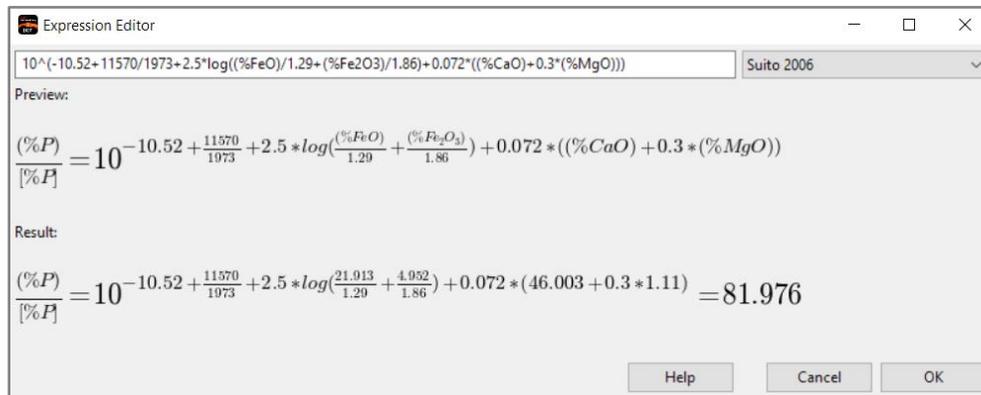
<sup>1</sup> W. Urban, M. Weinberg und J. Cappel, „Strategien und Modellierung der Entphosphorung von Roheisen im Sauerstoffaufblaskonverter,“ *Stahl und Eisen*, Bd. 08, pp. 27-39, 2014.

$$L \frac{(\%P)}{[\%P]} = -5,71 - \frac{13590}{T(K)} + 0,384 * \log(\%Fe_{total}) + 0,431 * [(\%CaO)/(\%SiO_2)] - 0,361 * \log(\%MgO)$$

$$L \frac{(\%P)}{[\%P]} = 5,41 - 0,00218 * T(K) + 0,00382 * (\%FeO) + 0,0228 * [(\%CaO)/(\%SiO_2)] - 0,0029 * (\%MgO)$$

$$\log \frac{(\%P)}{[\%P]} = 10,6 + 2,5 * \log(\%FeO) + 0,5 * \log(\%P_2O_5) + 5,0 * \log(\%CaO)$$

To use one of this relationships in the BOF Calculator, you simply type in the equation as it is given in the equation editor.



The editor understands the commonly used parenthesis logic to determine between [steel], (slag), <dust> or {off gas}. So every kind of chemical element or compound of one specific product phases can be addressed. Furthermore, process parameter like temperature, Basicity, as well as basic mathematical operation (logarithm, exponential) are implemented. The entered equation will be saved in the software and can be further used on for the next process calculation. This methodology is also applied for

- (% FeO)
- (% FeO) / (% Fe2O3)
- [% C] x [% O]
- (% MnO) / [% Mn]
- (% S)/[% S]

Following this approach, you have an easy way to implement your own know-how into the converter model. Just apply the results of your own statistical findings and directly implement them without any further abstraction.