

# 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

DRM3	Harden 1120C (2048F)	Draws (minimum of 2)	Maximum toughness	620C (1148F) HRC62	
	Recommend a minimum 6 barr quench		Good toughness & wear	590C (1094F) HRC64	
			Maximum wear	550C (1022F) HRC66	
				Hardness	
Re-forging	Heat treatment conditions (°C)				
Temperature	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)

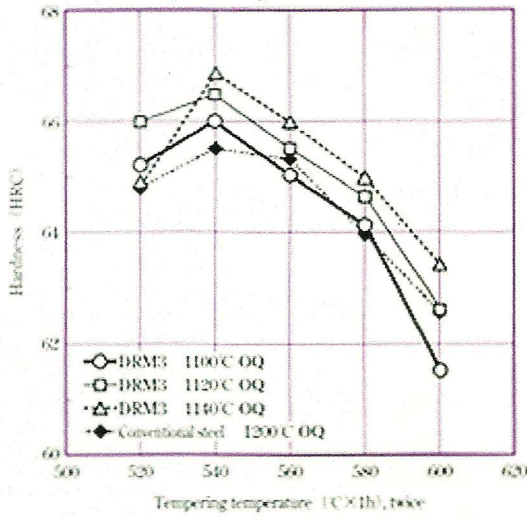


Conventional steel (Daido)



(Cr<sub>2</sub>O<sub>3</sub> Electrically etching)

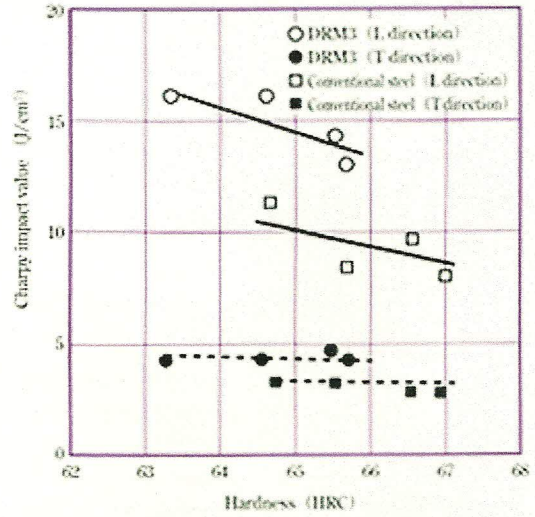
### Tempering hardness



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

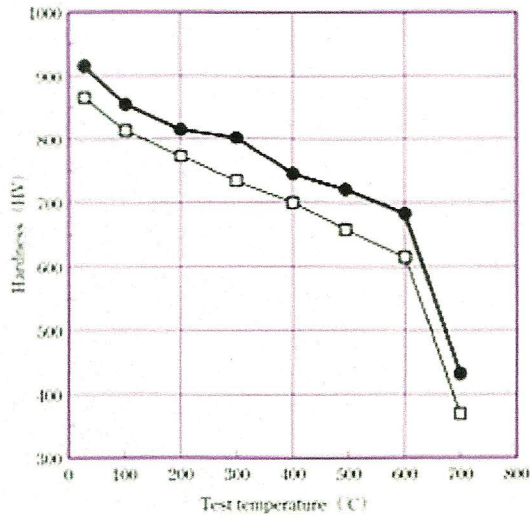
### Hot hardness

### Toughness: Charpy impact property

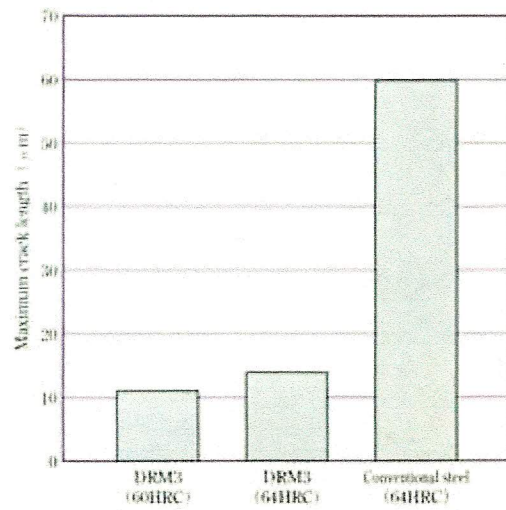


- Sampling : 100mm dia. Bar center
- Specimen : 10R notched
- Heat treatment : DRM3.....H : 1140°C OQ  
T : 540~600°C AC, twice
- Conventional Steel.....H : 1210°C OQ  
T : 540~600°C AC, twice

