Cement-free brick production technology for the use of primary and secondary raw material fines in EAF steelmaking

Introduction to the Fines2EAF project

Dr.-Ing. Thomas Echterhof

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University of Oulu
University of Leoben Department Metallurgy Nonferrous Metallurgy
sidenor
MAU Max Aicher Umwelt
MFG
Politecnico Milano 1863
Marienhütte
IOB Department for Industrial Furnaces and Heat Engineering
RWTH Aachen University

Cement-free brick production technology for the use of primary and secondary raw material fines in EAF steelmaking – Fines2EAF

Project fact sheet

Grant number:	754197
Acronym:	Fines2EAF
Title:	Cement-free brick production technology for the use of primary and secondary raw material fines in EAF steelmaking
Duration:	01.07.2017 – 30.06.2021 / 48 month

Project partners

RWTH Aachen University (RWTH)	Politecnico di Milano (POLIMI)
Max Aicher Umwelt (MAU)	Sidenor I+D (SID)
MFG Metall- & Ferrolegierungsgesellschaft (MFG)	Stahl- und Walzwerk Marienhütte (MH)
Montanuniversität Leoben (MUL)	University of Oulu (OU)

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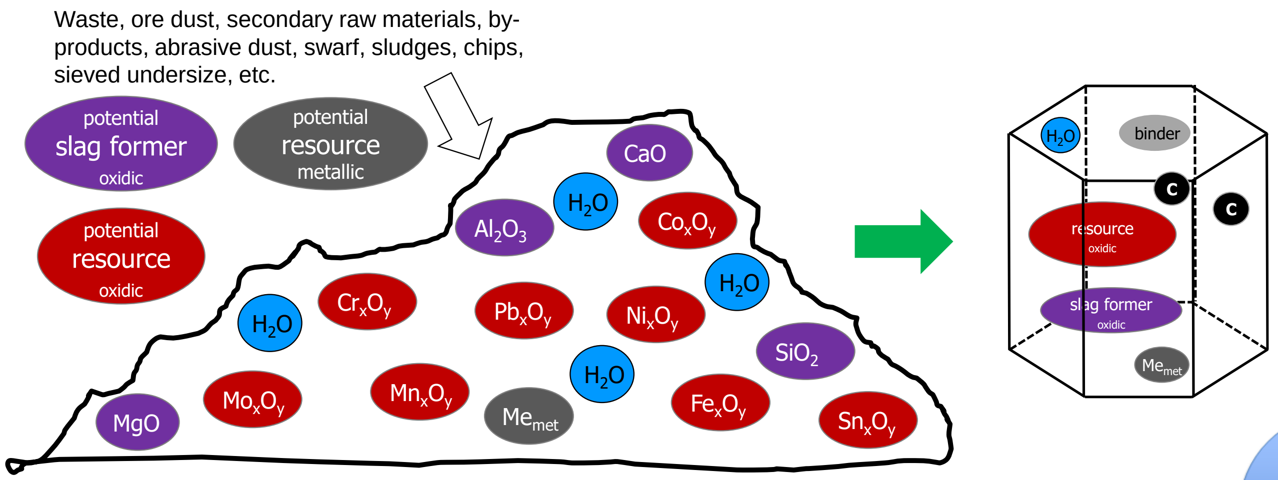
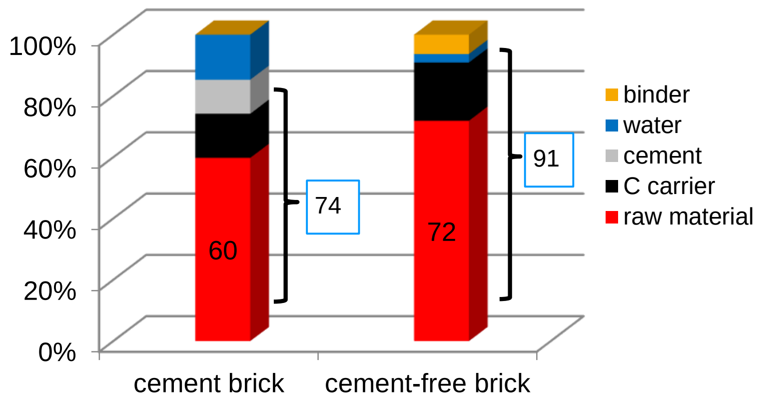
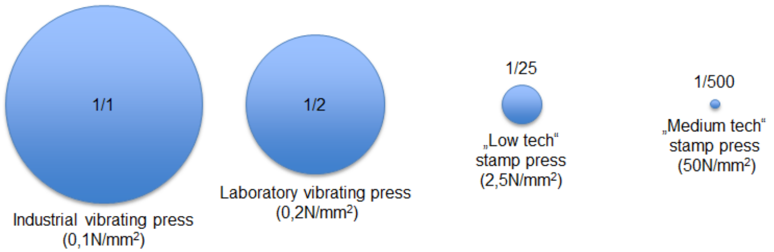
Schematic of the project approach



