Cutting-edge iron ore pelletizing technology in the context of TOREX company experience
RANGE OF SERVICES

**Engineering study of the operating equipment**
- evaluation of the process efficiency
- development of retrofitting options

**Basic engineering**
- development of heat flow and process flow diagrams
- development of technical documentation
- selection of equipment
- functional description of automation diagrams

**Start-up and commissioning and operating mode adjustment services**
- development of process parameter tables/charts
- development of operating procedures
- plant personnel training

**Manufacturing of custom equipment**

- Direct reduction/metallization process
- Blast furnace production process
CUSTOMERS WORLDWIDE

5,0 MTPY  Sangan Pelletizing Plant 1, IMIDRO, Iran
5,0 MTPY  Sangan Pelletizing Plant 2, Mobarakeh, Iran
Full-scale engineering of plants. Basic design/engineering of OM-672 [672 m³ indurating machine].
Audit of equipment selection. Basic design/engineering of the ACS. Supervision over detailed design, civil works and erection.
Training of the personnel. Adjustment. Commissioning

5,0 MTPY  TKOM-3, MGOK, RUSSIA
Comprehensive engineering of process complex of the indurating machine No 3. Patented thermal diagram of the indurating machine -1-592M

1.2 MTPY  Shri Jagannath & Steels Pvt. India
Basic design/engineering and supervision over detailed design by UZTM - MOK-2-189.
Basic design of the ACS, refractory lining and insulation

1.2 MTPY  Crest Steel & Power Ltd. Durg, India
Basic engineering, audit and process supervision over manufacturing 1.2 MTPY
UZTM MOK-1-189

0.8 MTPY  Minera Steel & Power Pvt Ltd. Bellary, India
Basic engineering/design and supervision over the detailed design documents prepared by UZTM MOK-108.
Basic design of the ACS, refractory lining and insulation

Tubarao Pellet Plant I & II, VALE, Brazil
Technological assistance in the design and implementation of the retrofitting of Lurgi-278 and Lurgi-430.
Performance tuning. Commissioning

TENOGA MINERALS, SOUTH AFRICA
Developing cooperation in the processing of chromite raw materials for customers in China and India

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5,0 MTPY  TKOM-3, MGOK, RUSSIA
Comprehensive engineering of process complex of the indurating machine No 3. Patented thermal diagram of the indurating machine -1-592M
COMPREHENSIVE APPROACH TO THE CREATION OF INNOVATIVE PRODUCTION FACILITY

Problem statement

Pelletizing and Induration Tests

Start-up & commissioning

Development and implementation of technologies

Pilot-scale tests

Numerical simulation

Engineering

Analysis of the basic data
- physical and chemical properties of raw materials/feed
- target values
- conceptual solutions

Laboratory studies
- determination of the optimum specific surface area value
- optimum blend proportioning
- moist, dry and fired pellets

Research/experiments at an operating plant
- balling (green pelletizing)
- firing in an industrial-scale unit
- metallurgical properties

Process engineering
- adaptation of research and experimental data
- numerical simulation to offer an optimal solution
- adjustment of the operating mode of a process unit/furnace
- justification of the efficiency

Start-up and commissioning and operating mode adjustment services
- plant personnel training
- Development of operating procedures/manuals
- start-up of equipment, performance guarantee tests

Technical documentation and services
- process flow sheet, heat flow diagram of the indurating machine
- technical specifications, process procedures etc.
- selection of equipment, consultations

Start-up and commissioning and operating mode adjustment services
- plant personnel training
- Development of operating procedures/manuals
- start-up of equipment, performance guarantee tests

Technical documentation and services
- process flow sheet, heat flow diagram of the indurating machine
- technical specifications, process procedures etc.
- selection of equipment, consultations
INTEGRATED TECHNOLOGY
FOR PRODUCTION OF IRON ORE PELLETS

ADVANCED ENGINEERING SOLUTIONS
- Combined flow sheet for the vacuum filtration of the slurry
- Prefeeding of additives to improve binder properties
- Non-contact measurement system of the grain-size composition and quality of green pellets
- Energy-efficient and environment-friendly thermal circuit of an indurating machine

