Industrial Application of *SimuSage* for Metallurgical Processes Simulation

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Herzogenrath, June 16-18 2010

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Business areas SMS Siemag

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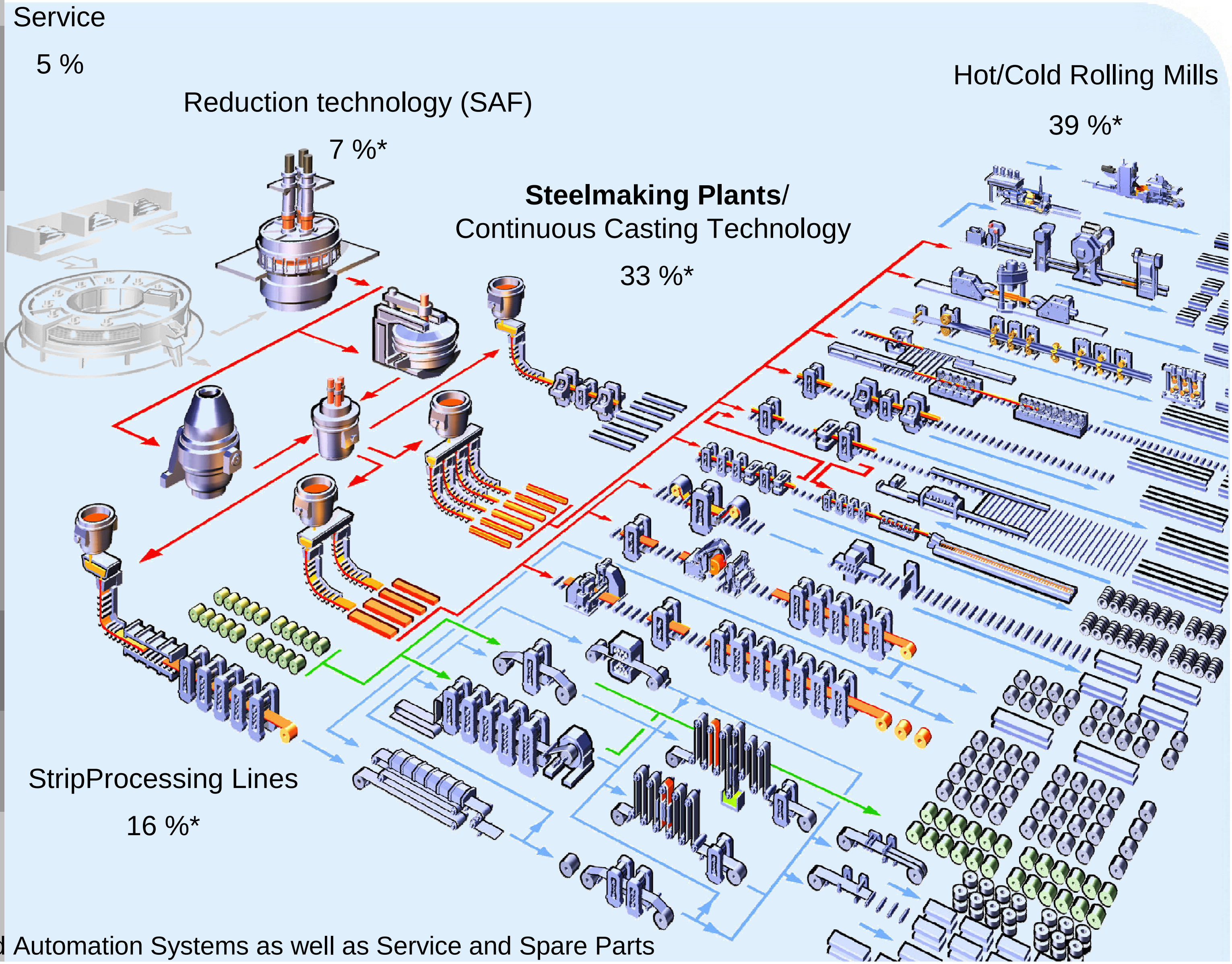

* Including Electrical and Automation Systems as well as Service and Spare Parts

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Steel production routes

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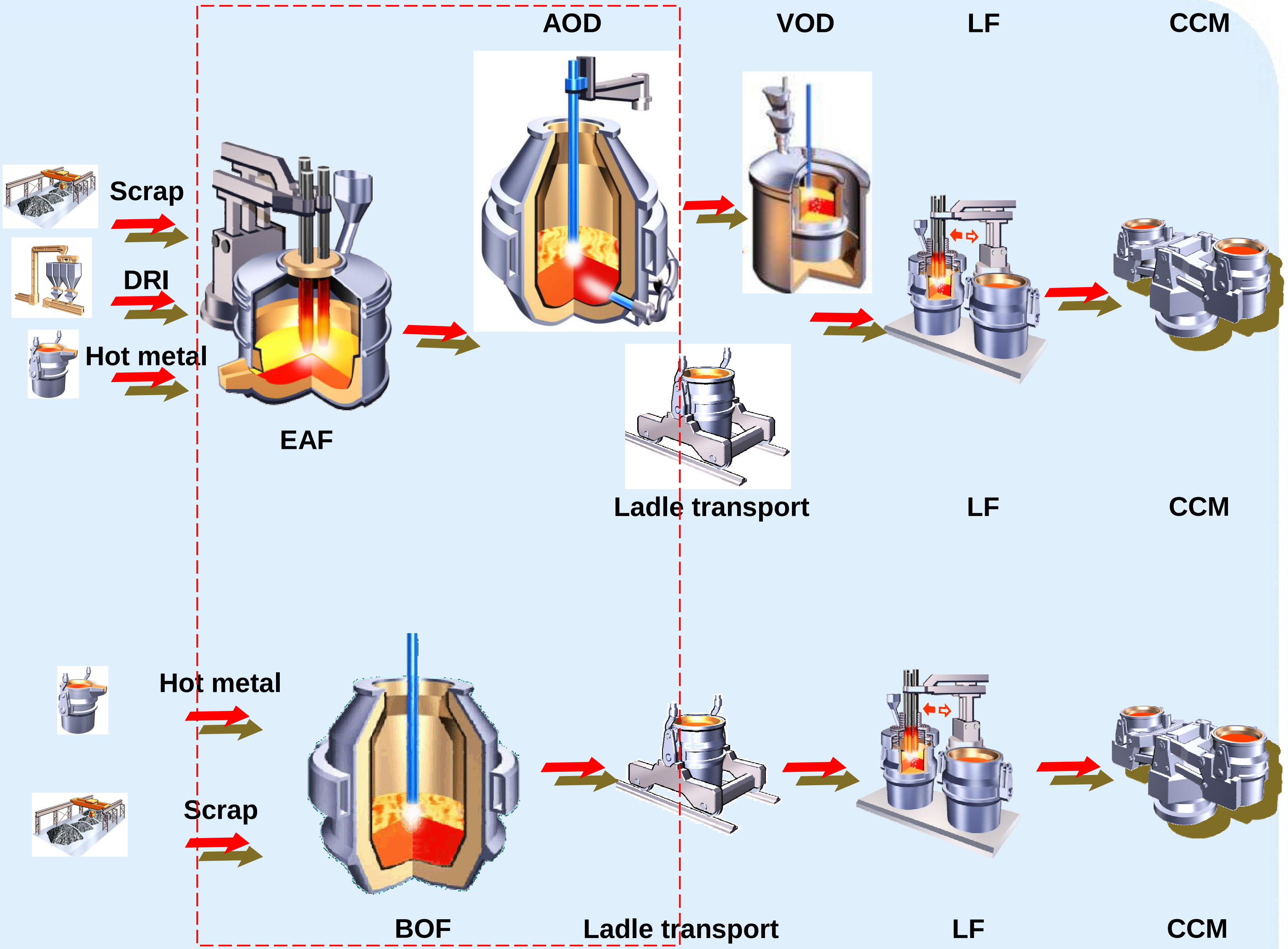

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General idea for primary energy melting - process

