Inorganic binder system to minimize emissions, improve indoor air quality and purify and reuse of contaminated foundry sand

Green Foundry LIFE

Green Foundry LIFE Webinar

LIFE17 ENV/FI/000173

Green Foundry

1/7/2018-30/6/2022

PROJECT LOCATION: Finland, Poland, Germany, Spain, Italy, France, Sweden

DURATION: Start: 01/07/18 - End: 30/06/22

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FACULTY OF FOUNDRY ENGINEERING

Mariusz Holtzer, Rafał Dańko

Results of chamber test emission reductions with different inorganic and organic binding systems

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Life

AGH University of Science and Technology

100 years
of activity in research and education

KRAKOW, POLAND

Facts and figures – AGH UST in 2022

- **the biggest technical university in Poland**
- **public university of science and technology**
- **16 faculties + three research centres**
- **62** teaching programs with **220** specializations

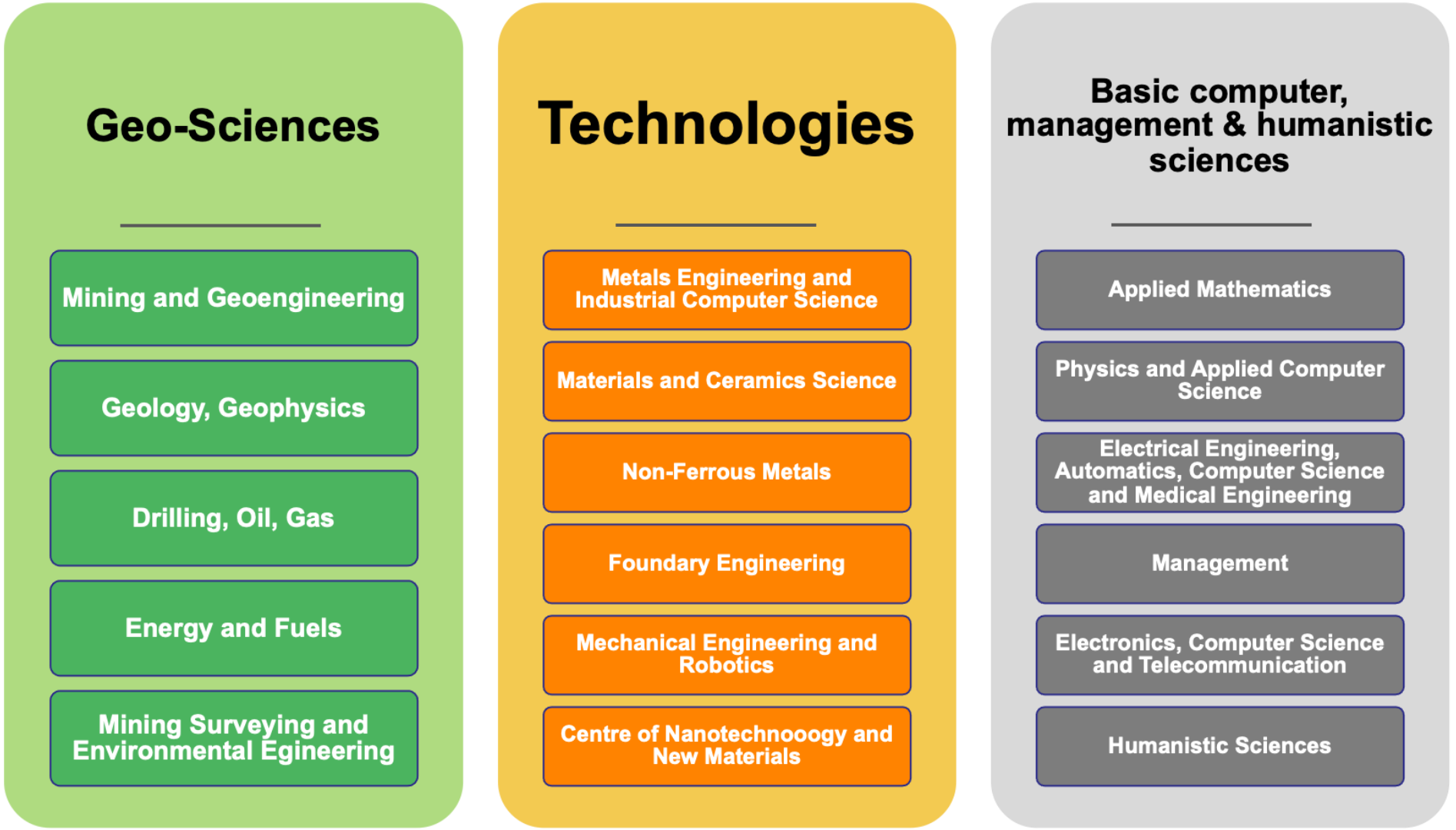
- **total number of students: 25,193**
  - full-time students: 18,841
  - part-time students: 3,252
  - doctoral students: 779
  - postgraduate students: 2,321

