DOOSAN FORGED STEEL ROLLS
Doosan quickly develops rolls in a variety of compositions to satisfy customer needs. Forged steel rolls from Doosan are helping to advance the global steel industry and provide benefit to people everywhere. People’s needs and aspirations are being met around the clock.
CONTENTS

INTRODUCTION ................................. 04
THE TYPES OF FORGED ROLLS .......... 06
MANUFACTURING SEQUENCE OF WORK ROLL .... 08
MANUFACTURING SEQUENCE OF BACK UP ROLL
AND PLATE BACK UP ROLL ............... 12
MAIN PRODUCTION FACILITIES FOR
FORGED STEEL ROLLS .................... 15
RESEARCH & DEVELOPMENT ............... 16
QUALITY ASSURANCE .................... 18
Doosan Heavy Industries & Construction Co., Ltd. (Doosan) has been producing various types of casting & forging products for many years ranging power generator, chemical vessel, steel mill, ship building, and steel plant. Doosan came into existence in 1962 as a pioneer in the field of heavy industries in Korea. Since that time, it has manufactured and supplied various types of steel castings and forgings both for domestic and foreign markets.

**Forged Steel Rolls**

A longer lasting roll means less down time for roll exchange and more production tonnage of the mill which can make roll users save more dollars, milling costs. Doosan’s forged work roll has a good combination, the hardened surface with high resistance to wear, heat check and tough core resistance to breakage. It also has an ideal hardness profile from surface to core and very high resistance to spalling. Doosan has three shops related to roll business, a steel foundry, a forge shop and a roll shop at its Changwon manufacturing complex, all of which are equipped with the most up-to-date facilities and equipments fully controlled automatically. With the modern facilities, a strict quality system and the latest technical know-how, Doosan looks forward to supplying its customers with the top quality rolls. This catalogue presents the principal characteristics of each process together with brief guidance on Doosan’s forged rolls.
DOOSAN FORGED STEEL ROLLS

THE TYPES OF FORGED ROLLS

Rolls for Cold Rolling Mill
Work Rolls & Intermediate Rolls
Back Up Rolls for Cold and Hot Rolling Mill
MANUFACTURING SEQUENCE OF WORK ROLL
**Work Roll & Intermediate Roll**

<table>
<thead>
<tr>
<th>Doosan Roll Symbols</th>
<th>Material</th>
<th>Applications and Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>R53HJ</td>
<td>3%Cr</td>
<td>Basic Work and Intermediate Rolls for Cold Rolling Mill</td>
</tr>
<tr>
<td>HR60</td>
<td>Modified 3%Cr</td>
<td>Deep Hardened Work and Intermediate Rolls</td>
</tr>
<tr>
<td>KR21HJ</td>
<td>5%Cr</td>
<td>Work and Intermediate Rolls With Improved Wear Resistances</td>
</tr>
<tr>
<td>HSR1</td>
<td>Modified 5%Cr</td>
<td>Super Deep Hardened Work and Intermediate Rolls</td>
</tr>
<tr>
<td>KRAHJ</td>
<td>Modified 5%Cr</td>
<td>Super Deep (100mm ø) Hardened Work and Intermediate Rolls</td>
</tr>
<tr>
<td>DSR1</td>
<td>Semi-HSS</td>
<td>Intermediate Rolls for Cold Rolling Mill</td>
</tr>
</tbody>
</table>

**Hardening Depth of Work Rolls**

![Graph showing hardening depth of work rolls](image)

- Electro-Slag Remelting
- Heating
- Forging
- Special Annealing
- Rough Machining
- Tempering
- Sub-zero (N2 gas)
- Quenching (Induction Hardening)
- Intermediate Machining
- Thermal Refining
- UST
- HS
MANUFACTURING SEQUENCE OF WORK ROLL

1. ESR Ingot
2. Forging
3. Low Frequency Induction Hardening
4. CNC Lathe
5. Automatic Ultrasonic Test
DOOSAN HEAVY INDUSTRIES & CONSTRUCTION

Characteristics of Doosan’s ESR Process

- Improvement of cleanliness in the solidified ESR ingot by refining process through the slag-metal reaction
- Minimization of segregation and a crystal formation of fine structure by the solidification speed control

Characteristics of Doosan’s Induction Hardening Process

- Induction heating coil gives a stable heating
- Automatic temperature measuring system keeps an accurate temperature control
- Cooling shower supply a quick and uniform cooling
- Cooling water controlling system gives a stable cooling
- Hardening process with high mechanical precise provides a high quality hardness deviation
MANUFACTURING SEQUENCE OF BACK UP ROLL AND PLATE BACK UP ROLL

1. Q-steel Scrap & Ferro Alloys
2. Melting & Refining (100t & 30t EAF)
3. Vacuum Refining (ASEA-SKF L/D P’CE)
4. Ingot Making (Vacuum Stream Degasser)
5. Inspection
6. Finishing M/C & Grinding
7. Tempering
### Back Up Roll