Typical composition of cement-bound and cement-free bricks





Pressing power and area for typical vibrating and stamp presses

Project objectives

Objective of the proposal is the economic (re)use of primary and secondary raw material fines in EAF steelmaking and conservation of resources by development of cement-free brick production technology, to be applied directly in the steel plant. This will bring the following advantages: avoid disposal of wastes, enhance the use of primary and the recycling of secondary raw material fines and save costs.

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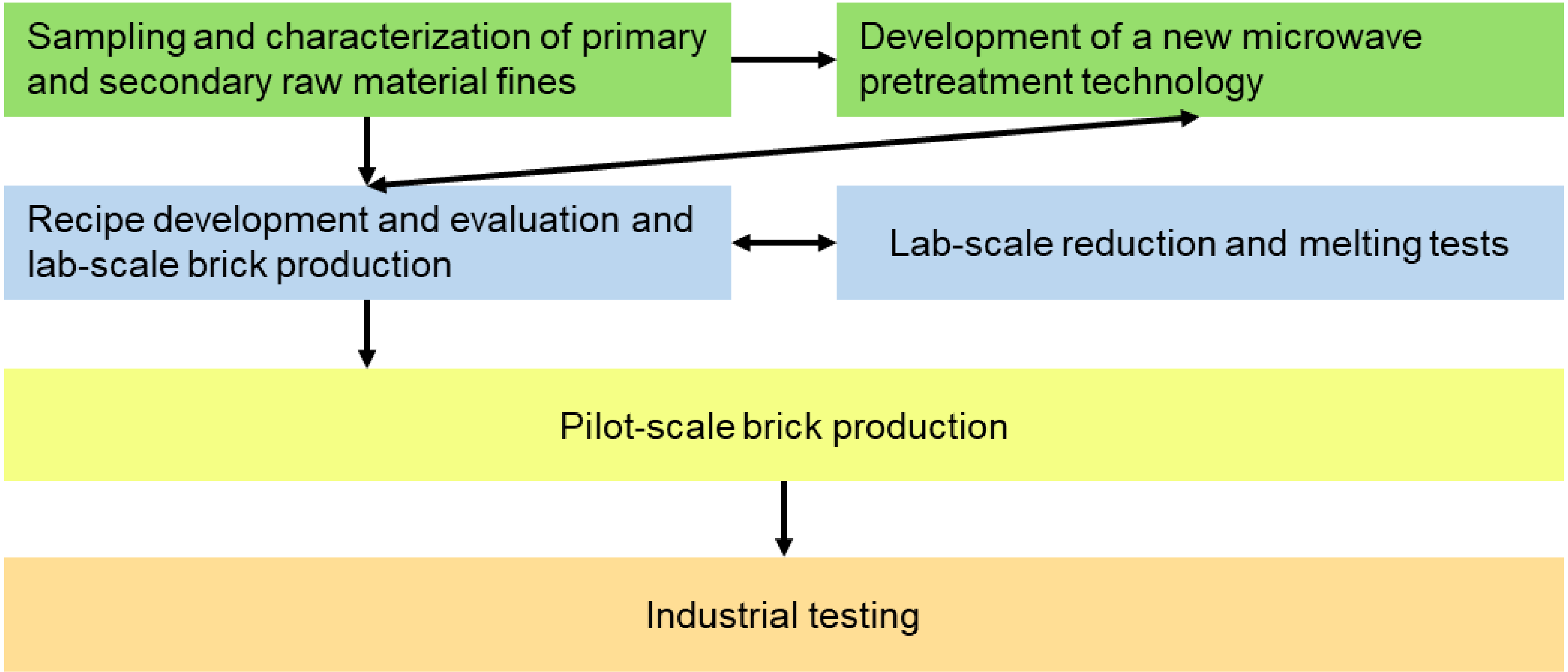
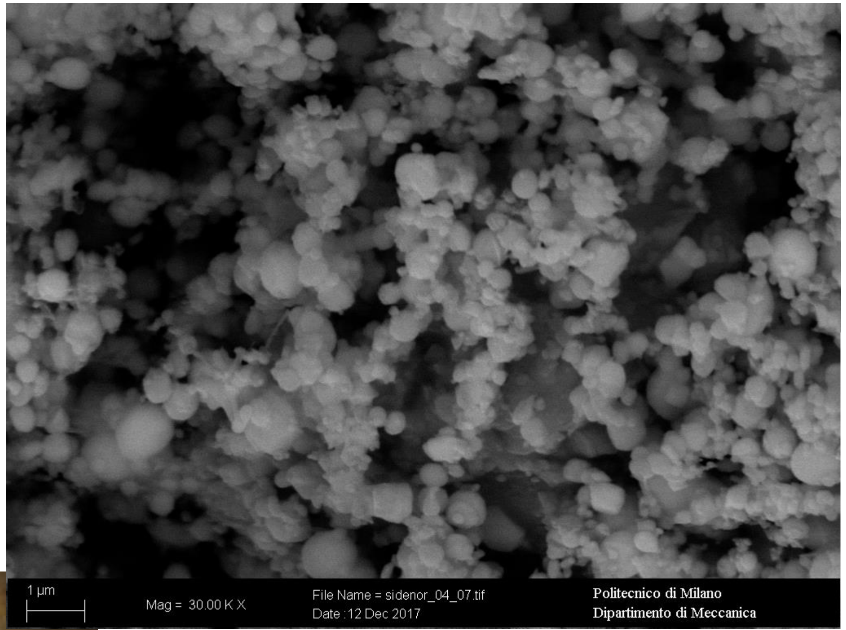
Work programme



Cement-free brick production technology for the use of primary and secondary raw material fines in EAF steelmaking – Fines2EAF

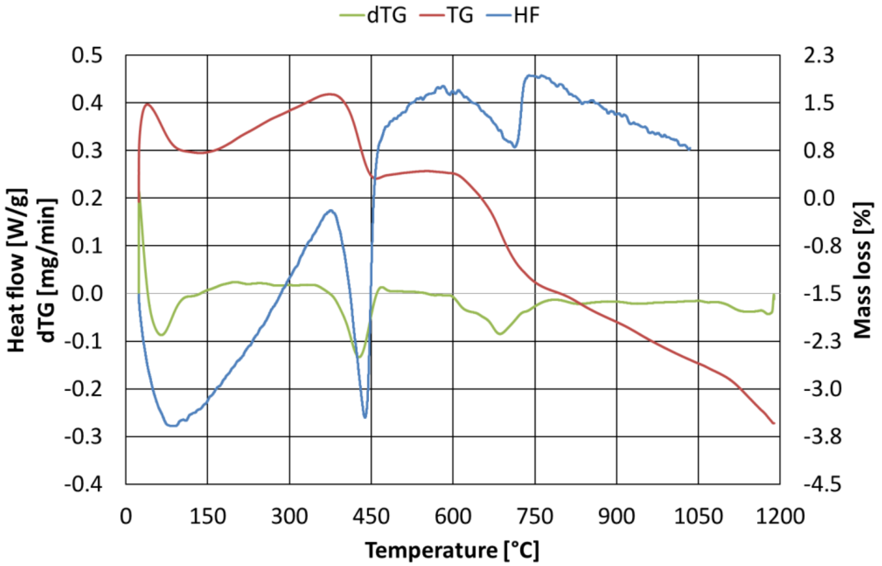
Sampling and characterisation of primary and secondary raw material fines

