The first results of the project

REGIONAL MATERIALS SCIENCE AND TECHNOLOGY CENTRE

in the company

MATERIAL AND METALLURGICAL RESEARCH Ltd.

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Managing Director and Chief Executive Officer

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CONTENT:

- Presentation of the company MATERIAL AND METALLURGICAL RESEARCH Ltd.
- Presentation of the project REGIONAL MATERIALS SCIENCE AND TECHNOLOGY CENTRE
- Possibilities and the first results of the project REGIONAL MATERIALS SCIENCE AND TECHNOLOGY CENTRE

- Research programme No.3 - FORMING PROCESSES
- Research programme No.4 - MATERIAL PROPERTIES
- Research programme No.6 - LIQUID METAL
History of company

- MATERIAL AND METALLURGICAL RESEARCH Ltd.

- The Research and Testing Institution were founded by the Director’s by law within the Vítkovice Ironworks of June 1946

- MMR continues the company research - development activities in the field of metallurgy, conventional and nuclear power and materials engineering
WHO ARE WE?

Since its foundation in 1946 the company had gone through a long transformation process, modernization and transformation. At present it is an independent research and development organization.

The constitution of owners:

- TŘINECKÉ ŽELEZÁRNY, J.S.C. 89 %
- VŠB – Technical university of Ostrava 10 %
- VÍTKOVICE, J.S.C. 1 %
MATERIAL & METALLURGICAL RESEARCH Ltd. is a RESEARCH ORGANISATION which means that the company fulfils the conditions given by the Czech legislature and the Framework of European Community for state support of research, development and innovations (2006/C 323/01).
What we do?

- Research of production technology and steel castings
- Research processes of secondary metallurgy
- Research of advanced technologies and controlled deformation by universal torsion Plastometr SETARAM, physical and mathematical modeling
- Testing of strength, fatigue and fracture behaviour in an accredited laboratory No. 1300
What we do?

- Evaluation of corrosion cracking resistance in the water environment of high temperature and pressure
- Evaluation of creep properties and material degradations
- Chemical analyses and oxide materials in the accredited laboratory No.1300
What we do?

- Production of special steels into ingot or electroslag remelting steels weighing up to 1 700kg
- Development and production of testing machines and equipment
LAboratory of Fatigue and Fracture Behaviour

Accredited testing laboratory No. 1300

- expert’s activities in the field of testing materials
- development of test methods on order

Accredited procedures

Testing of mechanical properties, fatigue and fracture behaviour, determination of tensile and plastic properties and welded joints by penetration test and brittle-ductile test.

Penetration test
CHEMICAL LABORATORY

ACCREDITED TESTING LABORATORY No.1300

- analysis of special steel grades and alloys inc. of development of new analytical methods
- special analytical methods focussed on determination of phases in steel (nitrides and carbides)
- expert's activities especially in the field of environmental protection
- development of waste treatment technologies.
- assessment of corrosion resistance of material by HIC and SCC tests in hydrogen sulphide

Accredited procedures

Analyses of metallic and oxide materials of iron and iron alloys production, analyses of gaseous, liquid and solid wastes including their extracts, assessment of corrosion resistance of material by HIC and SCC tests in hydrogen sulphide.
Company MATERIAL AND METALLURGICAL RESEARCH Ltd. as a partner of the project

Regional material science and technology centre

In Operation programme of EU „Research and Development for Innovation“, priority line 2
Regional R&D centres CZ.1.05/2.1.00/01.0040

Project grant recipient: VŠB- Technical University of Ostrava
This project is financed by the structural funds of EU and by the state budget of the Czech Republic
Project budget (100% subsidy) – 171 026,750 tis. Kč

- Eligible investment expenditures 139 000 tis. Kč
- Non-eligible investment expenditures 32 026,750 tis. Kč
Company MATERIAL AND METALLURGICAL RESEARCH Ltd. as a partner participates in three research programs RMSTC project:

- **RP No.3** – Control of specific properties of intensively rolled and thermo-mechanically processed materials by using their structural potential (Forming)

- **RP No.4** – New sources of strength and toughness of materials for demanding technological applications (Material properties)

- **RP No.** – Experimental verification of new technological procedures of metallic materials with high quality parameters (Liquid metal)
1. Physical modeling

- **Universal torsion plastometer SETARAM (upgrade)**

Research on the basic deformation behaviour of materials under heat, dynamic recrystallization, the simulation of forming processes with the possibility of verification microstructure on small samples. Torsion and tension test and combination.
1. Physical modeling

- *Drop weight testing machine for verification the influence of strain rate on formability of metals*

Research on the influence of high strain rates on the hot plasticity limit, respectively, embrittlement of the material by heat. The pressure and tension test at high temperatures (start up 2012)
1. Physical modeling

- **Laboratory facilities for research in technological processes of rolling seamless pipes**

