

Research Group for Process Metallurgy of Iron and Steelmaking, Indian Institute of Technology IIT Madras Chennai

Faculty: Dr. Ajay Kumar Shukla

Assistant Professor

Department of Metallurgical and Materials Engineering, IIT
Madras Chennai 600036 India

Office: 205, Materials Processing Section IIT Madras

Email: shukla@iitm.ac.in

Phone: 04422574762; 04422576762; 9445949765



Scope of Research Work

- **Process modeling, control and optimization of iron and steelmaking.**
- **Computational thermodynamics and its application to high temperature metallurgical processes.**
- **Application of Artificial Intelligence (ANN, GA) to metallurgical processes.**
- **Heat and Mass Transfer.**
- **Extractive Metallurgy**
- **Computer Aided Process engineering (CAPE)**

What is Process Metallurgy

Metallurgical engineering is concerned with extracting metals from their ores, their development and production at large scale for application and use of metallic materials. Metallurgical engineering which is based on the principles of science and engineering, may further be divided into **process metallurgy** and **physical metallurgy**. **Process metallurgy** which is concerned with extracting metals from their ores to make refined alloys, and physical metallurgy, which involves the shaping, alloying, heat treatment, joining, corrosion protection and testing of metals.

Research Areas

- Thermodynamics and kinetics of pyrometallurgical processes
- New technologies for iron-making, steelmaking and ferroalloy-making
- Reduction, smelting and refining processes
- Gas-solid reactions at high temperatures
- Ferrous and non-ferrous Extraction Metallurgy
- New Direct Ironmaking technologies (COREX/MIDREX)
- New developments in blast furnace iron-making
- Basic Oxygen (BOF) and Electric arc furnace (EAF) steelmaking
- Kinetics of liquid/solid/gas reactions in metallurgical processes
- Mathematical modelling of metallurgical processes
- Refractory reactions in metals processing
- Transport phenomena in process metallurgy
- Fluid flow, heat and mass transfer in packed and fluidised beds
- Heat transfer based modeling of continuous casting process
- Optimization of steel plant supply chain by evolutionary techniques
- Data based modeling of iron and steelmaking process (ANN/MTS/PCA etc.)



JSW-IITM Center for Applied Research (JICAR)



JSW-IITM Center for Applied Research is an Industry-Academic collaboration initiative to conduct research and to provide innovative technologies in the area of Iron and Steel. It was established in January 2014.

The team of JSW-IITM Center for Applied Research (JICAR) is multi-disciplinary in nature consisting of members from Chemical as well as Metallurgy department from IIT Madras side and similar composition from JSW Steel Plant side.



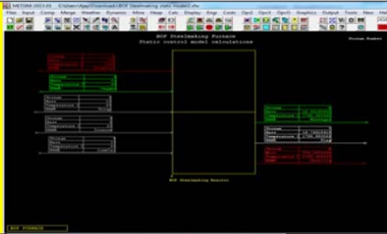
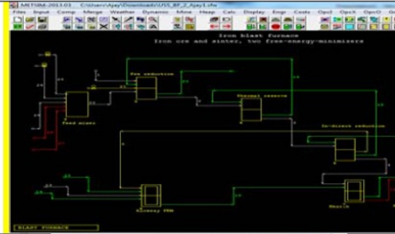
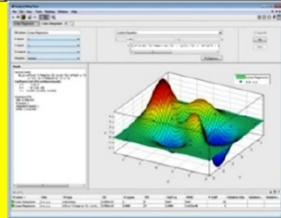
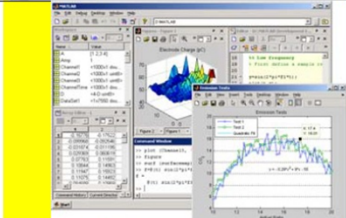

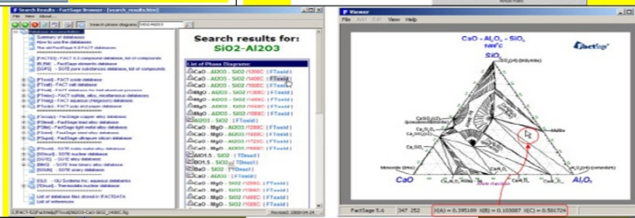
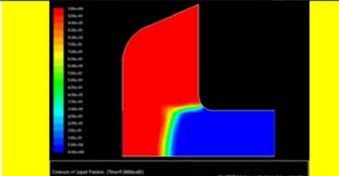
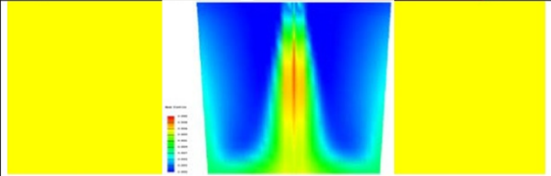

