MATERIALS AND SERVICES
FOR THE CEMENT AND ENERGY INDUSTRIES

WEAR RESISTANT HARDFACING USING DURMAT® MATERIALS
DURUM Verschleiss-Schutz GmbH was established in Mettmann near Dusseldorf, Germany in 1984 as a manufacturer and seller of advanced hard-facing products to the German and wider European markets.

That same year, DURUM started exporting to more than 10 European countries and from 1986 to Singapore, Thailand, Australia and other overseas markets. Today DURUM has production and service centres in Brazil, France and the USA and exports to the more than 60 countries all over the world!

DURUM provides high performance welding and surfacing wires and powders and is a global market leader in the supply of specialized overlaying consumables that can be applied by a range of processes including:

- Flux Cored Wire
- Plasma Transferred Arc (PTA) Welding
- Oxy-fuel welding
- Thermal Spray Powder and Wire

DURUM maintains production and workshop facilities through its subsidiaries in Brazil (Sao Paulo), France (Saint Victor) and the USA (Houston TX). We also support a network of independent agencies throughout the world, guaranteeing the propagation of correct production techniques and excellence of customer service.

Utilizing our products and services will reduce your costs, increase your capacity and with fast turnaround times provide you with a quality, dependable product. The company has a unique ability to cater for all customer needs from start to finish with manual and robotic welding services, machining and fitting providing a complete turnkey package.
HARDFACING MATERIALS

- Rods for oxy-acetylene welding
- Tungsten carbide products (tubular and flexible wire rods) for extreme wear solutions
- Nickel, Cobalt or Iron based Flux Cored Wire
- Special combinations of 2 or more alloys to provide specific surfacing properties that are unobtainable by other coating methods
- FCAW wires with carbides to provide extremely hard and tough coatings, used principally for extreme wear applications
- Tungsten carbide, complex carbide and chromium carbides for manual arc welding
- PTA welding powders
- Powders for oxy-acetylene welding and spraying
- Fused crushed and Spherical tungsten carbides
- Pre-manufactured replacement wear parts
- Thermal spray powders (conforming to DIN EN 1274)
- Thermal spray wires (conforming to DIN EN 14919)

Durum focuses on “continuous development” and sets aside a significant annual budget for research and development including new product development, product enhancement and the advancement of highly specialised solutions to the most challenging applications in the oil and gas industry.

We meet the demanding requirements of today’s industry with a wide array of Welding and Thermal Spray technologies including Flux Cored Wire, PTA (Plasma Transferred Arc) our famous oxy-acetylene products and last but not least Thermal Spray Powder and Wire.

Today we have a world-class solution developed for every aspect of wear, typically encountered throughout the industry that outperforms competitive products in the market.

Please observe all appropriate safety regulations in their entirety. The technical information given in this data sheet reflects the present state of knowledge. They do not form part of any sales contract as guaranteed properties of the delivered materials. Our delivery and sales conditions apply to all contracts included.

Rev.: 2.1 (03/2012)
WEAR OF COAL AND CEMENT CRUSHING EQUIPMENT

Due to close cooperation with our customers, we have developed many specialised solutions to unique problems based on the application field. We offer professional solutions in the fields of repair, maintenance and wear protection by hardfacing and thermal spraying in cooperation with our subsidiaries and representative offices.

These include:

- Hardfacing and repair of roller crushers (such as POLYCOM)
- NI-HARD IV or chromium cast grinding rolls for the coal and cement grinding
- Wear plates for by fine particles highly stressed fans

To reflect the constantly changing requirements in Surface Engineering, we attach great importance to long-term partnerships with our customers and suppliers.

WEAR OF COAL CRUSHING EQUIPMENT

The ever increasing demand for the fine grinding of black coal has ultimately resulted in an increased wear factor of grinding machinery. There are a number of systems commonly used in the industry to crush black coal for Power Stations.