Comprehensive sampling of residues and by-products was conducted in the steel plants. Additional samples from suppliers and other industrial sectors were added.

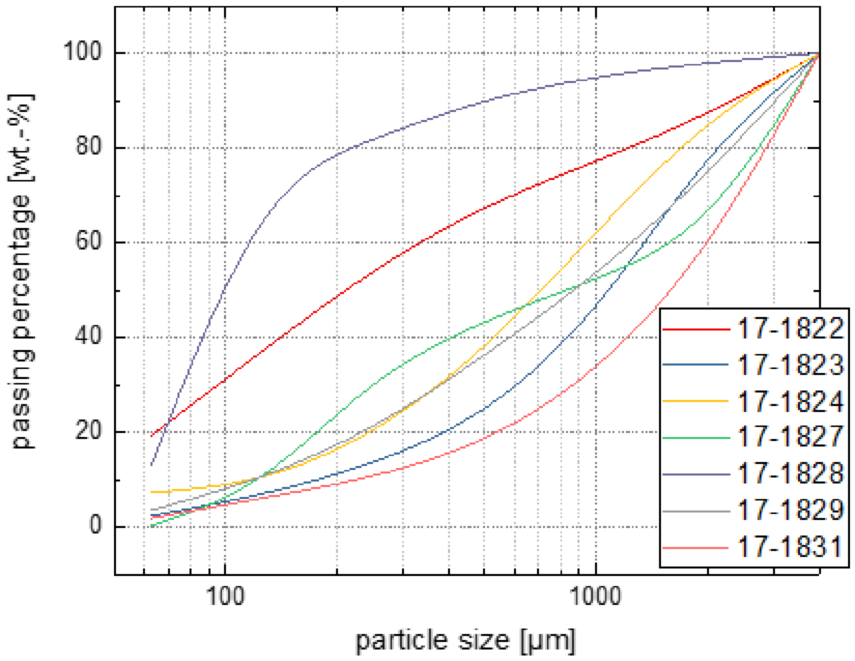


SEM-SE picture of EAF dusts

TG-DSC curves dolomite refractories

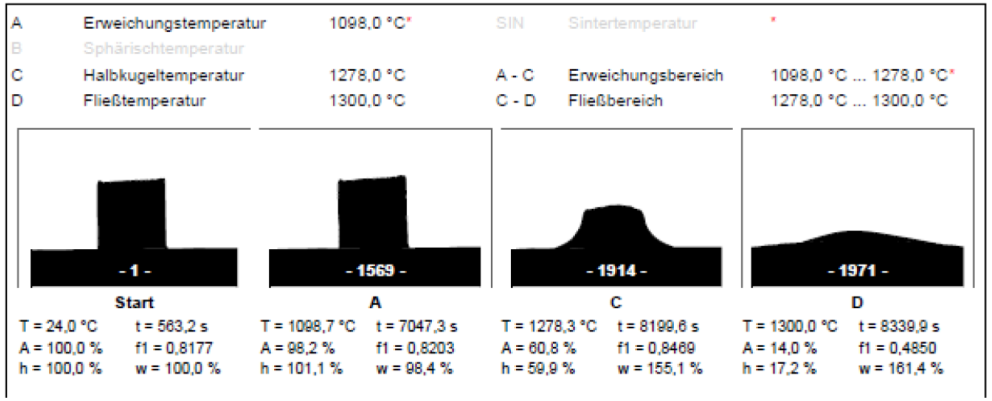


Sampling and characterisation of primary and secondary raw material fines



Plot of the weight percent passing a specified mesh size

Hot stage microscope of LF slag



Cement-free brick production technology for the use of primary and secondary raw material fines in EAF steelmaking – Fines2EAF