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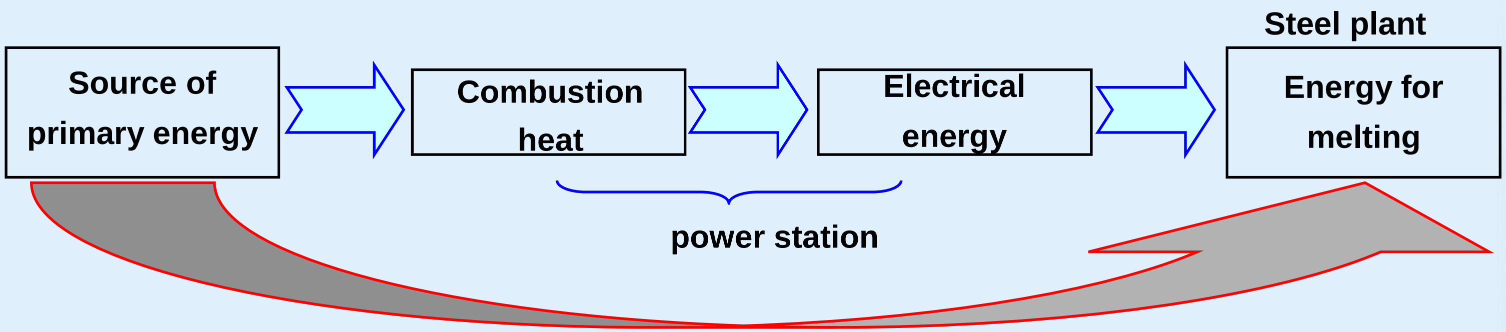
Optimum source of energy input and energy utilization by scrap melting



Energy

- **Improved utilisation of gas energy content**
- **High thermal efficiency**

Costs

- **Reduction of production costs**
- **Reduction of investment costs**
- **Reduction of capital costs**

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Primary Energy Melting – process line

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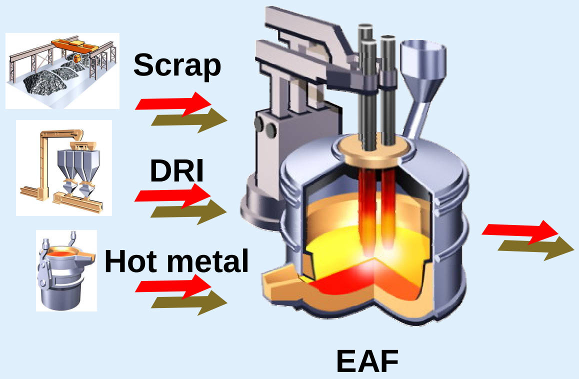
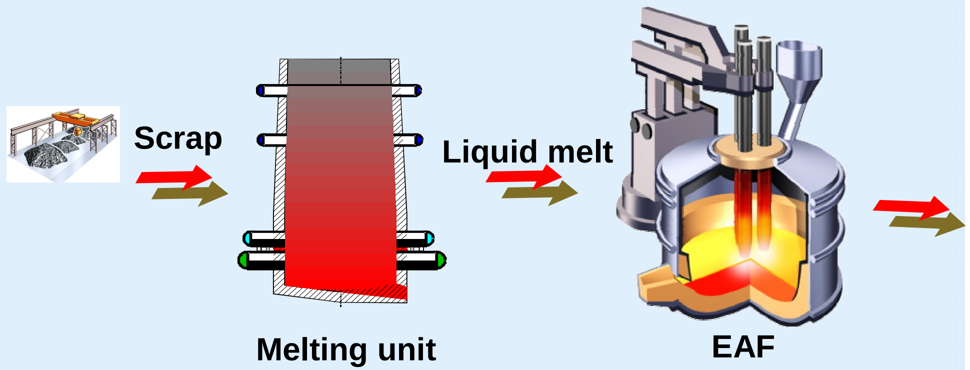
Conventional EAF rout



100% melting and overheating

PEM - EAF rout



85-90% melting

10-15% overheating

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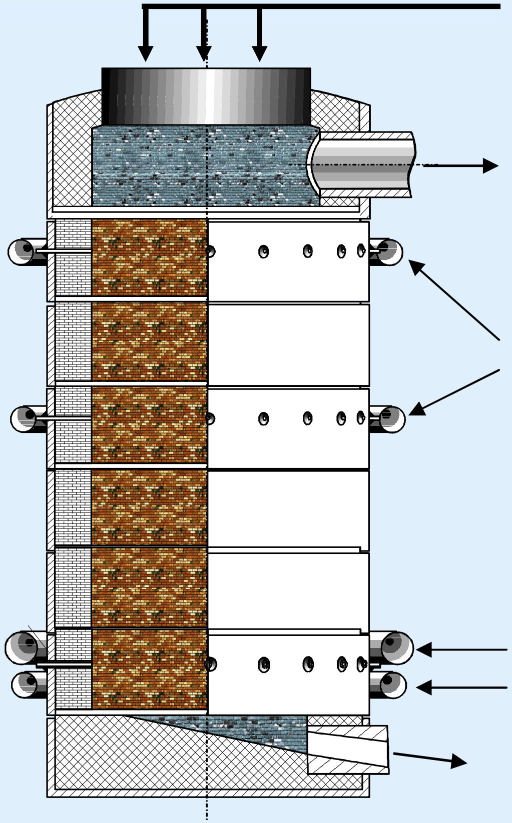
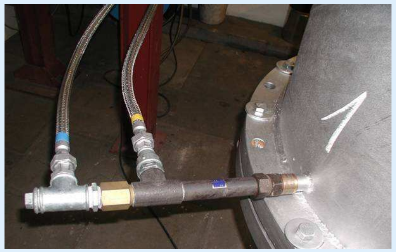
Melting unit design