JSW-IITM Center for Applied Research (JICAR)



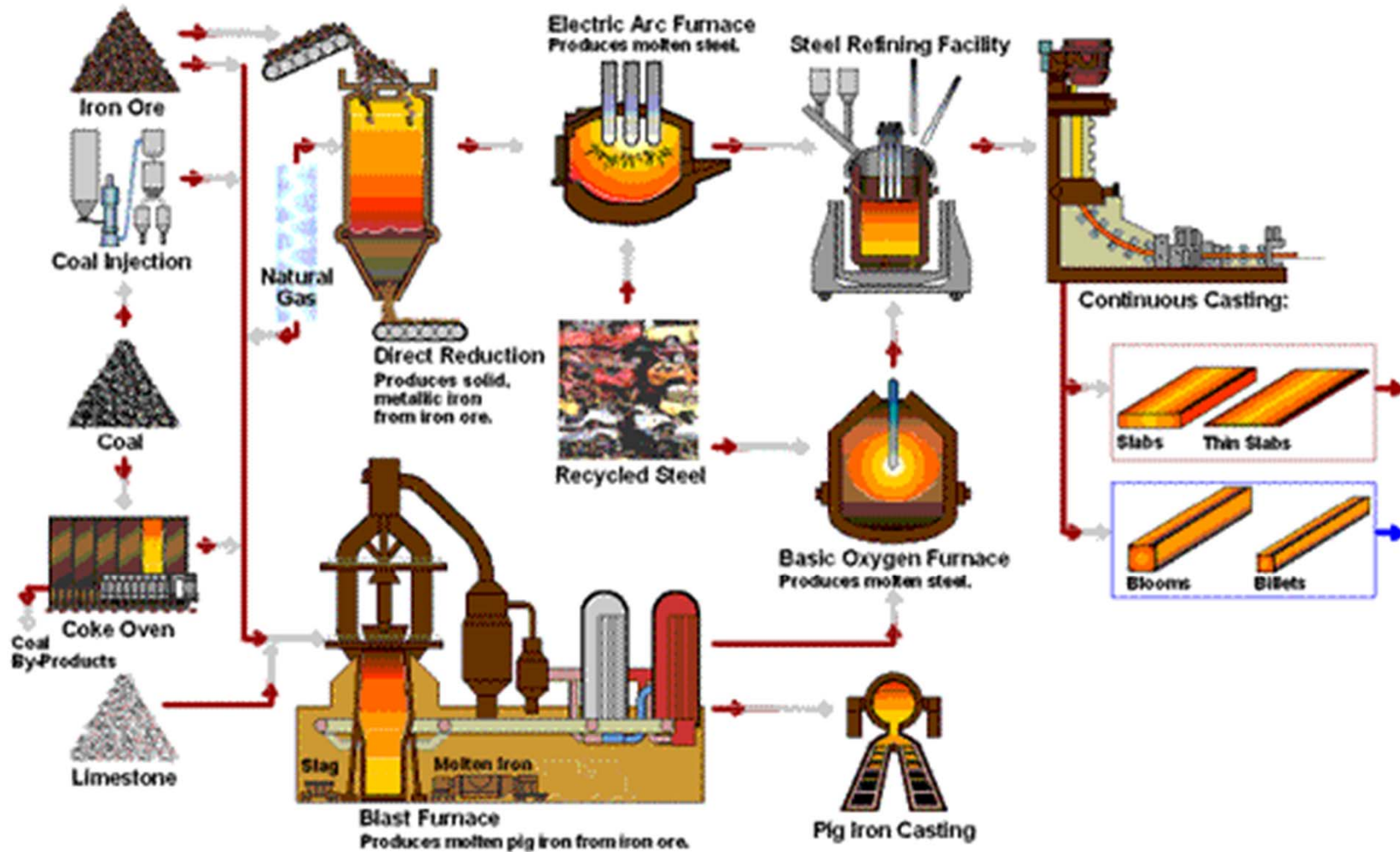
The projects under this center are mainly applied in nature for direct industrial application. Following Projects are underway with JSW Steel Plant under this Center:

1. Dry slag granulation process for energy recovery and clinker production
(Also supported and funded by Ministry of Steel, under Govt. of India)
2. Microwave assisted reduction roasting based beneficiation of lean quality iron ore and coal fines. (Supported by Ministry of Human Resources/JSW Steel, NMDC Ltd. project yet to start)
3. Static and Dynamic control of BOF Steelmaking process.
4. Development of dynamic control model for RH degassing process.
5. Data based models (ANN-GA based) for steel plant process control.
6. Development of Expert system for COREX Iron-making process