Sampling and characterisation of primary and secondary raw material fines

Inventory of available primary and secondary raw material fines
- 38 materials
- Quantities and current utilization

Characterization included:
- Photographic and micrographic documentation
- XRF analysis
- SEM-EDS investigations
- TG-DSC analysis
- Bulk and true density analysis
- Moisture analysis
- Particle size distribution analysis

label	samples	wt%																														
		Al_2O_3	Br	CaO	Cl	Co_3O_4	Cr_2O_3	CuO	Fe_2O_3	K_2O	MgO	MnO	MoO_3	Na_2O	Nb_2O_5	NiO	P_2O_5	PbO	S	SeO_2	SiO_2	SnO_2	SrO	TiO_2	Tl_2O_3	V_2O_5	WO_3	ZnO	moisture in % t = 0 days	moisture in % (intern) t = 20 days	true density [g/cm³]	bulk density [g/cm³]
Black Slag (EAF Slag)		6,373	-	23,802	0,022	0,056	2,957	0,022	41,897	0,028	4,613	6,570	0,017	0,210	0,062	-	0,693	-	0,105	-	11,341	-	0,025	0,471	-	0,230	0,021	0,018	2,630	0,932	4,028	2,252
White Slag (Second Metallurgy Slag)		4,839	-	53,601	0,030	-	1,643	0,020	14,565	0,019	3,790	2,665	0,004	0,221	0,027	0,017	0,471	0,011	0,675	0,003	15,643	-	0,073	0,425	-	0,086	-	0,074	5,950	3,048	3,270	1,703
Refractories MgO - C		2,332	-	3,885	0,024	-	0,075	-	1,301	0,046	87,615	0,120	-	0,431	-	0,011	0,723	0,010	0,326	0,002	2,541	-	0,005	0,044	-	-	-	0,016	0,070	0,095	3,297	2,459
Refractories Alumina		62,537	0,002	1,697	0,108	-	0,106	0,008	2,493	0,816	1,374	0,099	-	0,263	0,011	0,010	1,325	0,068	0,098	-	25,757	-	0,064	2,710	0,000	-	-	0,015	0,110	0,003	3,376	1,897
EAF Dust		0,578	0,055	2,909	1,270	-	0,844	0,161	43,721	0,868	1,407	3,577	0,016	-	0,008	0,049	0,738	0,851	0,304	-	2,245	-	0,005	0,058	-	0,027	-	39,767	0,310	0,043	4,541	1,059
Secondary Dust (Ladle Furnace)		0,932	0,081	24,211	0,750	-	1,414	0,122	29,967	1,202	7,189	4,158	0,047	-	0,004	0,385	0,583	1,835	1,266	0,120	3,966	-	0,029	0,092	-	0,025	0,475	18,886	0,670	0,589	3,832	0,875
Combustion Chamber Dust		1,912	0,031	9,301	0,301	-	1,289	0,127	64,089	0,192	1,950	3,455	0,029	3,171	0,029	0,056	0,631	0,161	0,199	-	4,389	-	0,013	0,202	-	0,078	0,194	7,779	6,950	2,096	4,276	2,193
Dry Mill Scale		0,460	-	1,158	0,016	0,166	0,519	0,108	93,344	0,024	0,370	0,691	0,044	0,406	-	0,155	0,478	0,013	0,030	-	1,831	-	0,002	0,024	-	0,025	-	0,083	0,980	0,405	5,145	2,992
Wet Mill Scale		0,524	-	1,373	0,033	-	0,851	0,114	91,954	0,043	0,562	1,239	0,068	0,199	-	0,200	0,486	0,008	0,058	-	2,051	-	-	0,032	-	0,067	-	0,048	5,180	1,647	3,501	2,414
Oxi-cutting fines (fines coming from the cutting of billets and blooms)		0,170	0,023	1,295	0,122	-	0,654	0,628	92,724	0,033	0,368	0,815	0,121	0,270	-	0,382	0,530	0,199	0,188	-	1,065	0,050	-	0,012	-	0,000	-	0,041	4,730	0,228	4,739	1,824
Fines from EAF belt additions		0,214	-	90,081	0,030	-	1,064	0,012	1,759	0,098	0,995	1,452	-	0,096	-	0,015	0,337	0,018	0,211	-	2,979	-	0,168	0,035	-	0,025	-	0,095	**-2,910**	**-3,430**	3,651	1,029
Fines from LF additions		0,478	-	48,531	0,046	0,033	23,041	0,010	11,410	0,075	0,584	6,311	0,030	0,093	-	0,101	0,391	0,009	0,100	-	8,154	-	0,023	0,200	-	0,074	-	0,147	**-2,510**	**-2,970**	1,915	1,028
Sludge (water treatment)		7,008	0,213	20,972	0,074	0,018	0,601	0,448	15,906	0,223	8,777	15,168	0,035	-	0,009	0,125	1,356	2,189	0,747	-	9,797	0,067	0,039	0,266	-	0,059	-	14,582	44,070	19,133	2,220	0,790
Sludge		726	-	048	053	096	355	209	543	155	167	323	117	228	006	510	772	213	576	004	213	-	018	140	-	045	-	072	890	451	00	939