Parts subject to wear within the Milling Station are the Crushing Rolls, the Grinding Dishes and the Spring mechanisms.

The Crushing Rolls or Wheels and the Grinding Dishes or Tables are produced from a cast iron quality. The quality commonly used is Ni-Hard I, II, IV, or an approved equivalent cast-iron steel.

The different crushing systems commonly used in power stations are illustrated in FIG. 1. The black coal is placed on the grinding dish / table and ground through the pressure applied by the rolls, creating a high friction and low impact wear characteristic between the rolls and the table/dish. This wear produces a rugged and irregular surface on both the rolls and dish which decreases the black coal fineness and so reducing the efficiency of the Power Station dramatically. At the stage when the machine is operating at the minimum efficiency rate which is also the maximum wear tolerance, evidence of the worn-out parts can be clearly seen.

In previous times and throughout literature, it has been stated that maintenance hardfacing of these types of steels was impossible. Only recently (20 years) has it been possible to hardface cast-irons with excellent results.
The customers basically look at hardfacing with the following in mind:

- Selecting the optimal weld deposit analysis for the particular wear taking place.
- Selecting the optimal welding technique due to their expected weld deposit characteristics and alloy development.
- Financial benefits of hardfacing rather than replacing components. Apart from costing figures, the benefits of hardfacing far outweigh the cost of automatic welding machinery as this machinery allows for higher weld deposits, uniformity in shape and reproducible quality.

DURUM have a number of specialists who can give customized solutions with respect to the above points, that will help the customer achieve optimal results.

**SURFACE PREPARATION:**

The cast-iron rolls and dishes that require resurfacing must undergo a liquid penetration test (PT crack test). The base material must be crack-free before hardfacing can begin, which means that large crack defects or cavities must be ground out. Any detectable porosity in the Ni-Hard casting, depending on the volume of the porosity, is not detrimental to the service life of the hardfaced parts.

**METALLURGICAL DESCRIPTION:**

The hardfacing alloy acting against the abrasive mineral wear, belongs to the solidified over-eutectic ledeburitic cast-irons. The carbon's function is to form Primary Carbides of the form M₇C₃ and MC. Therefore the wear resistance is due to the carbide's volume, size and hardness, as well as the hardness of the matrix. **TABLE 1** illustrates a small selection of DURMAT® alloys belonging to the solidified over-eutectic ledeburitic alloy group, as a flux cored wire for the hardfacing of cast iron, coal/ cement crushing wheels/rolls and dishes/tables.

<table>
<thead>
<tr>
<th>ALLOY TYPE</th>
<th>CHEMICAL COMPOSITION by %-weight</th>
<th>PROPERTIES</th>
<th>STRUCTURE</th>
<th>PRODUCERS NAME</th>
<th>HARDNESS (HRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Symbol</td>
<td>Max No.</td>
<td>C</td>
<td>Si</td>
<td>Mn</td>
</tr>
<tr>
<td>G-X330CrMoNi 15 2 1</td>
<td>0.9640 23-36 0.2-0.8 0.5-10 140-170 0.8-1.2' 1.8-2.2</td>
<td></td>
<td>High wear resistance, usable for larger impact stresses. With less carbon the alloy will decrease its wear resistance and its ability to resist impact stresses accordingly. The alloy types 0.9650, 0.9640, 0.9645 and 0.9650 can be annealed, however the finished result depends on the carbon content. 0.9640 has a high hardenability state, but 0.9645 has the highest.</td>
<td>Ni-Hard 1</td>
<td>56 - 64 **</td>
</tr>
<tr>
<td>G-X330CrMoNi 15 2 1</td>
<td>0.9645 23-29 0.2-0.8 0.5-10 180-220 0.8-1.2' 1.8-2.2</td>
<td></td>
<td>Very high wear resistance, usable for lower impact stresses.</td>
<td>Ni-Hard 1</td>
<td>56 - 64 **</td>
</tr>
<tr>
<td>G-X330CrMoNi 15 2 1</td>
<td>0.9650 23-29 0.5-1.5 0.5-15 240-280 0.0-12 1.0-10</td>
<td></td>
<td>Predominantly Chrome carbides in a matrix which can be either Pearlite, Martensite or Austenite depending on the annealing process.</td>
<td>Ni-Hard 1</td>
<td>56 - 64 **</td>
</tr>
<tr>
<td>G-X330CrMoNi 15 2 1</td>
<td>0.9655 30-35 0.2-1.0 0.5-10 230-280 0.0-12 1.0-20</td>
<td></td>
<td>Predominantly Chrome carbides in a martensitic matrix and sometimes with austenitic making up the rest of the structure.</td>
<td>Ni-Hard 1</td>
<td>56 - 64 **</td>
</tr>
</tbody>
</table>

