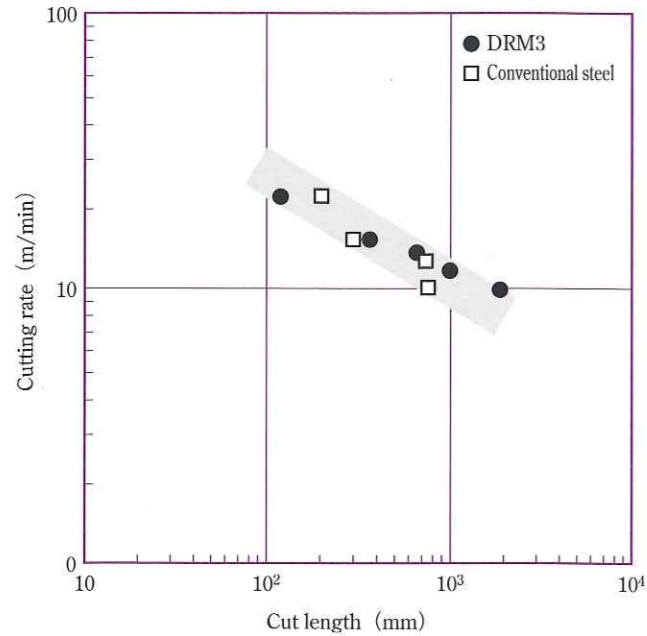


Durability of drilling tool



- Specimen : As annealed
- Tool : NACHI SD ϕ 5mm (non-coated)
- Test condition · Feed : 0.15mm/rev · Hole depth : 20mm
- Cutting fluid : none

Physical Properties

◆ Coefficient of expansion

| | 20~100°C | 20~200°C | 20~300°C | 20~400°C | 20~500°C | 20~600°C |
|--------------------|----------|----------|----------|----------|----------|----------|
| $\times 10^{-6}/K$ | 11.1 | 11.5 | 11.9 | 12.2 | 12.4 | 12.7 |

◆ Thermal conductivity

| | 25°C | 200°C | 300°C | 400°C | 500°C | 600°C | 700°C |
|-----------------|---------|---------|---------|---------|---------|---------|---------|
| W/m·K | 18.0 | 21.5 | 23.1 | 24.2 | 24.4 | 25.2 | 26.0 |
| [cal/cm·sec·°C] | [0.043] | [0.051] | [0.055] | [0.058] | [0.058] | [0.060] | [0.062] |

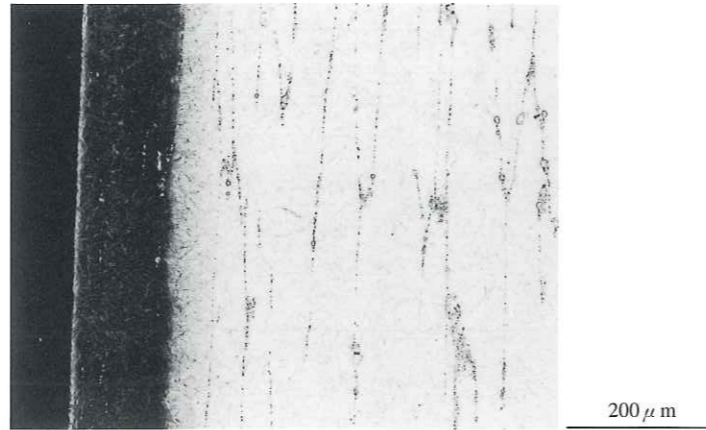
◆ Specific heat

| | 25°C | 200°C | 300°C | 400°C | 500°C | 600°C | 700°C |
|------------|---------|---------|---------|---------|---------|---------|---------|
| J/kg·K | 424 | 480 | 520 | 560 | 612 | 698 | 830 |
| [cal/g·°C] | [0.101] | [0.115] | [0.124] | [0.134] | [0.146] | [0.167] | [0.198] |

