Corus’ steels for crankshafts meet demands for high performance engines, lightweight design, component reliability and low through cost manufacturing.

In converting the linear motion of the piston into rotational motion, crankshafts operate under high loads and require high strength. Elimination of the conventional heat treatment process by specifying Corus’ air cooled steels offers manufacturers significant cost savings.

Performance Requirements
Crankshafts require the following characteristics:
- High strength and stiffness to withstand the high loads in modern engines, and to offer opportunities for downsizing and weight reduction
- Resistance to fatigue in torsion and bending
- Low vibration
- Resistance to wear in the bearing areas

Manufacturing Requirements
The manufacturing route for forged steel crankshafts is usually: hot forging, heat treatment, machining and surface treatment. Controlled air cooling after forging is lower cost than the traditional quench and temper and is now the preferred route.

Efficient and cost effective processing requires:
- Consistent hardening response
- Good machinability in the hardened condition
- Predictable response to surface modification such as induction hardening, nitriding or fillet rolling

Material Requirements
In addition to standard grades, Corus offers a range of steels for forged crankshafts with some, or all, of the following optional characteristics:
- Controlled hardenability steels ensure repeatability of mechanical properties
- Optimised sulphur content balances the conflicting benefits of low sulphur for fatigue properties and high sulphur for improved machinability
- Controlled carbon content produces consistent response to induction hardening
- Controlled chromium and aluminium additions ensure consistent surface hardening through nitriding
- Clean steels provide good fatigue resistance from a low overall inclusion content
Crankshafts

Material Selection

Forced steel crankshafts offer higher strength and stiffness than the cast iron alternative. Lower through cost, controlled air cooled steels are now preferred to traditional quench and tempered grades.

Strength and durability requirements determine the appropriate steel type. VANARD 925®, developed by Corus, offers higher strength than carbon manganese steels and improved machinability compared with alternative microalloyed steels such as 38MnVS5.

<table>
<thead>
<tr>
<th>Designation</th>
<th>0.2% Proof Stress (MPa)</th>
<th>UTS (MPa)</th>
<th>Elongation (%)</th>
<th>Air Cooled</th>
<th>Quench &amp; Temper</th>
</tr>
</thead>
<tbody>
<tr>
<td>42CrMo4</td>
<td>680</td>
<td>850</td>
<td>1000</td>
<td>13</td>
<td>✓</td>
</tr>
<tr>
<td>38MnVS5 (C38mod)</td>
<td>580</td>
<td>850</td>
<td>1000</td>
<td>12</td>
<td>✓</td>
</tr>
<tr>
<td>VANARD 925</td>
<td>560</td>
<td>850</td>
<td>1000</td>
<td>12</td>
<td>✓</td>
</tr>
<tr>
<td>38MnVS6 (C38+N)</td>
<td>450</td>
<td>750</td>
<td>900</td>
<td>12</td>
<td>✓</td>
</tr>
<tr>
<td>SAE1548mod</td>
<td>450</td>
<td>700</td>
<td>900</td>
<td>17</td>
<td>✓</td>
</tr>
</tbody>
</table>

Material Properties

Consistency of Hardenability

Calculated from the chemical composition, the ideal diameter (DI) is a recognised measure of hardenability. Using fully computerised control of steel making and models of hardenability response, Corus’ enhanced SAE1548mod crankshaft steel achieves a narrow 10mm range of DI. This consistency is a significant improvement on the typical 50mm DI range of comparable standard steels and fully satisfies customers needs for tight specifications to control variations in hardening response.

Bending Fatigue Performance

Resonant dwell tests on crankshafts illustrate the superior fatigue strength of steel grade 38MnVS5 compared with SAE1548mod for the same bending section.

Data courtesy of Bifrangi, Sheffield

Additional Product Enhancements

Corus supplies steels with enhanced cleanliness levels to customer or application specific requirements, for improved fatigue performance in very highly loaded crankshafts. Corus offers improved machining steels with additions of tellurium for sulphide modification.

