Droplet Generation in Oxygen Steelmaking

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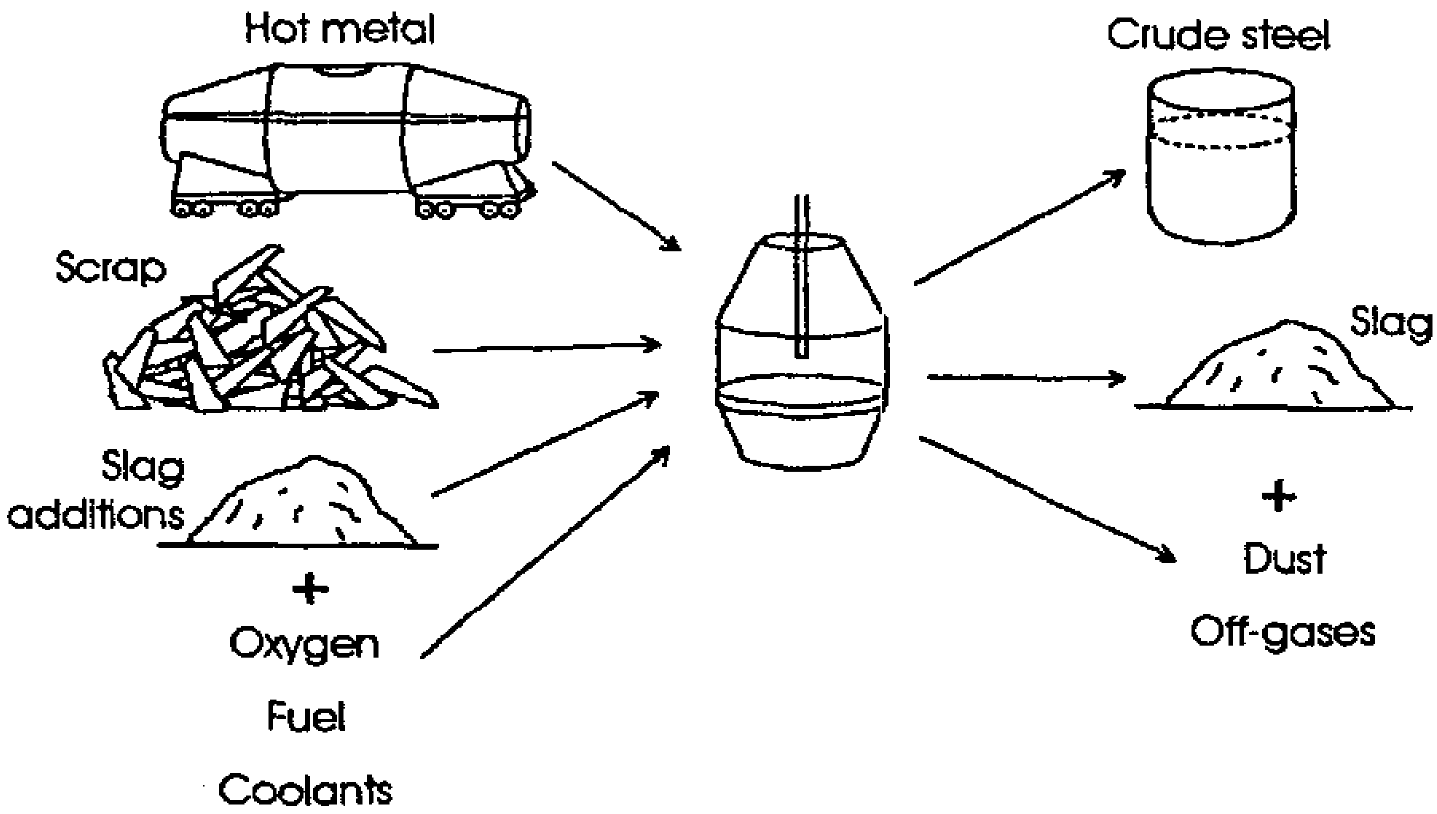
Content Outline

