Continuous-Cooling Transformation Diagrams

Continuous-cooling transformation diagrams of selected medium-carbon and heat-resistant chromium-molybdenum low-alloy steels are shown in the graphs. (a) 4130 (0.30 C, 0.25 Si, 0.50 Mn, 0.020 P, 0.020 S, 1.0 Cr, 0.20 Mo). (b) Low-carbon 2.25Cr-1.0Mo workhorse alloy for heat-resistant applications. (c) 4150 (0.50 C, 0.25 Si, 0.85 Mn, 0.020 P, 0.020 S, 1.0 Cr, 0.22 Mo). (d) Low-carbon 3.25Cr-0.5Mo steel.

Because both chromium and molybdenum are carbide-forming alloying elements, the austenitizing temperature should be high enough to dissolve all of the carbides before quenching. Chromium carbide is more stable than molybdenum carbide, which requires control of the austenitizing temperature.

The low-carbon 4118 alloy is classified as a carburizing grade and is not usually directly hardened. The medium-carbon chromium-molybdenum low-alloy steels are all direct hardenable and normally quenched in oil. Polymer quenching media also are used for some alloys. Water quenching requires care to avoid quench cracking.

Chromium has a significant effect on hardenability, as illustrated by the end-quench curves and CCT diagrams in the graphs for some medium-carbon grades (e.g., 4130) and higher-chromium grades with low carbon. Low-alloy chromium-molybdenum steel alloys have higher hardenability than alloys with similar levels of only molybdenum (40xx, 44xx) or only chromium (50xx and 51xx) additions.