  Universal rolling mill for production of seamless tubes. Departments of heat treatment of tubes cut to verify the heat treatment (hardening, tempering) with subsequent evaluation of the mechanical properties and microstructure of the standard specimens. (start - up 2013)
1. Physical modeling

- *Universal rolling mill for production of seamless tubes*
1. Physical modeling

Technical parameters of laboratory

1. **Rolling mill**
   - Temperature: max 1250° C
   - Weight of billet: 1,1 – 9 kg
   - Work-rolls angles: rotation of roller 0 ÷ 7,5°; inclination of roller axis ± 15°
   - Max. diameter of rolles : 200 ÷ 240 mm
   - Work-rolls speed: 20 ÷ 180 ot/min,
   - Piersing rolling - billet: Ø 50 ÷ 60 mm, délka 200 – 400 mm
   - Elongation – billet : Ø 50 ÷ 60 mm, délka 400 – 800 mm

2. **Department of heat treatment of pipes**
   - Furnace for quenching – up 1100 °C, max. batch size Ø 410 - 1000 mm;
   - Furnace for tempering – up 700 °C , max. batch size Ø 410 - 1000 mm;
   - Quenching equipment-tank, shower, mist quenching medium is water or polymer.
2. Mathematical modeling
Numerical simulation of forming technology

Solidworks 2012 – software for creating 3D models;
Forge 2011 – Numerical modeling of forming processes using finite element method (FEM);
- Temperatured field and stress-strain analysis of the workpiece;
- Numerical simulation of phase transformation, the final microstructure and mechanical properties.
Magma – Numerical modeling of the liquid phase using the finite difference method (FDM);
- Research on the influence of metallurgical parameters in the relation to the forming process.
MAGMA
Ingot casting
FORGE
Free forging

Effective strain

Temperature

Effective strain
Numeric simulation of penetration test

SPT - comparison of simulation results with experimental data for various LC criteria

Effective stress

Tenzor ZZ

LC – Latham-Cockroft criterion
Cold Wire Drawing

Stress tensor YY

Lemaitre criterium
Hydroforming of thin-walled welded pipe for automobile industry

Effective strain

Wall thickness
Rolling processes of seamless tubes (so-called „Big Manesmann“ in TŽ J.S.C.)

Effective strain during rolling process
Air quenching of the cutting tool

Temperature field

Frontier of 20% volume fraction of ferrite in the microstructure
2. Mathematical modeling
Statistical data processing

- Statgraphic Centurion, Mathematica, Eviews;
- Processing and statistical analysis of production data and databases;
- Suggestion of appropriate mathematical description (model).
Numerical analysis of thermodynamic stability of phases and its chemical composition and kinematic transformation of phases

- ThermoCalc a Dictra; multicomponent systém (steels, Ni alloys, slags, oxide);
- Phase stability in thermodynamic stable state of creep resistant materials;
- Diffusion processes, e.g. heterogeneous welded joint.
Servohydraulic testing machine is developed both for static and dynamic tests. Primarily is focused on testing of miniaturized specimens for evaluation of conventional as well as unconventional mechanical properties in temperatures range from -196°C up to 1000°C.
Developed for high cycle fatigue testing of specimens with diameter between 5 and 30 mm. Possible to used for Nakamura tests - evaluation of effect of metallurgical cleanness on fatigue properties.
Servohydraulic testing machine allows to carry out tensile tests, fatigue tests (high cycle as well as low cycle), fracture toughness tests, evaluation of crack growth rate etc. Test temperature range -196°C up to 1000°C.
Instrumented Charpy hammer allows to carry out Charpy impact tests (standard as well as instrumented) in the temperature range -196°C up to 500°C. Maximum energy is 450 J. Charpy test according ISO or ASTM standards.
Wavelength dispersive X-ray fluorescense spectrometer allows to analyse solid samples in the range of elements from fluorine after the uranium. It is suitable for the analysis of all types of steel, as well as slag, ash and sludge.
RP MATERIAL PROPERTIES
LABORATORIES
LECO analyzer
For evaluation of nitrogen, oxygen and hydrogen content

The combustion analyzer for the determination of nitrogen, oxygen and hydrogen in metals and inorganic materials.
the activities deal with R&D of methodics for testing of surface properties and with the result interpretation and transfer of obtained knowledge to industrial application

laboratory is equipped with new, advanced instruments
- GDOES spectrometer with SW for depth profile analysis (LECO GDS850A)
- C, S and N, O, H determinators (LECO CS600 and TCH600)
- SEM with microanalytical systems EDS, WDS and EBSD (QUANTA 450 FEG)
- climatic and corrosion chambers (CTS C-70/1350 and Liebisch KB300 for Kesternich test)

laboratory performs the analyses and evaluations of various types and states of surfaces/substrates to obtain
- new knowledge about interaction of materials and products with
Examples
- depth profile analysis and evaluation of multi-layer coating PA CVD
- evaluation of surface chemical treatment efficiency (pickling process)
- surface contamination after physical treatment (grinding) etc.
Quenching dilatometer for:
- Determination of linear and volume expansion coefficients
- Determination of transformation temperatures
Small Punch Creep Testing Machine V1.7