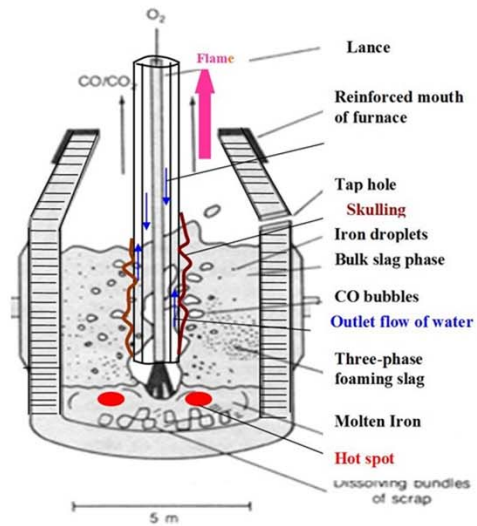
Modelling tools applied for simulation of iron and steelmaking processes

MetSim																																																																																		
MATLAB																																																																																		
FactSage																																																																																		
Fluent																																																																																		
Excel-VBA and Excel-Solver	 <table><tr><th colspan="2">Thermodynamic Data</th><th colspan="2">All Weights in Kgs</th></tr><tr><td>Hot Metal (KJ/Kg)</td><td></td><td>Hot Metal</td><td>Price(RxKgs) 5</td></tr><tr><td>Enthalpy of iron</td><td>1136.34515</td><td>Weight of Hot Metal</td><td>122852.508</td></tr><tr><td>Enthalpy of carbon</td><td>2857.444375</td><td>Composition of Hot Metal</td><td>%C Hot Metal 4.5 %Mn Hot Metal</td></tr><tr><td>Enthalpy of Silicon</td><td>3962.7425</td><td>Lime</td><td>Price(RxKgs) 5</td></tr><tr><td>Scrap</td><td></td><td>Weight of Lime</td><td>265.7142858</td></tr><tr><td>Enthalpy of iron</td><td>1136.34515</td><td>Composition of Line</td><td>%CaO Line 88 %SiO2 Line</td></tr><tr><td>Enthalpy of carbon</td><td>2762.279475</td><td>Scrap</td><td>Price(RxKgs) 5</td></tr><tr><td>Enthalpy of Silicon</td><td>3799.7325</td><td>Weight of Scrap</td><td>1642.292344</td></tr><tr><td>Scrap</td><td></td><td>Composition of Scrap</td><td>%C Scrap</td></tr><tr><td>Enthalpy of CaO</td><td>1439.25296</td><td>Oxygen</td><td>Price(RxKgs) 1</td></tr><tr><td>Enthalpy of FeO</td><td>1887.21</td><td>Weight of Oxygen</td><td>Values of Oxygen (Mg)</td></tr><tr><td>Enthalpy of SiO2</td><td>1686.562</td><td>Iron Ore</td><td>Price(RxKgs) 1</td></tr><tr><td>Waste Gas (KJ/Kg)</td><td></td><td>Composition</td><td>Weight of Iron Ore</td></tr><tr><td>Enthalpy of CO</td><td>2522.5932</td><td>Pig Iron</td><td>Price(RxKgs) 1</td></tr><tr><td></td><td></td><td>Composition</td><td>Weight of Pig Iron</td></tr><tr><td></td><td></td><td>Sponge Iron</td><td>Price(RxKgs) 1</td></tr><tr><td></td><td></td><td>Composition</td><td>Weight of Sponge Iron</td></tr><tr><td></td><td></td><td>Limestone</td><td>Price(RxKgs) 1</td></tr><tr><td></td><td></td><td>Composition</td><td>Weight of Limestone</td></tr></table>		Thermodynamic Data		All Weights in Kgs		Hot Metal (KJ/Kg)		Hot Metal	Price(RxKgs) 5	Enthalpy of iron	1136.34515	Weight of Hot Metal	122852.508	Enthalpy of carbon	2857.444375	Composition of Hot Metal	%C Hot Metal 4.5 %Mn Hot Metal	Enthalpy of Silicon	3962.7425	Lime	Price(RxKgs) 5	Scrap		Weight of Lime	265.7142858	Enthalpy of iron	1136.34515	Composition of Line	%CaO Line 88 %SiO2 Line	Enthalpy of carbon	2762.279475	Scrap	Price(RxKgs) 5	Enthalpy of Silicon	3799.7325	Weight of Scrap	1642.292344	Scrap		Composition of Scrap	%C Scrap	Enthalpy of CaO	1439.25296	Oxygen	Price(RxKgs) 1	Enthalpy of FeO	1887.21	Weight of Oxygen	Values of Oxygen (Mg)	Enthalpy of SiO2	1686.562	Iron Ore	Price(RxKgs) 1	Waste Gas (KJ/Kg)		Composition	Weight of Iron Ore	Enthalpy of CO	2522.5932	Pig Iron	Price(RxKgs) 1			Composition	Weight of Pig Iron			Sponge Iron	Price(RxKgs) 1			Composition	Weight of Sponge Iron			Limestone	Price(RxKgs) 1			Composition	Weight of Limestone
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Process Layout Steel Plant (Courtesy : American Iron and Steel Institute)