scrap,
lime, coal

secondary post
combustion and
quenching

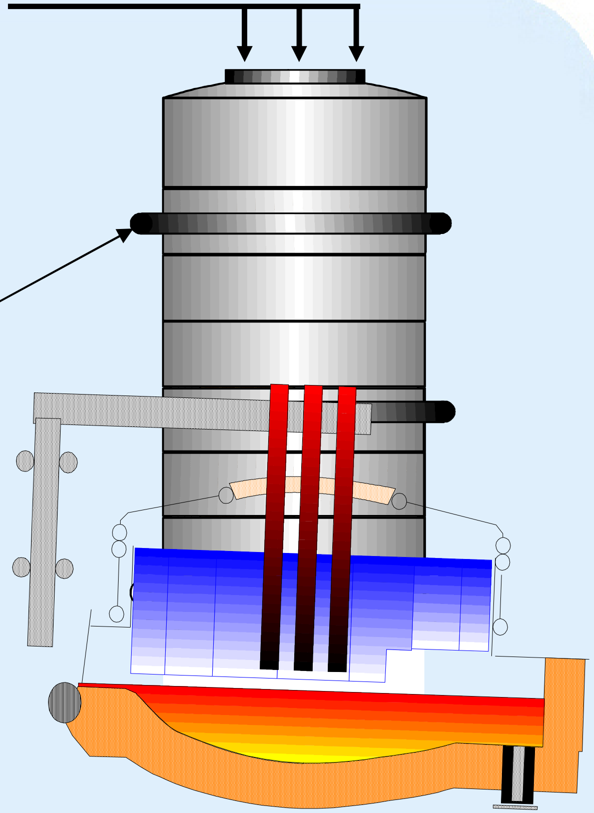
post combustion air



oxygen

natural gas

continuous tapping
into the EAF



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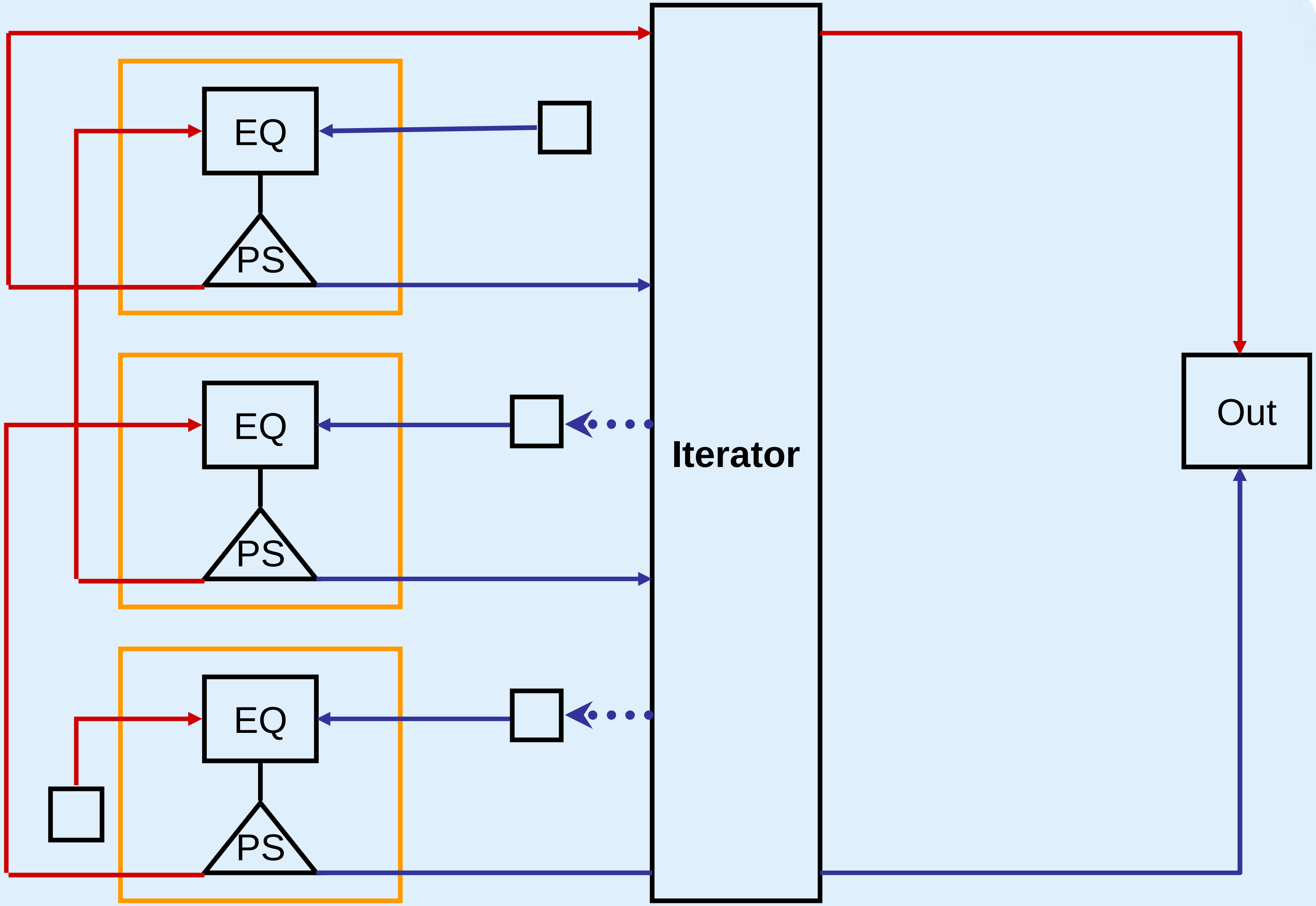
Simulation of PEM – process

Counter-current reactor



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Simulation of PEM – process

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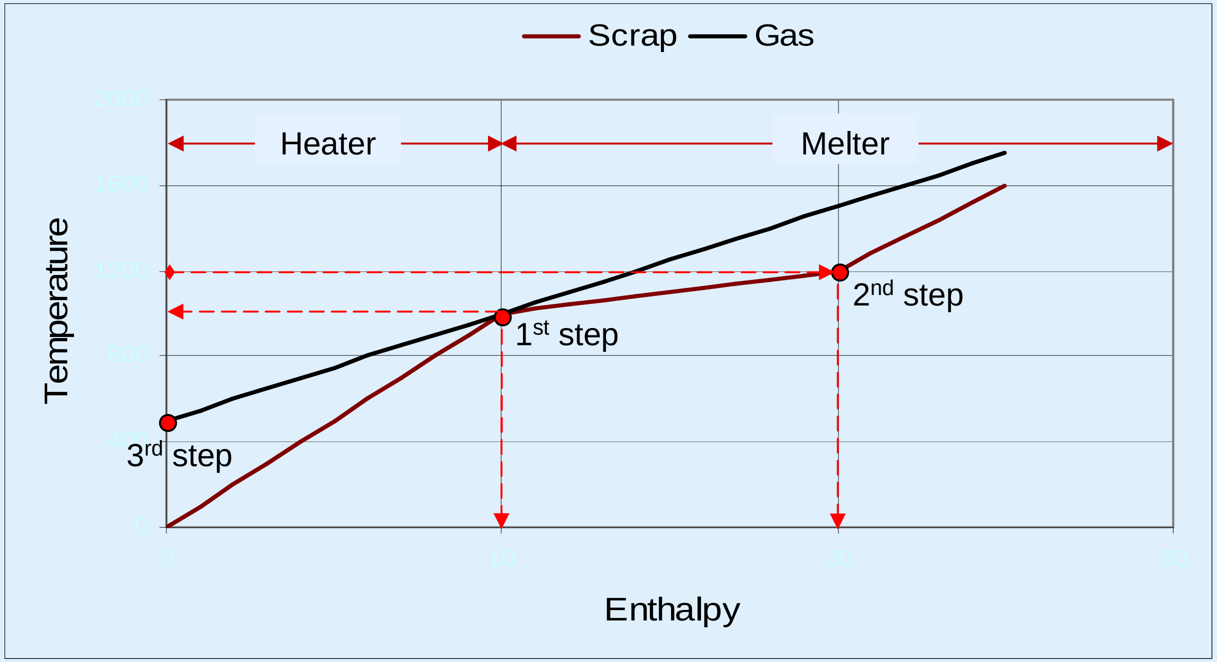
3-step simulation of counter flows: cold scrap – burning gas (natural gas – oxygen burner)

- Temperature exchange
- No mass exchange
- No chemical reactions between scrap and gas



1-step simulation of counter flows: cold scrap – burning gas (natural gas – oxygen burner) with the partial slagging of scrap

- Temperature exchange
- No mass exchange
- No chemical reactions between scrap and gas

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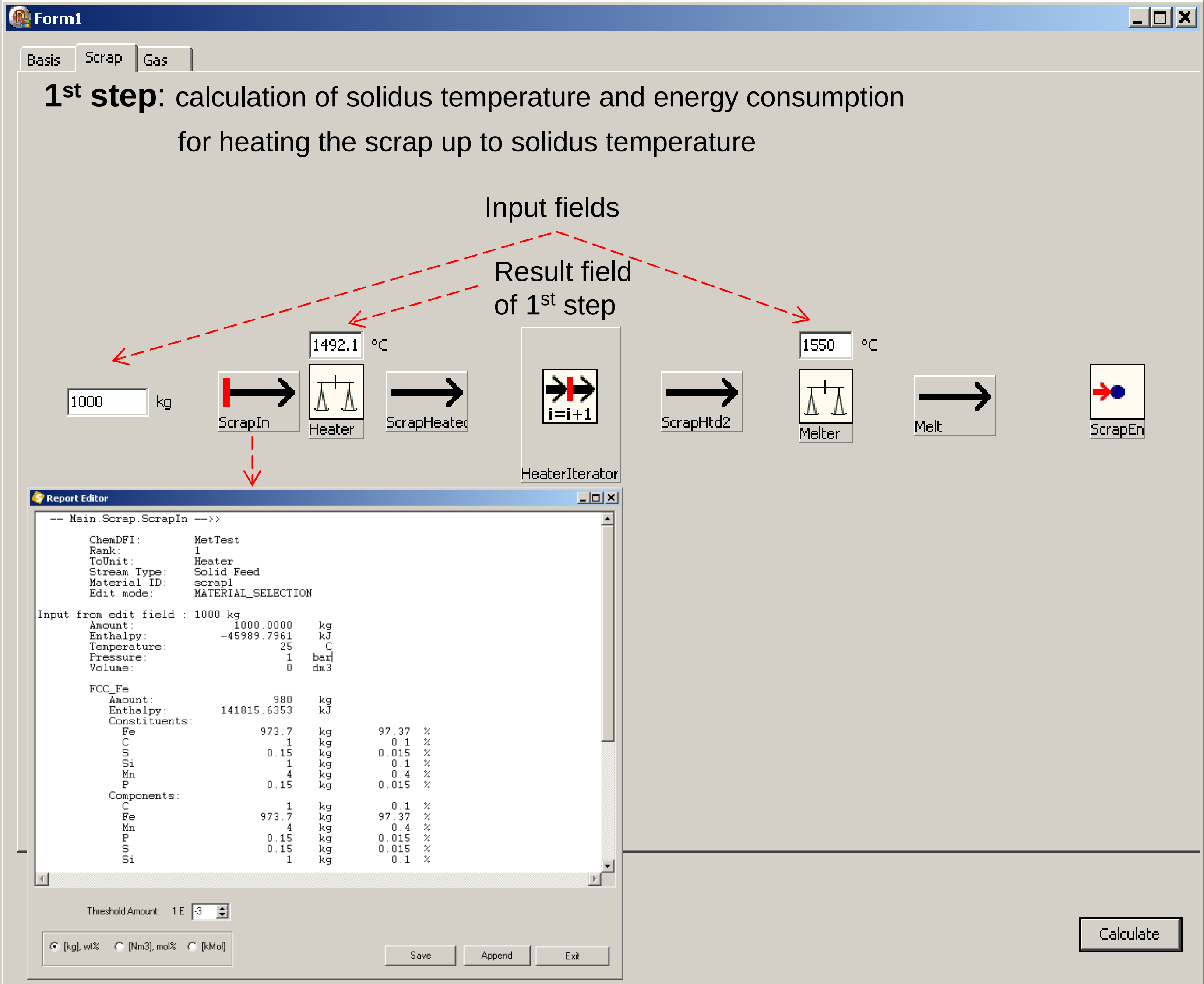
Simulation of 3-step process