*) Can also be produced as a variation with Cu.
**) Casting Process: Iron Molds
**) Casting Process: Sand
*) Handling: Heat-Treated
By using alloys according to **TABLE 1**, the resulting microstructure will contain a greater amount of smaller sized primary Chrome-carbides than is possible within cast-iron microstructures (e.g. Ni-Hard alloys). It is for this reason that hardfaced cast-iron components have a longer working life than those components that are not hardfaced. However it is important to note that an alloy high in Chrome content will have improved wear resistant characteristics compared to the Ni-Hard alloys, but will still contain fewer and smaller Chrome carbides than the hardfaced cast iron crushing components.

The expected performance of a hardfacing alloy greatly depends on the welding process and parameters. This is especially critical when only one layer is required. The chosen welding process directly affects the dilution of the base material, the alloy content, the microstructure development, therefore influencing the wear resistance of the hardfacing deposit.

As can be seen in **FIG. 2** and **3**, the build-up of the Crushing Rolls can be considerable. They are bead welded using wire Ø 2.8 or Ø 3.2 at a high welding speed with a proportional deposit rate. This results in minimal dilution (very important in first two layers) and helps in forming a network of stress relieving cracks. Due to the large number of layers, an all weld metal analysis is achieved, thus resulting in the increased wear resistance.

Each layer of weld deposit contains what is commonly known as 'quality cracking'. These stress relieving cracks are necessary and are deliberately created due to the process when welding. They form an irregular pattern across the weld beads throughout the entire roll or table. Through **FIG. 4** and **5**, the network of cracks is clearly illustrated on a worn roll. The Crushing Rolls made from Ni-Hard IV (size: Ø 1100 x 500 mm) are removed from operation after approximately 18000 working hours (depending on the rock, sand, ash or other inclusions). They can be resurfaced without the removal of the original hardfacing 'quality cracks'. This is illustrated in the two pictures an the next page.

**FIG. 6** shows the hardness (HRc) versus hardfacing thickness between Ni-Hard IV and the alloy **DURMAT® FD - 60**. It clearly illustrates a slight decrease in hardness in the first few hardfaced layers with a steep incline to its required hardness. **FIG. 7** shows the hardness profile of Ni-Hard IV / welding material X550CrNb7. A small decrease in hardness can be seen then a rapid increase until the nominal hardness is reached.

**FIG. 8** shows the microstructure of a typical all-weld metal deposit as per **Table 1**. The primary carbide or main wear

<table>
<thead>
<tr>
<th>ALLOY</th>
<th>ALL - METAL WELD DEPOSIT in % as per DIN 8555</th>
<th>HARDNESS HRc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>Cr</td>
</tr>
<tr>
<td>FD 56</td>
<td>5.40</td>
<td>32.00</td>
</tr>
<tr>
<td>FD 60</td>
<td>5.50</td>
<td>22.00</td>
</tr>
<tr>
<td>FD 65</td>
<td>5.50</td>
<td>22.00</td>
</tr>
<tr>
<td>FD 67</td>
<td>5.40</td>
<td>21.0</td>
</tr>
<tr>
<td>FD 70</td>
<td>5.20</td>
<td>27.0</td>
</tr>
</tbody>
</table>

