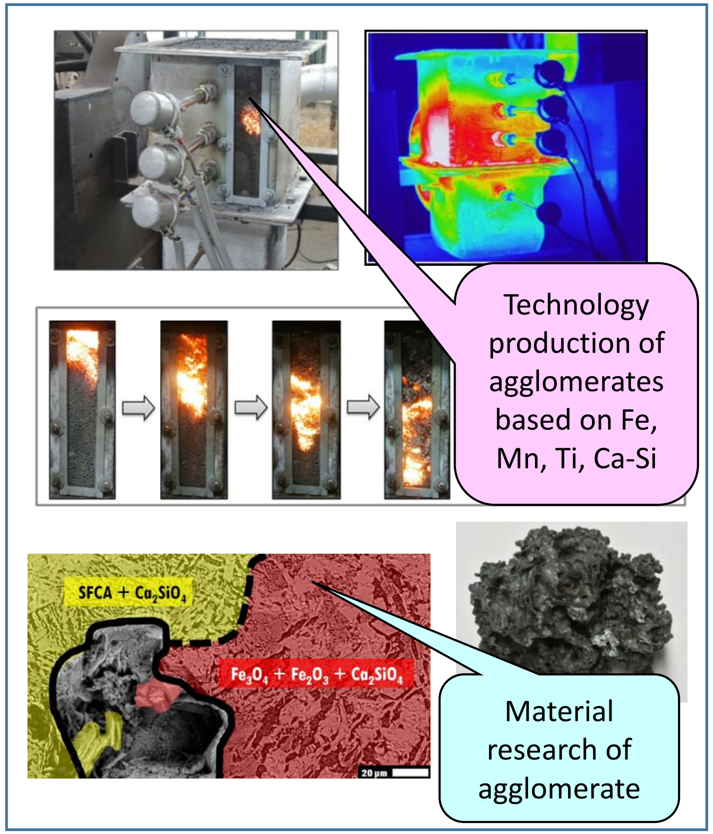
EÚ HORIZON-CL4-2024-TWIN-TRANSITION-01-3

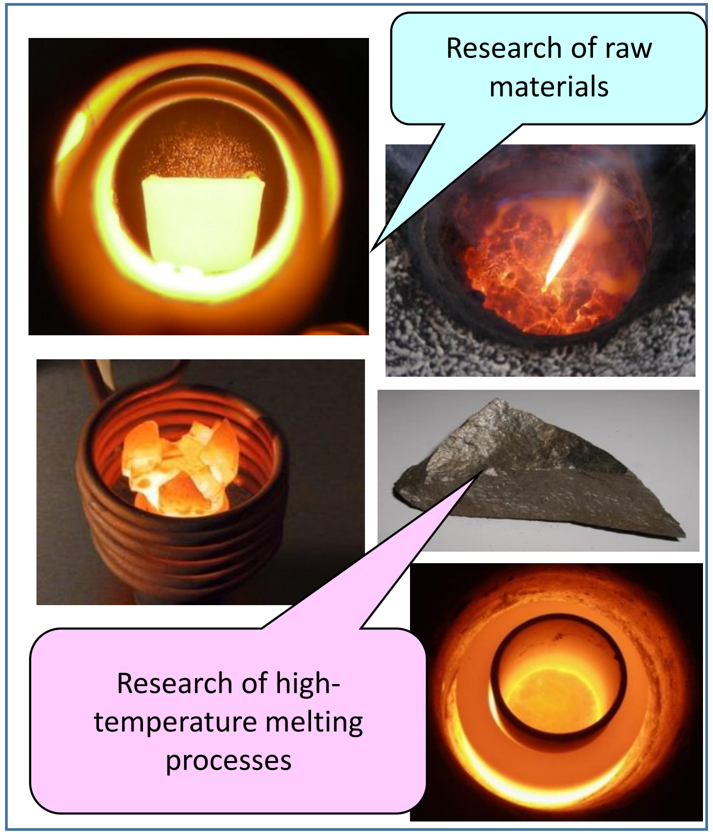
New Process Routes Enabling Mn Alloy production with H_2