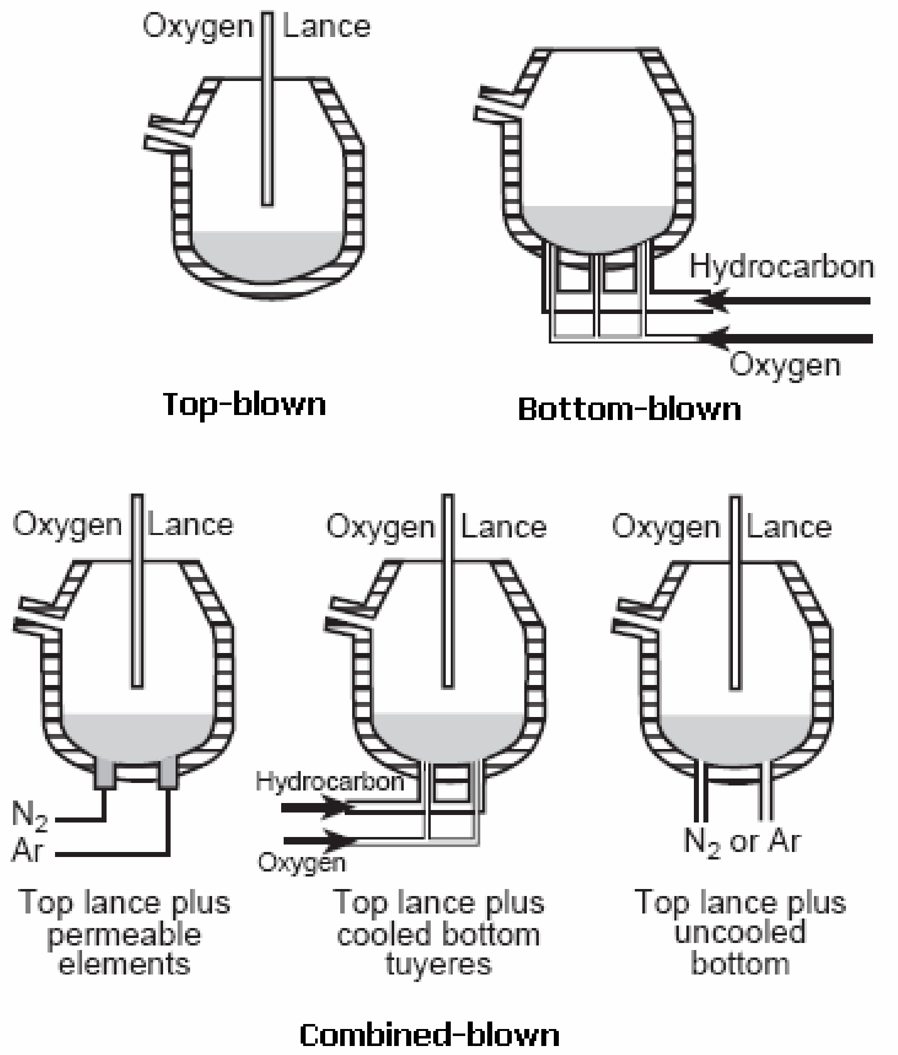
1. Introduction
2. Overview of Project
3. Droplet Generation
4. Future Work

Basic Oxygen Steelmaking Process



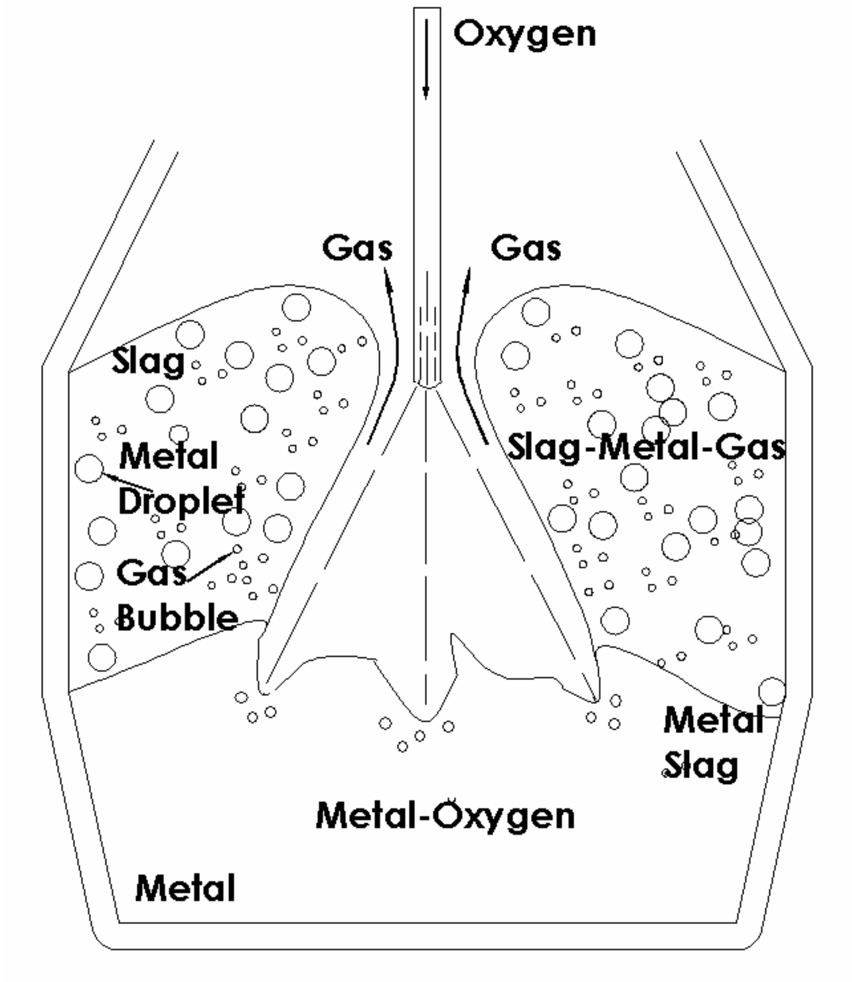
Johansson, Medvedev and Widlund, IAS Annual Meeting, 2000

