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C-Fe-N-Ti (Carbon-Iron-Nitrogen-Titanium)

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The previous results on this quaternary system depicting the equilibrium of the titanium carbonitride with liquid iron were reviewed by [2003Rag]. Recently, [2009Gor] did a thermodynamic assessment and presented graphs depicting the composition and fraction of the carbonitride in equilibrium with austenite at 1200 and 1000 °C.

Lower Order Systems

For brief descriptions of the lower-order binary and ternary systems, see [2003Rag].

The Computed Quaternary Phase Equilibria

For the lower order ternary systems of Fe-Ti-C and Fe-Ti-N, [2009Gor] used the descriptions given by [2001Lee]. They replaced the optimized ternary interaction parameter $L_{Ti:C,N}$ of [2001Lee] with the values from direct measurements reported in the literature. The CALPHAD method was used and the optimized interaction parameters were listed. The isothermal sections for Fe-rich alloys of the Fe-Ti-C and Fe-Ti-N ternary systems were computed at 1200, 1000, and 800°C. For the quaternary system, the composition and amount of the carbonitride Ti(C,N) in equilibrium with austenite and the Ti content in austenite were computed at 1200 and 1000 °C for three fixed nitrogen contents of 0.01, 0.02, and 0.03 mass%. As examples, for a fixed nitrogen content of 0.01 mass%, the composition and amount of Ti(C,N) and the Ti content of austenite at 1200 and 1000 °C are shown in Fig. 1 and 2 as perspective views with three axes [2009Gor]. For the composition and temperature ranges shown in the above figures (and also for nitrogen contents of 0.02 and 0.03 mass% not shown here), the formation of other carbonitrides such as $Ti_2(C,N)$ and the Fe_2Ti Laves phase was ruled out by calculation [2009Gor].

In stoichiometric TiN, the mass ratio of Ti/N = 3.4. For a nitrogen content of 0.01 mass%, TiN forms till the Ti content increases to 0.034 mass%. Beyond 0.034 mass%, the nitride content remains constant, with C at 0%. As the C content increases, the carbonitride forms and its content increases (Fig. 1a and 2a). Also, as the C content increases, the C/(C+N) ratio in the carbonitride increases (Fig. 1b and 2b). The Ti content in austenite at 0% C increases linearly beyond 0.034 mass% Ti in the steel (Fig. 1c and 2c). With increasing C, the Ti content in austenite decreases due to increasing tie-up of Ti in the carbonitride phase.

References

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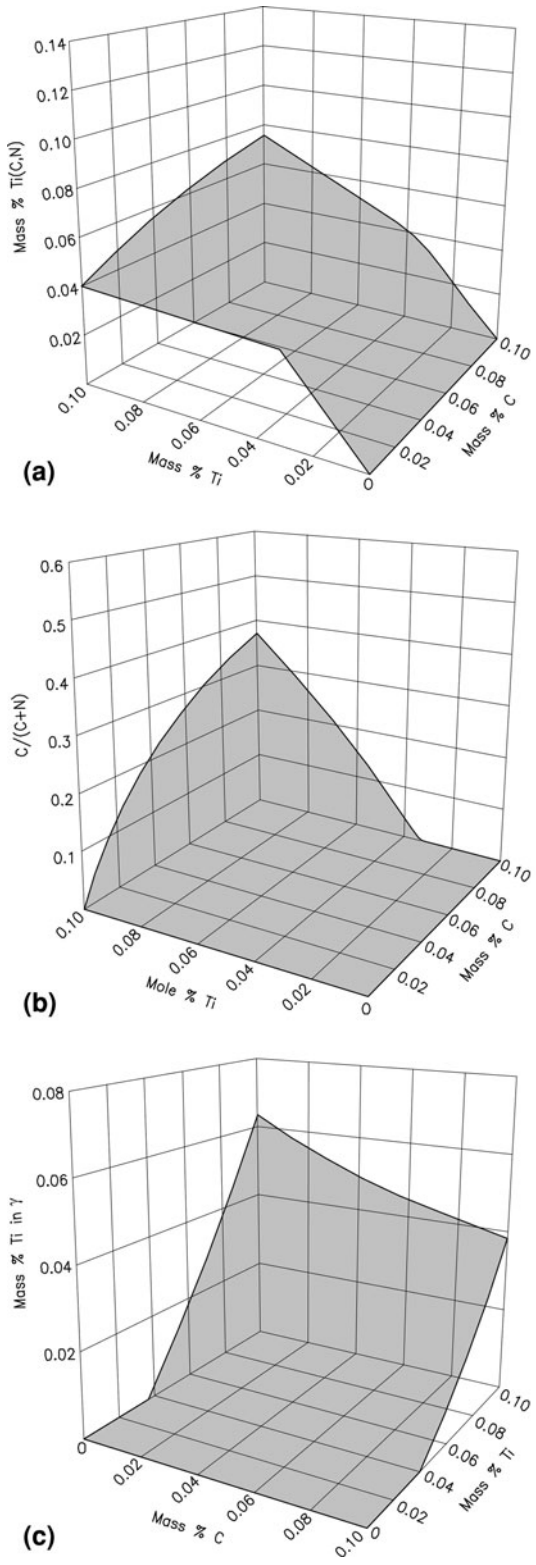