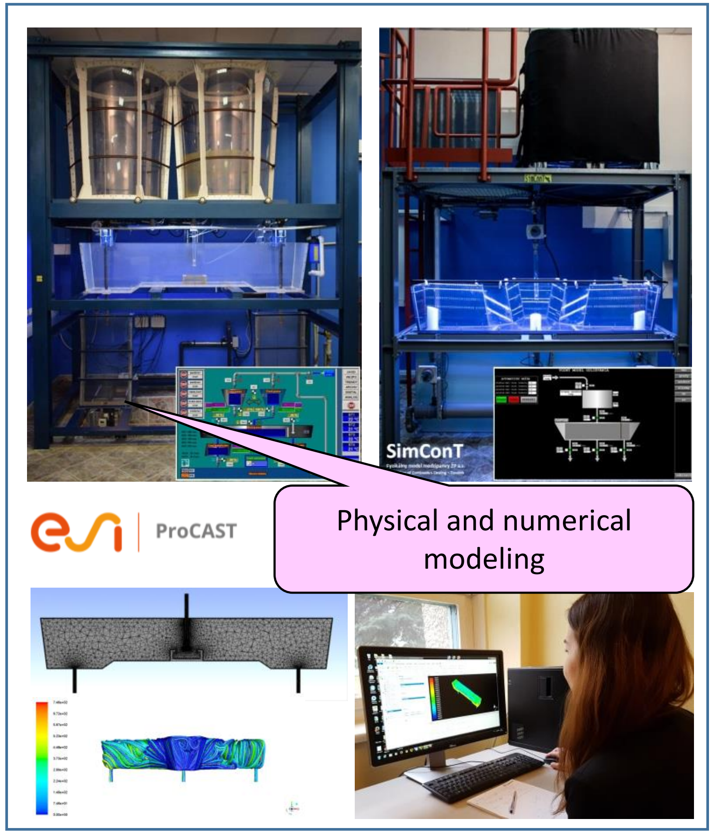
Consortium of 18 partners from 10 countries on 3 continents