▲ **Table 1**: Weld deposit - Actual analysis from ledeburitic flux cored wires for hardfacing
Fig. 2: Hardness Variations
Base Material: Ni-Hard IV
Hardface Material: DURMAT® FD-60

Fig. 4: WEZ

Fig. 6: Hardness Variations
Base Material: Ni-Hard IV
Hardface Material: DURMAT® FD-60

Fig. 7: Microstructure from hard Cast Iron alloys

% Carbide = 12.33 % C + 0.55 % Cr - 15.2
resistant component is a chrome enriched M₇C₃ type carbide. Through the special strip layered – hard surfacing, it is possible to hardface using a over-eutectic lederburitic Cr – Alloy with a hardness from 60 HRC, a layer thickness up to 80 mm, with a base material of Ni-Hard or a similar cast-iron alloy, without the weld metal pitting or chipping out due to high mechanical loads.

**FIG. 9** shows a worn crushing roll that has been successfully repaired (**FIG. 10**) to its designed shape by using a contoured template. **FIG. 11** and **12** show a crushing roll made of Ni-Hard IV with a Ø 2250 mm, width 700 mm and a weight of 4500 kg, when received (after a PT crack test) and during the welding process.
CONCLUSION

The hardfacing of Crushing Rolls and Dishes in this day and age is widely recognized as having excellent results. It has therefore increased the demand worldwide and has also become common practice within European and American industries. It considerably improves the product working life, reducing down time, which will significantly reduce the maintenance cost for the producer whether it be in power stations or in the cement industry, as well as reducing the cost for the end user.
HARDFACING OF ROLLER PRESS

Roller Presses or Cement Rolls undergo extreme pressure loads whereby hardfacing of new and old rolls is standard practice within industry. They can be either as a solid roll or as a sleeve as shown here in this case study:

- **Base Material:** 18NiCrMo14-6
- **Roll Dimensions:** Ø 1400 mm x 2140 mm (approx. 25 t)
- **Wear Mechanism:** Extreme pressure loads causing abrasive wear along with slight impact wear
- **Deposited Alloy:** DURMAT® FD - 600 TIC, DURMAT® FD - 760 SA
- **Deposit Thickness:** 3 layers and one layer profile with DURMAT® NIFD
- **Flux cored wire size:** Ø 2.4 mm - twin-arc
- **Deposited Hardness:** 56 – 58 HRC

This particular hardfacing procedure is an example to show the flexibility to design specific alloys to the customers’ requirements or in accordance with the wear observed.

- **Base Material:** 18 NiCrMo 14 6
- **Roll Dimensions:** Ø 2140 mm x 1300 mm wide (Total L=5200 mm)
- **Weight of Roll:** 56 tonnes
- **Wear Mechanism:** Extreme pressure loads causing abrasive wear along with slight impact wear
- **Deposited Alloy:** DURMAT® FD - 600 TIC, DURMAT® FD - 760 SA
- **Deposit Thickness:** 3 layers and one layer profile with DURMAT® NIFD
- **Flux cored wire size:** Ø 2.4 mm - twin-arc
The roller was standard hardfaced. The working life time was about 3000 hours. Surface shows high wear attack. The coating was removed and a high performance wear resistant multilayer was applied.

**DURMAT® - FD NiCrMo2** or **DURMAT® - FD 341 SA, DURMAT® - 600 TiC** or **DURMAT® - FD 760 SA**. Working life time increased to 4000 hours and no wear was visible.

A Polycom-roller with crack formation was repaired. The crack was worked out completely. A buffer layer of **DURMAT® - FD NiCrMo2** with a hardfacing top layer **DURMAT® - FD 600 TiC** was used to repair and improve the roller performance.
**CP - WEAR PLATES**

The fabrication of the CP – plate is carried out by use of a core-wire welding process. The extreme wear resistance is achieved by use of high quality DURMAT® Flux Cored Wires consumables with high Chromium and Carbon content. The addition of complex carbides enables the formation of a high content of Chromium-carbides and special carbides, so that the required properties are achievable in the first layer in accordance to the DIN EN 14700 (group 10 former DIN 8555).

