SKD61 Tool Steel: Properties, Composition & Machining Guide

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What is SKD61 Tool Steel?

SKD61 is a hot-work tool steel under the Japanese JIS standard. It belongs to the medium-carbon, high-chromium, molybdenum-vanadium alloy steel series. It possesses excellent high-temperature hardness (maintaining HRC 38-42 even at 600°C), outstanding thermal fatigue resistance, and a superior combination of toughness. It is the preferred material for aluminum alloy die-casting molds and is widely used in high-temperature operating molds such as hot extrusion dies and hot forging dies. Its performance exceeds that of standard H13 and is equivalent to the American H13 modified version.

Key Characteristics of SKD61 Steel

- **Excellent Thermal Stability:** Maintains a high-temperature hardness of HRC 38-42 at 600°C with a hardness retention rate of 80%. Suitable for long-term high-temperature molds like aluminum alloy die-casting and hot extrusion dies.
- **Strong Thermal Fatigue Resistance:** Thermal fatigue life reaches 80,000 to 100,000 cycles. Resistance to heat checking is 30% stronger than H13, significantly extending the service life of die-casting molds.
- **High Toughness Synergy:** Impact toughness is 18-25 J/cm², 20% higher than H13. It can withstand rapid cooling and heating cycles without cracking, making it ideal for molds with complex geometries.
- **Superior Wear Resistance:** A vanadium content of 0.8-1.2% forms high-hardness VC carbides. Wear resistance is improved by 25-30% compared to H13, suitable for severe wear conditions.
- **Good Hardenability:** The effective hardening depth in oil quenching is 100mm. Large cross-section molds exhibit uniform hardness distribution, with the core hardness being only HRC 3-5 lower than the surface. Hardenability, a key property of SKD61, refers to the steel's ability to obtain martensite during quenching, directly affecting the overall performance of large mold parts.
- **Excellent Polishing Performance:** Can be polished to a mirror finish of Ra 0.025μm. Suitable for high-gloss plastic molds and transparent component molds requiring high surface quality.

- **Effective Nitriding Reinforcement:** Surface nitriding hardness reaches HV 850, increasing wear resistance by 3-5 times and significantly extending mold life. Nitriding is a chemical heat treatment process that infiltrates elements into the surface to alter its composition, achieving surface strengthening with minimal deformation.
- **Great Dimensional Stability:** Residual austenite is fully transformed after triple tempering. Heat treatment deformation is <0.05mm, ensuring the dimensional precision of precision molds. Tempering is a necessary process after quenching, which eliminates internal stress and prevents cracking, while triple tempering further optimizes the material's internal structure.

SKD61 Performance Parameter Tables

1. SKD61 Chemical Composition

Element Symbol	Typical Content (%)	Standard Range (%)	Core Role
C	0.39	0.35-0.42	Provides hardness and wear resistance; forms carbides; determines quenching hardness.
Si	1.0	0.80-1.20	Improves strength and oxidation resistance; enhances thermal stability; acts as a deoxidizer.
Mn	0.4	0.25-0.50	Increases hardenability; improves hot-working performance and strength.
P	≤0.025	≤0.030	Impurity element; strictly controlled to prevent reduction in toughness and plasticity.
S	≤0.020	≤0.030	Impurity element; strictly controlled to prevent reduction in toughness and plasticity.
Cr	5.15	4.80-5.50	Improves hardenability, wear resistance, and high-temperature strength; forms carbides; improves corrosion resistance.
Mo	1.3	1.00-1.50	Improves hardenability and high-temp strength; enhances tempering resistance and thermal fatigue performance. High Mo content is one of the key factors for SKD61's

			excellent thermal fatigue resistance.
V	0.95	0.80-1.15	Refines grains; forms hard vanadium carbides; improves wear resistance and toughness. The higher vanadium content distinguishes SKD61 from standard H13.

