CR12 Tool Steel Properties, Applications, Machining & Heat Treatment Guide

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What Is CR12 Steel?

CR12 is a high-carbon, high-chromium cold work tool steel with a carbon content of 2.0–2.3% and a chromium content of 11.5–13%. After quenching, its hardness can reach HRC 60–62. It features excellent wear resistance, good hardenability, and high cost-effectiveness.

CR12 is widely used in cold stamping dies, cold extrusion dies, wire drawing dies, and thread rolling dies that require high wear resistance. However, its toughness is relatively low, making it unsuitable for applications with heavy impact loads. As a type of high-carbon high-chromium ledeburite steel, CR12 is a widely used cold work die steel with a long application history and stable performance.

Main Characteristics of CR12 Steel

- **High Hardness and Wear Resistance:** Quenched hardness of HRC 60–62. Chromium content of 11.5–13% forms abundant carbides. Tool life is 3–5 times longer than T10 steel. The high-hardness chromium carbides (Hv2300) in CR12 steel are the key to its excellent wear resistance, and the total amount of carbides in annealed CR12 steel can reach about 20%.
- **Cost-Effectiveness:** 20–30% cheaper than Cr12MoV and SKD11 while meeting most cold work tooling requirements. Compared with other similar cold work die steels, CR12 has obvious cost advantages and can meet the basic performance requirements of most cold processing scenarios.
- **Good Hardenability:** Sections below 100 mm can be fully hardened, with low quenching deformation and good dimensional stability. CR12 steel has excellent hardenability and can be hardened by oil cooling even for workpieces with a diameter of 200–300 mm, so it is also known as "micro-deformation steel".
- **Mature Processing Technology:** Long application history, stable heat treatment process, and consistent quality. After vacuum degassing refining and spheroidizing annealing softening treatment, CR12

steel has pure steel quality and good cutting performance.

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CR12 Performance Parameter Tables

1. Chemical Composition of CR12

Element	Typical Content (%)	Standard Range (%)	Main Function
C	2.15	2.00–2.30	Forms eutectic carbides, provides high hardness and wear resistance; the high carbon content ensures the formation of sufficient alloy carbides, laying the foundation for the high hardness of the steel.
Cr	12.25	11.50–13.00	Improves hardenability, forms chromium carbides, enhances corrosion resistance; chromium can greatly improve the hardenability of the steel, produce secondary hardening phenomenon, and form high-hardness carbides with carbon to improve wear resistance.
Si	0.25	≤0.40	Improves strength and tempering stability
Mn	0.25	≤0.40	Improves hardenability and hot workability
P	≤0.030	≤0.030	Impurity element, reduces toughness
S	≤0.030	≤0.030	Impurity element, reduces toughness

2. Physical Properties of CR12

Property	Range	Unit	Remarks
Density	7.70–7.80	g/cm^3	Room temperature
Elastic Modulus	190–210	GPa	Room temperature

Poisson’s Ratio	0.27–0.30	-	Room temperature
Thermal Expansion	10.5–11.5	$\times 10^{-6}$/°C	20–200°C
Thermal Conductivity	25–30	W/(m·K)	Room temperature
Specific Heat	460–500	J/(kg·K)	Room temperature
Resistivity	0.55–0.65	μΩ·m	Room temperature
Melting Point	1370–1400	°C	-
Magnetism	Ferromagnetic	-	-

3. Mechanical Properties of CR12

Property	Range	Unit	Remarks
Hardness (Quenched)	60–64	HRC	Oil quench 950–1000°C + tempering; the quenching temperature of CR12 steel can be adjusted according to needs, and the hardness after quenching and tempering can reach more than HRC60.
Hardness (Annealed)	217–269	HB	830–870°C annealing; the delivery state of CR12 steel is usually annealed, with a hardness of 269–271HBW and an indentation diameter of 3.7–4.1mm.
Compressive Strength	2800–3000	MPa	Quenched and tempered
Bending Strength	2500–2600	MPa	Quenched and tempered
Tensile Strength	1800–2200	MPa	Quenched and tempered
Yield Strength	1500–1800	MPa	Quenched and tempered

Impact Toughness	20–30	J/cm^2	No notch; CR12 steel has relatively low toughness, which is one of its main shortcomings.
Elongation	1.5–2.5	%	Brittle material
Fracture Toughness	18–22	MPa·m½	-

Typical Applications of CR12 Tool Steel

Application Field	Typical Uses	Working Temperature	Remarks
Cold Stamping Dies	Gasket dies, motor laminations, auto parts dies	Room temperature	Main application, 100k–1M cycles; it can be used for silicon steel cold stamping dies and other dies that require high wear resistance and simple shape under dynamic load conditions.
Shearing Tools	Steel sheet cutters, slitting blades	Room temperature	High wear resistance; it can also be used to make various scissors and inlaid blades.
Cold Extrusion Dies	Aluminum and copper extrusion dies	Room temperature	Low deformation resistance; when used as a punch for aluminum cold extrusion dies, the recommended hardness is 60–62HRC.
Cold Heading Dies	Bolt and nut forming dies	Room temperature	Small to medium batches; it can be used to make cold heading dies for truck compartment bolts, but the service life is relatively short under heavy load conditions.
Wire Drawing Dies	Low-carbon steel and copper wire dies	Room temperature	≤5 mm diameter; it is one of the common applications of CR12 steel, relying on its excellent wear resistance to extend the service life of the die.
Powder Metallurgy	Iron and copper	Room	450–550 MPa pressure

Dies	powder molds	temperature	
Measuring Tools	Plug gauges, precision gauges	Room temperature	High accuracy
Threading Tools	Thread rolling dies	Room temperature	Thread forming; it is widely used to make thread rolling dies, and the service life can be significantly improved after surface treatment.
Bending Dies	V-type and U-type bending dies	Room temperature	Simple forming; when used to make punches and dies for bending dies that require high wear resistance and complex shapes, the recommended hardness is 60–64HRC.