Calculation of energy consumption for the smelting of scrap



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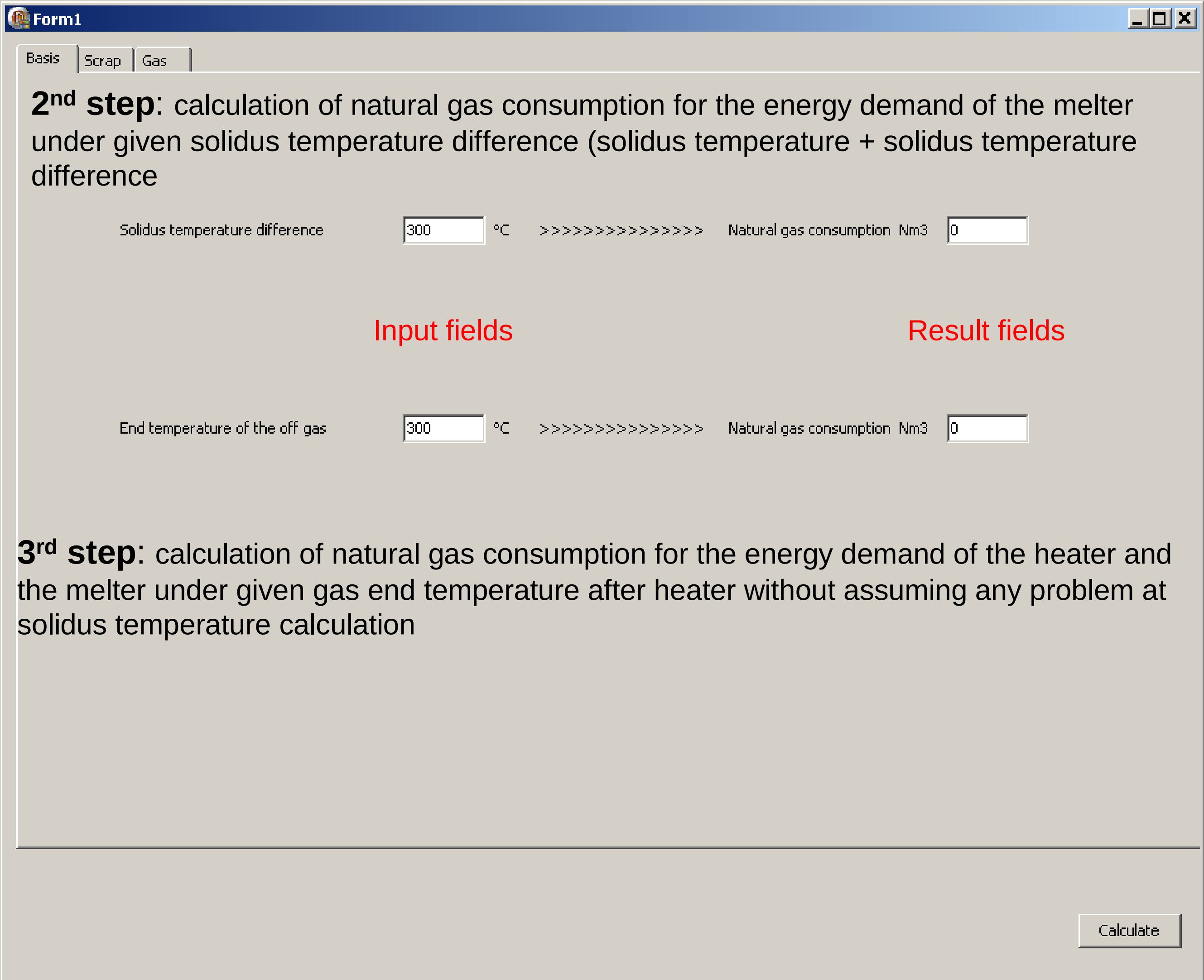
Simulation of 3-step process

Calculation of natural gas consumption for the smelting of scrap under given solidus temperature difference and end temperature of the off gas



2nd step: calculation of natural gas consumption for the energy demand of the melter under given solidus temperature difference (solidus temperature + solidus temperature difference

3rd step: calculation of natural gas consumption for the energy demand of the heater and the melter under given gas end temperature after heater without assuming any problem at solidus temperature calculation

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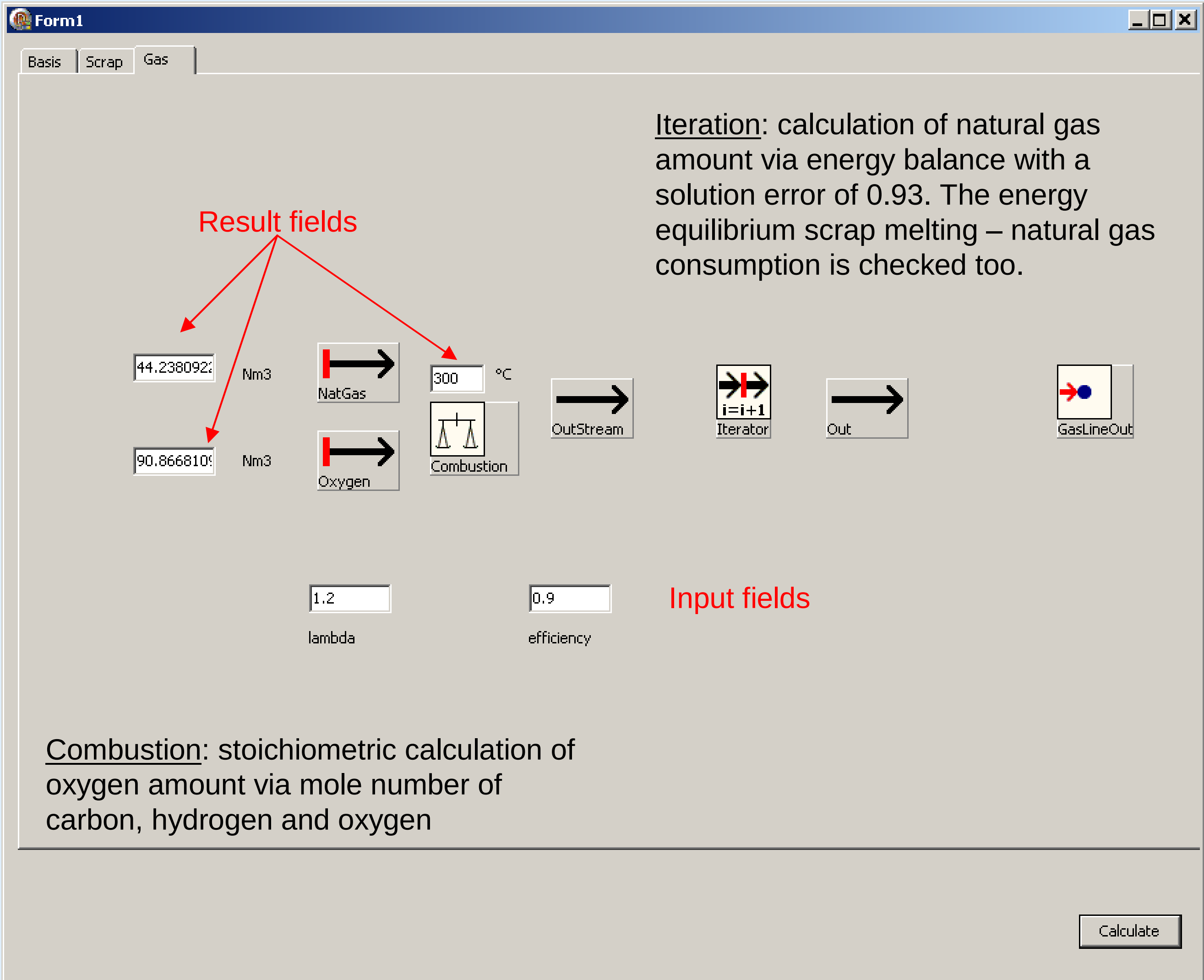
Simulation of 3-step process