Testing machine to determine the operational life of plant components which work at elevated temperatures, by testing small samples.
RP MATERIAL PROPERTIES

PILOT PLANT PRODUCTION

CNC vertical machining center- QUASER MV 204CE

CNC vertical machining center for test specimens production
RP  MATERIAL PROPERTIES

PILOT PLANT PRODUCTION

CNC precision surface grinding machine – Jakobsen 1832 FL

CNC precision surface grinding machine for test specimens production
RP MATERIAL PROPERTIES

PILOT PLANT PRODUCTION
CNC electro-erosive wire divider

CNC electro-erosive wire divider fot test specimens production
RP MATERIAL PROPERTIES

PILOT PLANT PRODUCTION

CNC Lathe machine ACCUWAY UT 300L with inclined bedding, turret head and powered tools

CNC Lathe with inclined bedding, turred head and powered tools for test specimens production
The main unit of the metallurgical laboratory is VPIM (Vacuum and overPressuried Induction Melting furnace). The current state of the VPIM:

- Electric melting power: 600 kW
- Frequency of inductor: 1000 Hz
- Voltage: 2000 V
- Weight of molten metal: 1750 kg
- Dimension of melting crucible: diameter 610 mm, height 1000 mm
- Maximum height of ingot mould set: 2800 mm
- Working vacuum: 50 Pa (0.5 mbar) abs.
- Working pressure (argon or nitrogen): 0.5 Mpa
- Volume of VP chamber: 26.4 m3
- Height of VP chamber with a cover: 4250 mm
- Diameter of VP chamber: 3000 mm
RP LIQUID METAL
UP – GRADE of the VPIM

Casting to the casting ladle

After casting to the ingot mould set

General view VPIM
UP – GRADE of the VPIM

- The Up-Grade of the VPIM contains:
  - Increase of the performance vacuum station,
  - On-line temperature measurement,
  - On-line hydrogen measurement,
  - On-line CO and CO₂ measurement,
  - Argon/oxygen jet-on the surface of the molten steel,
  - Place for the bottom pouring.
Metallurgical laboratory:

- Study of the decarburization of molten steel (C < 0,01 %),
- On-line study of kinetic of dehydrogenization,
- Bottom pouring lead to better surface of the ingot and inner quality,
- On-line temperature measurement to control of metallurgical operations,
- Research and development of production technology high quality steels, high-alloyed steels and metal alloys,
- Possibility of physical simulation of chosen metallurgical operations of big metallurgical units (low pressure-vacuum, Ar/O jet,..).
RP LIQUID METAL

UP – GRADE of the VPIM

Example of current research work

Special steel for boilers was made on the VPIM

Tab. 1 Chemical composition specification and the melt in the casting ladle (after VPIM), grade 10Cr2WCoNB

<table>
<thead>
<tr>
<th>[Wt %]</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Mo</th>
<th>Cr</th>
<th>W</th>
<th>Co</th>
<th>V</th>
<th>N</th>
<th>B</th>
<th>Ni</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>min.</td>
<td>0,10</td>
<td>0,33</td>
<td>0,46</td>
<td>0,12</td>
<td>10,80</td>
<td>2,40</td>
<td>2,8</td>
<td>0,20</td>
<td>0,02</td>
<td>0,005</td>
<td>0,35</td>
<td>0,35</td>
</tr>
<tr>
<td>max.</td>
<td>0,12</td>
<td>0,42</td>
<td>0,54</td>
<td>0,16</td>
<td>11,20</td>
<td>2,60</td>
<td>3,0</td>
<td>0,25</td>
<td>0,03</td>
<td>0,008</td>
<td>0,45</td>
<td>0,45</td>
</tr>
<tr>
<td>Melt in the ladle after VPIM</td>
<td>0,11</td>
<td>0,40</td>
<td>0,49</td>
<td>0,16</td>
<td>11,14</td>
<td>2,60</td>
<td>3,0</td>
<td>0,24</td>
<td>0,03</td>
<td>0,007</td>
<td>0,45</td>
<td>0,38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[ppm]</th>
<th>P</th>
<th>S</th>
<th>Ti</th>
<th>Zr</th>
<th>Ca</th>
<th>Pb</th>
<th>Bi</th>
<th>As</th>
<th>Sb</th>
<th>Sn</th>
<th>Al</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>max.</td>
<td>200</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>Melt in the ladle after VPIM</td>
<td>120</td>
<td>100</td>
<td>60</td>
<td>&lt;60</td>
<td>&lt;7</td>
<td>30</td>
<td>&lt;30</td>
<td>60</td>
<td>30</td>
<td>30</td>
<td>&lt;40</td>
<td>2</td>
</tr>
</tbody>
</table>
Questions, please.................?
Contact

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Thank you for your attention