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Recipe development and evaluation and lab-scale brick production

The steel plants defined priorities for the recipe development based on the inventory:

Max Aicher Umwelt and Marienhütte defined CaO and MgO containing residues as priority materials

➔ Reuse as much as possible of ladle furnace slags, spent refractory/mixed residues and collected dusts

Sidenor on the other decided to focus on Fe recovery from materials like oxy-cutting fines, combustion chamber dust and an external grinding sludge. Also, fines from EAF belt additions should be recovered by agglomeration at Sidenor.

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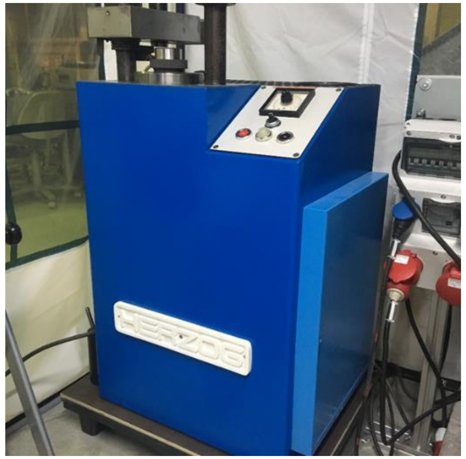
Recipe development and evaluation and lab-scale brick production

The binders tested include sodium silicate, polyethylenglycol (PEG), carboxymethylcellulose (CMC), different types of starch, molasses, copolymer binders and superabsorbers.

In addition to the different binding systems and agglomeration parameters like pressing force, pressing time, aging condition etc. also additives have been investigated. $CaCO_3$, Bentonite, SiO_2, SiOxide and sodium silicate hardener have used with sodium silicate binder. Fibres from paper recycling have also been tested to increase the strength of the produced agglomerates.



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Recipe development and evaluation and lab-scale brick production

Based on the selected materials and priorities of the steel plants and the developed recipes, the lab-scale brick production started and more than 150 recipes have been tested.

