Drilling machinability

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

Physical Properties

- Coefficient of expansion
  - 20°C to 200°C: 1.1 x 10⁻⁵/°C
  - 200°C to 600°C: 1.3 x 10⁻⁵/°C

- Thermal conductivity
  - 21°C: 29.1 W/m·K
  - 200°C: 27.3 W/m·K

- Specific Heat
  - 21°C: 413 J/kg·K
  - 200°C: 407 J/kg·K

- Young's modulus: 310 GPa
  - Specimen condition: W: 1140°C, Q: 560°C, AC twice

Daido's Dream Series

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.
- Applicable with the maximum hardness of 58HRC
- High hardness and tough grade with excellent heat checking resistance
- Fine microstructure as that of hot work die steels resulting in higher toughness than conventional high speed tool steels
- High softening resistance and hot hardness
- 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>Annealing</td>
<td>800〜880</td>
<td>550〜620</td>
</tr>
<tr>
<td>Quenching</td>
<td>1100〜1140</td>
<td>AC Service</td>
</tr>
<tr>
<td>Tempering</td>
<td>550〜620</td>
<td>AC Service</td>
</tr>
<tr>
<td>Annealed</td>
<td>800〜880</td>
<td>55〜58HRC</td>
</tr>
</tbody>
</table>

Applications

- OQ: Oil quenching
- AC: Gas quenching in vacuum furnace
- Air: Air cooling

Microstructure (As annealed)

- Fine and uniform microstructure with less course carbides

Chemical Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.81%</td>
</tr>
<tr>
<td>Cr</td>
<td>12.0%</td>
</tr>
<tr>
<td>Mn</td>
<td>2.3%</td>
</tr>
<tr>
<td>Si</td>
<td>0.4%</td>
</tr>
<tr>
<td>Ni</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

Daido's Dream Series

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.
- Applicable with the maximum hardness of 58HRC
- High hardness and tough grade with excellent heat checking resistance
- Fine microstructure as that of hot work die steels resulting in higher toughness than conventional high speed tool steels
- High softening resistance and hot hardness
- 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>Annealing</td>
<td>800〜880</td>
<td>550〜620</td>
</tr>
<tr>
<td>Quenching</td>
<td>1100〜1140</td>
<td>AC Service</td>
</tr>
<tr>
<td>Tempering</td>
<td>550〜620</td>
<td>AC Service</td>
</tr>
<tr>
<td>Annealed</td>
<td>800〜880</td>
<td>55〜58HRC</td>
</tr>
</tbody>
</table>

Applications

- OQ: Oil quenching
- AC: Gas quenching in vacuum furnace
- Air: Air cooling

Microstructure (As annealed)

- Fine and uniform microstructure with less course carbides

Chemical Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.81%</td>
</tr>
<tr>
<td>Cr</td>
<td>12.0%</td>
</tr>
<tr>
<td>Mn</td>
<td>2.3%</td>
</tr>
<tr>
<td>Si</td>
<td>0.4%</td>
</tr>
<tr>
<td>Ni</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

Daido's Dream Series

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.
- Applicable with the maximum hardness of 58HRC
- High hardness and tough grade with excellent heat checking resistance
- Fine microstructure as that of hot work die steels resulting in higher toughness than conventional high speed tool steels
- High softening resistance and hot hardness
- 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>Annealing</td>
<td>800〜880</td>
<td>550〜620</td>
</tr>
<tr>
<td>Quenching</td>
<td>1100〜1140</td>
<td>AC Service</td>
</tr>
<tr>
<td>Tempering</td>
<td>550〜620</td>
<td>AC Service</td>
</tr>
<tr>
<td>Annealed</td>
<td>800〜880</td>
<td>55〜58HRC</td>
</tr>
</tbody>
</table>

Applications

- OQ: Oil quenching
- AC: Gas quenching in vacuum furnace
- Air: Air cooling

Microstructure (As annealed)

- Fine and uniform microstructure with less course carbides

Chemical Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.81%</td>
</tr>
<tr>
<td>Cr</td>
<td>12.0%</td>
</tr>
<tr>
<td>Mn</td>
<td>2.3%</td>
</tr>
<tr>
<td>Si</td>
<td>0.4%</td>
</tr>
<tr>
<td>Ni</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
### Characteristics

#### Tempering hardness

<table>
<thead>
<tr>
<th>Tempering Temperature (°C)</th>
<th>Hardness (HRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1120°C</td>
<td>60</td>
</tr>
<tr>
<td>1140°C</td>
<td>55</td>
</tr>
</tbody>
</table>

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

#### Toughness: Charpy impact property

- Specimen: 100mm dia. Bar center
- Specimen: HR notched
- Heat treatment:
  - DRM1: H: 1140°C, OQ
  - Conventional steel: H: 1120°C, OQ
  - T: 540°C - 600°C, AC, twice

#### Heat checking resistance

- Specimen: 15mm dia. 10mm thick
- Heat treatment:
  - DRM1: H: 1140°C, OQ
  - Conventional Steel: H: 1140°C, OQ
  - T: 560°C, AC, twice

- Test method: Induction heating 20°C → 700°C (1000 times)

#### Fatigue strength

- Specimen: 100mm dia. Bar center
- Heat treatment:
  - DRM1: H: 1140°C, OQ
  - Conventional steel: H: 1140°C, OQ
- Test method: Rotating bending fatigue test (20°C)

#### Temper softening resistance

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

#### Hot hardness

- Heat treatment:
  - DRM1: H: 1140°C, OQ
  - Conventional steel: H: 1140°C, OQ
  - T: 560°C, AC, twice

#### Hardenability

- Equivalent diameter in 6 bar gas cooling (mm)

#### Dimensional changes in heat treatment

- Sample: 100mm dia. × 60 mm
- Hardening: 1140°C salt bath quenching