2. SKD61 Physical Properties (Intrinsic Material Attributes)

Performance Indicator	Value Range	Unit	Remarks
Density	7.80-7.85	g/cm^3	At 20°C room temperature
Modulus of Elasticity	210-215	GPa	At 20°C room temperature
Poisson's Ratio	0.27-0.30	-	At 20°C room temperature
Melting Point	1427	°C	-
Coefficient of Linear Expansion (20-100°C)	9.1-10.9	$\times 10^{-6}$/°C	Temperature range 20-100°C
Coefficient of Linear Expansion (20-300°C)	11.5-12.3	$\times 10^{-6}$/°C	Temperature range 20-300°C
Coefficient of Linear Expansion (20-500°C)	12.8-13.0	$\times 10^{-6}$/°C	Temperature range 20-500°C
Thermal Conductivity (20°C)	20.1-32.2	W/(m·K)	At 20°C room temperature
Thermal Conductivity (350°C)	23.1-28.6	W/(m·K)	350°C working temperature
Thermal Conductivity (700°C)	26.3-30.3	W/(m·K)	At 700°C high temperature
Specific Heat Capacity (20°C)	460	J/(kg·K)	At 20°C room temperature
Specific Heat Capacity (500°C)	548	J/(kg·K)	500°C working temperature
Hardness (Annealed)	≤229-235	HB	Delivery in annealed state. Annealing reduces hardness,

			eliminates internal stress, and refines grains, laying the foundation for subsequent processing.
Hardness (After Quenching)	52-58	HRC	Quenching temp 1020-1050°C. Quenching is the key step for steel hardening, obtaining martensite structure through rapid cooling to significantly improve hardness and wear resistance.
Hardness (After Tempering)	38-53	HRC	Tempering temp 530-680°C. Tempering after quenching eliminates internal stress, preventing cracking and adjusting the material's hardness and toughness to meet application requirements.
Critical Temp Ac1	845-860	°C	Start of austenite transformation
Critical Temp Ms	270-340	°C	Start of martensite transformation

3. SKD61 Mechanical Properties (Loading Response)

Performance Indicator	Value Range	Unit	Remarks
Hardness (After Quenching)	52-58	HRC	Quenching at 1020-1050°C, oil cooling. Oil quenching is a common quenching method for alloy steels, which can reduce quenching stress and avoid material cracking.
Hardness (After Tempering)	38-53	HRC	Tempering at 530-680°C, typically 42-48 HRC
Tensile Strength (Room Temp)	1200-1600	MPa	After heat treatment, hardness 42-52 HRC
Tensile Strength	800-850	MPa	High-temperature operating state

(600°C)			
Compressive Strength	2000-2500	MPa	Hardness 45-48 HRC
Impact Toughness αk	20-40	J/cm²	Charpy V-notch, related to tempering temp
Fatigue Strength (10^7 cycles)	550	MPa	Cycle life 10^7

Typical Applications of SKD61 Tool Steel

Application Field	Specific Use	Working Temp	Remarks
Die-Casting Molds	Aluminum, Zinc, and Copper alloy die-casting molds	600-700°C	Primary application area. Die-casting is a high-efficiency, low-cutting production process, and SKD61's excellent thermal fatigue resistance effectively reduces mold thermal cracking.
Hot Extrusion Dies	Aluminum profile, copper, and steel extrusion dies	500-600°C	Requires high-temp strength
Hot Forging Dies	Automotive parts and hardware tool forging dies	800-1100°C	Withstands impact loads
Plastic Molds	High-volume injection molds, reinforced plastic molds	200-300°C	High wear resistance requirements

Non-Recommended Application Scenarios for SKD61

Non-	Specific	Reason	Recommended Substitute

Recommended Type	Scenario		
Cold-Work Molds	Cold stamping, cold extrusion, cold heading dies	Insufficient hardness (HRC45-52); wear resistance is only 1/3-1/4 of cold-work steel.	Cr12MoV, DC53, D2, High-speed steel
High-Polish Molds	Mirror injection molds, Class A surface molds	Susceptible to pinholes and pitting; difficult to reach Ra 0.02μm.	S136, NAK80, STAVAX
Large Molds	Molds >100mm thickness requiring full hardening	Limited hardenability; core hardness is insufficient and inconsistent.	Modified H13, Pre-hardened large mold steel. Modified H13 is an improved type based on standard H13, with better hardenability and high-temperature performance.
Corrosive Environment	PVC plastic molds, acid/alkali resistant molds	Limited corrosion resistance; prone to surface pitting.	S136, 420 Stainless Steel
Cost-Sensitive Molds	Small batch simple molds	Higher cost; overkill for low-end requirements.	#45 Steel, P20

