

Carbide Coarsening in H13 Die Steel in Service

The strength of a hot work die is held by a fine dispersion of alloy carbides, and coarsening is what takes it away. The tables below give the three carbides that matter in a 5 percent chromium hot work steel and the undissolved carbide left at each austenitizing condition.

Reference only. This is a reference summary of a published study and it is not a specification of ours. The values are reproduced from the source, which tested one grade, one specimen shape and one set of casting conditions. What a particular die reaches depends on the die design, the alloy, the cycle and the cooling circuit. Final design is confirmed on the job.

Why carbides decide how a die softens

Three carbides, three different jobs

Carbide	Where it comes from	How it behaves at temperature	What the EDS found
Chromium-rich carbide, Cr7C3	From the chromium in solid solution, and detected at tempering temperatures as low as 500 C	The most susceptible of the three to growth, which is why the steel softens steadily between 500 C and 700 C	The largest carbides in the softened band
Molybdenum-rich carbide, M2C or M6C	Precipitates during tempering, and holds its size above 1000 F	Far less sensitive to growth than the chromium carbide, and it also slows the growth of the chromium carbide	The smaller carbides in the softened band
Vanadium-rich carbide, VC or V4C3	The most stable of the three, and the only one that resists solution at 1010 C for an hour	Holds a very fine dispersion even at temperatures approaching 700 C	Not detected, because it stays too fine to resolve

The three carbides in a 5 percent chromium hot work steel, the way each one forms, how each one behaves at service temperature, and how each one appeared in the EDS analysis of the softened band.

Austenitizing temperature sets how much carbide is left in the steel

Condition	Carbide that stays undissolved	Hardness after quenching
As annealed	Total carbide content about 4.4 wt percent	Not applicable
Austenitized at 1850 F for one hour	About 2.3 wt percent, mostly vanadium with some molybdenum	About 59 HRC
Austenitized at 1950 to 2000 F	About 1.5 wt percent, mostly vanadium carbide	About 61 HRC

Undissolved carbide and quenched hardness against the austenitizing condition for H13. Most of the carbide goes into solution between the annealed condition and the lower austenitizing temperature, and the remaining vanadium carbide needs the higher band.

The coarsening law behind the loss of hardness

What this means on the job

Aobo Steel, tool steel supplier

Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, DC53, A2, O1, H13, H11, H10, H21, S7, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.

Source, Effect of Design Factors on Thermal Fatigue Cracking of Die Casting Dies, D. Schwam, J. F. Wallace and S. Birceanu, Case Western Reserve University, final technical report to the U.S. Department of Energy, Award No. DE-FC07-00ID138486, October 2004.

CONTACT

EMAIL

sales@aobosteel.com

WHATSAPP

+86 180 6294 5370

WEB

aobosteel.com



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