Corus crankshaft steels are used by:
DAF, Daimler-Chrysler, Iveco, John Deere, MAN, Perkins, Saab, Scania, Volvo

Corus Engineering Steels PO Box 50 Aldwarke Lane Rotherham S60 1DW United Kingdom
Telephone +44 (0) 1709 371234 Facsimile +44 (0) 1709 826233 www.corusengineeringsteels.com
Corus’ steels for connecting rods meet the demands of high performance engines, lightweight design, component reliability and low through cost manufacturing.

The rod and cap are usually produced as a single unit and subsequently separated. Fracture splitting of the rod and cap is the latest major industry development and gives significant cost saving compared with conventional machining.

**Performance Requirements**

Connecting rods operate under high loads requiring:
- High strength in both tension and compression
- High fatigue strength

Highly efficient engines demand the lowest possible component weight. More slender rod designs must have:
- Materials with good rigidity / high strength
- Weight consistency to facilitate engine balancing

**Manufacturing Requirements**

Forged steel offers the best combination of strength, stiffness and cost. Cast iron rods are heavier and sintered powder products are more expensive.

In future the rod and cap will be fracture split to minimise cost for most volume produced connecting rods.

Lower through cost pressures demand:
- Elimination of a heat treatment process
- Improved machinability for high volume production
- Low distortion on fracture splitting

**Material Requirements**

In addition to standard grades, Corus offers a range of steels for connecting rods with some, or all, of the following optional characteristics:

- **Air cooled forging steels** develop the strength requirements without subsequent heat treatment
- **Controlled hardenability steels** ensure repeatability of mechanical properties
- **Optimised sulphur content** balances the conflicting benefits of low sulphur for fatigue properties and high sulphur for improved machinability
- **Controlled microstructure** improves fracture splitting characteristics and minimises distortion

**Material Developments**

High proof and fatigue strength steels are desirable. Corus has developed, and is validating, improved strength steels which retain the fracture splitting characteristics and machinability of existing grades.
Connecting Rods

Material Selection

Controlled air cooled steels have largely replaced heat treated steels for connecting rod applications. Higher strength grades are required for the heavier loads typically found in diesel engines and higher performance petrol driven cars. Weight reduction and packaging constraints are also driving up the need for higher strength materials.

For conventionally machined rods, VANARD 925®, developed by Corus offers higher strength than the commonly used C45S6 grade and improved machinability compared with alternative microalloyed steels such as 38MnVS5.

FRACTIM® is a fracture splittable steel from Corus, with machining performance superior to the C70S6 grade initially developed for this cost effective manufacturing route.

<table>
<thead>
<tr>
<th>Designation</th>
<th>0.2% Proof Stress (MPa)</th>
<th>UTS (MPa)</th>
<th>Elongation (%)</th>
<th>Air Cooled</th>
<th>Fracture Splittable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td></td>
</tr>
<tr>
<td>C45S6</td>
<td>370</td>
<td>630</td>
<td>780</td>
<td>17</td>
<td>✓</td>
</tr>
<tr>
<td>VANARD 925</td>
<td>560</td>
<td>850</td>
<td>1000</td>
<td>12</td>
<td>✓</td>
</tr>
<tr>
<td>30MnVS5</td>
<td>580</td>
<td>850</td>
<td>1000</td>
<td>12</td>
<td>✓</td>
</tr>
<tr>
<td>C70S6</td>
<td>560</td>
<td>850</td>
<td>1010</td>
<td>10</td>
<td>✓</td>
</tr>
<tr>
<td>FRACTIM</td>
<td>580</td>
<td>850</td>
<td>1000</td>
<td>12</td>
<td>✓</td>
</tr>
</tbody>
</table>

Material Properties

Fatigue Strength

The S-N chart below compares data from fatigue tests on the Corus branded and industry standard steel grades. The fatigue limit is indicated by the horizontal part of the curve. Materials with higher fatigue limits such as FRACTIM and VANARD 925 can be used for connecting rods subjected to higher loads.

Machinability

The charts below illustrate the machinability benefits in drilling and tapping operations achievable by the use of FRACTIM compared to C70S6.
Drive Line & Transmission

Constant Velocity Joints and Driveshafts

Corus’ steels for drive line systems consistently withstand heavy loads in delivering power to the steered wheels of modern vehicles.