INNOVATIVE TECHNICAL SOLUTIONS
- Slurry averaging in tanks with agitators
- Application of high-efficiency mixers for blend components’ mixing
- Installation of bins for blend conditioning prior to pelletizing
- Application of water-air nozzles in pelletizers
- Collecting & distributing conveyor with a reciprocating discharge section for green pellets
- Air-tight and water-proof longitudinal seals at the MOK-1-592M indurating machine
- Flexible pellet screening and handling system for fired pellets
- Sheltered warehouse for product pellets

Diagram:
- 2 radial thickeners D = 50 m
- 18 disc vacuum filters
- 3 groups of bins
- 8 pelletizing lines with an individual three-product roller screen each
- Blend components preparation
- Pelletizing
- Heat treatment
- Blast furnace process
- Direct reduction process
FILTRATION, PRODUCTION AND FEEDING OF GREEN PELLETS ONTO THE INDURATING MACHINE

Control over the balling process

CALCULATION OF SET POINTS:
1. Stabilization of blend feed rate to pelletizers
2. Control over:
   - rate of a binder (bentonite)
   - water feed rate to pelleting
   - drum screen rotation speed
   - rotation speed of roller feeder rollers

SLURRY FILTERING
- 3 process lines with 6 disc vacuum filters each (1 filter in each line as standby);
- 3 vacuum systems;
- 3 compressed air systems for cake blowing

UNIQUE MATERIAL HANDLING SYSTEM
- Reduction in the number of transfer points and transfer height
- Uniform distribution across the width
- Reduction in the amount of recycled/return product - energy saving
- Consistent quality of green pellets

Point of feeding of pellets to a collecting conveyor is selected automatically
MOK-1-592M THERMAL CIRCUIT
OF THE NEW GENERATION STRAIGHT-GRATE INDURATING MACHINE DEVELOPED BY NPVP TOREX

PRINCIPAL SOLUTIONS

- 3-section drying area preventing overmoistening
- Selective feeding of the cool medium from the cooling zone
- Optimal distribution of the heat medium by process zones
- Fan-less gas recycling mains (2 collecting mains/manifolds)
- No dedusting of gases in recycled gas ducts
- Application of injection burners
- Gas ducts and collecting mains/manifolds ensuring minimum aerodynamic resistance
- Flexibility of in-furnace thermal and gas flow mode

EFFICIENCY

- High recycling rate of the heat medium
- Rational proportioning of loads on process fans (max efficiency)
- Low volume of off gases
- Low natural gas and power consumption

### Item | Parameter | UOM | Values
--- | --- | --- | ---
1 | Annual production (output) | mln. t | 5.0
2 | Specific production rate | t/m²·h | 1.07
3 | Specific fuel consumption | nm³/h | 9.5
4 | Specific power consumption (Fans) | kWt/ton | < 36 (22)
5 | Volume of off gases transferred to the off gas stack | nm³/h | 1400
6 | Compression strength | kg/pellet | > 250
## Types of Raw Materials and Pellets Quality

<table>
<thead>
<tr>
<th>Raw material type</th>
<th>Ordinary concentrate MGOK</th>
<th>Flotation concentrate MGOK</th>
<th>Mix MGOK+LGOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFe, %</td>
<td>60,6</td>
<td>58,9</td>
<td>63,3</td>
</tr>
<tr>
<td>FeO, %</td>
<td>0,64</td>
<td>0,65</td>
<td>1,00</td>
</tr>
<tr>
<td>CaO</td>
<td>4,38</td>
<td>4,1</td>
<td>0,62</td>
</tr>
<tr>
<td>SiO₂</td>
<td>8,20</td>
<td>8,5</td>
<td>8,49</td>
</tr>
<tr>
<td>MgO</td>
<td>-</td>
<td>1,7</td>
<td>0,35</td>
</tr>
<tr>
<td>Basicity CaO/SiO₂, %</td>
<td>0,534</td>
<td>0,482</td>
<td>0,073</td>
</tr>
<tr>
<td>Contraction strength, kg/pel</td>
<td>279,0</td>
<td>294</td>
<td>273,0</td>
</tr>
<tr>
<td>Tumble index +5 mm,%</td>
<td>97,75</td>
<td>96,83</td>
<td>97,00</td>
</tr>
<tr>
<td>Tumble index -0,5 mm,%</td>
<td>2,25</td>
<td>2,98</td>
<td>2,65</td>
</tr>
<tr>
<td>LTD +6,3 (ISO 13930), %</td>
<td>95,72</td>
<td>91,72</td>
<td>98,09</td>
</tr>
<tr>
<td>LTD -3,15 (ISO 13930), %</td>
<td>3,02</td>
<td>6,48</td>
<td>1,67</td>
</tr>
<tr>
<td>LTD -0,5 (ISO 13930), %</td>
<td>2,63</td>
<td>6,03</td>
<td>1,57</td>
</tr>
<tr>
<td>RI (ISO 4695), %</td>
<td>66,6</td>
<td>51,17</td>
<td>49,9</td>
</tr>
</tbody>
</table>
MOK-1-592M
POWER AND ENVIRONMENTAL EFFICIENCY IN EACH DESIGN ELEMENT

