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C-Co-Fe-Ni-W (Carbon-Cobalt-Iron-Nickel-Tungsten)

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In cemented WC tools, the transverse rupture strength is influenced by the phases present in the alloy. Favorable results are obtained, only when two phases [WC and the face-centered cubic (fcc) binder phase] are present in the microstructure, with the avoidance of graphite or M_6C carbide. [1989Gui] developed a thermodynamic description of this quinary system and calculated the phase equilibria in the region of interest, with (Co + Fe + Ni) fcc solid solution as the binder phase.

Quinary Phase Equilibria

For details of the thermodynamic modeling and a list of the optimized parameters, see [1989Gui]. Here, we will discuss only the calculated phase diagrams. All calculations were carried out for the composition of 90 wt.% of (W + C) and 10 wt.% of (Co + Fe + Ni). The results were presented as vertical sections between 1000 and 1500 °C,

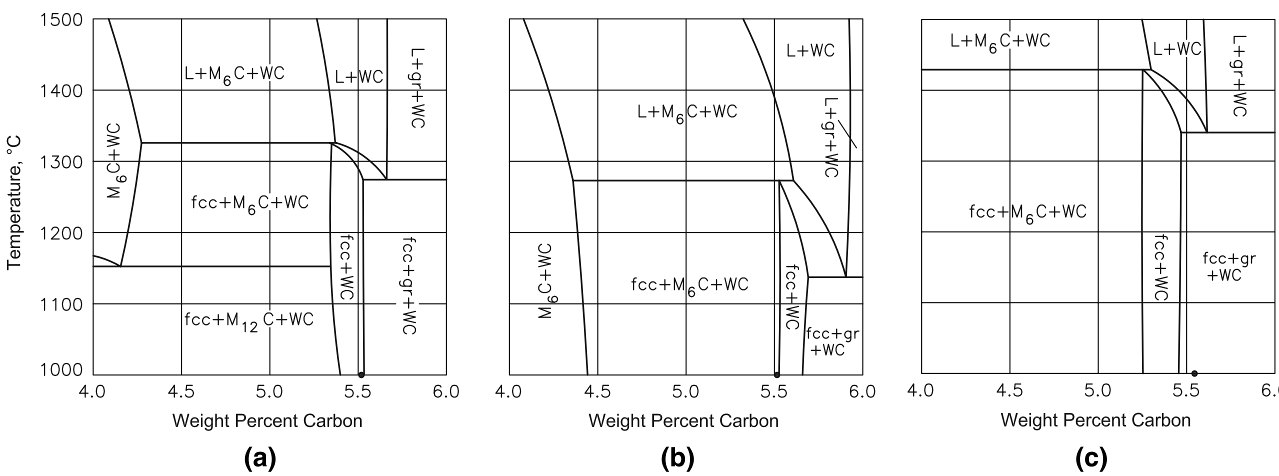

Fig. 1 C-Co-Fe-Ni-W vertical sections of subsystems (a) C-Co-W, (b) C-Fe-W, and (c) C-Ni-W, at 10 wt.% Co, Fe and Ni, respectively [1989Gui]