CV joints and driveshafts are made and finished to high standards for reliable and efficient operation. Corus offers steels specifically tailored to optimise individual component manufacture.

Performance Requirements

The torsional loading and rotational motion in the system determine the main requirements for CV joints and driveshafts:

- High strength with a tough core
- Hard wear resistant surface
- Resistance to failure by torsional and rolling contact fatigue

Manufacturing Requirements

The outer races are precision formed usually by warm forging from bar, followed by machining and induction hardening.

Inner races and tripods are cold forged, machined and carburise heat treated.

Drive shafts are produced from peeled bar and the splines are formed by cold rolling. The entire surface is then induction hardened.

An efficient manufacturing process for each of these components demands:

- Sufficient ductility for the forming process
- Good machinability
- Consistent and repeatable response to heat treatment

Material Requirements

Outer races and driveshafts are made from medium carbon through hardening steels. Inner races and tripods are made from low carbon carburising steels.

Steels with optimised performance and reduced through costs are required. In addition to the standard grades Corus offers enhanced steels with some, or all, of the following optional characteristics:

- Controlled sulphur content balances the conflicting requirements of low sulphur for formability and fatigue properties, and high sulphur for improved machinability
- Controlled hardenability steels with tight compositional control ensure repeatability of mechanical properties
- Defect free bar prevents cracking during warm or cold forging
- Controlled carbon content produces consistent response to induction hardening of outer races and driveshafts

Future Developments

Lean Manufacturing, throughout the supply chain, offers the most scope for further improved value CV joints and driveshafts. Existing steel enhancements fully satisfy anticipated future performance requirements.
Constant Velocity Joints and Driveshafts

Material Selection
Steels for CV joints and driveshafts are highly developed products. Appropriate grades for the different applications, and their typical chemical composition (wt %) are:

<table>
<thead>
<tr>
<th>Designation</th>
<th>C</th>
<th>Mn</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>B</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>C50*</td>
<td>0.50</td>
<td>0.75</td>
<td>0.015</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Outer Races</td>
</tr>
<tr>
<td>C45</td>
<td>0.45</td>
<td>0.75</td>
<td>0.025</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Driveshafts</td>
</tr>
<tr>
<td>38B3</td>
<td>0.38</td>
<td>0.95</td>
<td>0.030</td>
<td>-</td>
<td>-</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>16MnCr5</td>
<td>0.16</td>
<td>1.15</td>
<td>0.030</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>Inner Races and Tripods</td>
</tr>
<tr>
<td>20MnCr5</td>
<td>0.20</td>
<td>1.25</td>
<td>0.030</td>
<td>1.15</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10CrMo4</td>
<td>0.18</td>
<td>0.75</td>
<td>0.030</td>
<td>1.00</td>
<td>0.20</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* C50 is used for both outer races and driveshafts. Lower sulphur levels for improved formability are normally specified for outer races.

Material Properties

Consistency of Induction Hardening Response
Calculated from the chemical composition, the ideal diameter (DI) is a recognised measure of hardenability. Using fully computerised control of steelmaking and models of hardenability response, Corus’ enhanced 38B3 driveshaft steel achieves a narrow 10mm range of DI, fully satisfying customers needs for tight specifications to control variations in mechanical properties. This consistency is a significant improvement on comparable standard steels which typically have a DI range >50mm.

Consistency of Hardenability
Corus achieves tight control of hardenability from cast to cast. Results on over 50 casts of 16MnCr5 steel fall within a much narrower hardenability band than specified by the recognised standard BS EN 10084:1998.

Corus Engineering Steels PO Box 50 Aldwarke Lane Rotherham S60 1DW United Kingdom Telephone +44 (0) 1709 371234 Facsimile +44 (0) 1709 826233 www.corusengineeringsteels.com
Corus' steels for diesel injectors meet demands for high performance engines, lightweight design, component reliability and low through cost manufacturing. Common rail and integral unit injector systems accurately deliver fuel at high pressure for efficient combustion, better fuel economy and lower emissions. Corus' high strength steels for nozzles, body holders and unit injectors are produced to exceptional cleanness levels for maximum fatigue resistance.