Presentation of the partner (UMET FMMR TUKE)
in the project PreMa H_2

Research on UMET FMMR TUKE





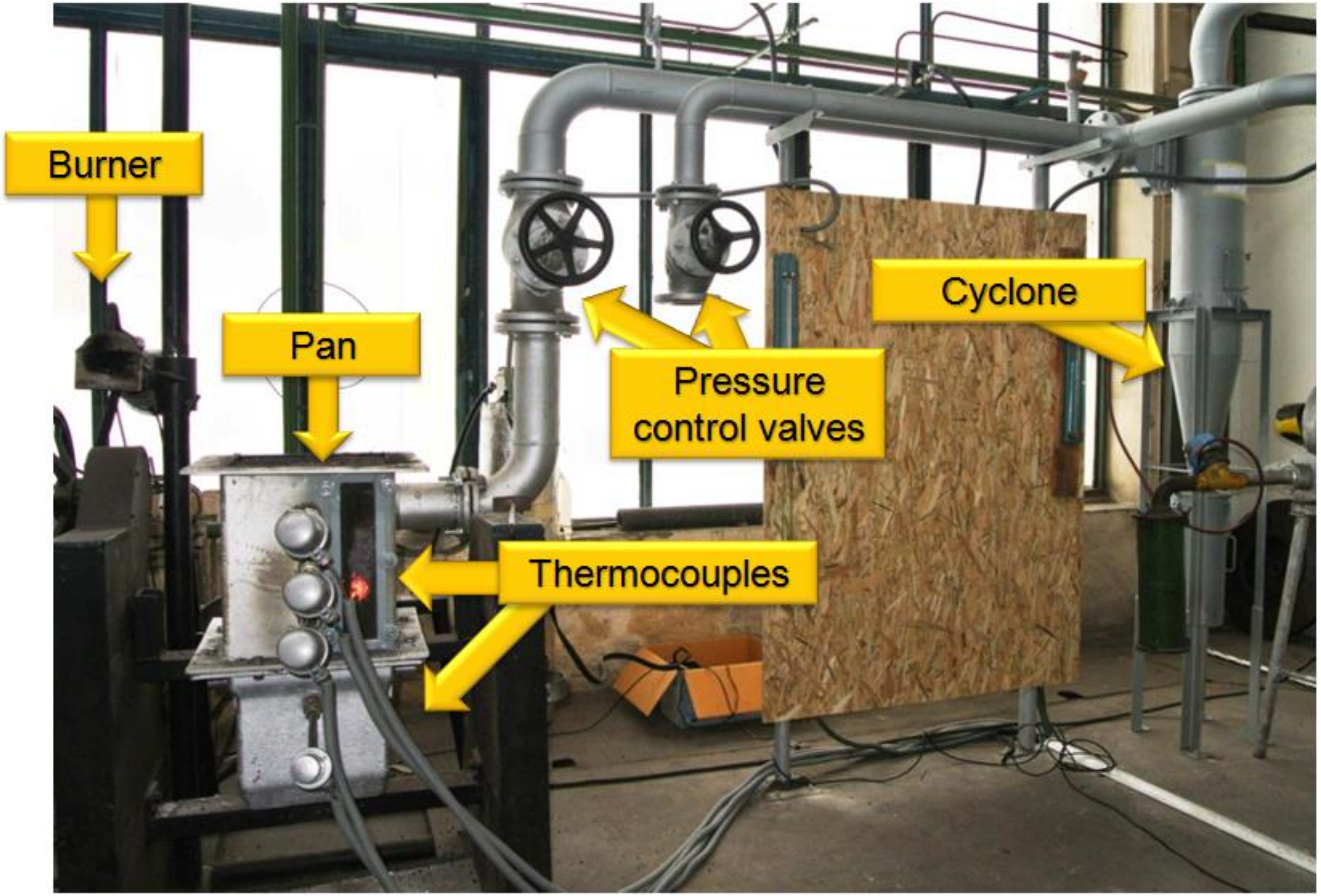


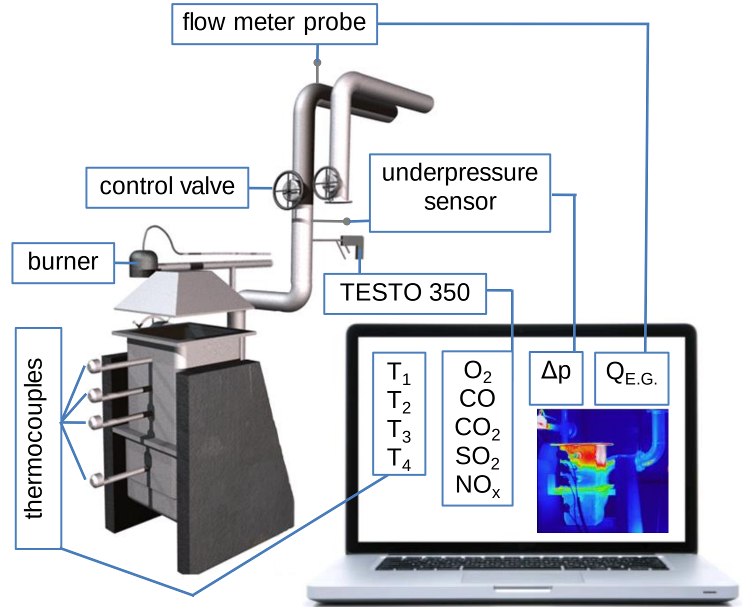
Laboratory of simulation of flow processes – LSPP

modelling of liquid steel flow processes in continuous casting

built in cooperation with:
U.S.Steel, Košice
Železiarne Podbrezová

Laboratory sintering pan



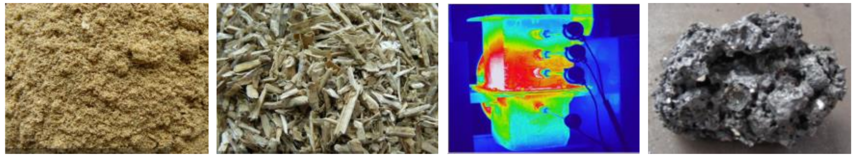


technology production of agglomerates based on Fe, Mn, Ti, Ca-Si

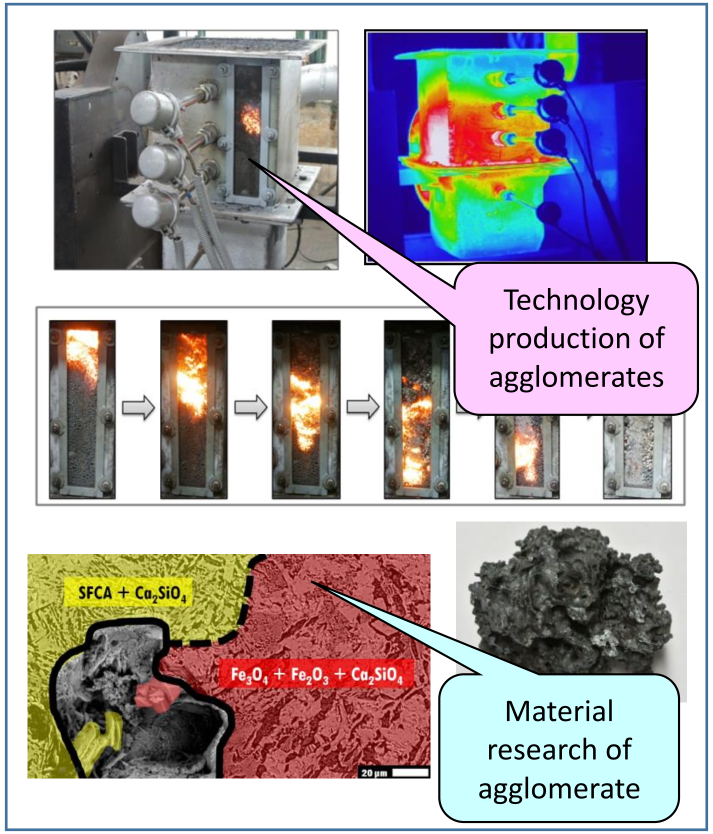
cooperation with:
KU Leuven (Belgium)
Třinecké železárny (Czech)
U.S.Steel, Košice (Slovakia)
OFZ (Slovakia)