Calculation of natural gas and oxygen consumption for the smelting of scrap under given temperature, lambda and combustion efficiency



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Simulation of 1-step process

Calculation of natural gas and oxygen consumption for the melting of scrap under given off gas temperature, lambda, combustion efficiency and slagging fraction

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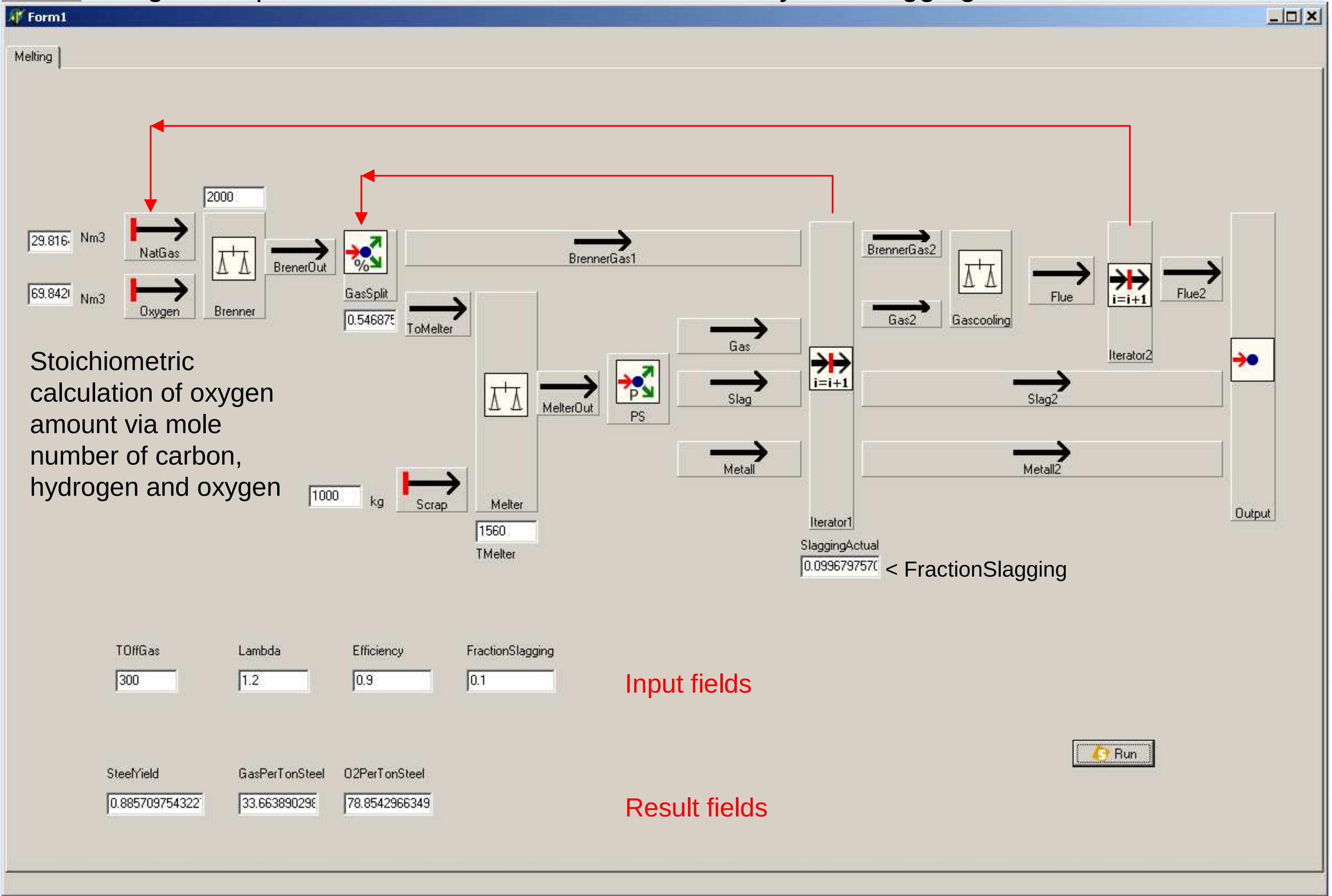

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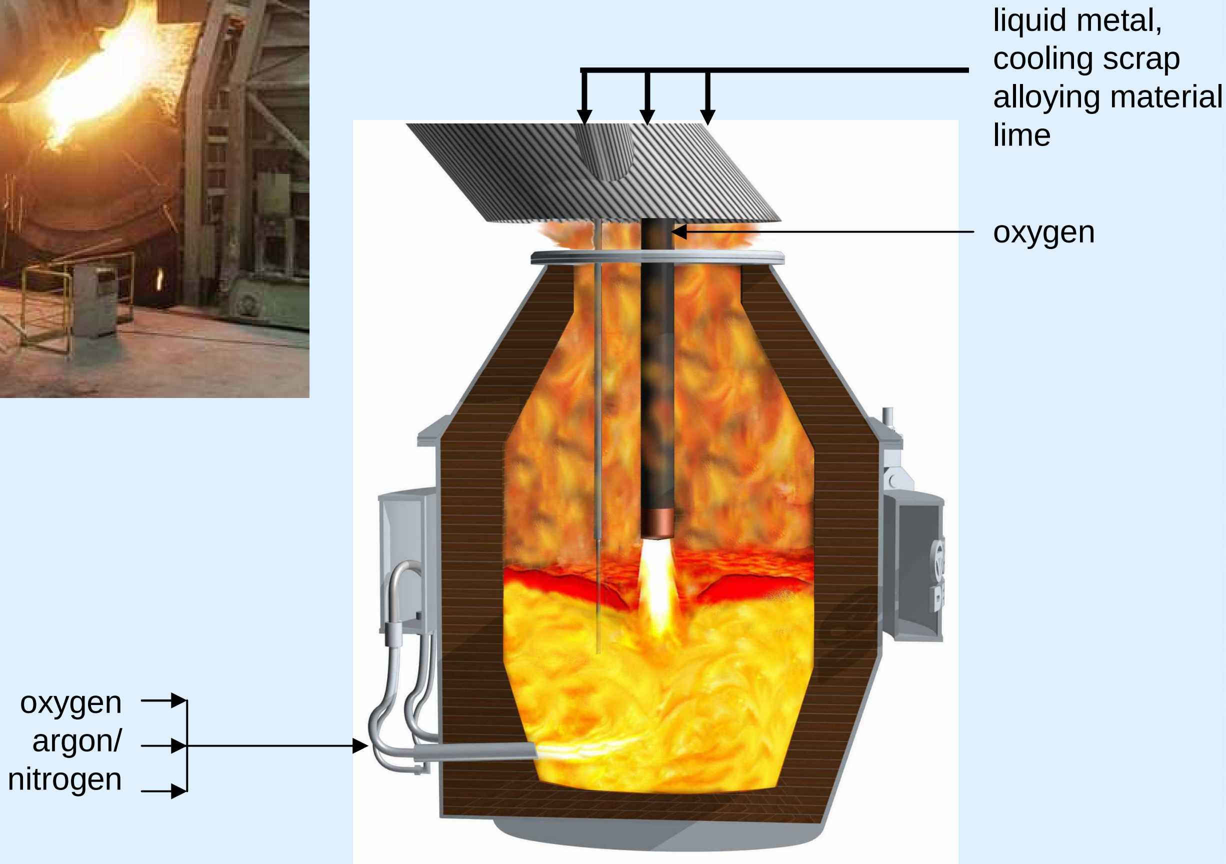
AOD - process