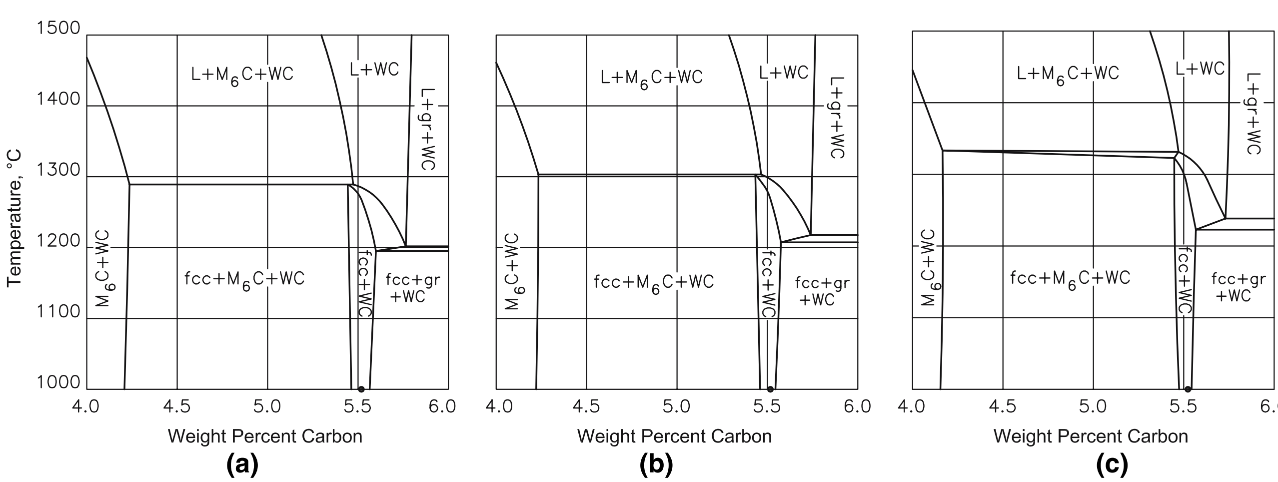

Fig. 2 C-Co-Fe-Ni-W vertical sections at 5 wt.% Fe and at (a) 4 wt.% Co-1 wt.% Ni, (b) 2.5 wt.% Co-2.5 wt.% Ni, and (c) 1 wt.% Co-4 wt.% Ni [1989Gui]

with C content on the *x*-axis. Figure 1a-c shows the vertical sections for the ternary subsystems of C-Co-W, C-Fe-W and C-Ni-W, where the binder phase is Co, Fe and Ni, respectively. The dot on the *x*-axis indicates the weight percent of C in the alloy, which corresponds to the stoichiometric composition WC. This dot falls inside the two-phase region of (fcc + WC) in the C-Co-W system (Fig. 1a), just to the left of the region in the C-Fe-W system (Fig. 1b) and to the right in the C-Ni-W system (Fig. 1c). This means that, in the latter two cases, an adjustment of the C content of the alloy is required to ensure the presence of only the (fcc + WC) phases in the microstructure.

The five quaternary subsystems are C-Co-Fe-W, C-Fe-Ni-W, C-Co-Ni-W, C-Co-Fe-Ni, and Co-Fe-Ni-W. The first two systems were reviewed by [1996Rag], who presented vertical sections similar to the above, at a constant Co and Fe of 5 wt.% each for the C-Co-Fe-W system from [1989Gui] and at weight percents of (5 Fe + 15 Ni), (10 Fe + 10 Ni), and (15 Fe + 5 Ni) for the C-Fe-Ni-W system from [1987Gui]. For the latter system, an additional vertical section at (5 Fe + 5 Ni) was given by [1989Gui]. For the C-Co-Ni-W system, [1989Gui] computed vertical sections at weight percents of (8 Co + 2 Ni), (5 Co + 5 Ni), and (2 Co + 8 Ni). The C-Co-Fe-Ni and Co-Fe-Ni-W systems were reviewed by [1996Rag].

The vertical sections for this quinary system calculated by [1989Gui] at constant weight percents of (5 Fe + 4 Co + 1 Ni), (5 Fe + 2.5 Co + 2.5 Ni) and (5 Fe + 1 Co + 4 Ni) are shown in Fig. 2a-c. In all these three cases, the stoichiometric dot falls within the two-phase region of (fcc + WC).

Other contributions to the cemented carbide systems, where Fe is not one of the elements, have appeared in recent years. [2001Kru] made an experimental study of the solid-liquid equilibria in the C-Co-W system and with the addition of Nb, Ti, or Ta to C-Co-W alloys. An improved thermodynamic description of the C-Co-W system was presented by [2005Mar]. A reassessment of the Mo_6C thermodynamics was reported by [2005Fri].

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