Biomass in the sintering process

SLOVAK RESEARCH
AND DEVELOPMENT
AGENCY



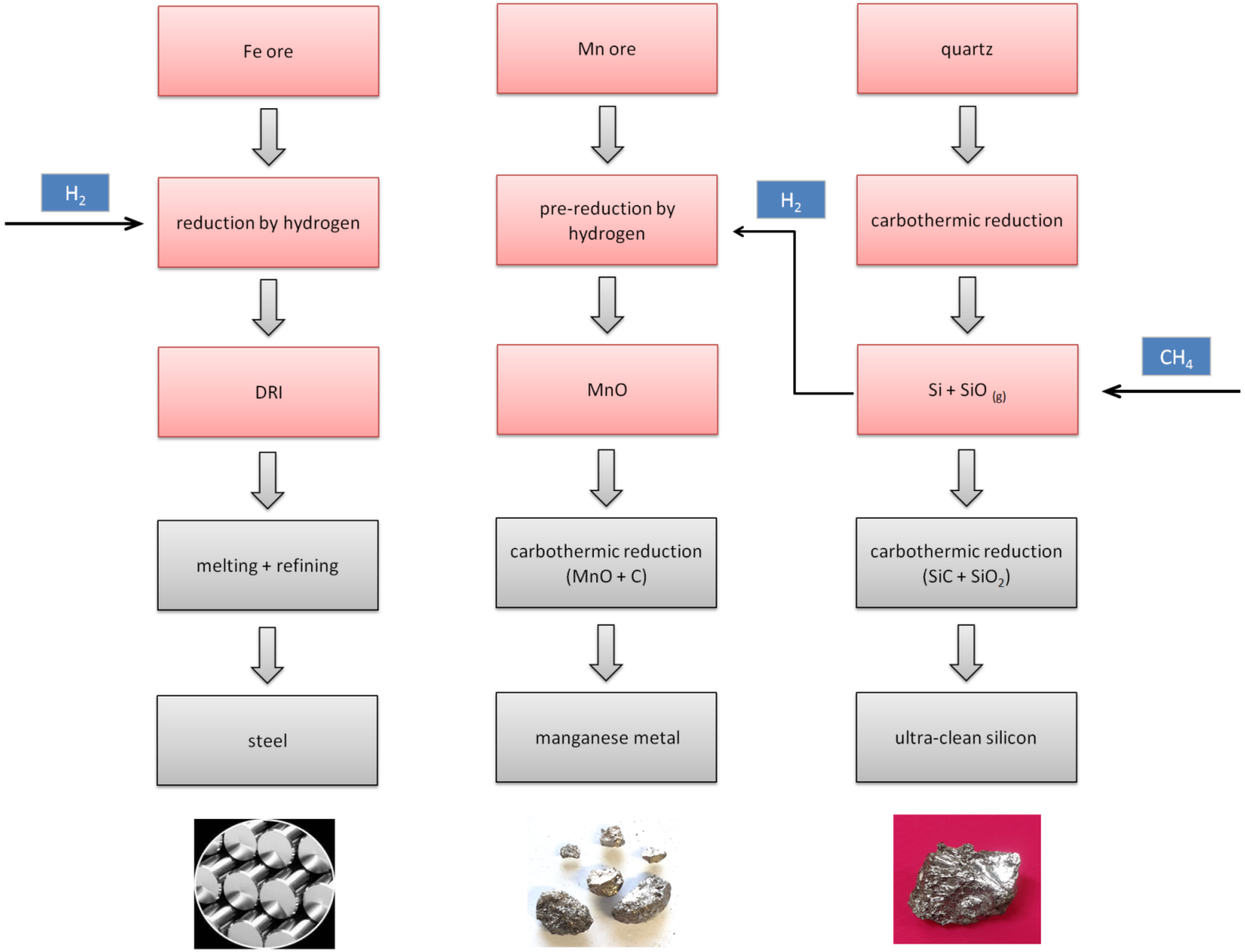
- charcoal, wood sawdust and nut shells were used for sintering,
- substitution in the agglomeration process by waste biomass is limited to a level of about 10-20%,
- types of biomass reduces the emissions of carbon, nitrogen and sulfur oxides by 5 – 40%,
- the quality of the agglomerate produced with the substitution of coke with biomass has not changed significantly at lower substitutions (8–14 %).