◆ Young's modulus 210 Gpa

· Specimen condition : H : 1140°C OQ T : 560°C AC twice

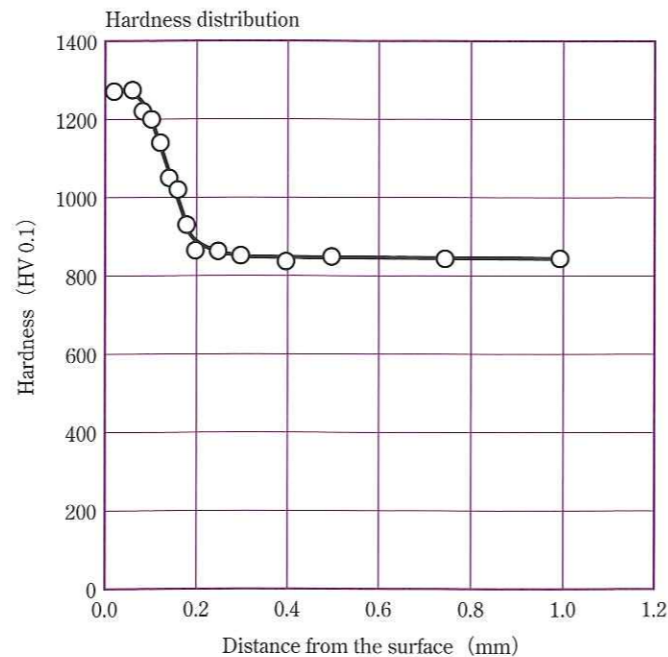
Nitriding



An example of micro structure nitrided by PS process

● PS process

· Daido Amistar's originally developed process featured by high scuffing and erosion resistance



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■ IMPORTANT NOTE

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Dream Series Daido's DRM3

Cold Forging Die Steel

High hard and tough high speed tool steel with excellent hardenability

Features

Conventional grade MH88 has been improved to DRM3. High hardness and tough DRM3 with excellent hardenability is suitable for high precision cold working tools.

- ① Applicable with the maximum hardness 66HRC
- ② Fine carbides contribute higher toughness and fatigue strength than those of MH51 equivalent to SKH51
- ③ Greater hardenability results in high performance even in large dies and gas quenching in vacuum furnace.
- ④ Double melting realizes clean and homogeneous steel with less non-metallic inclusions

Applications

- Cold forging dies and punches
- Cold work roll, emboss roll
- Tools quenched by gas in vacuum furnace

Heat treatment

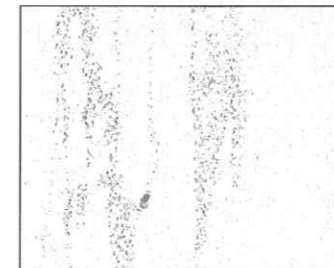
| Re-forging Temperature | Heat treatment conditions (°C) | | | Hardness | |
|------------------------|--------------------------------|--------------------------------|-----------------------------|--------------|-----------------------|
| | Annealing | Quenching | Tempering | Annealed | Hardening / Tempering |
| Requested to inquire | 800~880 Slow cooling | 1100~1140 OQ, GC, Salt bath | 550~620 AC, \geq twice | \leq 235HB | 62~66HRC |

OQ : Oil quenching, GC : Gas quenching in vacuum furnace, AC : Air cooling

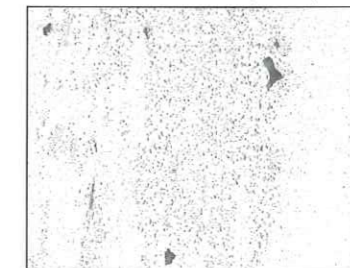
Microstructure (As annealed)

● Finely distributed coarse carbides

DRM3 (Middle of 100 dia. bar)



Conventional steel (Daido)