Variations of Oxygen Steelmaking Process



Making, Shaping and Treating of Steel,1998

Oxygen Steelmaking Process



Hot Zone

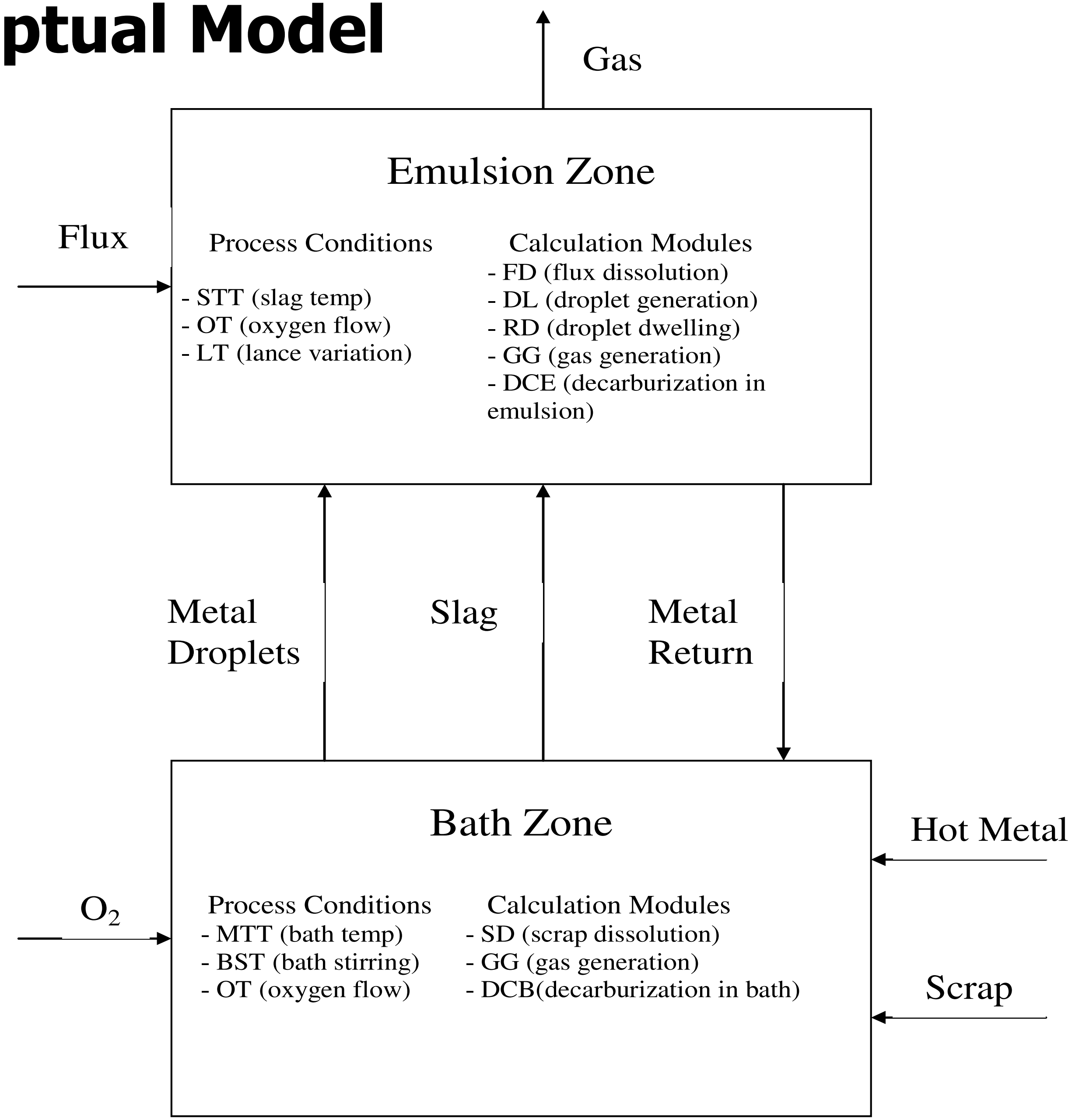
$O_2(g) = 2\underline{O}$

$\underline{O} + \underline{C} = CO(g)$

Emulsion

$(FeO) + \underline{C} = Fe + CO(g)$

Conceptual Model

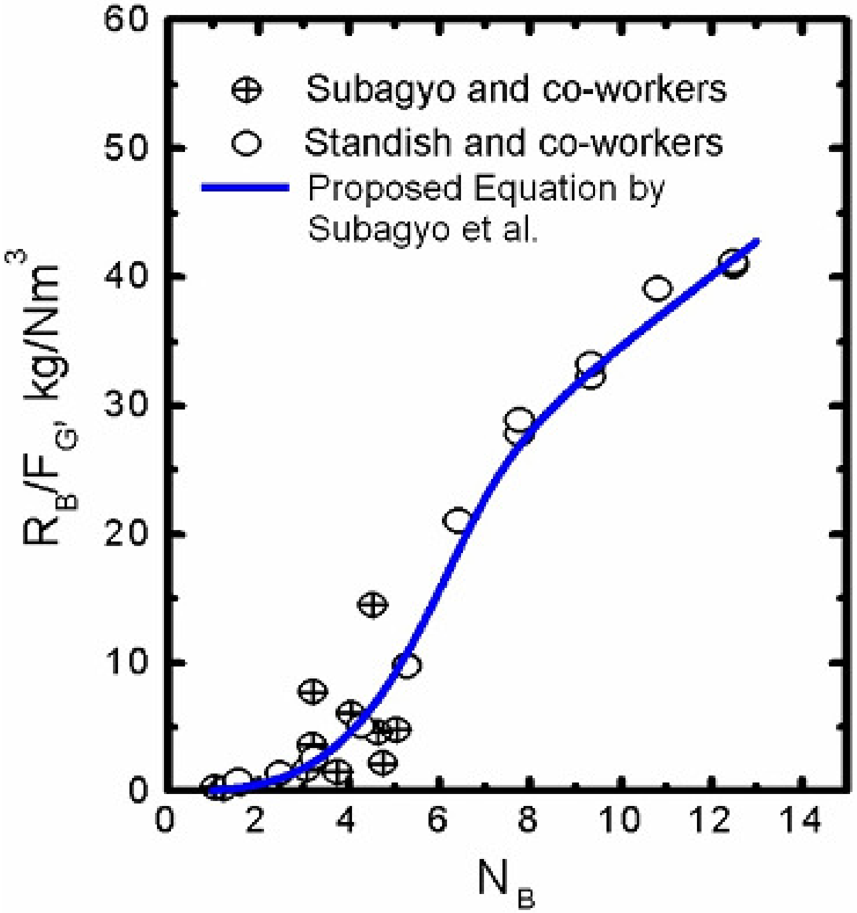