Non-Recommended Applications for CR12

Application	Condition	Reason	Recommended Alternative
Large Dies	Size > 400 mm	Insufficient core hardness; CR12 steel has serious carbide segregation, especially for rolled materials with a cross-section larger than 40 mm, which affects the core hardness.	Cr12MoV, SKD11, D2
Thick Plate Dies	>3 mm plates	High impact, edge chipping; low toughness of CR12 steel makes it easy to chip under high impact conditions	Cr12MoV, DC53
High Impact Dies	Heavy load	Low toughness; the impact toughness of CR12 steel is relatively low, which cannot meet the requirements of heavy impact load applications	Cr12MoV, DC53
Hot Work Dies	>250°C	Poor heat resistance; CR12 steel is a cold work die steel,	H13, 3Cr2W8V

		which has poor heat resistance and cannot be used in high-temperature environments	
Plastic Molds	Injection molds	Poor polishability	P20, 718H, S136
Precision Dies	High accuracy	Large deformation; although CR12 steel has small quenching deformation, its deformation is still larger than that of some high-precision die steels under high-precision requirements	DC53, SKD11

Recommended Cutting Tools for CR12 Machining

Dimension	Selection Principle	Rough Machining	Finish Machining
Tool Type	Select by hardness	Coated Carbide	CBN Tools
Cutting Speed	Higher hardness, lower speed	100–150 m/min	60–100 m/min
Feed Rate	Large for roughing, small for finishing	0.2–0.3 mm/r	0.05–0.1 mm/r
Cutting Depth	Large for roughing	1–2 mm	0.1–0.3 mm
Cooling Method	Full cooling required	Emulsion	High-pressure cooling

CR12 Machining Parameter Selection Logic

Dimension	Selection Logic	Rough Machining	Finish Machining
Cutting Speed	Depends on tool and hardness	80–120 m/min	40–80 m/min

Feed Rate	Higher for roughing	600–1500 mm/min	200–800 mm/min
Depth of Cut	≤1/3 tool diameter	1–5 mm	0.1–0.5 mm
Spindle Speed	S=1000V/(πD)	2000–3500 rpm	3000–5000 rpm
Tool Path	Optimize cutting force	Trochoidal milling	Contour milling

CR12 Tool Steel FAQ

1. Tool Wear Is Too Fast After Quenching (HRC 58–62)

- Use CBN or TiAlN-coated carbide tools
- Speed: 100–300 m/min, Feed: 0.05–0.2 mm/r
- Use oil mist or high-pressure cooling
- Complete roughing before heat treatment; this can reduce the wear of tools during the processing of high-hardness workpieces after quenching

2. Severe Deformation After Heat Treatment

- Forging ratio ≥4–5; sufficient forging can break the network eutectic carbides in CR12 steel and improve the uniformity of the structure.
- Step heating: 600→800→980°C; step heating can reduce the thermal stress during heating and avoid deformation
- Isothermal quenching at 200–250°C
- Temper 2–3 times at 180–220°C; multiple tempering can fully eliminate the internal stress after quenching and stabilize the structure

3. Cracking and Edge Chipping in Service

- Select high-quality steel (carbide grade ≤3); high-quality CR12 steel has less carbide segregation and better toughness
- Quench at 950–1000°C, temper twice; reasonable quenching and tempering process can improve the toughness of the steel
- Edge radius R0.3–0.5 mm; increasing the edge radius can reduce stress concentration and avoid edge chipping

- Use Cr12MoV or DC53 for high impact; these steels have better toughness than CR12 steel and are suitable for high impact applications

4. Grinding Cracks After Quenching

- Use white corundum wheels (46–80 grit)
- Wheel speed: 15–20 m/s
- Use sufficient cooling; sufficient cooling can reduce the grinding heat and avoid thermal cracks
- Apply intermittent grinding; intermittent grinding can reduce the accumulation of grinding heat

5. Drill and Tap Breakage at HRC >55

- Use EDM drilling first
- Carbide drills: 300–400 rpm
- Carbide taps with TiAlN coating
- Pre-drill before heat treatment; pre-drilling before heat treatment can avoid drilling and tapping on high-hardness workpieces after quenching

6. Large Differences in Tool Life

- Use high-quality steel; the quality of steel directly affects the service life of the tool
- Hardness: HRC 58–60; reasonable hardness can balance wear resistance and toughness
- PVD or TD coating; surface coating can improve the wear resistance of the tool
- Cryogenic treatment: -80 to -120°C; cryogenic treatment can reduce the content of residual austenite and improve the hardness and wear resistance of the steel
- Regular maintenance; regular maintenance of tools can extend their service life

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