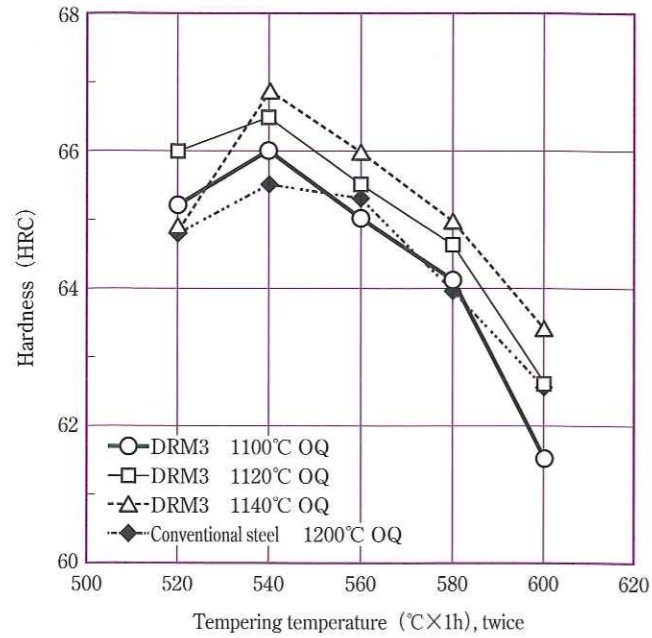


(Cr₂O₃ Electrically etching)



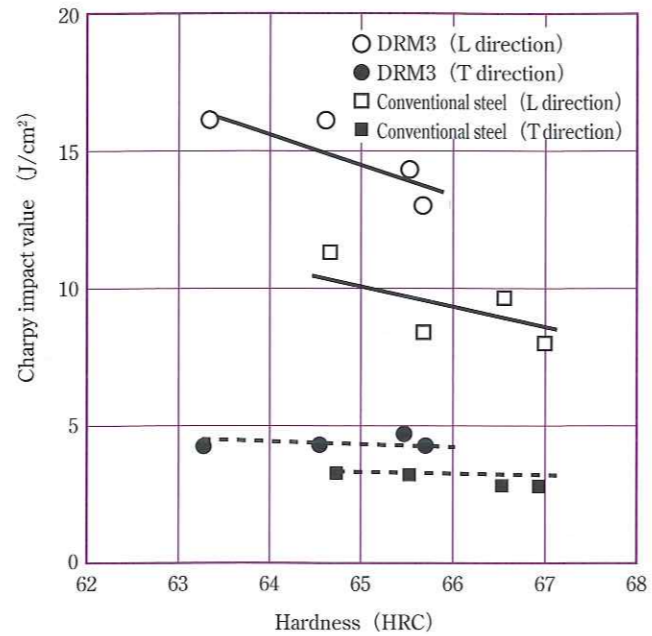
Characteristics

Tempering hardness



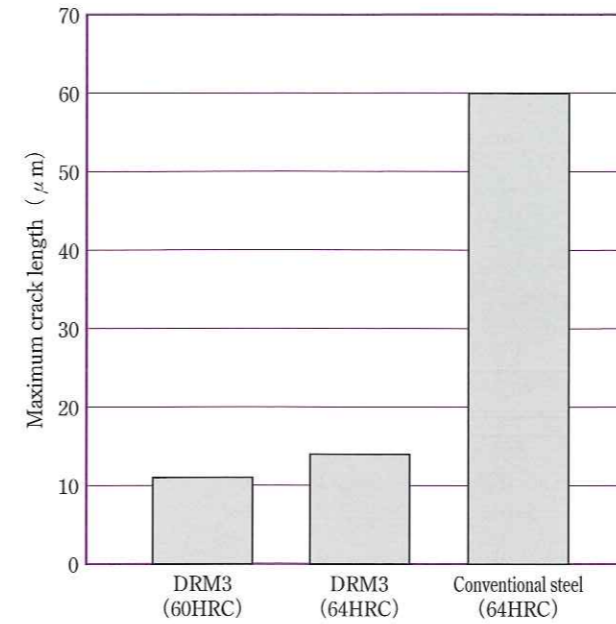
- Specimen : 15mm square
- Hardening : Oil quenching
- Tempering : Air cooling