3. Droplet Generation

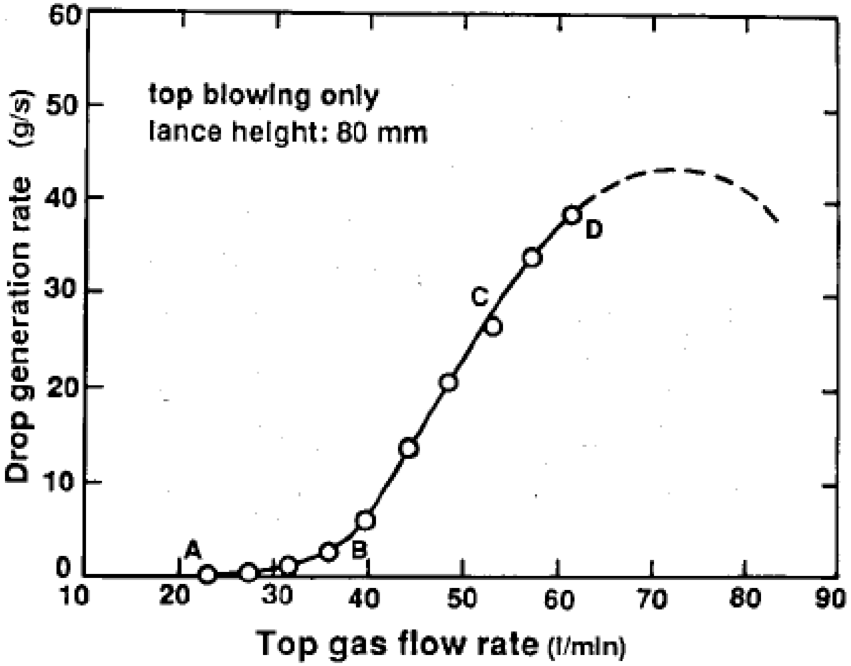
Kelvin-Helmholtz Instability
Criteria

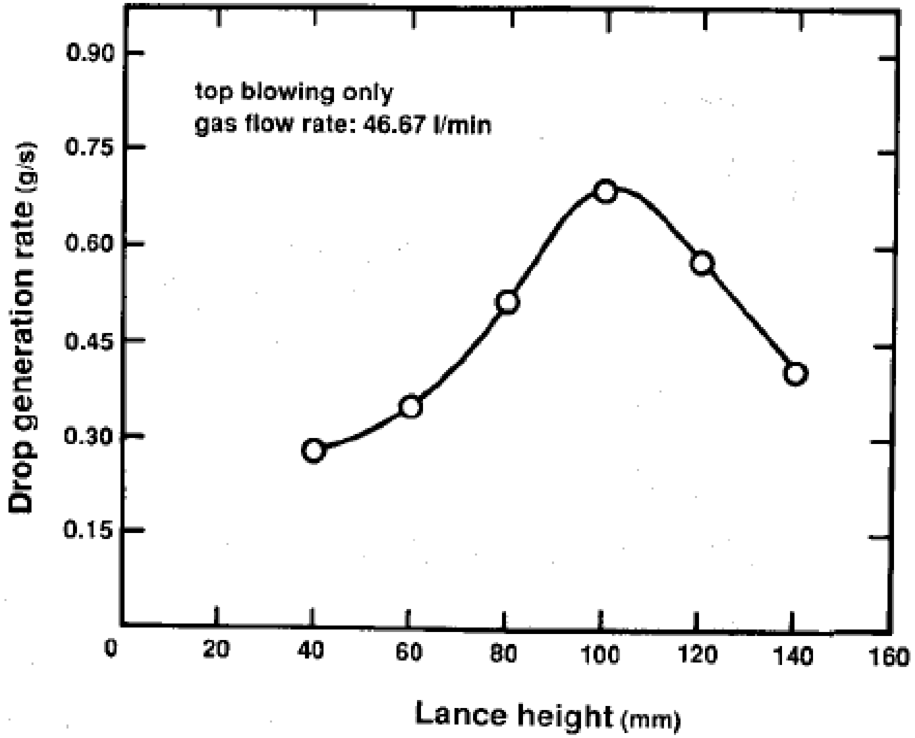
$$N_B = \frac{\rho_g U_G^2}{2\sqrt{\gamma g \rho_m}}$$

R_B=droplet generation rate (kg/s)
F_G=gas flow at lance exit (Nm^3/s)



Subagyo, Brooks, Coley and Irons, ISIJ, 2003