**Performance Requirements**

Nozzles must have:
- High mechanical strength to tolerate the high system pressures
- Resistance to the fatigue stresses imposed by the fuel delivery cycle
- Durability at high combustion temperatures

Nozzle body holders are also subjected to high fatigue stresses from pulsating fuel pressures. Additionally, weight and packaging constraints are demanding smaller components.

Nozzle body holders and unit injector bodies therefore need:
- High mechanical strength to resist the ever increasing fuel pressures
- Fatigue resistance, especially in regions of high stress

**Manufacturing Requirements**

Nozzle production is a high volume operation which demands:
- Good machinability
- Appropriate heat treatment response to give the final properties

Nozzle body holders and unit injector bodies can be either machined from bright bar, or hot forged then machined. A heat treatment process follows machining. Optimal processing of these components requires:
- Good machinability with special reference to gun drilling of small holes
- Minimum distortion on heat treatment

**Material Requirements**

For nozzles, Corus has developed a low carbon case hardenable steel fulfilling the essential requirements for:
- Excellent machinability in the pre-heat treated, annealed condition
- High strength and fatigue resistance after heat treatment
- Strength at elevated temperatures

Nozzle body holder and unit injector bodies have more demanding machinability requirements. For these applications Corus provides:
- Bars with exceptional straightness which are stress and defect free to avoid hole drift during gun drilling
- Controlled resulphurised or leaded steels to further improve machinability

In addition, all components demand:
- Clean steels for good fatigue resistance from a low overall inclusion content
**Material Selection & Development**

Diesel injection engineering is developing rapidly in response to the increasing service demands. Corus works closely with manufacturers to develop steels that meet the needs for higher operating pressures, temperatures and reliability.

**Nozzles**

The 2Ni2Cr steel developed by Corus for injector nozzles has been tailored to meet the combined requirements of machinability, strength, fatigue and high temperature durability. This steel is in use in the latest common rail systems, operating at pressures of up to 1800 bar and temperatures in excess of 200°C.

**Nozzle Body Holders & Unit Injector Bodies**

Medium carbon steels, sometimes resulphurised and / or leaded (e.g. C45Pb) are used for the less demanding applications where machinability overrides fatigue considerations. Through hardening alloy steels (e.g. 42CrMo4) are needed for higher fuel pressure systems where fatigue strength is more critical. On heat treatment these steels develop the required mechanical strength and retain adequate machinability. Special clean steel practices are necessary to minimise inclusion content and further improve fatigue properties.

The table below shows typical chemical compositions (wt %) for diesel injector steels.

<table>
<thead>
<tr>
<th>Designation</th>
<th>C</th>
<th>Mn</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Pb</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>C45Pb</td>
<td>0.45</td>
<td>0.65</td>
<td>0.045</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.20</td>
<td>Nozzle body holder</td>
</tr>
<tr>
<td>42CrMo4</td>
<td>0.42</td>
<td>0.90</td>
<td>0.040</td>
<td>1.10</td>
<td>0.30</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2Ni2Cr</td>
<td>0.175</td>
<td>0.50</td>
<td>0.035</td>
<td>2.00</td>
<td>-</td>
<td>2.00</td>
<td>-</td>
<td>Nozzle</td>
</tr>
</tbody>
</table>

**Material Properties**

**Consistency of Hardenability (Nozzle Bodies)**

Calculated from the chemical composition, the ideal diameter (DI) is a recognised measure of hardenability. Using fully computerised control of steelmaking and models of hardenability response, Corus’ enhanced 42CrMo4 steel for nozzle bodies achieves a 10mm range of DI. This consistency is a significant improvement on the typical 50mm DI range of comparable standard steels and fully satisfies customers needs for tight specifications to control variations in mechanical properties.

**Consistency of Steel Cleanliness (Nozzles)**

Very clean steels have well dispersed and relatively few inclusions. Oxygen content is an appropriate measure of cleanliness. Low oxygen levels are more difficult to achieve in low carbon steels. Through close control of steelmaking practice Corus’ enhanced 2Ni2Cr nozzle steel consistently achieves oxygen levels below 10ppm. These are well below industry standards of 12-15ppm and more comparable with the much higher carbon 1%Cr bearing steels for which fatigue resistance, and therefore cleanliness, is paramount.
Gears

Corus’ steels withstand the high stresses at the mating surfaces and in the core of gears transmitting rotational forces from the engine / crankshaft to the road wheels.