Toughness : Charpy impact property



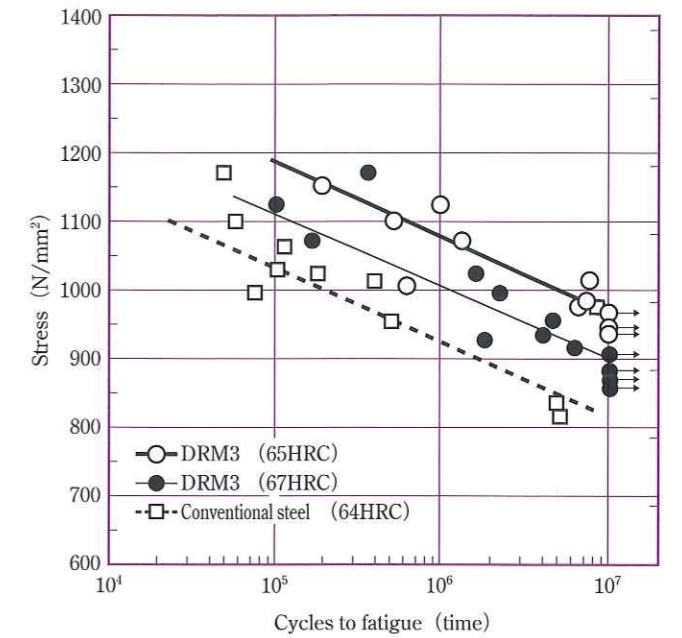
- Sampling : 100mm dia. Bar center
- Specimen : 10R notched
- Heat treatment : DRM3...H : 1140°C OQ
T : 540~600°C AC, twice
- Conventional Steel...H : 1210°C OQ
T : 540~600°C AC, twice

Heat checking resistance



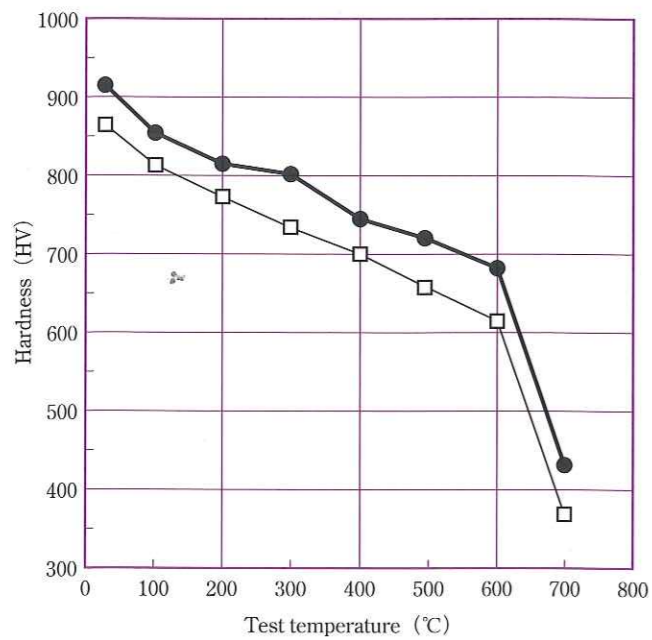
- Specimen : 15 mm dia. 10 mm thick
- Heat Treatment : DRM3...H : 1120°C OQ
T : 560~620°C AC, twice
- Conventional Steel...H : 1200°C OQ
T : 560°C AC, twice
- Test method : Induction heating 20↔600°C (1000 times)

Fatigue strength



- Heat Treatment : DRM3 (65HRC)...H : 1100°C OQ
T : 560°C AC, twice
- DRM3 (67HRC)...H : 1140°C OQ
T : 550°C AC, twice
- Conventional Steel...H : 1200°C OQ
T : 560°C AC, twice
- Test method : Rotating bending fatigue test (20°C)