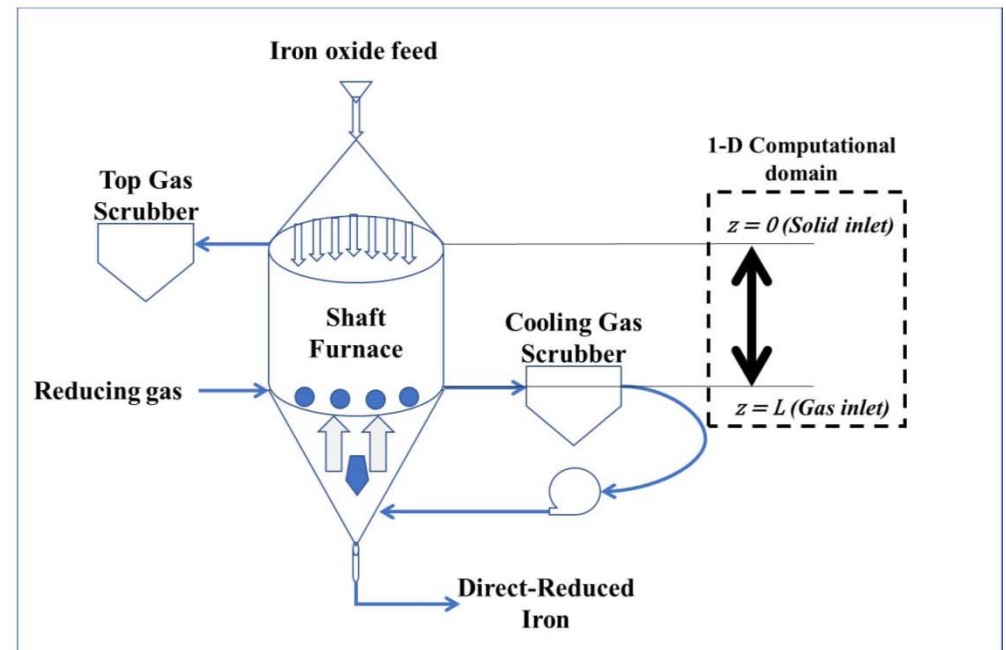
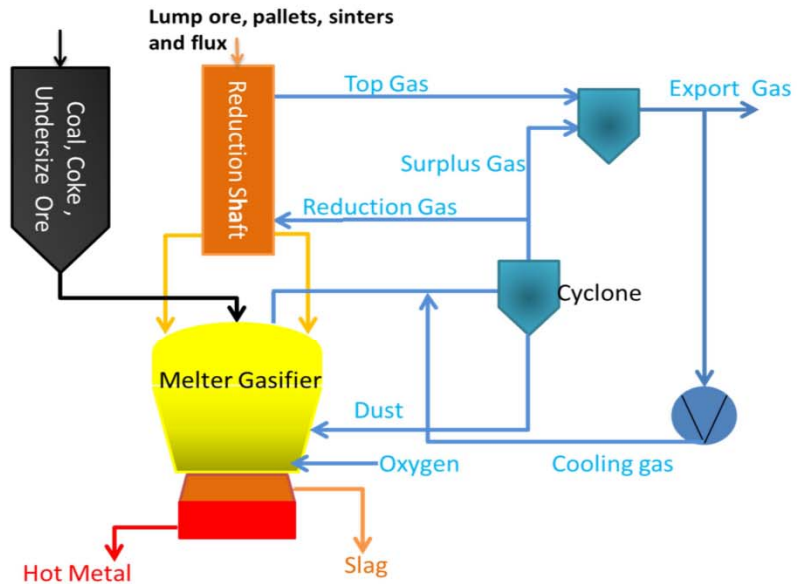
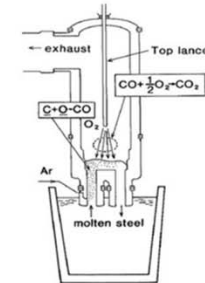
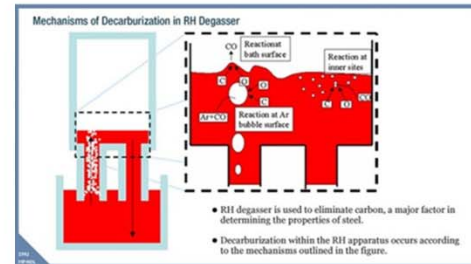