Hydrogen project in Slovakia (2022 – 2025)

The potential of hydrogen utilization in metallurgical industry of SR aimed on decrease of CO_2 production

SLOVAK RESEARCH AND DEVELOPMENT AGENCY



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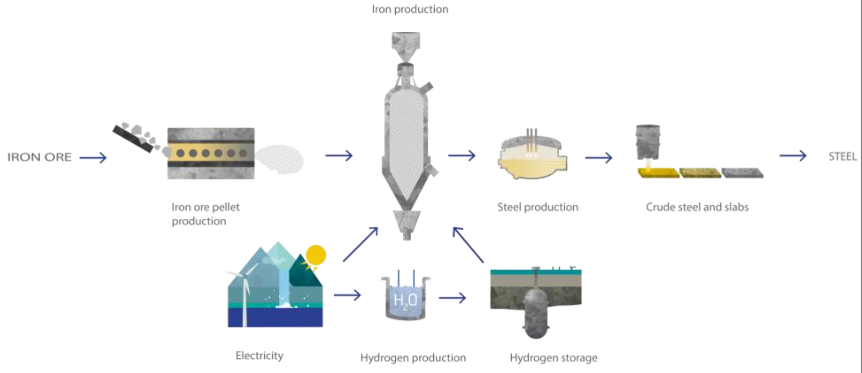
Analysis of current knowledge of hydrogen application as a reducing agent in metallurgical processes of iron production.

Potential Uses of Hydrogen in Metallurgy

- Enrichment of blast furnace gas with H_2
- Utilization of synthesis gas ($CO+H_2$) in direct reduced Iron (DRI) production
- **Direct reduction of ores using 100% H_2 as a reducing agent**
- Hydrogen production from coking gas
- Utilization of hydrogen-based protective atmospheres
- Reduction of iron Ore in hydrogen plasma

In the world, there are already technologies for utilizing hydrogen in metal production, most commonly in connection with the production of iron and steel (DRI, HBI) – **HYL/Energiron, SALCOS, H2FUTURE**



HYBRIT

Pilot testing of hydrogen as a reducing agent in semi-operational conditions

Laboratory research on the reduction of Fe materials using Hydrogen

Studied Fe materials

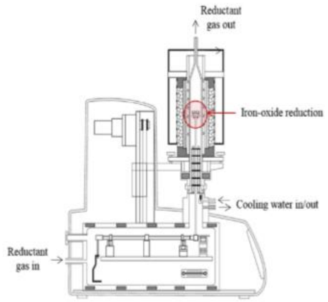
Ores/Concentrates

Pellets

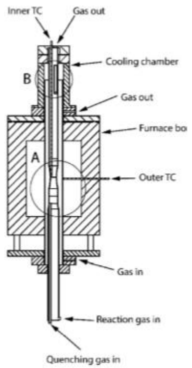
Synthetic Powders

Laboratory equipment

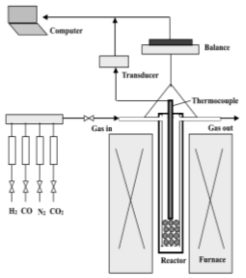
TGA Equipment



Fluidization equipment



Custom laboratory equipment



Monitored Parameters

- Influence of the composition of the reducing atmosphere
- Impact of reaction temperature
- Effect of Rreaction time
- Influence of Flow rate of reducing Gas

Insights into the use of Hydrogen as a reducing agent in the reduction of Fe materials

Reduction using H_2 occurs more intensely and rapidly than using CO or a mixture of H_2/CO

Hydrogen has a higher reduction and diffusion capacity than CO

The reduction by hydrogen occurs more intensively at higher temperatures (approximately 800°C)

H_2

The reaction rate and the degree of reduction increase with an increase in the reduction temperature

The reduction of hematite to magnetite and the reduction of magnetite to wüstite are very fast processes.

CO

The slowest step within the reduction reactions is the transformation of wüstite into iron

In the presence of CO in a mixture with H_2, a carbon precipitation reaction occurs, which slows down the rate of reduction

SLOVAK RESEARCH AND DEVELOPMENT AGENCY

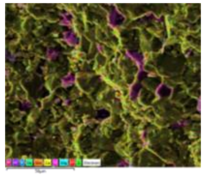
This work was supported by Slovak Research and Development Agency (APVV), Slovak Republic, No. **APVV-21-0142**

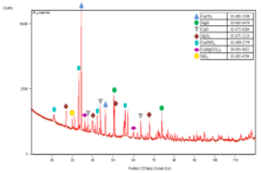
Comprehensive material research of Fe and Mn ores and assessment of possibilities for their reduction with hydrogen.