$$U_G = \eta U_j$$

$$U_j = f(h, d_t, P, n, \alpha, \rho_l)$$

Standish and He, ISIJ, 1989

Surface tension of liquid iron can be found by (Chung & Cramb, 2000)

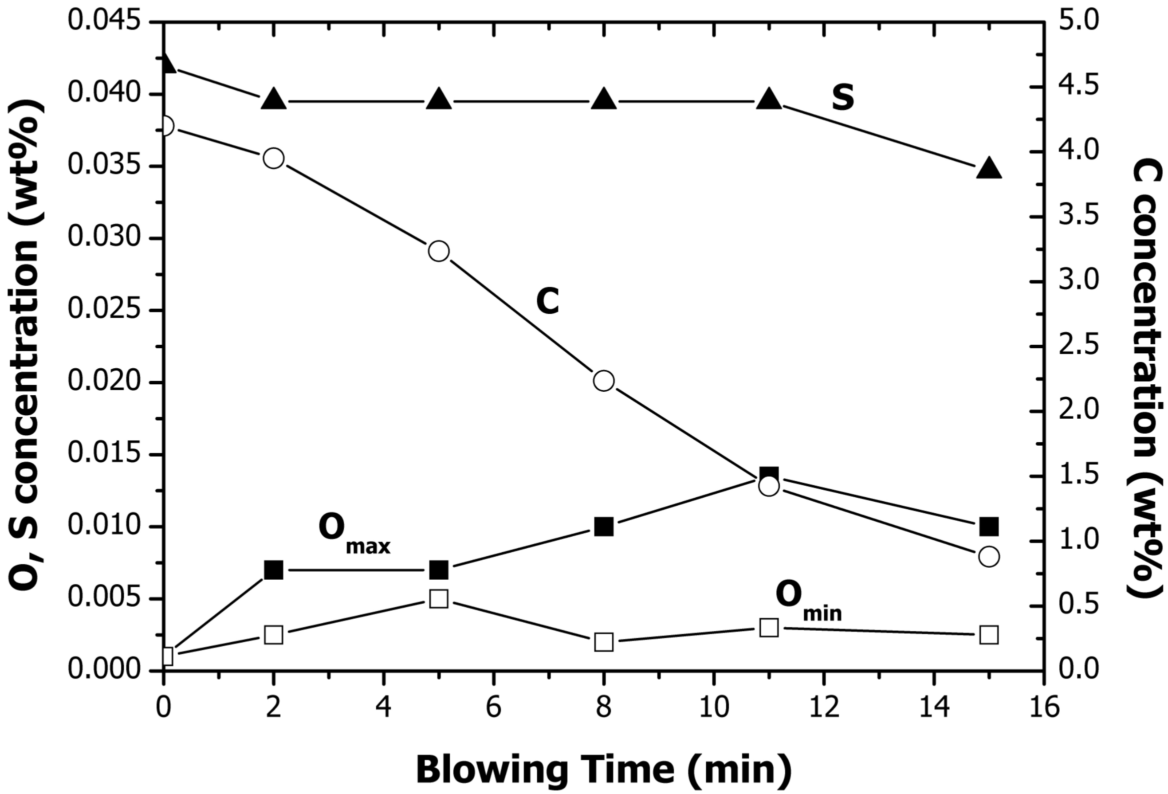
$$\gamma = 1913 + 0.43[1823 - T_b] + 67.75[\%C] - 0.107T_b \ln[1 + K_S a_S] - 0.153T_b \ln(1 + K_O a_O)$$