The characteristic, hyper-eutectic weld metal of the FeCrC hardfacing alloy consists of large, primary deposited carbides of the type M₇C₃, embedded in the eutectic matrix. The content of the primary carbides mainly affect the wear resistance and can be determined according to the Maratray formula, as follows:

\[
% K = 12.33 \times (% C) + 0.55 \times (% Cr) - 15.2 \%
\]

The increasing carbide content is related to steady rises of the Cr and C content.

Through the application of flux cored wires DURMAT®- FD 56 and 62 the primary carbide content can be increased significantly. The addition of complex carbides e.g. NbC subsequently increases the wear resistance performance of the plates.

<table>
<thead>
<tr>
<th>BASE MATERIAL (mm)</th>
<th>COATING (mm)</th>
<th>TOTAL (mm)</th>
<th>WEIGHT (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
<td>8</td>
<td>62</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>10</td>
<td>78</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>11</td>
<td>85</td>
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<tr>
<td>8</td>
<td>5</td>
<td>13</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>16</td>
<td>125</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>18</td>
<td>140</td>
</tr>
</tbody>
</table>

Further dimensions on request

DURMAT® - CP – plates can be delivered as prefinished blanks with fixation elements, sinkhole bores or others. Recoating is carried out with similar alloy electrodes or core wires. Please consult the core wire catalog.
**DURMAT® - CP 960 (DURMAT® FD 56)**

C: 4.8 ± 0.3%  Cr: 27.5 ± 1.5%
Hardness: 60 ± 2 HRC
Working Temperature: 350°C

For parts exposed to moderate abrasive wear combined with moderate impact and corrosion. Maximum working temperature: 350°C. Typical applications are the steel and cement industries, power stations, mining, concrete, glass and recycling as well as chemical and petrochemical industries.

**DURMAT® - CP 1000 (DURMAT® FD 60)**

C: 4.8 ± 0.3  Cr: 27.5 ± 1.5%  Nb: 4.3 ± 0.5%
Hardness: 61 ± 2 HRC
Working Temperature: 350°C

Similar to CP 960 but for parts exposed to high abrasive wear in combination with corrosion and low impact. Maximum working temperature: 350°C. Typical applications are the mining, steel, cement, power stations, glass and recycling industries.

**DURMAT® - CP 1100 (DURMAT® FD 75)**

C: 4.8 %  Cr: 22.0 %  Nb: 5.0 %  Mo: 4.0 %  W: 1.0 %  V: 0.7 %
Hardness: 64 ± 2 HRC at 300°C, approx. 56 HRC at 600°C

For parts subject to high abrasive wear in combination with temperatures up to 650°C together with moderate corrosion and impact. Typical applications are the mining, steel, cement, chemical and petrochemical industries.

Afore mentioned analysis and hardness values are typical for a 1-layer deposit with even hardness from the top to the base material. These figures are typical for our Flux Cored Plus process.
DURUM is dedicated to the field of high performance, wear resistant materials and overlays.

DURUM’s family of Tungsten Carbide - Nickel base alloys exhibit superior resistance to abrasion and wear, retaining their hardness up to 600°C (approx. 1,000°F) in combination with excellent corrosion resistant properties.

PTA - Plasma Transferred Arc is suitable for almost all cobalt and nickel based alloys as well as specially designed iron based alloys. Primary carbides in combination with those nickel, cobalt and iron based alloys improve the wear resistance remarkably compared to chromium carbide plates.

PTA is a true welding process, with deposits forming a metallurgical bond with the base metal. The dilution level is very close to those obtained by using the oxy-acetylene process.