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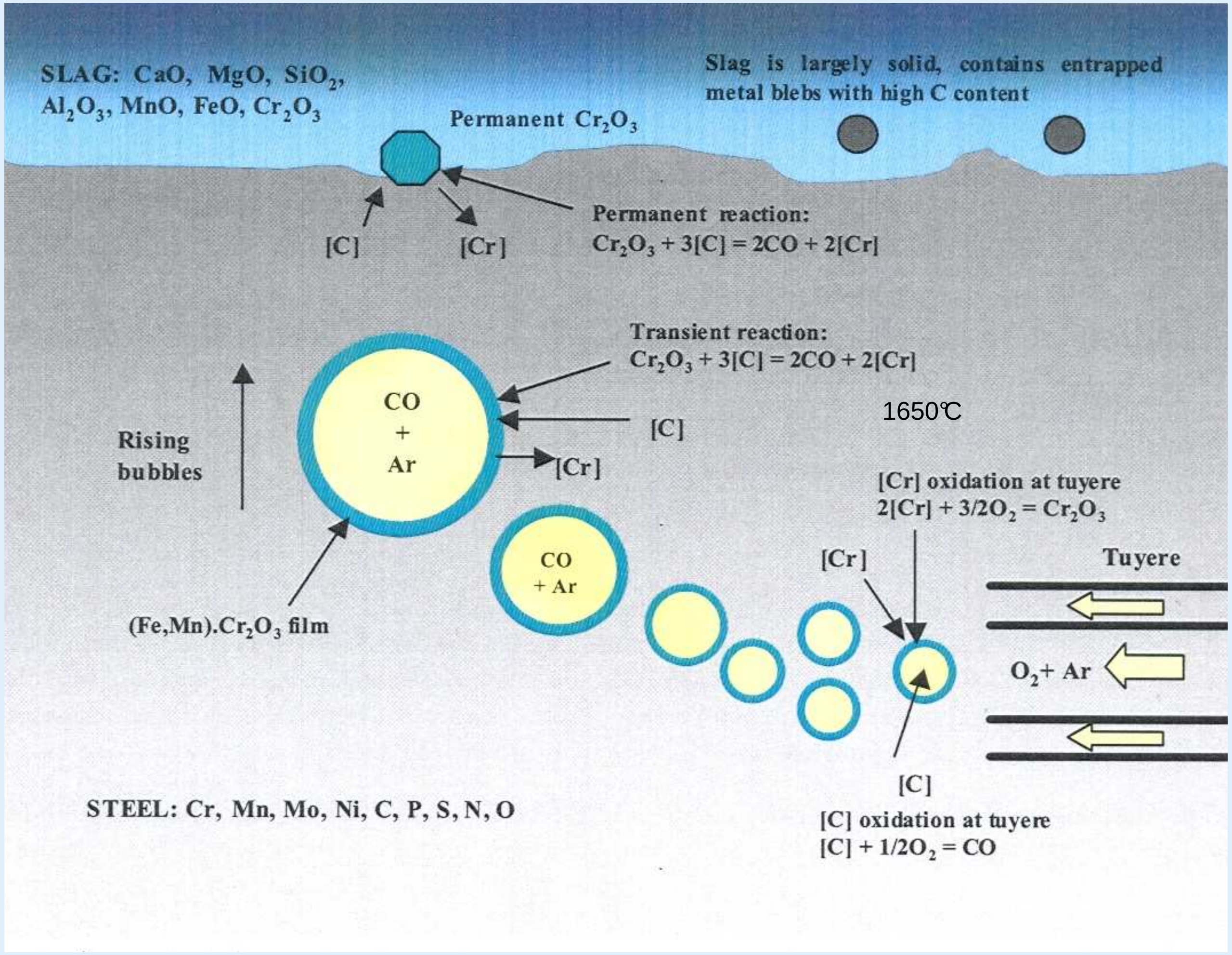
Reaction mechanisms in AOD-converter

liquid metal (**C ≤ 3.5%**) → stainless steel (**C< 0.05%**, Cr > 10%, Ni, Mo, Mn, Ti,…)



Metals oxidation: $[Fe] + \frac{1}{2}\{O_2\} = (FeO)$ $2[Cr] + \frac{3}{2}\{O_2\} = (Cr_2O_3)$

Decarburization: $[C] + \frac{1}{2}\{O_2\} = \{CO\}$ $3[C] + (Cr_2O_3) \rightleftharpoons 2[Cr] + 3\{CO\}$

[ ] melt
( ) slag
{ } gas

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Simulation of steam injection

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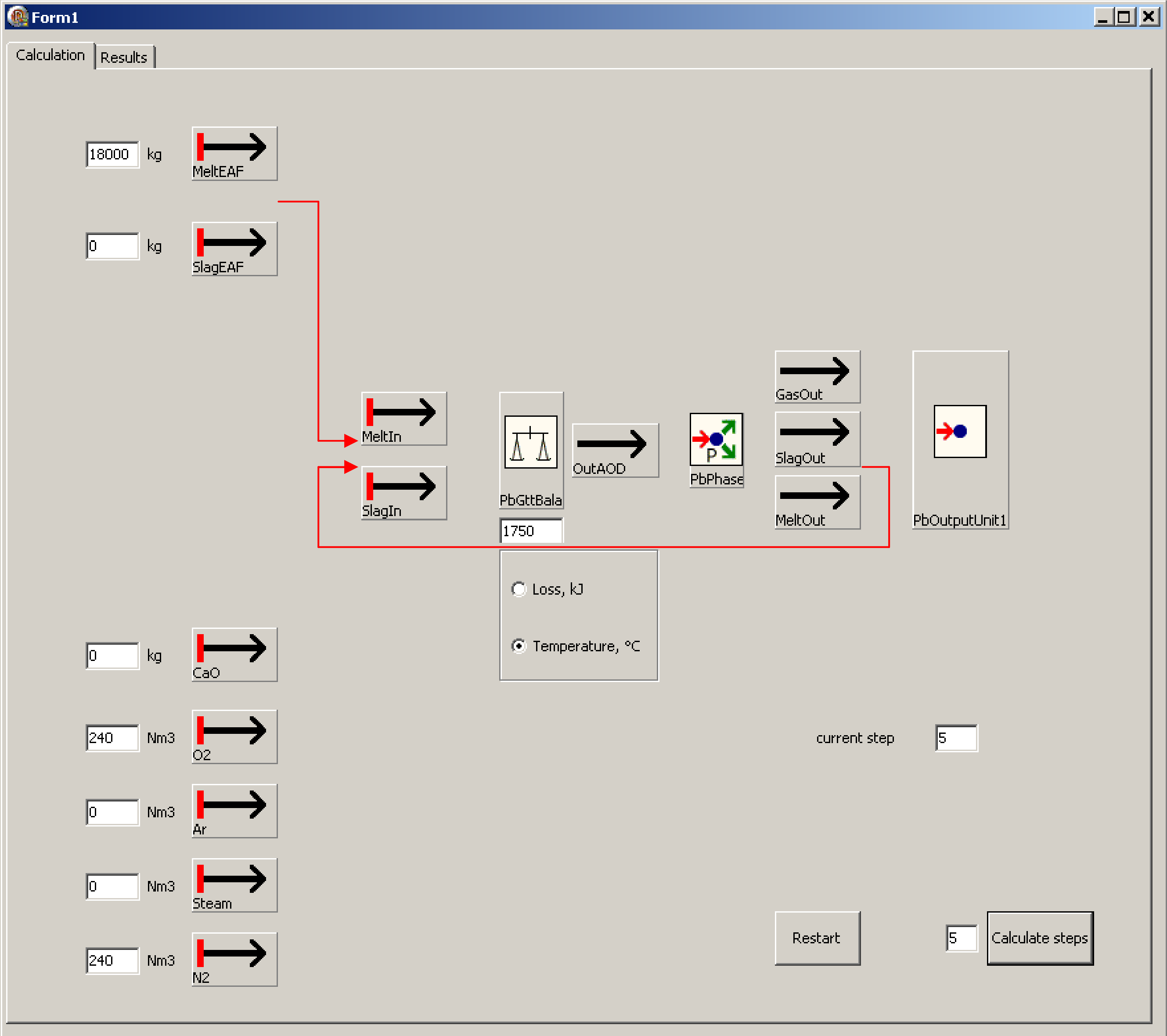

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Simulation of steam injection

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Form1

Calculation | Results

Step	O2,Nm3	Ar,Nm3	Steam,Nm3	N2, Nm3	Melt,kg	[C],wt.%	[Si],wt.%	[Cr],wt.%	[Mn],wt.%	[Fe],wt.%	Slag,kg	(Cr),wt.%
1	240	0	0	240	16988.49070	5.832863854	1.056929103	0	78.20518863	14.60178588	0	0
2	240	0	0	240	15828.22119	4.631529495	1.131245483	0	78.32805759	15.66105169	0	0
3	240	0	0	240	14448.44513	3.293143917	1.234785881	0	78.09163619	17.14151114	0	0
4	240	0	0	240	12737.09520	1.718887620	1.391969565	0	77.20609743	19.42238142	0	0
5	240	0	0	240	10782.09967	0.118991267	1.510751002	0	75.70921272	22.37717032	194.2130375	0

Results table:

Input data
- Step
- O_2, Nm^3
- Ar, Nm^3
- Steam, Nm^3
- N_2, Nm^3

Melt output
- Melt, kg
- [C], wt.%
- [Si], wt.%
- [Cr], wt.%
- [Mn], wt.%
- [Fe], wt.%