Adsorption coefficients of oxygen and sulphur are (Chung & Cramb, 2000)

$$\log K_O = 11370/T_b - 4.09$$

$$\log K_S = 10013/T_b - 2.87$$

Evaluation of metal composition during the blow



Jalkanen and Holappa, VII International Conference on Molten Slags Fluxes and Salts, 2004

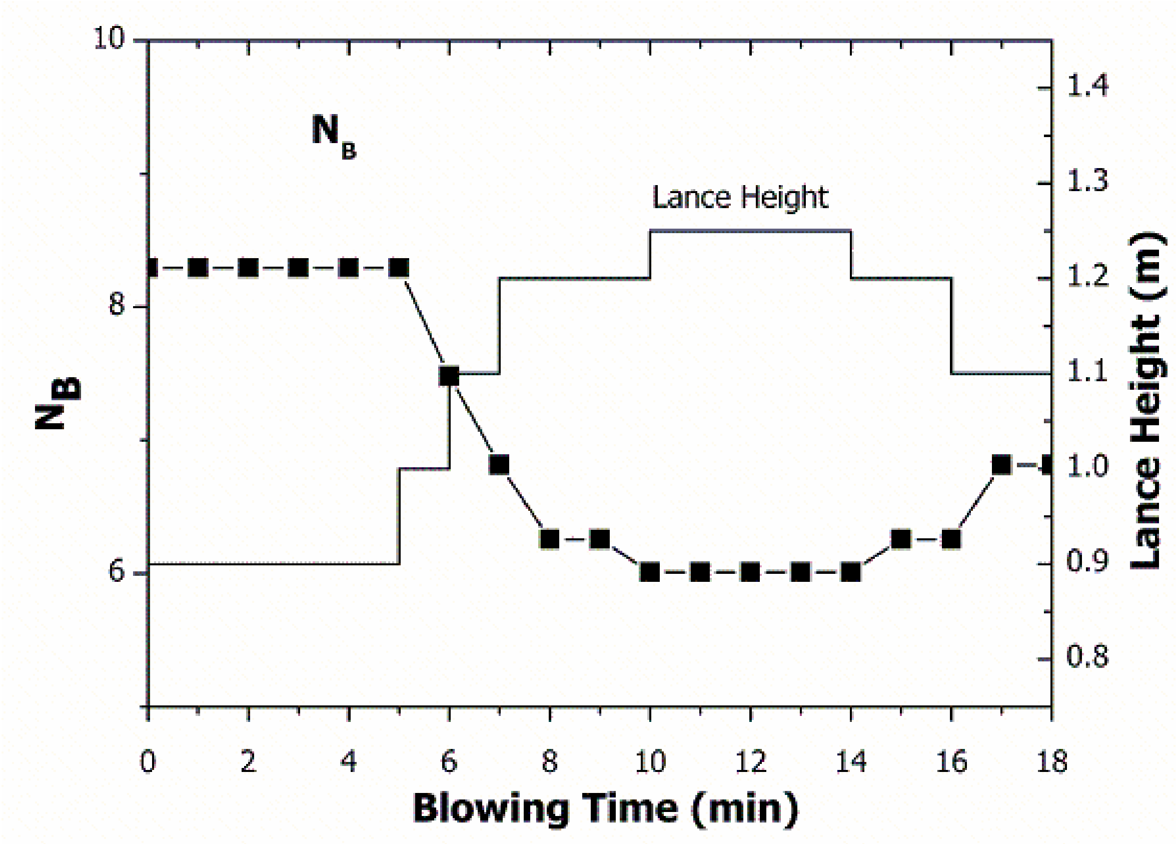
Data used for calculations

Furnace capacity	55 t
Blowing time	18 min
Oxygen flow rate	130 Nm^3/min
Supply pressure	8 atm
Number of nozzle	3
Diameter of throat	24 mm
Lance height	0.9-1.25 m
Initial hot metal temperature	1330°C
Tapping temperature	1640-1700°C

Jalkanen and Holappa, VII International Conference on Molten Slags Fluxes and Salts, 2004