Basic Oxygen Steelmaking process

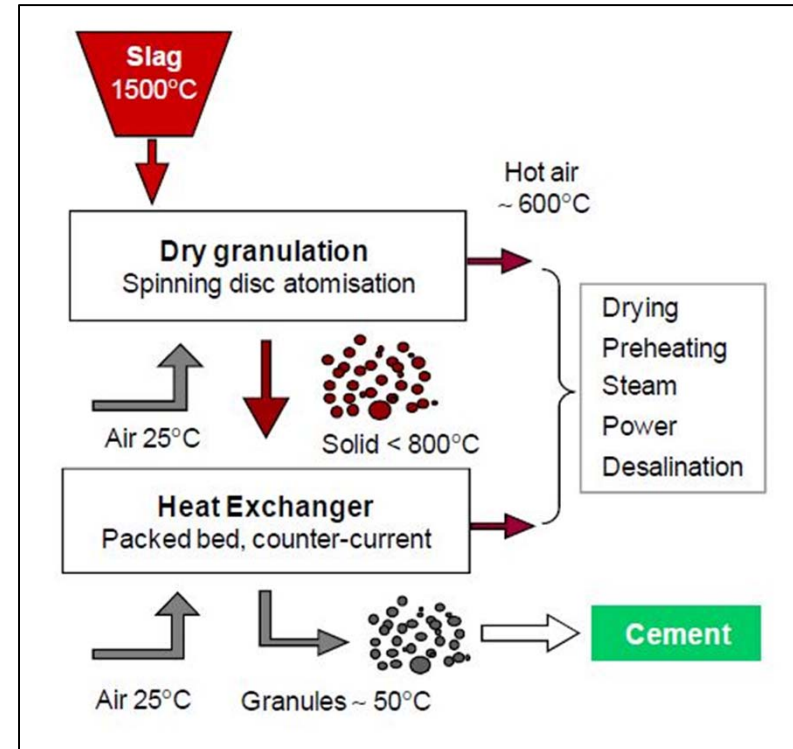


Physical state of the Basic Oxygen Steelmaking Process in the middle of the blow

THE RH PROCESS

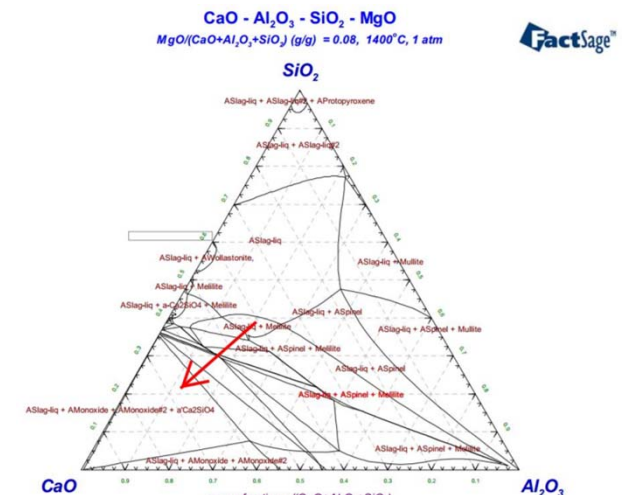


Dry Slag Granulation Process to recover energy from blast furnace slag

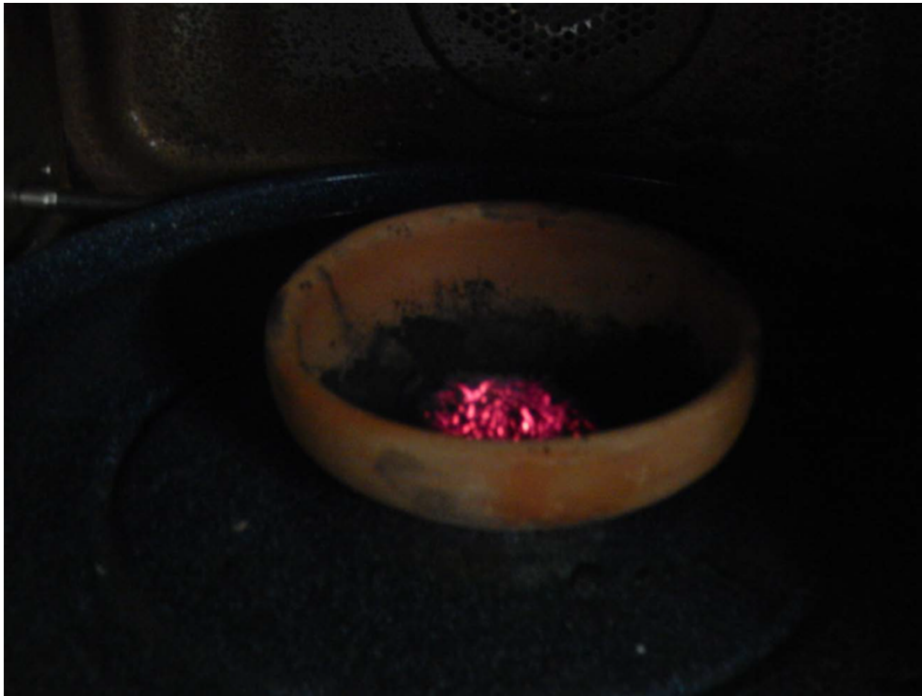


Sharif Jahanshahi et.al ICS 2012

The scope of work involves Physical Modeling, Mathematical Modeling to derive design parameters for pilot plant



Microwave assisted reduction of iron ore/slimes: An innovative and cost effective approach for dry beneficiation for maximization of iron recovery from low grade ores



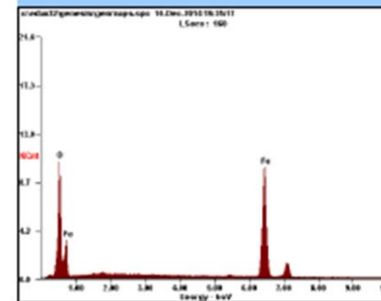
Microanalysis Report



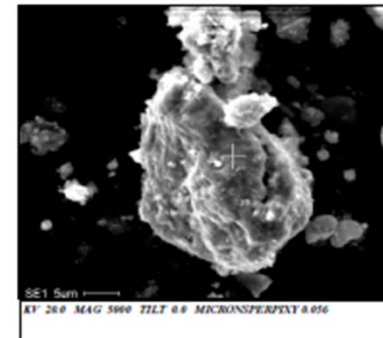
Prepared for: Company Name Here

Prepared by: Your Name Here

12/15/2014



Element	Wt%	At%
OK	27.45	56.91
FeK	72.55	43.09
Matrix	Correction	ZAF



GUI Snapshots...