<table>
<thead>
<tr>
<th>Doosan Roll Symbols</th>
<th>Material</th>
<th>Applications and Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>KFB43</td>
<td>3%Cr</td>
<td>Basic Steel for Hot Strip Mill</td>
</tr>
<tr>
<td>KFB48</td>
<td>Modified 3%Cr</td>
<td>High Hardness Steel for Hot &amp; Cold Strip Mill</td>
</tr>
<tr>
<td>KFB53</td>
<td>High C + 3%Cr</td>
<td>High Hardness Steel for Cold Strip Mill</td>
</tr>
<tr>
<td>HFB55</td>
<td>5%Cr</td>
<td>Improved Wear Resistance and High Toughness for Hot &amp; Cold Strip Mill</td>
</tr>
<tr>
<td>DFPBR</td>
<td>High C + Cr</td>
<td>Improved Wear Resistance and High Toughness for Plate Mill</td>
</tr>
</tbody>
</table>

### Hardening Depth of Back Up Roll

![Graph showing hardening depth of back up roll](image-url)

- **Forging (13,000 ton press)**
- **Preliminary Heat Treatment**
- **Rough Machining**
- **Hardening**
- **Mist Quenching**
- **Induction Heating**
- **Preheating**
MANUFACTURING SEQUENCE OF BACK UP ROLL AND PLATE BACK UP ROLL

1. Melting
2. Forging
3. Induction Hardening (65Ton)
4. Finish Machining
5. Skid Packing
## MAIN PRODUCTION FACILITIES FOR FORGED STEEL ROLLS

<table>
<thead>
<tr>
<th>Shop</th>
<th>Facilities</th>
<th>Capacity</th>
<th>Q'ty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel Foundry Shop</strong></td>
<td>Electric Arc Furnace</td>
<td>100Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Electric Arc Furnace</td>
<td>30Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Vacuum Ladle Furnace</td>
<td>155Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td><strong>Forged Shop</strong></td>
<td>Electro-Slag Remelting Furnace</td>
<td>80Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Forging Press with Manipulator</td>
<td>13,000Ton</td>
<td>3 Unit</td>
</tr>
<tr>
<td></td>
<td>Heating Furnace</td>
<td>4,200Ton</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heat Treatment Furnace</td>
<td>1,600Ton</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15~450Ton</td>
<td>16 Units</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50~300Ton</td>
<td>21 Units</td>
</tr>
<tr>
<td><strong>Work Roll Shop</strong></td>
<td>Auto UT Equipment</td>
<td>8Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Electric Vertical Furnace</td>
<td>8Ton</td>
<td>3 Units</td>
</tr>
<tr>
<td></td>
<td>Cooling Equipment</td>
<td>8Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Horizontal Lathe</td>
<td>35Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Horizontal Furnace(Gas)</td>
<td>30Ton</td>
<td>3 Units</td>
</tr>
<tr>
<td></td>
<td>Induction Heating &amp; Hardening Equipment</td>
<td>15Ton</td>
<td>2 Units</td>
</tr>
<tr>
<td></td>
<td>Sub-Zero Equipment</td>
<td>8Ton</td>
<td>2 Units</td>
</tr>
<tr>
<td></td>
<td>Electric Vertical Furnace</td>
<td>15Ton</td>
<td>5 Units</td>
</tr>
<tr>
<td></td>
<td>Band Sawing Machine</td>
<td>Max. Ø 400 ~ Min. Ø 100</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Plano Miller</td>
<td>W: 1.7m, H: 1.4m, Max Load: 20Ton</td>
<td>1 Unit</td>
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<tr>
<td></td>
<td>CNC Roll Lathe</td>
<td>D: 1m, L: 6.5m, Max Load: 20Ton</td>
<td>4 Units</td>
</tr>
<tr>
<td></td>
<td>CNC Milling Machine</td>
<td>D: 1m, L: 6.5m, Max Load: 10Ton</td>
<td>2 Units</td>
</tr>
<tr>
<td></td>
<td>CNC Roll Grinder</td>
<td>D: 1m, L: 6.5m, Max Load: 20Ton</td>
<td>4 Units</td>
</tr>
<tr>
<td><strong>Back Up Roll Shop</strong></td>
<td>Induction Hardening Equipment</td>
<td>65Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Cooling Equipment</td>
<td>65Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Electric Vertical Furnace</td>
<td>80Ton</td>
<td>3 Units</td>
</tr>
<tr>
<td></td>
<td>Horizontal Lathe</td>
<td>100Ton</td>
<td>3 Units</td>
</tr>
<tr>
<td></td>
<td>Horizontal Boring Machine</td>
<td>100Ton</td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>Grinding Machine</td>
<td>200Ton</td>
<td>1 Unit</td>
</tr>
</tbody>
</table>
A. Thermal Shock Cracking
   Evaluation of thermal shock resistance of roll materials
   Relation between thermal shock crack depth and hardness, quenching temperature

B. Rolling Contact Fatigue
   Evaluation of rolling contact fatigue life
   Relation between hertzian stress and number of rolling contact

C. Wear Resistance
   Evaluation of wear resistance
   Comparison of wear resistance in roll materials
   Ra change during rolling

D. Fracture Toughness
   Evaluation of fracture toughness

E. Metallography / Analysis Apparatuses
   Examination of the microstructure and fracture surface
   TEM(Transmission Electron Microscope), AES(Auger Electron Spectroscopy),
   SEM(Scanning Electron Microscope)
Doosan is dedicated to producing rolls which meet or exceed applicable codes, standards and customers’s specifications.

As a result of its unreserved efforts to guarantee product quality, Doosan Heavy Industries & Construction Co., Ltd. acquired ISO 9001 certification for its 24 products including rolls used in power generation facilities and industrial plants in 1993.
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