A further advantage of using the PTA process is the capability of producing thin edge surfaces. Together with the very low dilution (approx. 5%) and the minimal distortion risk, the process is ideal for applications on parts such as Fan Blades.

<table>
<thead>
<tr>
<th>BASE MATERIAL (mm)</th>
<th>OVERLAY (mm)</th>
<th>TOTAL ± 1mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>10</td>
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<td>6</td>
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<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

DURMAT® PTA Plates can be cut, bent, rolled, welded, bolted or incorporated into structures to build anti- abrasion assemblies.

Standard base plate type NF A36-201 E390 / DIN 17102 StE36 / ASTM A 572gr50. Other types according to customers specifications e.g. stainless, heat resisting, high strength, etc.
CHARACTERISTICS:

**DURMAT® - WP 1061** is a composite Wear Plate consisting of a mild steel base plate and a high wear resistant overlay.

The hard-facing deposit consists of a Ni-B-Si matrix with very evenly dispersed Fused Tungsten Carbide (FTC) particles. The chromium free Ni-B-Si alloy shows much harder phases than the well known M7C3 carbides. The inserted fine dispersed FTC shows a hardness of >2,340 HV.

Due to the low melting point of the Ni alloy in combination with our unique PTA system for application, the material shows a very low and uniform dilution with the base material.

APPLICATIONS:

**DURMAT® - WP 1061** is rust and acid durable, resistant to heavy abrasion and heat up to 500°C. Because of the high FTC content, the overlay is highly wear resistant. **DURMAT® - WP 1061** protects components that encounter heavy mechanical and mineral wear.

In particular the 3 + 2 mm **DURMAT® - WP 1061** wear plates offer extremely economical solutions for parts such as high speed fan blades, or in the cement industry where components are subject to substantial erosion by abrasive particles such as quartz or feldspar dust.

BENEFITS:

- Very low dilution with the base material (<5%)
- Dense surface with low coefficient of friction
- Extremely economical solutions due to its light weight
- Good formability and can be cut with plasma
- Base material easy to weld

TECHNICAL DATA:

| Base material size: | 2,000 x 1,000 x 3+2 mm |
| Coated surface:    | 1,800 x 800 x 3+2 mm   |
| Base material size: | 2,500 x 1,250 x 4+2 mm |
| Coated surface:    | 2,300 x 1,100 x 4+2 mm |
| Base material size: | 2,500 x 1,250 x 5+2 mm |
| Coated surface:    | 2,300 x 1,100 x 5+2 mm |

Smallest thickness of hardfacing: 2 mm ± 0.5 mm
Thickness of base material: between 4 and 20 mm on customers specification

* REMARKS: other weld material sizes as well as other hardfacing alloys are available on request
HARDFACING: REPAIR WELDING

WEAR SOLUTIONS WITH CREATIVE IDEAS FOR PRACTICAL SOLUTIONS
EXAMPLES: ENERGY INDUSTRY

APPLICATION FIELD:

- Coal mills
- Mineral mills
- Fine particle mills
- Breaker tools
- Pressure frames rebuilding

EXAMPLES: CEMENT INDUSTRY

APPLICATION FIELD:

- Roller mills
- Raw mills
- Clinker mills
- Breaker tools
- Grinding tools
COMMON HARDFACED EXAMPLES

• Worn-out and Hardfaced Ni-Hard IV Grinding Dish.
• Suitable for Berz and Pfeiffer Systems.

Condition when received with design template

Finished hardfaced condition
DURMAT is a registered trademark of DURUM Verschleiss-Schutz GmbH. DURUM has developed world-class solutions for every aspect of wear encountered in a variety of industries, from steel to mining to oil and gas.

DURMAT products are now available from Swedish ME Steel, a provider of special steel and maintenance and repair solutions in the Middle East and Indian Subcontinent. With over twenty years of experience in the industry, Swedish ME Steel offers solutions developed in close cooperation with its customers to achieve more efficient production, better cost analysis, and longer service life.