MINIMUM POWER CONSUMPTION ON THE TRANSFER OF THE HEAT MEDIUM. STABILIZATION OF FLOW VELOCITY
- aerodynamic shape of recuperating mains/manifolds
- Attachment of the combustion chamber downcomers with the recuperating main at 45 deg
- directional attachment of wind-box branch pipes with conical collecting mains/manifolds.

INJECTION BURNERS
- small volume of air for combustion
- low NOx

ELECTROSTATIC PRECIPITATORS
Hydraulic resistance of less than 200 Pa
Dust cleaning efficiency up to 98%

SWIRLERS
Rapid temperature averaging of the gas mixture transferred to the preheating zone

LINING AND INSULATION
- Efficient advanced materials
- Low heat losses via the outer surface

Drying 1 hood with distributed air input
Central and side recuperating mains
Drying 2 hood
Drying 3 hood
MOK-1-592M
POWER AND ENVIRONMENTAL EFFICIENCY IN EACH DESIGN ELEMENT

3-SECTION DRYING ZONE

- Removal of physical and chemical bound moisture rapidly, without the decomposition of green pellets
- Flexibility in the selection of drying modes for different types/grades of pellets

THREE RECUPERATING MAINS

- Uniform flow temperature as opposed to the recuperating mains of a large diameter
- Lower hydraulic resistance to the flow and lower losses on the hot air transfer
- Decreased height of an indurating building - savings on capital expenses

1st section with the updraft of gases of 250°C ensures minimum overmoistening and maximum removal of the capillary moisture
2nd section with the downdraft of gases of 300°C - preparation for the intensive treatment
3rd section: gases of 550°C are supplied by a designated ‘hot medium’ process fan
Torex®

**Intelligent subsystems**

- Group control over start and stop of the continuous handling systems
- Ratio between the green pelletizing area and indurating area outputs
- Optimization of green pelletizing with the Granulometer technology

**Contactless Measuring System**

Measurements and numerical processing:
- Grain-size composition
- Shape coefficient
- Roughness index
- Moisture content

**Sampling Tower**

Automated evaluation of the product quality

**Management of Information Flows in the DCS of TKOM-3**

**Process Algorithms for Production Management**

1. A slot sampler;
2. A sleeve chute;
3. A belt conveyor;
4, 14, 16 - Weighing hoppers;
5, 15 - Belt reversible conveyors;
6, 8, 10 - Sector-type dividers;
7. A jaw crusher;
9. A roller crusher;
11. A ball mill;
12. An analytical scale;
13. A single-sieve vibrating screen;
17. A quartering device;
18. A platform scale;
19. A compression strength evaluation system;
20. A drum for mechanical properties' tests.
## COMPARATIVE ANALYSIS OF PERFORMANCE INDICES OF THE MOK-1-592 INDURATING MACHINE WITH SIMILAR MACHINES