### Heat checking resistance



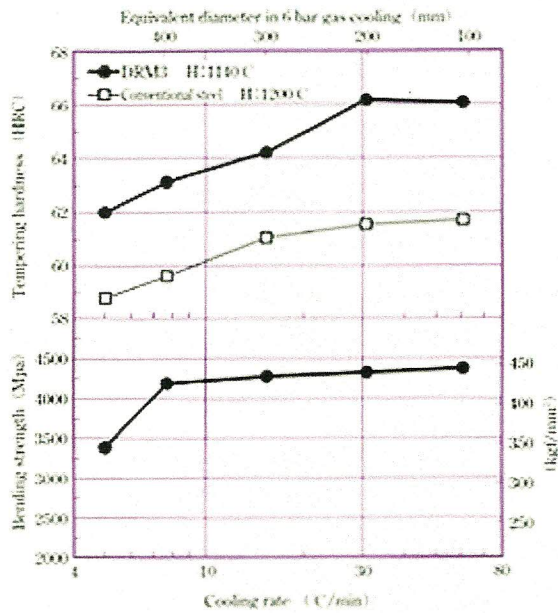
● Heat treatment : DRM3 ..... H : 1140°C OQ  
 T : 560°C AC, twice  
 Conventional Steel ... H : 1200°C OQ  
 T : 580°C AC, twice



● 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)

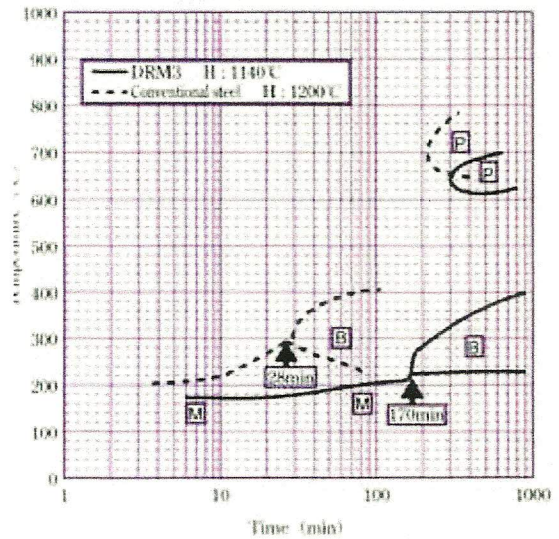
### Hardenability

● Quenching cooling rate VS Bending strength Hardness

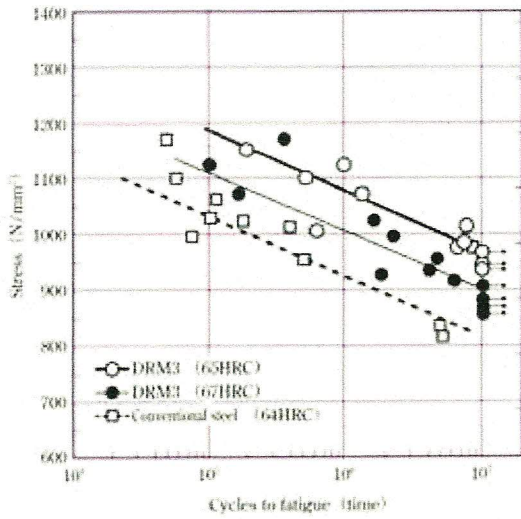


### Fatigue Strength

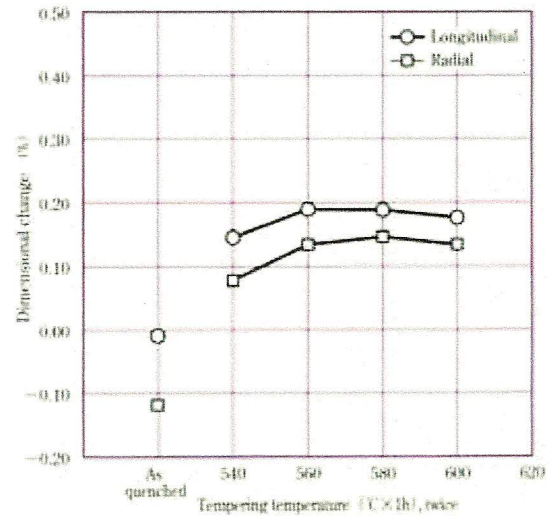
● Continuous cooling transformation curve



### Dimensional changes in heat treatment

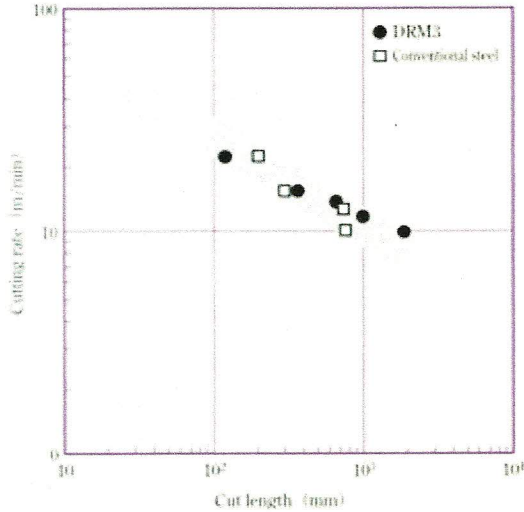


- Heat Treatment : DRM3 (65HRC) ... H : 1100°C OQ  
T : 560°C AC, twice
- DRM3 (67HRC) ... H : 1140°C OQ  
T : 550°C AC, twice
- Conventional Steel ... H : 1200°C OQ  
T : 560°C AC, twice
- Test method : Rotating bending fatigue test (20°C)



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

### Durability of drilling tool



- Specimen : As annealed
- Tool : NACHI SD φ5mm (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
×10 <sup>6</sup> /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]	[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	489	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