Consistency of material response during manufacture, particularly on final heat treatment, minimises expensive rectification and reduces gearbox noise and vibration.

Performance Requirements
Transmission gears require:
- Hard wear resistant surfaces
- Resistance to tooth root bending fatigue
- Resistance to surface fatigue which leads to pitting
- A tough core
- Dimensional accuracy for smooth meshing and reduced NVH (noise, vibration and harshness)
- Transmission of higher loads without increasing size and weight

Manufacturing Requirements
Transmission gears have a complex manufacturing route usually involving forging, machining, heat treatment and surface improvement treatment.

The continuous pressure on component manufacturers for low through costs demands:
- Predictable distortion effect of heat treatment to eliminate or reduce hard machining operations
- Reduced heat treatment times using higher temperatures
- Improved machinability

Material Requirements
The majority of transmission gears are case hardened by carburising to achieve a high surface hardness and a tough core. In addition to the standard grades, Corus has developed steel for transmission gears with all or some of the following enhancements:

- Controlled hardenability steels ensure repeatability of mechanical properties and heat treatment distortion behaviour
- Controlled low silicon steels improve the bending fatigue life by reducing internal oxidation during carburising
- Optimised sulphur content balances the conflicting benefits of low sulphur for improved bending fatigue properties and high sulphur for improved machinability.
- Inclusion modified IM steels improve machining throughput rates with reduced tool wear
- Clean steels provide good fatigue resistance from a low overall inclusion content

Material Developments
High temperature carburising steels offer significant cost reductions allowing carburising above 1000°C for shorter times. In conventional steel these conditions promote grain growth and a consequential deterioration in fatigue properties.
Gears

Material Selection

The most appropriate material for an individual application will give the optimum balance of properties and through cost. The table below lists the nominal chemical composition of the most common automotive transmission gear steels. Hardenability, toughness and material cost generally increase with increasing alloy content. High alloy grades are used for larger and high performance components, where hardenability is more critical, but the trend for high volume production of smaller gears is to select the lower alloyed steel such as the manganese chromium (MnCr) grades.

<table>
<thead>
<tr>
<th>Material</th>
<th>C</th>
<th>Mn</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>17Cr3</td>
<td>0.17</td>
<td>0.75</td>
<td>0.85</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16MnCr5</td>
<td>0.16</td>
<td>1.15</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20MnCr5</td>
<td>0.20</td>
<td>1.25</td>
<td>0.45</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18CrMo4</td>
<td>0.18</td>
<td>0.75</td>
<td>1.00</td>
<td>-</td>
<td>0.20</td>
</tr>
<tr>
<td>20MnCr4</td>
<td>0.20</td>
<td>0.85</td>
<td>0.45</td>
<td>-</td>
<td>0.45</td>
</tr>
<tr>
<td>20NiCrMo2-2</td>
<td>0.20</td>
<td>0.80</td>
<td>0.50</td>
<td>0.55</td>
<td>0.20</td>
</tr>
<tr>
<td>17NiCrMo2-4</td>
<td>0.17</td>
<td>0.75</td>
<td>0.95</td>
<td>1.35</td>
<td>0.20</td>
</tr>
<tr>
<td>14NiCrMo13-4</td>
<td>0.14</td>
<td>0.45</td>
<td>0.95</td>
<td>3.25</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Value Engineering

There is considerable overlap in the hardenability properties of different alloyed steels made to standard commercial composition ranges. Using fully computerised control of steel making and models of hardenability response Corus can value engineer lean alloyed steels to meet specific customer needs with consistent quality to ensure predictable and repeatable response to heat treatment and downstream processing.

Material Properties

Lean Alloy Design

The chart below illustrates the hardenability response of a value engineered lean alloyed MnCr steel compared with the standard 1%NiCrMo steel it replaced. The hardenability band width is maintained with a marginal decrease in hardenability for the leaner alloy.

Distortion Control

Close control of hardenability reduces component rejection rates caused by inconsistent distortion after heat treatment.