Methodologies for material research of Fe and Mn ores

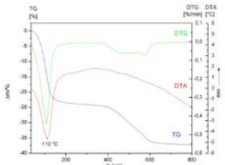

chemical composition


physical properties

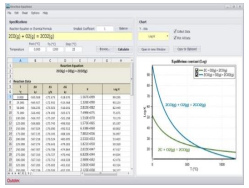

microstructure of grains


XRD composition


intervals of melting


DTG, DTA analysis


high – temperature of stability


thermodynamics models


reducibility

possibilities for reduction with hydrogen

Material research of Fe and Mn ores

Iron ore		 Krivbas (Ukraine)	 Rudomain (Ukraine)	 Carajas (Brazil)
Chemical composition (wt%)	Fe TOTAL	62.25	58.20	65.23
	SiO_2	7.80	13.40	2.21
	P	0.03	0.06	0.05
	S	0.03	0.01	0.01
Mineralogical composition	XRD	hematite, hydrohematite, quartz	hematite, hydrohematite, hydrated iron silicate, cronstedtite, quartz	hematite, quartz
Melting point (°C)		1472	1453	1540

Manganese ore		 Burkina Faso (Africa)	 Gabon (Africa)	 Ghana (Africa)	 RSA (Africa)
Chemical composition (wt%)	Mn TOTAL	52.05	53.09	37.73	34.32
	SiO_2	4.66	3.94	5.02	5.61
	P	0.07	0.04	0.08	0.03
Mineralogical composition	XRD	pyrolusite, manganite, pyrochroite, quartz	pyrolusite, quartz, magnetite	rhodochrosite, quartz	rhodochrosite, braunite, quartz, hematite
Melting point (°C)		> 1550	> 1550	1470	1410

The most suitable ores for pilot experiments of hydrogen reduction

iron ore  **Carajas**

Carajas contains easily reducible phase – hematite, high quality, high stability

manganese ore  **Gabon**

Gabon contains easily reducible phase – pyrolusite, high quality, high stability

SLOVAK RESEARCH AND DEVELOPMENT AGENCY

This work was supported by Slovak Research and Development Agency (APVV), Slovak Republic, No. **APVV-21-0142**