<table>
<thead>
<tr>
<th></th>
<th>UOM</th>
<th>Mikhailovsky GOK MOK-1-592</th>
<th>Karelskiy Okatysh Pellet Plant</th>
<th>Kachkanarsky GOK</th>
<th>Lebedinsky GOK</th>
<th>OEMK</th>
<th>Severniy GOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine vendor</td>
<td></td>
<td>UZTM/Uralmash</td>
<td>UZTM/Uralmash</td>
<td>UZTM/Uralmash</td>
<td>UZTM/Uralmash</td>
<td>Outotec</td>
<td>UZTM/Uralmash</td>
</tr>
<tr>
<td>Machine area</td>
<td>m²</td>
<td>592</td>
<td>520/536</td>
<td>228</td>
<td>306</td>
<td>480</td>
<td>306</td>
</tr>
<tr>
<td>Production rate/Output</td>
<td>t/h</td>
<td>631</td>
<td>540</td>
<td>200</td>
<td>270</td>
<td>473</td>
<td>263</td>
</tr>
<tr>
<td><strong>Specific production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption on fans</td>
<td>kWt*h/t</td>
<td>22</td>
<td>36.14</td>
<td>33.8</td>
<td>45.1</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>Specific fuel consumption</td>
<td>m³/t</td>
<td>9.5</td>
<td>7.92 kg/ton (fuel oil)</td>
<td>20.6</td>
<td>15.9</td>
<td>9.4</td>
<td>18.8</td>
</tr>
<tr>
<td>Specific heat consumption</td>
<td>MJ/ton</td>
<td>303</td>
<td>317</td>
<td>686</td>
<td>506</td>
<td>303</td>
<td>599</td>
</tr>
<tr>
<td>Specific volume of gases in a waste gas stack</td>
<td>m³/t</td>
<td>1400</td>
<td>2700</td>
<td>3400</td>
<td>3000</td>
<td>2200</td>
<td>3400</td>
</tr>
</tbody>
</table>
# REFERENCE PROJECT IN IRAN

## PERFORMANCE INDICES OF THE 672 m² INDURATING MACHINE

### SANGAN 1

<table>
<thead>
<tr>
<th>Customer</th>
<th>Plant Type &amp; Capacity</th>
<th>Area, m²</th>
<th>Feed Material &amp; Fuel</th>
<th>Design Rates</th>
<th>Product Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMIDRO</td>
<td>Pelletizing Plant 5Mty</td>
<td>672</td>
<td>Hematite/Magnetite blend</td>
<td>654 38 24.8</td>
<td>DR grade 250 6.0 94.0</td>
</tr>
<tr>
<td>Sangan Pelletizing Plant 1 Iran</td>
<td>Straight-grate indurating machine</td>
<td></td>
<td></td>
<td>654/670 38/30 24.8/15.4</td>
<td>DR grade 250/280 6/2.5 94/97.2</td>
</tr>
</tbody>
</table>

### SANGAN 2

<table>
<thead>
<tr>
<th>Customer</th>
<th>Plant Type &amp; Capacity</th>
<th>Area, m²</th>
<th>Feed Material &amp; Fuel</th>
<th>Design Rates</th>
<th>Product Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobarakeh Steel</td>
<td>Pelletizing Plant 5Mty</td>
<td>672</td>
<td>Hematite/Magnetite blend</td>
<td>654 38 24.8</td>
<td>DR grade 250 6.0 94.0</td>
</tr>
<tr>
<td>Sangan Pelletizing Plant 2 Iran</td>
<td>Straight-grate indurating machine</td>
<td></td>
<td></td>
<td>654/670 38/30 24.8/15.4</td>
<td>DR grade 250/280 6/2.5 94/97.2</td>
</tr>
</tbody>
</table>

**Design values / values during the performance guarantee tests**

**Fast**

**Efficient**

**Cutting-Edge**
<table>
<thead>
<tr>
<th>Name</th>
<th>Performance index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic impact:</strong></td>
<td></td>
</tr>
<tr>
<td>Additional output of product pellets</td>
<td>5.2 mln. t/year</td>
</tr>
<tr>
<td><strong>Environmental impact:</strong></td>
<td></td>
</tr>
<tr>
<td>Reduction of nitrogen dioxide emissions</td>
<td>75 %</td>
</tr>
<tr>
<td>Reduction of nitrogen oxide emissions</td>
<td>75 %</td>
</tr>
<tr>
<td>Reduction of dust emissions</td>
<td>10 %</td>
</tr>
<tr>
<td><strong>Social impact:</strong></td>
<td></td>
</tr>
<tr>
<td>Creation of additional jobs</td>
<td>267 jobs</td>
</tr>
<tr>
<td>Additionally employed</td>
<td>604 pax</td>
</tr>
</tbody>
</table>
Thanks for your attention!