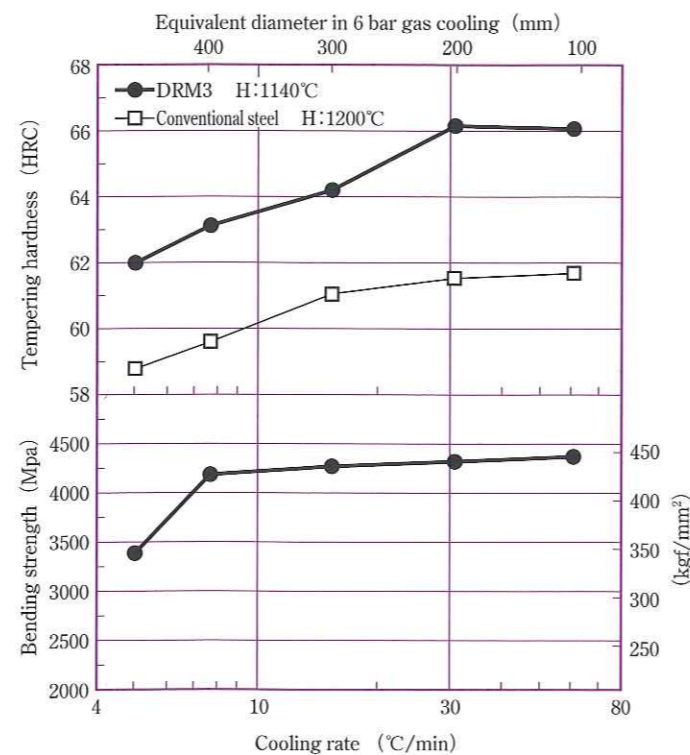
Hot hardness



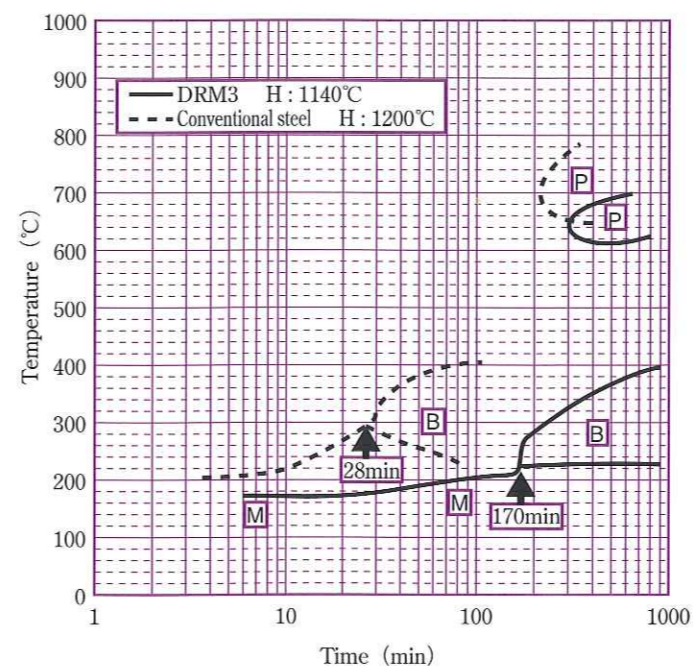
- Heat treatment : DRM3...H : 1140°C OQ
T : 560°C AC, twice
- Conventional Steel...H : 1200°C OQ
T : 580°C AC, twice

Hardenability

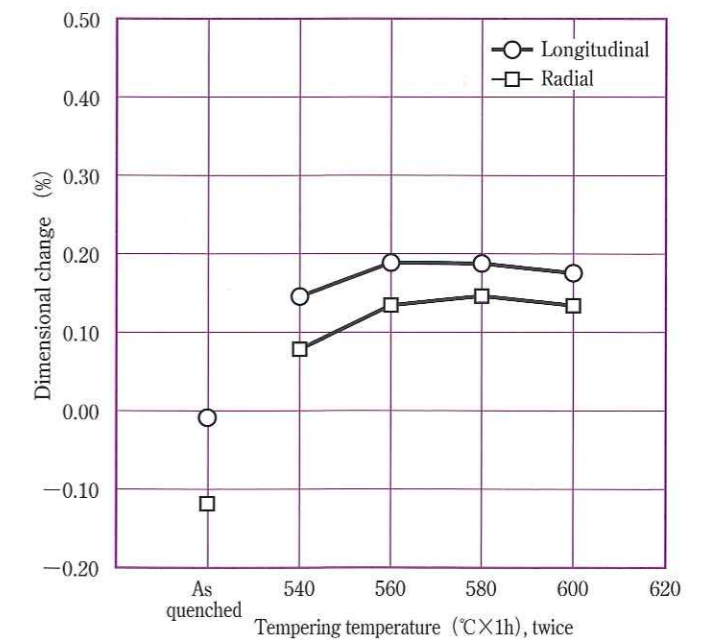
Quenching cooling rate VS Bending strength Hardness



Continuous cooling transformation curve



Dimensional changes in heat treatment



- Specimen : 100mm dia. x 60mm
- Hardening : 1140°C salt bath quenching