Presentation of the project PreMa H_2

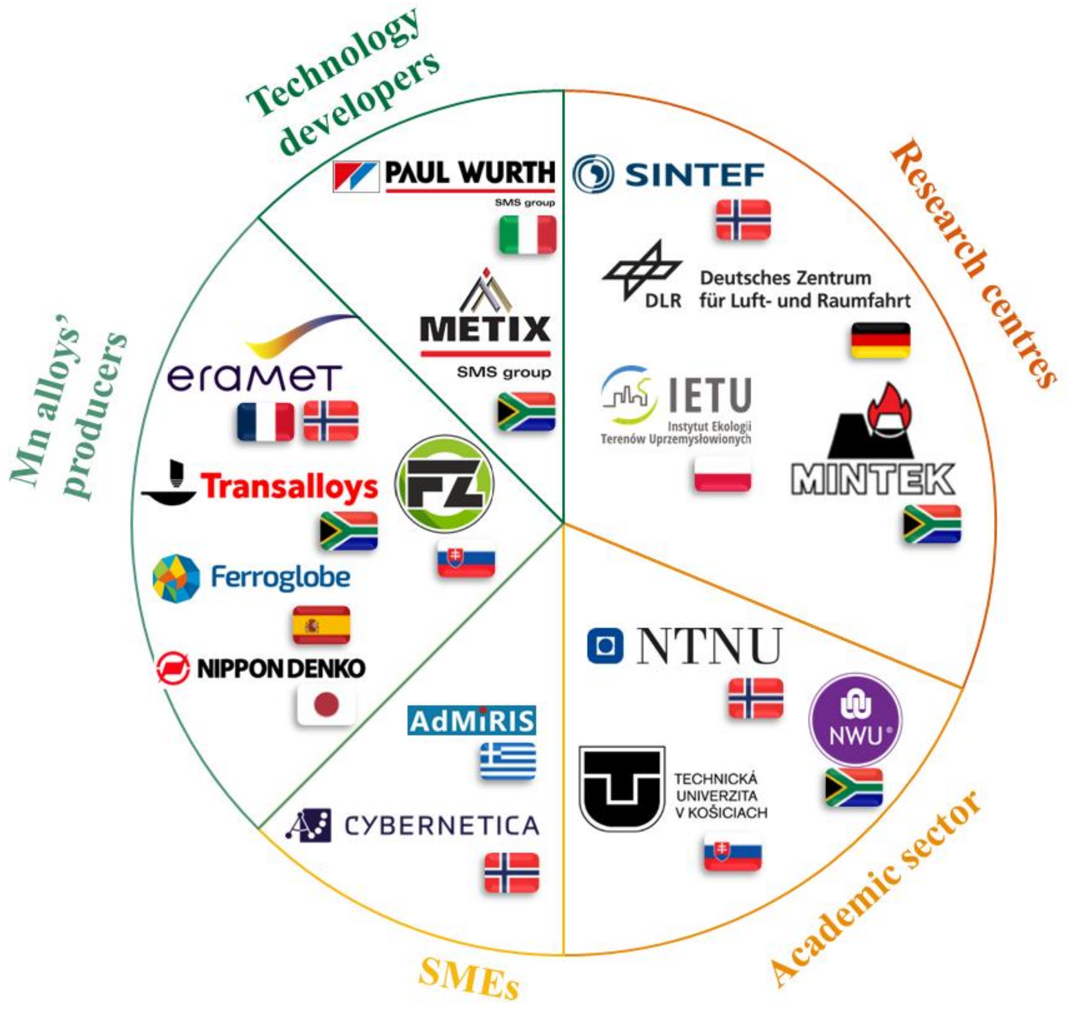
PREMA H_2

The upcoming project "New Process Routes Enabling Mn Alloy production with H_2 (PreMa H_2)" is focused on the reduction of CO_2 emissions and energy consumption in the production of Mn-alloys and the development of technologies for the use of gaseous hydrogen for the pretreatment and production of Mn-alloys. The best world research centers in the field of ferroalloy production are represented in the project, e.g. Sintef, NTNU, Swerim, Metix, Ferroglobe, Eramet, Mintek, etc. TUKE works in the consortium of the upcoming project, as a partner it will participate in research on the pre-reduction of Mn ores and in the framework of the use of hydrogen plasma in the production of Mn alloys.

Project submission deadline : 8.2.2024

Budget for TUKE : 402 000 €

Team leaders for TUKE : Jaroslav LEGEMZA, Róbert FINDORÁK



Objective

Reduced CO_2 emission and energy consumption in Mn-alloy production

- By pretreatment of Mn-ores to MnO in shaft furnace using of hydrogen (and other gases) and transfer of warm materials to SAF
- By Mn-alloy production in single step with hydrogen plasma and other new furnace technologies
- By integration of pretreatment technologies and new furnace technologies.
- By increased recirculation of waste streams through treatment with hydrogen plasma.
- By enable industrialisation of developed technologies through new measurements, modelling and control
- TRL 4-6

Activities TUKE in WP 4.3

- Analysis of plasma technologies using hydrogen
- Material research of Mn ores
- Creation of balance and thermodynamic models
- Laboratory experiments in reduction retorts
- Laboratory experiments in plasma furnace

Verification in semi-plant plasma reactor SILVERGAS (Slovakia)

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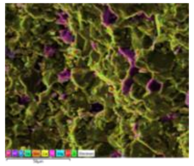
Department of power engineering

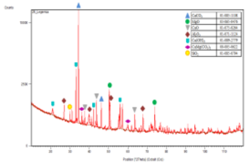
Activities TUKE in WP 4.3

chemical composition

physical properties

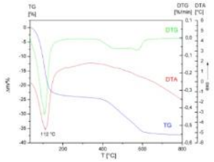


microstructure of grains



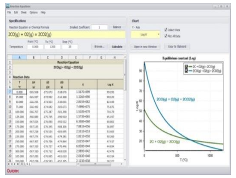
XRD composition

intervals of melting



DTG, DTA analysis

high – temperature of stability



thermodynamics models

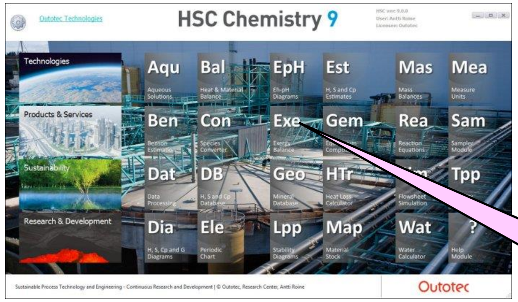
reducibility

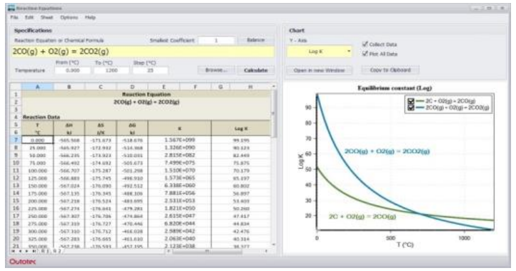
optimalization of properties

use for the production of a products with higher added value

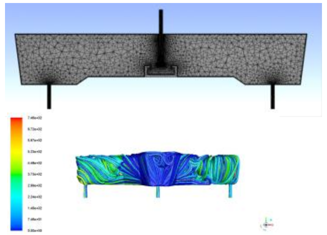
Material research for thermodynamics modeling and for prediction of laboratory experiments