Corus gear steels are used by:
BMW, Caterpillar, Eaton, Ford, GM, Honda, Renault, Rover, Saab, Scania, Volvo, ZF

Corus Engineering Steels PO Box 50 Aldswarke Lane Rotherham S60 1DW United Kingdom
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Corus’ bearing steels reliably withstand the high fluctuating loads in modern automotive systems, delivering smooth rotational motion with minimum friction for the lifetime of the bearing.

Integral hub bearings combine the hub and a rolling element bearing in a single cost efficient component. Irrespective of bearing design and specific grade Corus steels are produced to closely controlled and very demanding cleanness levels for excellent fatigue resistance.

**Performance Requirements**

Automotive bearings require:
- Hard wear resistant surfaces
- Resistance to failure by rolling contact fatigue
- High surface integrity to promote smooth running

**Material Requirements**

In addition to standard grades, Corus has developed steels for bearing applications which utilise specialist steelpoaking practices to meet exacting durability demands. These steels have some, or all, of the following optional characteristics:
- Clean steels provide good fatigue resistance from a low overall oxygen and inclusion content
- Controlled hardenability steels ensure repeatability of mechanical properties
- Controlled carbon content produces consistent response to induction hardening
- Optimised sulphur content balances the conflicting benefits of low sulphur for cold formability and high sulphur for improved machinability
- Defect free as-rolled bar prevents cracking on forging
- Air cooled forging steels for integral hubs develop the strength requirements without subsequent heat treatment thereby reducing through costs

**Manufacturing Requirements**

The manufacturing route for rolling elements and raceways involves cold forging, hot forging, followed by machining, heat treatment and grinding.

The efficient processing of these components demands:
- Consistent hardening response
- Good formability
- Predictable and consistent mechanical properties

**Material Developments**

Low oxygen, high fatigue resistant steels are continuously being developed for higher loaded bearing applications.
Rolling Element Bearings

Material Selection

Through hardening 1% carbon chromium steel is the industry standard for bearings. Machinability during manufacture is maximised by a spheroidise annealing process. The high hardness levels required in the finished product are achieved by quenching and tempering.

Case carburised bearings exhibit equivalent surface hardness and wear resistance to those of through-hardened bearing steels yet with a relatively soft and tough core.

Medium carbon steels are now used for integral hubs, which can be air-cooled after forging. The required surface hardness of the integral bearing raceway is obtained by induction hardening.

Examples of popular steels, chemical compositions (wt %) and applications are:

<table>
<thead>
<tr>
<th>Designation</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Hardening Process</th>
<th>Typical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%CCr</td>
<td>1.00</td>
<td>0.20</td>
<td>0.30</td>
<td>0.015</td>
<td>1.35</td>
<td>-</td>
<td>-</td>
<td>Through hardening</td>
<td>Rolling elements, raceway</td>
</tr>
<tr>
<td>SAE1070</td>
<td>0.70</td>
<td>0.25</td>
<td>0.90</td>
<td>0.025</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Through hardening</td>
<td></td>
</tr>
<tr>
<td>18CrNiMo2</td>
<td>0.18</td>
<td>0.20</td>
<td>1.20</td>
<td>0.015</td>
<td>0.60</td>
<td>0.14</td>
<td>0.35</td>
<td>Case hardening</td>
<td>Integral hubs</td>
</tr>
<tr>
<td>20CrMo2</td>
<td>0.20</td>
<td>0.20</td>
<td>0.80</td>
<td>0.015</td>
<td>0.60</td>
<td>0.10</td>
<td>-</td>
<td>Case hardening</td>
<td></td>
</tr>
<tr>
<td>853C</td>
<td>0.53</td>
<td>0.25</td>
<td>0.85</td>
<td>0.010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Air cooling</td>
<td></td>
</tr>
</tbody>
</table>

Material Properties

Improvements in steelmaking over the last 30 years have led to a reduction in the oxygen and inclusion content of 1%CCr steel and a corresponding increase in the fatigue life.

N.B The B10 fatigue life is a recognised measure of a materials fatigue performance and is defined as the number of cycles at which there is a 10% probability of failure by fatigue for an appropriate standard load.