Slag output
- Slag, kg
- (Cr), wt.%
- (Mn), wt.%
- (Fe), wt.%

Off gas output
- Off gas, Nm3
- {Mn}, vol.%
- {CO}, vol.%
- {H2}, vol.%

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BOF - process

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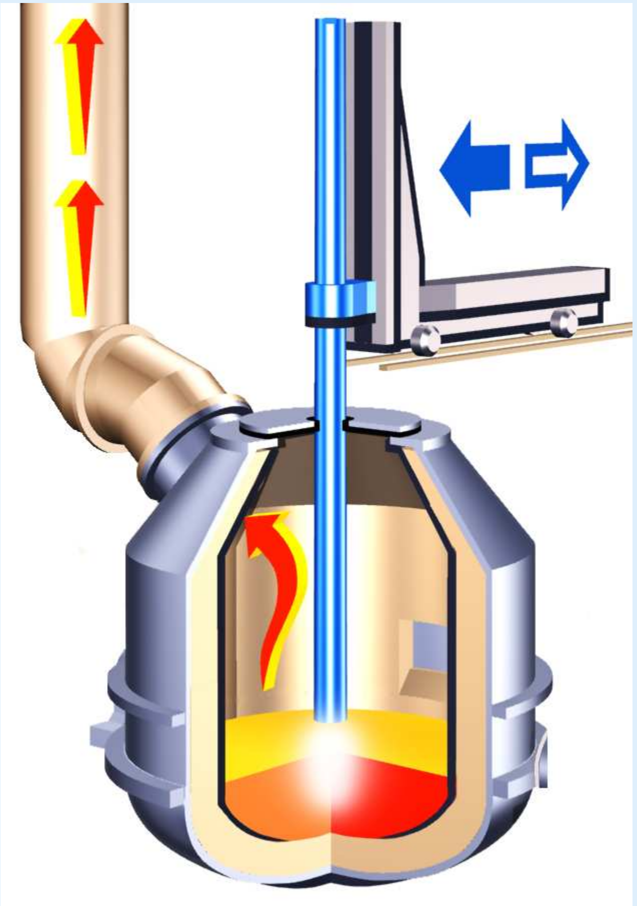
Charge of
hot metal, cooling scrap, lime

Oxygen blowing through the top lance



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Emulsion generation in BOF-converter

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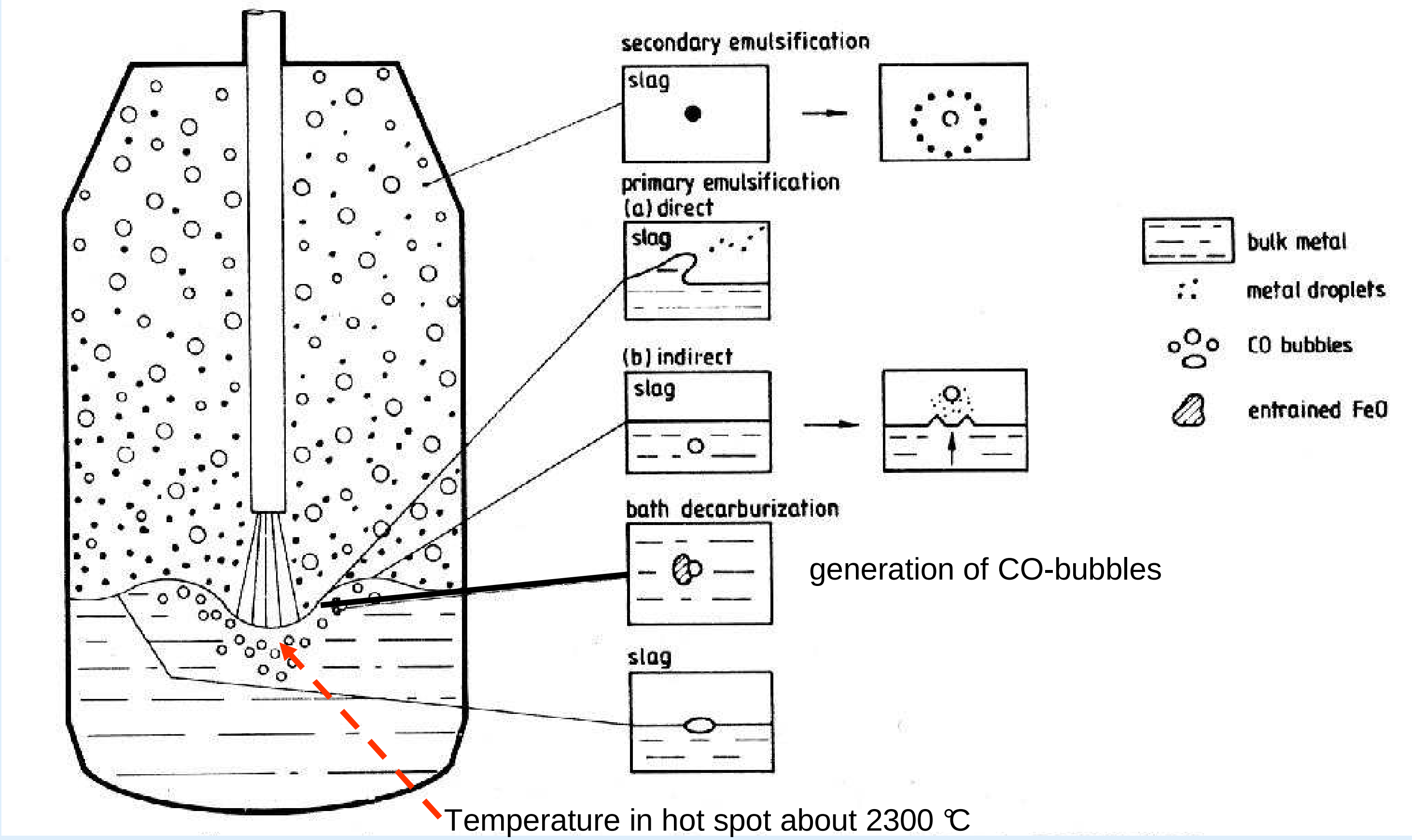

Oxidation reactions in BOF-converter

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silicon oxidation at the begin of oxygen blowing	$[Si] + 2\,[O] <=> (SiO_2)$
iron slagging (partly)	$[Fe] + [O] <=> (FeO)$
manganese slagging	$[Mn] + [O] <=> (MnO)$
phosphor burn off	$2\,[P] + 5\,[O] <=> (P_2O_5)$
slag enrichment with the oxygen	$2\,(FeO) + [O] <=> (Fe_2O_3)$
phosphor stabilisation in the slag by the lime	$3\,(CaO) + (P_2O_5) <=> (CaO)_3\,(P_2O_5)$
main decarburisation	$[C] + [O] <=> \{CO\}$
partly post combustion	$\{CO\} + [O] <=> \{CO_2\}$

all reaction with [O] can also proceed with $^1/_2\,\{O_2\}$ from gas phase

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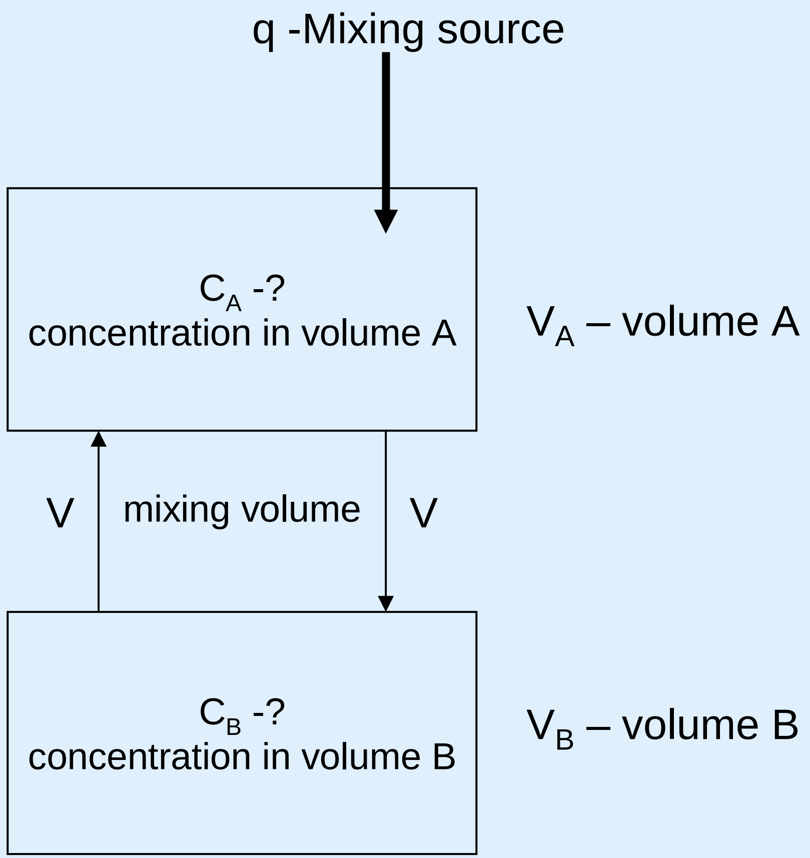
Process simulation with melt bulk mixing



$$\frac{d}{dt}(C_A \cdot V_A) = V \cdot C_B - V \cdot C_A + q$$

$$\frac{d}{dt}(C_B \cdot V_B) = V \cdot C_A - V \cdot C_B$$

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Process simulation with melt bulk mixing