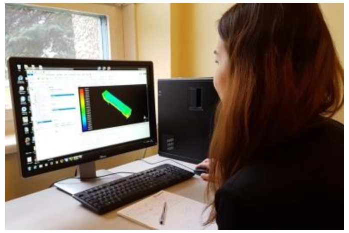
Software HSC Chemistry





Thermodynamical and numerical modeling





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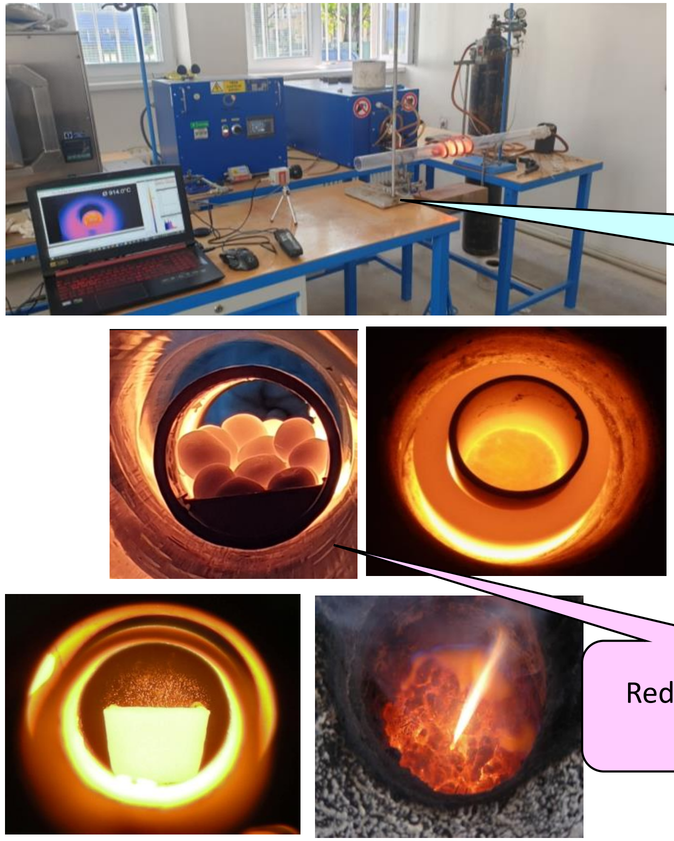
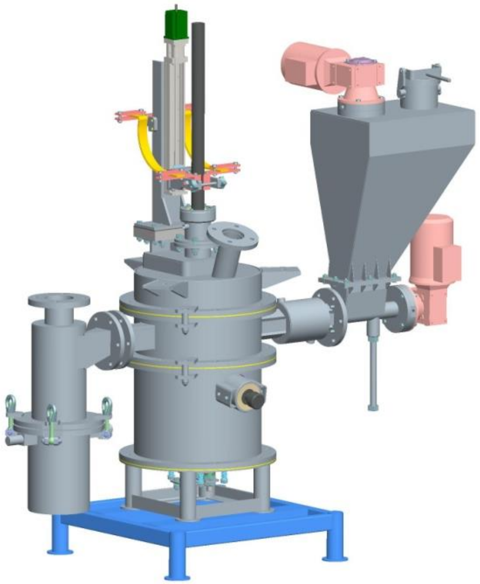
Activities TUKE in WP 4.3

Furnace equipments
(Marsh furnaces, high-frequency induction furnace, Tamman furnace, resistance retorts)



Laboratory 10 kVA plasma reactor



Test the influence of the quantity and flow of hydrogen on the reaction mechanism of Mn ore,
test the impact of hydrogen on the quantity and chemical composition of Mn alloys,
examine the effect of hydrogen on the quantity and composition of process gases.

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Outputs TUKE in WP 4.3

- New thermodynamic models
- Development of an interactive dynamic module with the application of material-thermal balance for reduction processes using hydrogen
- Application of new and original knowledge that will be applied to the design of a new industrial plasma furnace with a capacity of 3MW
- Creation of new fundamental scientific knowledge to determine the impact of hydrogen on the course of chemical reactions, to assess reduction levels, to determine energy consumption, and to establish the emission profile of CO-CO_2 during the production of Mn alloys in plasma furnaces
- Scientific articles in a peer-reviewed journals and scientific monograph