Material	N° of recipes tested
grinding sludge (dried)	17
grinding sludge (wet)	60
belt conveyor fines	7
combustion chamber dust	9
grinding sludge and oxy-cutting fines	5
LF slags	17
dolomitic refractory	2
ferromanganese carbon filter dust	36

Recipe development and evaluation and lab-scale brick production

Recipe development and agglomeration tests – grinding sludge

Exp.-No.	Condition	Slag former	Fibres	Sodium silicate	Water	Starch	CMC	LoW in drop test
X	Dry	15 % Bentonite	3 % Type 3	15 %	7 %			1.7 %
Y	Dry	15 % $CaCO_3$	3 % Type 3	15 %	7 %			3.9 %
EM	Wet					10 % T1		2.2 %
AA	Wet					10 % T2		7.4 %
EO	Wet						14.3 % T1	n.a.
EN	Wet						14.3 % T2	n.a.

CMC - Carboxymethyl cellulose

before

after drop test
(3 times from 5 m)

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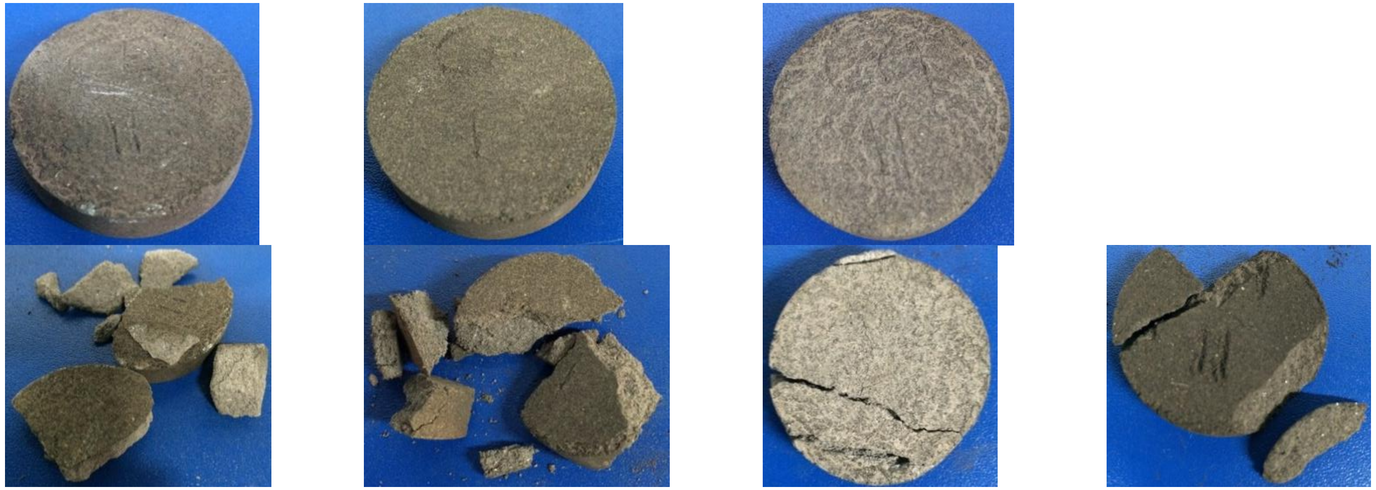
Recipe development and agglomeration tests – combustion chamber dust

Exp.-No.	Condition	Slag former	Fibres	Sodium silicate	Water	LoW in drop test
CE	Wet	14 % $CaCO_3$	1.2 % Type 3	14 % Type 1	4.7 %	15.9 %
CF	Wet	6.7 % $CaCO_3$	1.6 % Type 3	6.7 % Type 1	2 %	23.4 %
CG	Wet	15 % $CaCO_3$	1.3 % Type 3	15 % Type 2	7.1 %	1.2 %
CH	Wet		1.3 % Type 3	15 % Type 2	7.1 %	11.8 %



before

after drop test
(2 times from 5 m)

Acknowledgement

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Thank you for your attention

Dr.-Ing. Thomas Echterhof
RWTH Aachen University
Department for Industrial Furnaces and Heat Engineering
Kopernikusstraße 10
52074 Aachen
Germany
echterhof@iob.rwth-aachen.de