Fig. 1 C-Fe-N-Ti perspective views of (a) amount of Ti(C,N), (b) composition of Ti(C,N), and (c) V content in austenite (γ), in a steel with 0.01 mass% N at 1200 °C [2009Gor]

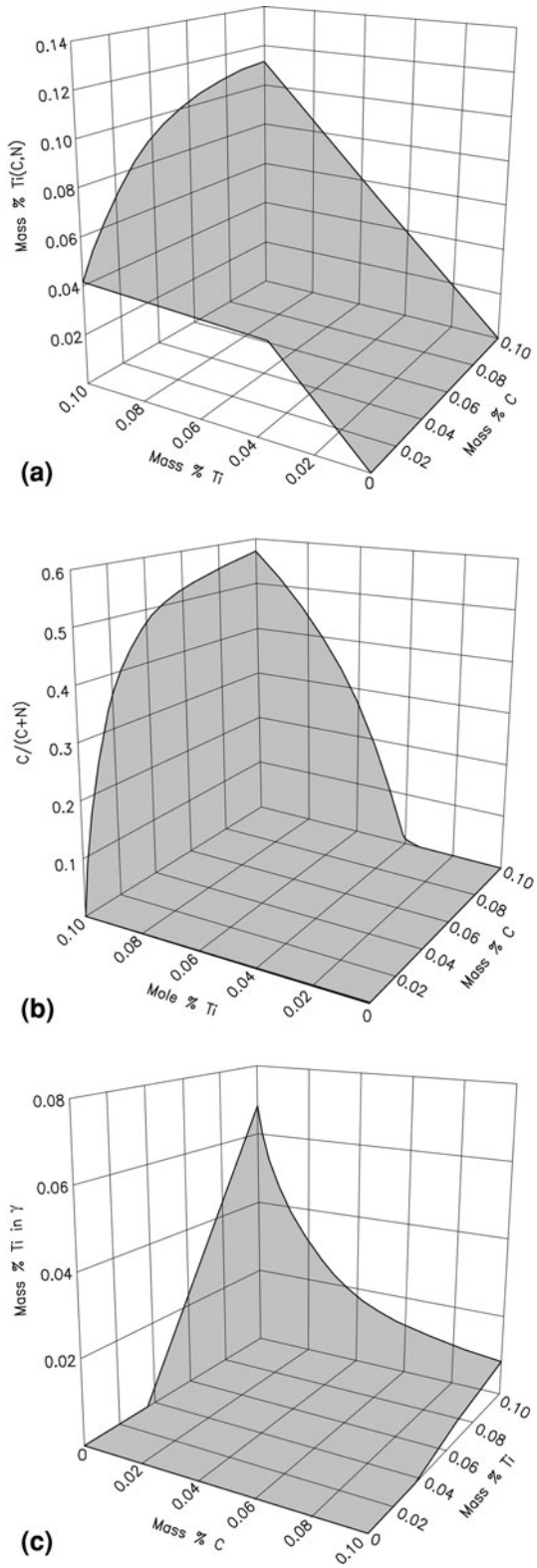

Fig. 2 C-Fe-N-Ti perspective views of (a) amount of Ti(C,N), (b) composition of Ti(C,N), and (c) V content in austenite (γ), in a steel with 0.01 mass% N at 1000 °C [2009Gor]