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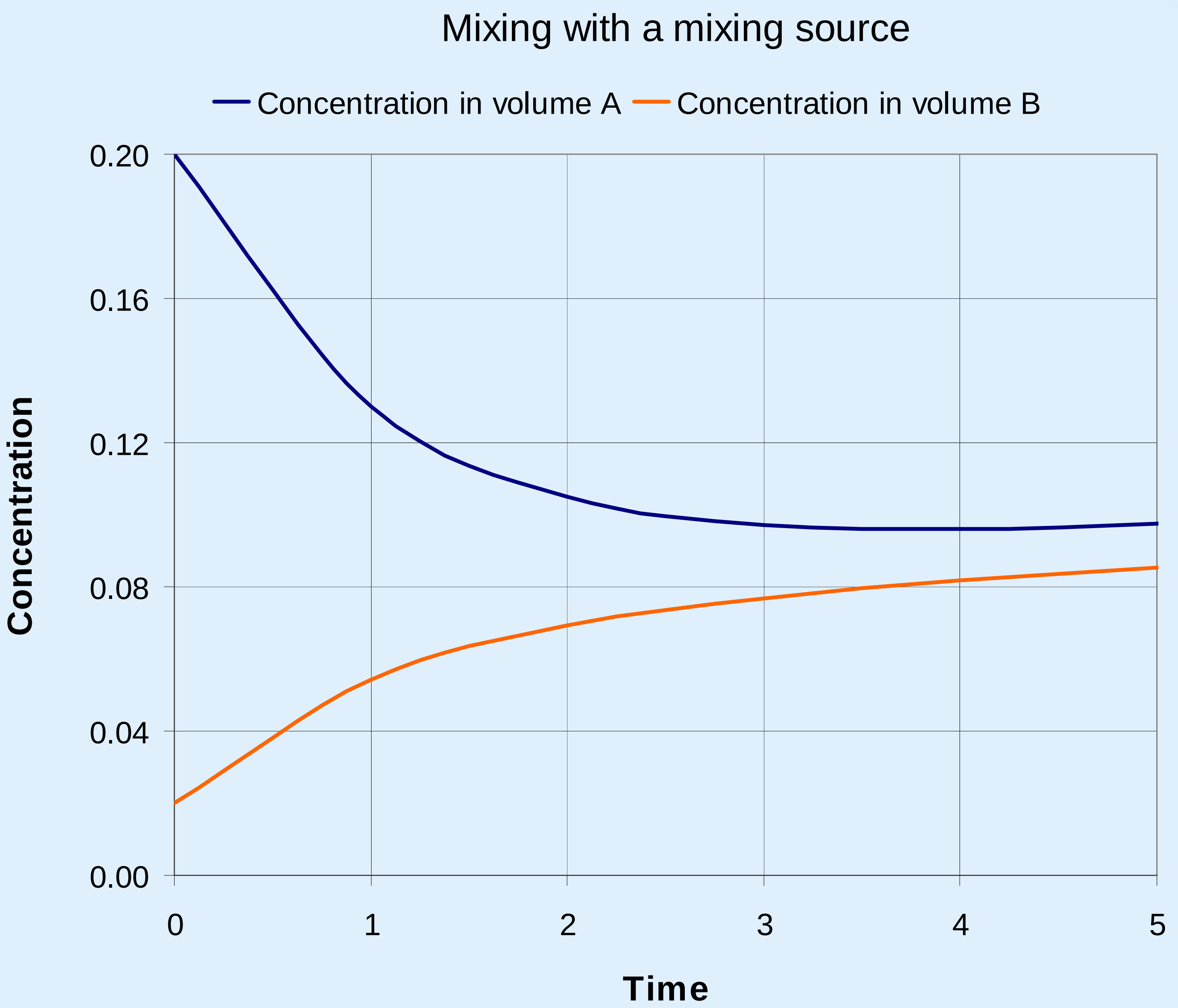

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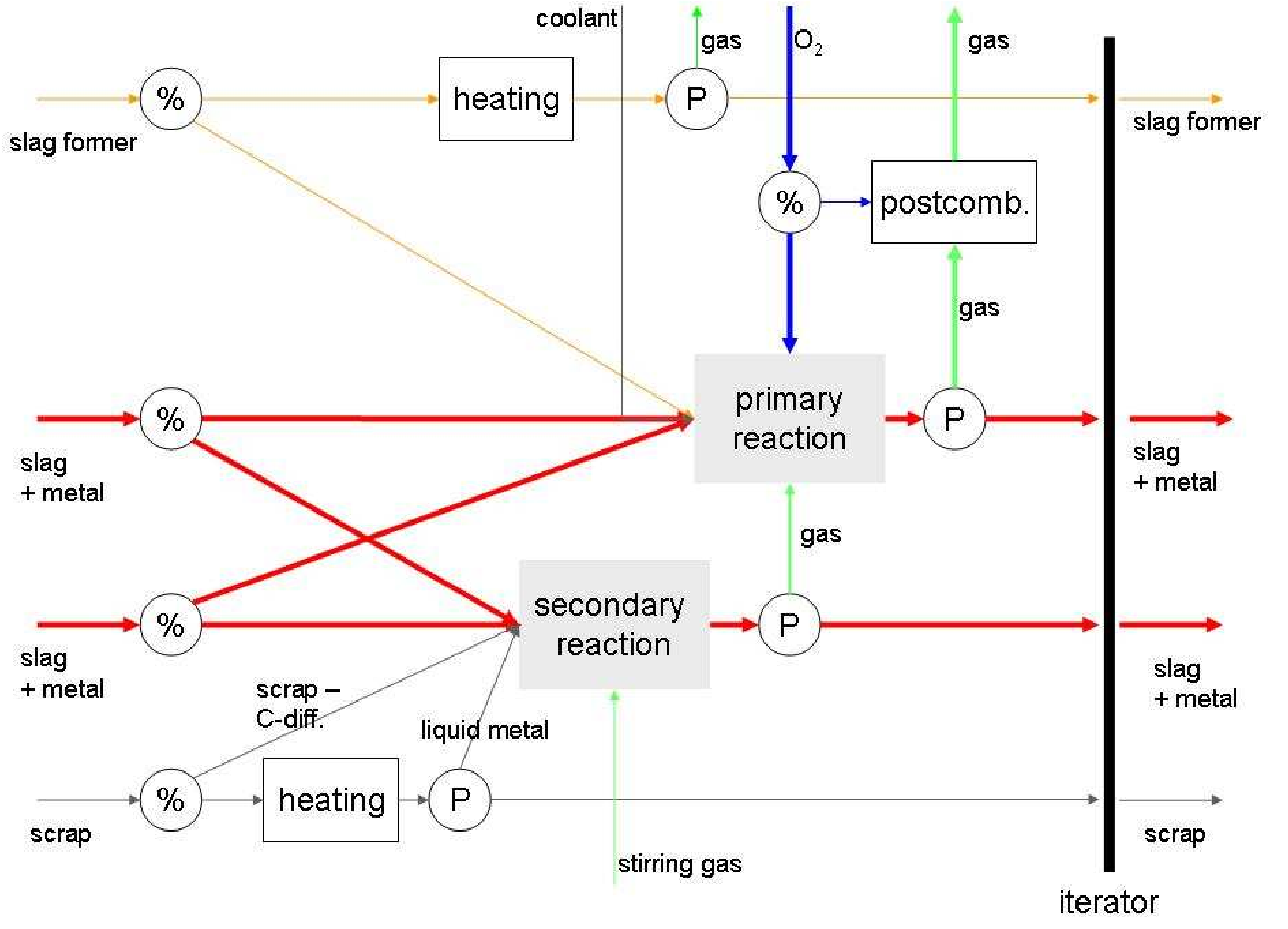
Process simulation with melt bulk mixing



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Process simulation with melt bulk mixing