Tooling Selection for SKD61 Machining

Phase / Hardness	Tool Type	Coating Priority	Recommended Brands
Roughing / HRC < 40	Standard Carbide	TiN, TiCN, TiAlN	Imported: Sandvik, Kennametal; China: ZCC·CT, Xiamen Tungsten
Roughing / HRC 40-50	Ultra-fine Grain Carbide	AlTiN, TiAlSiN, AlCrN	Imported: Sandvik, Walter, Kyocera; China: ZCC·CT, Xiamen Tungsten
Finishing / HRC 45-52	CBN Tools	Uncoated CBN, TiAlSiN	Imported: Sumitomo, Kyocera, Element Six; China: ZCC·CT CBN Series
Drilling / HRC 40-	Carbide Drill	AlTiN, TiAlN	Imported: Sandvik, OSG, Guhring; China:

50			Chengliang, Harbin Tools

Machining Parameter Selection Logic for SKD61

Parameter	Hardness: HRC 40-45	Hardness: HRC 45-52	Cooling / Strategy
Cutting Speed (Vc)	80-150 m/min	50-90 m/min	Reduce speed by 20-30% for every HRC 5-10 increase.
Feed Rate (f)	0.08-0.25 mm/r	0.03-0.15 mm/r	Lower feed for higher hardness to avoid chipping.
Cutting Depth (ap)	0.5-5.0 mm	0.1-1.5 mm	Use layer-by-layer milling (2-3mm per layer) for deep cavities.
Cooling Method	Extreme pressure emulsion (8-12%)	MQL or High-pressure internal cooling	High pressure ≥10 bar required for deep cavities.

Frequently Asked Questions (FAQ)

Can SKD61 and H13 heat treatment processes be used interchangeably?

No. SKD61 has a higher vanadium content. The quenching temperature must be 20-30°C higher (1020-1050°C), and the tempering temperature must also be 20-50°C higher to achieve the same hardness. Using H13 specs will result in substandard hardness and toughness. The heat treatment process of H13 typically includes annealing at 800~820℃, quenching at 1000~1040℃, and tempering at different temperatures according to hardness requirements.

How much harder is SKD61 to machine than H13?

Cutting speed should be reduced by 15-20%, and tool wear is typically 30-40% faster. This is due to the higher vanadium content forming more hard carbides. CBN or ultra-fine grain carbide tools with TiAlN or AlCrN coatings are recommended.

Can SKD61 be used for molds operating above 600°C?

Not recommended. 600°C is the upper limit for SKD61; beyond this, hardness and strength drop rapidly. For copper alloy die-casting (850-1100°C), use H11, H10, or Tungsten-Molybdenum hot-work steels. As a common hot-work mold steel, H13 also has limitations in high-temperature applications, which is why improved steel types like SKD61 and modified H13 are developed.

How to identify authentic SKD61?

Check the vanadium content. Authentic SKD61 contains 0.8-1.2% V. Counterfeits often have less. Request a material certificate verifying C (0.35-0.42%), Cr (4.8-5.5%), Mo (1.0-1.5%), and V (0.8-1.2%). Choose reputable brands like Hitachi, Daido, or Fushun Special Steel.

What should I do if the core hardness of an SKD61 mold thicker than 100mm is insufficient?

SKD61 has limited hardenability; the core hardness can be HRC 5-8 lower than the surface in thick sections. Solutions: Extend soaking time (1 hour per 25mm), apply cryogenic treatment, or switch to a modified H13 or pre-hardened mold steel. Avoid solid structures >100mm in the design where possible.

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