Static Model BOF Shop JSW Steelplant

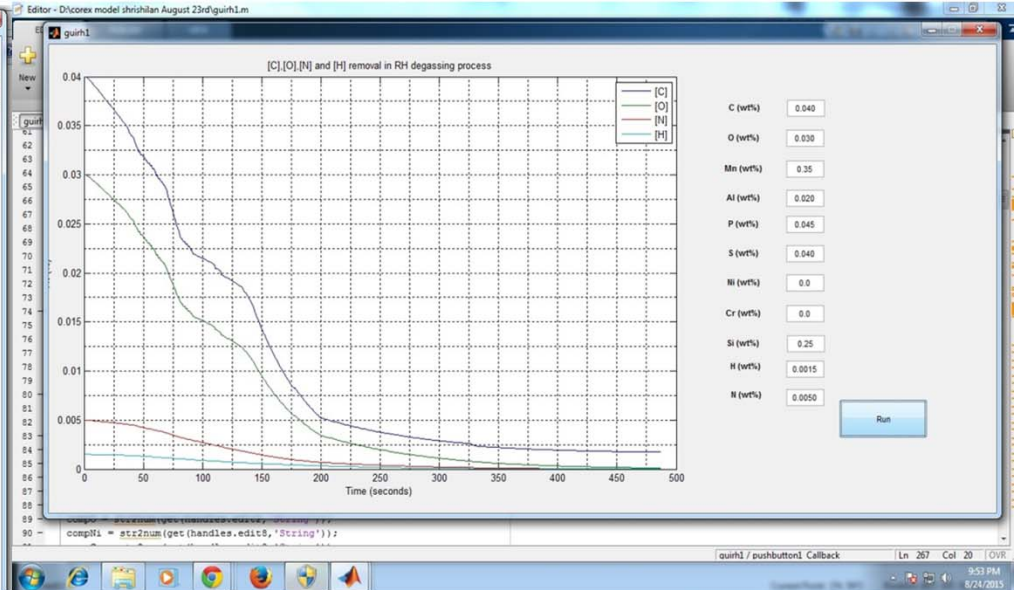
Input Parameters

Hot metal weight (tons)	<input type="text"/>	Target Steel C (%)	<input type="text"/>
Hot metal temperature (C)	<input type="text"/>	Target Steel temperature (C)	<input type="text"/>
HM_C (%)	<input type="text"/>	Target slag-MgO	<input type="text"/>
HM_Mn (%)	<input type="text"/>	Target slag-FeO(%)	<input type="text"/>
HM_P(%)	<input type="text"/>	Target slag-basisity	<input type="text"/>
HM_S(%)	<input type="text"/>	Added mill scale briq (kg)	<input type="text"/>
HM_Si(%)	<input type="text"/>	Added iron ore (kg)	<input type="text"/>
Scrap (tons)	<input type="text"/>	Added DRI (ton)	<input type="text"/>
Closing item heat balance	<input type="text"/>	Closing item Oxy balance	<input type="text"/>

Model Predictions

Suggested Oxygen blow (NM3)	<input type="text"/>
Suggested Lime additions (kg)	<input type="text"/>
Slag weight (tons)	<input type="text"/>
Suggested calcined dolomite (kg)	<input type="text"/>
Steel produced (tons)	<input type="text"/>
Final steel temperature (C)	<input type="text"/>
Final Steel Composition	
C (%)	<input type="text"/>
Mn (%)	<input type="text"/>
P (%)	<input type="text"/>
S (%)	<input type="text"/>

Execute



ANN_GA Model BOF Shop JSW Steelplant

Input Parameters

Hot metal weight (tons)	<input type="text"/>	Target Steel temperature (C)	<input type="text"/>
Hot metal temperature (C)	<input type="text"/>	Charge-tap duration (min)	<input type="text"/>
HM_C (%)	<input type="text"/>	Target slag-FeO(%)	<input type="text"/>
HM_Mn (%)	<input type="text"/>	Target slag-basisity	<input type="text"/>
HM_P(%)	<input type="text"/>	Added Cal_dolomite (kg)	<input type="text"/>
HM_S(%)	<input type="text"/>	Added iron ore (kg)	<input type="text"/>
HM_Si(%)	<input type="text"/>	Added DRI (ton)	<input type="text"/>
Scrap (tons)	<input type="text"/>		

Model Predictions

Suggested Oxygen blow (NM3)	<input type="text"/>
Suggested Lime additions (kg)	<input type="text"/>
Suggested mill scale briquette (kg)	<input type="text"/>

