Pinholes and Blowholes (3)

Question

How do I calculate the partial pressures of carbon monoxide, hydrogen and nitrogen dissolved in liquid steel and when do the gasses cause billet and slab pinholes and blowholes ?

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Answer

The charts used for determining the partial pressure of carbon monoxide, hydrogen and nitrogen were derived from the following relationships:

$P_{N2} = k_N (wt.\% N)^2$

$P_{H2} = k_H (wt.\% H)^2$

$P_{CO} = k_{CO} (\% C)(\% O)$

Where:

kN, kH and kCO are the equilibrium constants from their respective reactions.[i]

The solutes' concentrations are greatly increased because of interdendritic enrichments. The general relationship for interdendritic solute enrichment is given by:

$C^l_i = C^B_i / (1 - k_i f)$

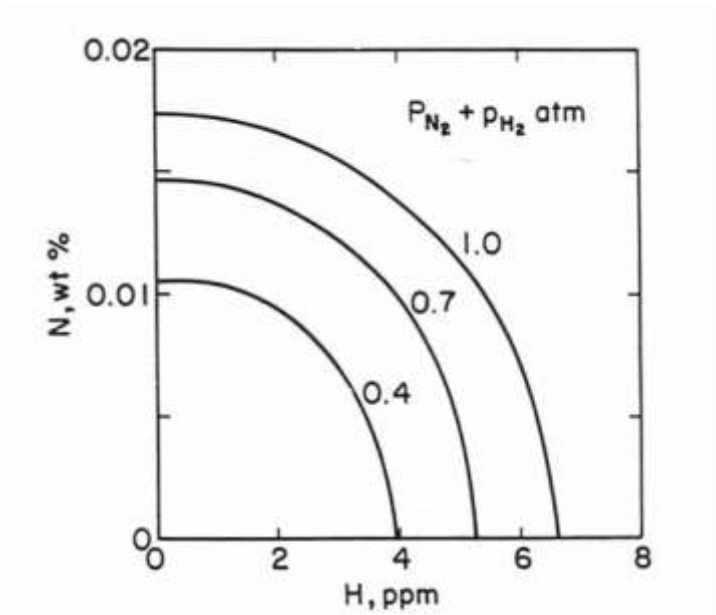
Where:

C^l_i and C^B_i = The liquid concentration and bulk concentrations, respectively

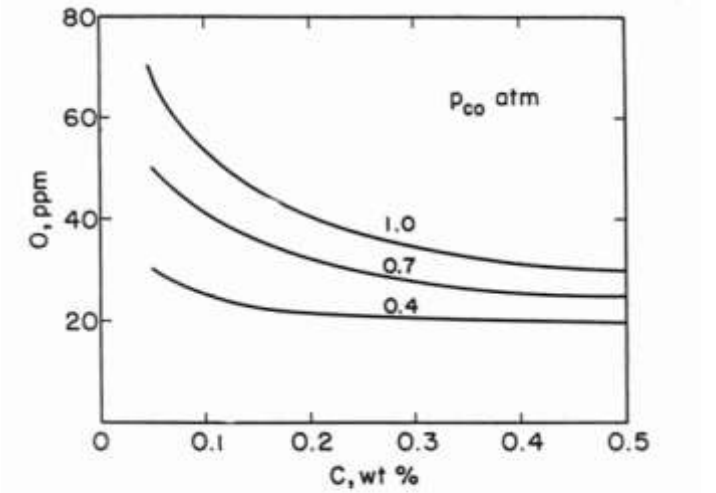
k_i = The liquid/solid distribution ratio

f = The fraction solidified

For practical purposes, the charts provided in *Ladle Metallurgy Principles and Practices*[ii], give a much more direct result.



2-11. The equilibrium pressure of H_2 and N_2 in last liquid to solidify as a function of hydrogen and nitrogen content.



2-12. The equilibrium CO pressure in the last liquid to solidify as a function of carbon and oxygen content.

By adding the partial pressures of the gasses from the charts, one can quickly determine if the total exceeds 1.05 atm, at

which point the gasses evolve from the cooling steel and cause pinholes.

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[i] R.J. Fruehan and E.T. Turkdogen, *The Making, Shaping and Treating of Steel,* United States Steel Corporation, Monroeville, PA, 1984

[ii] R.J. Fruehan, *Ladle Metallurgy Principles and Practices,* Iron and Steel Society, Warrendale, PA, 1985 p. 11.