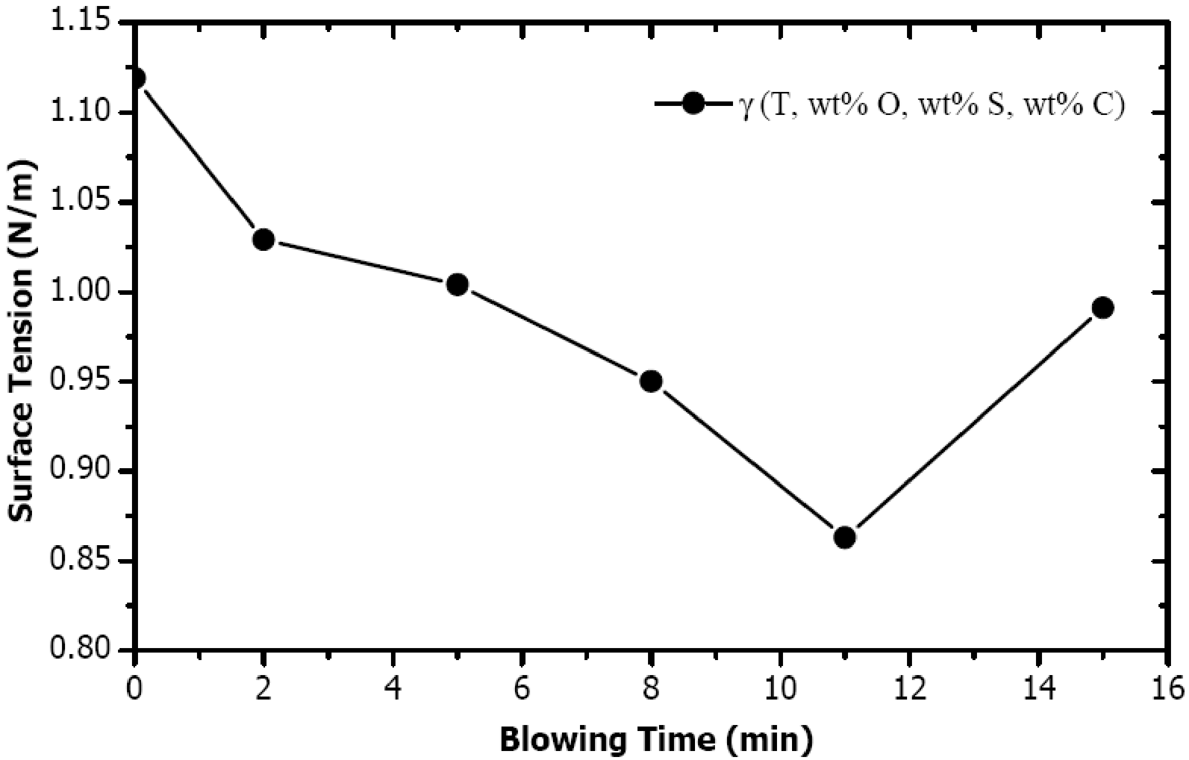
Results

Effect of jet intensity



Results

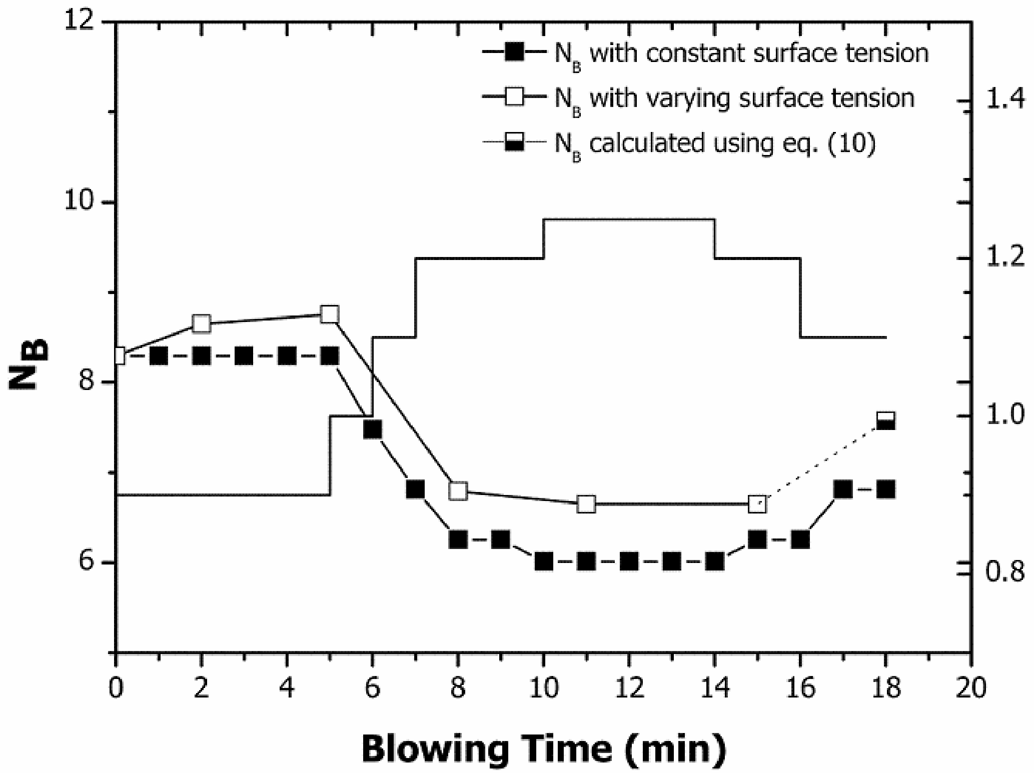
Effect of Surface Tension



Dogan, Brooks and Rhamdhani, ISIJ, 2009

Results

Comparison of the blowing number as a function of surface tension



Dogan, Brooks and Rhamdhani, ISIJ, 2009

for [C]<0.05 wt pct

$$[ppmO][\%C] = 30$$

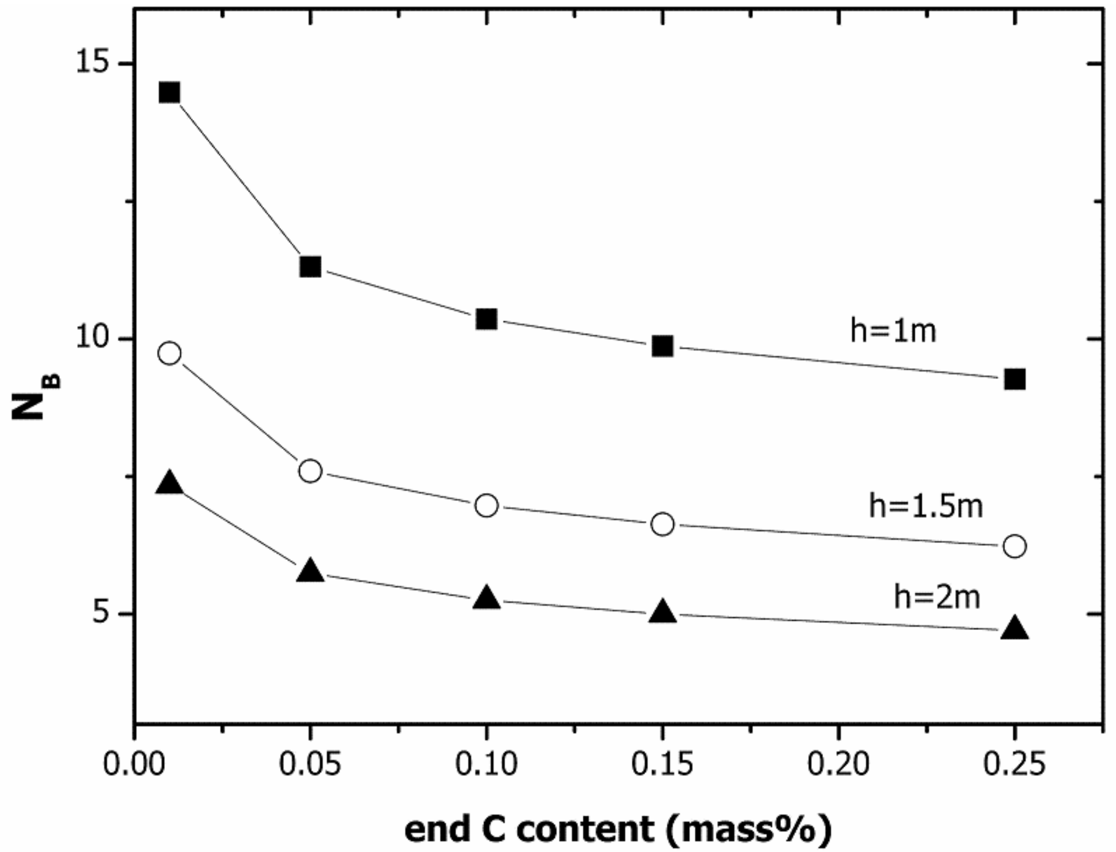
for [C]>0.05 wt pct

$$[ppmO]\sqrt{\%C} = 135 \pm 5$$

(After Turkdogan, 1996)

Results

Effect of End Carbon



Dogan, Brooks and Rhamdhani, ISIJ, 2009

Summary of Droplet Generation Model

- The blowing number increases with decreasing the lance height.

- During the blow, the droplet generation increases with decreasing surface tension of liquid metal.

- **We proposed that the droplet generation in top blown oxygen steelmaking is mainly dominated by the blowing conditions, not by the physical properties of liquid metal.** However, the composition of the steel does strongly effect the generation of droplets for low carbon steels towards the end of the blow.

4. Future Work

- developing mathematical models for the sub-models
- verification and validation of these models against the previous models based on industrial trials
- combination of sub-models
- validation against industrial data

Thank you

Any Questions??