Read Input Data **Run**

Model Prediction HMPT Shop JSW Steel Plant

Input Parameters

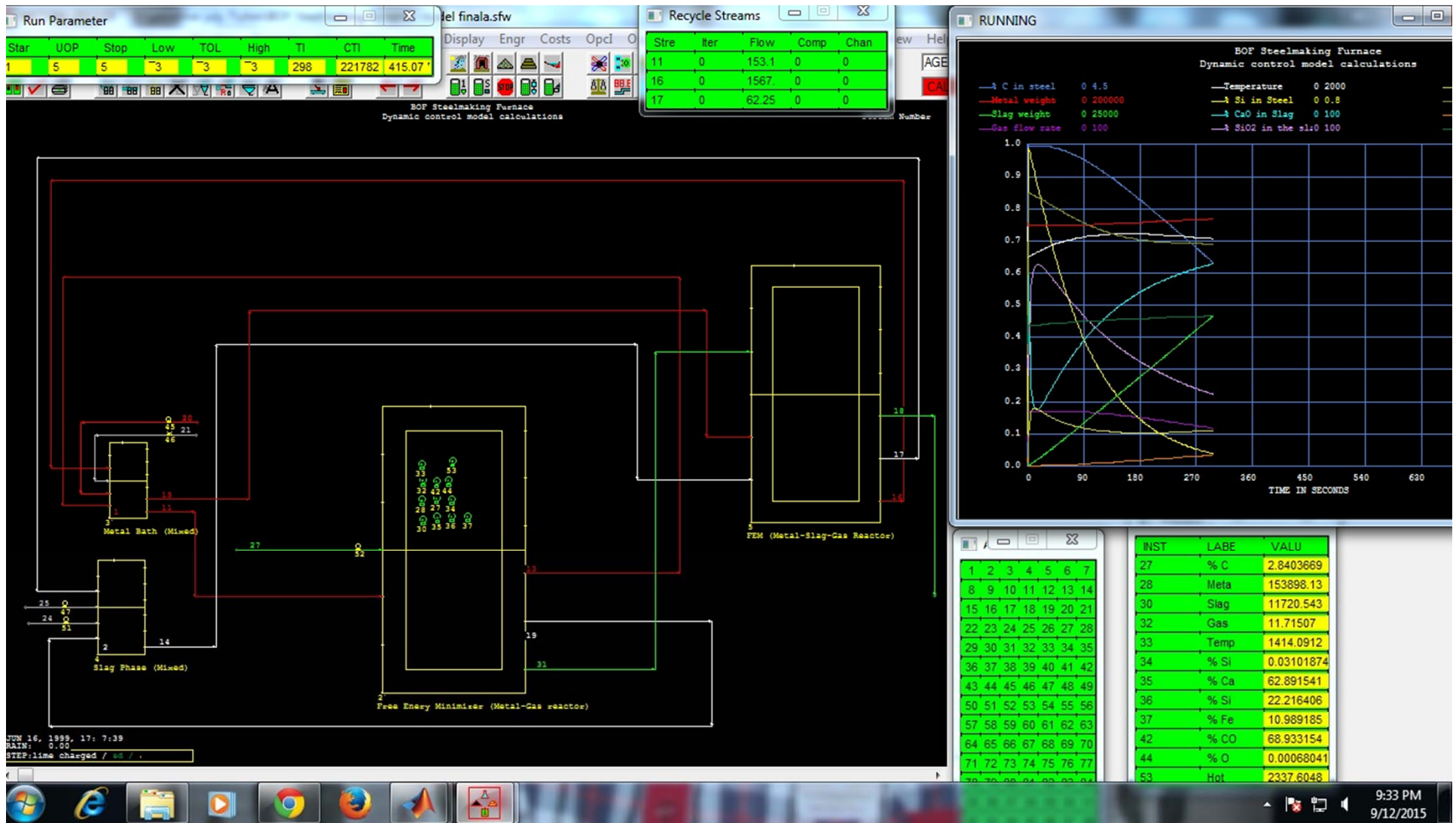
Sulphur Input (%)	<input type="text" value="0.045"/>
Temperature In (C)	<input type="text" value="1400"/>
Process time (min)	<input type="text" value="30"/>
CaC2 to Mg ratio	<input type="text" value="25"/>
Sulphur target (%)	<input type="text" value="0.01"/>

Model Predictions

Suggested Mg (Kg)	<input type="text" value="36.991"/>
Suggested CaC2 (tons)	<input type="text" value="0.761157"/>

Read Input Data **Run**

Virtual Simulation Laboratory



Research Group:

Current Students:

Ph.D.

1. Mr. C. Srishilan (since 2013)

Project title: **Optimization and control of Corex Ironmaking process employing suitable expert systems.**

M.Tech

1. Priyesh Jain (since 2017)

Project title: **Heat Transfer based Modeling of dry slag granulation process and its integration with earlier developed models predicting particle size.**

2. Arvind M (since 2017)

Project title: **Microwave assisted reduction of iron-ore and coal composites**

Research Group:

Past students:

MS:

1. Mr. Yuvaraj Patil (2017)

Project title: **Heat transfer, fluid flow and solidification modeling of Twin Roll Casting Process.**

2. Mr. Kali Prasad (2017)

Project title: **Physical and mathematical modeling of dry slag granulation process for energy recovery and cement clinker production.**

M.Tech:

1. Mr. Tanay Pandey (under sandwich DAAD programme with RWTH Aachen, Germany) (2014)

Project title: **Mathematical modeling of RH degassing process for clean steel production.**

2. Mr. Shwetank Pandey (under sandwich DAAD with RWTH Aachen, Germany) (2014)

Project title: **Expert model of Basic Oxygen Steelmaking process.**

3. Mr. Sachin Santosh (Dual degree scholar) (2014)

Project title: **Role of Artificial Intelligence and Data Based Modelling approaches for control of various iron and steelmaking processes.**

4. Mr. Deepjyoti Mukherjee (DAAD with RWTH Aachen, Germany) (2016)

Project title: **Physical and Mathematical modeling of RH degassing process.**

5. Mr. Abhishek Sharma (2016)

Project title: **Optimization of steel plant supply chain with minimum cost and energy consumption by application of Genetic Algorithm.**

6. Mr.S. Sivakumar (2017)

Project title: **Mathematical modeling and industrial validation of MIDREX Ironmaking process.**

7. Mr.S. Hariharan (2017)

Project title: **CFD modeling of dry slag granulation process.**

8. Ms. J. Vaishnavi (2017)

Project title: **Optimization of steel plant supply chain with minimum cost and energy consumption by application of Genetic Algorithm.**

