Dream Series

Daido's DRM1

Hot and Warm Forging Die Steel

High tough matrix type high speed tool steel

Features

High hardness and high tough Matrix type high speed tool steel vastly surpassing hot work die steels. DRM1 improves hot and warm die life by its higher toughness than conventional grade.

1. Applicable with the maximum hardness of 58HRC
2. High hardness and tough grade with excellent heat checking resistance
3. Fine microstructure as that of hot work die steels resulting in higher toughness than conventional high speed tool steels
4. High softening resistance and hot hardness
5. Double melting realizes clean and homogeneous steel with less non-metallic inclusions

Applications

- Hot forging dies and punches
- Warm forging dies and punches

Heat treatment

<table>
<thead>
<tr>
<th>Re-forging Temperature</th>
<th>Heat treatment conditions (°C)</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annealing</td>
<td>Quenching</td>
</tr>
<tr>
<td>Requested to inquire</td>
<td>800~880</td>
<td>1100~1140</td>
</tr>
<tr>
<td>Slow cooling</td>
<td>OQ, GC, Salt bath</td>
<td>AC, x2 twice</td>
</tr>
</tbody>
</table>

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

Microstructure (As annealed)

- Fine and uniform microstructure with less coarse carbides

DRM1 (Middle of 100 dia. bar) • Conventional steel (Daido)

(Cr2O3 Etchically 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: DRM1
  - H: 1140°C QO
  - T: 540~600°C AC, twice
- Conventional steel
  - H: 1120°C QO
  - T: 540~600°C AC, twice

Temper softening resistance

- Heat treatment: DRM1
  - H: 1140°C QO
  - T: 600°C AC, twice
- Conventional steel
  - H: 1120°C QO
  - T: 610°C AC, twice

Hot hardness

- Heat treatment: DRM1
  - H: 1140°C QO
  - T: 560°C AC, twice
- Conventional steel
  - H: 1110°C QO
  - T: 560°C AC, twice
**Heat checking resistance**

- Specimen: 15 mm dia. 10 mm thick
- Heat treatment: DRM1 \( H : 1140°C \) QQ
  - Conventional Steel \( H : 1140°C \) QQ
  - T: 560°C AC, twice
- Test method: Induction heating 20\( → \) 700°C (1000 times)

**Fatigue strength**

- Sampling: 100 mm dia. Bar center
- Heat treatment: DRM1 \( H : 1140°C \) QQ
  - Conventional Steel \( H : 1140°C \) QQ
  - T: 560°C AC, twice
- Test method: Rotating bending fatigue test (20°C)

**Hardenability**

- Sampling: 100mm dia. Bar center
- Heat treatment: H: 1140°C (200°C / min \( → \) equal to OQ)
  - T: 560°C AC, twice
- Hardening: 1140°C salt bath quenching

**Dimensional changes in heat treatment**

- Sampling: 100 mm dia. × 60 mm
- Tempering temperature: \( (°C×1h) \), twice

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**Graphs and Diagrams**

- Heat checking resistance chart showing maximum crack length for DRM1 and Conventional steel.
- Fatigue strength graph showing stress vs. cycles to fatigue for DRM1 and Conventional steel.
- Hardenability chart showing tempering hardness vs. equivalent diameter in 6 bar gas cooling.
- Dimensional changes chart showing dimensional change vs. tempering temperature.

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Drilling machinability

Nitriding

An example of micro structure nitrided by PS process

- Daido Amistar’s originally developed process featured by high scuffing and erosion resistance

Physical Properties

- Coefficient of expansion

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>20 → 100°C</th>
<th>20 → 200°C</th>
<th>20 → 300°C</th>
<th>20 → 400°C</th>
<th>20 → 500°C</th>
<th>20 → 600°C</th>
<th>20 → 700°C</th>
<th>20 → 800°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>X10^-5/K</td>
<td>11.2</td>
<td>11.4</td>
<td>11.7</td>
<td>11.9</td>
<td>12.2</td>
<td>12.4</td>
<td>12.7</td>
<td>12.3</td>
</tr>
</tbody>
</table>

- Thermal conductivity

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>25°C</th>
<th>200°C</th>
<th>300°C</th>
<th>400°C</th>
<th>500°C</th>
<th>600°C</th>
<th>700°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/m-K (cal/cm²·K)</td>
<td>22.4</td>
<td>[0.054]</td>
<td>26.3</td>
<td>[0.063]</td>
<td>27.3</td>
<td>[0.065]</td>
<td>28.6</td>
</tr>
</tbody>
</table>

- Specific heat

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>25°C</th>
<th>200°C</th>
<th>300°C</th>
<th>400°C</th>
<th>500°C</th>
<th>600°C</th>
<th>700°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>J/kg-K (cal/g·K)</td>
<td>413</td>
<td>[0.099]</td>
<td>487</td>
<td>[0.116]</td>
<td>519</td>
<td>[0.124]</td>
<td>562</td>
</tr>
</tbody>
</table>

- Young’s modulus 210 GPa

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

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