- over **200,000** graduates in history

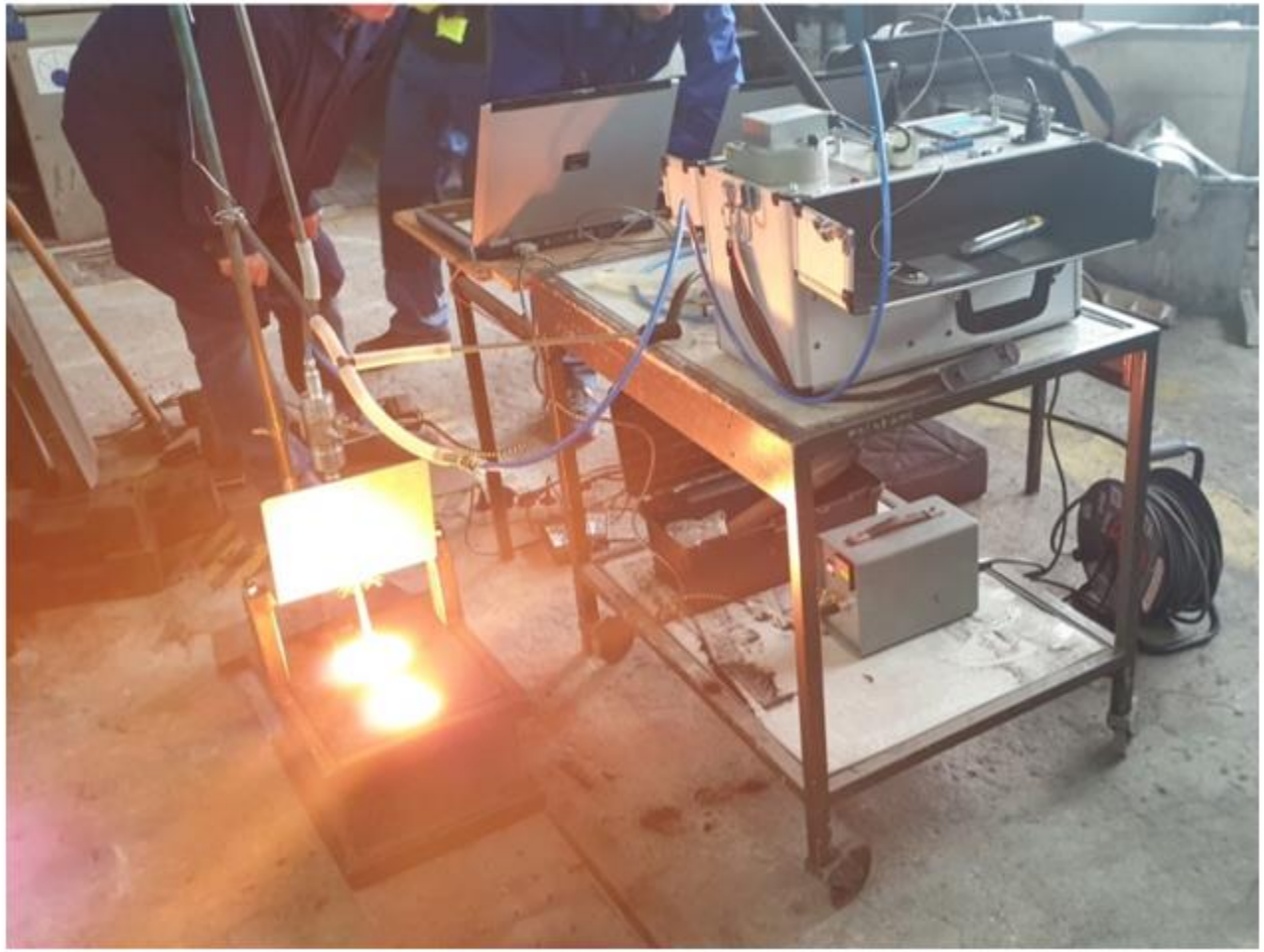
- over **2,000** teaching and research staff, **1,800** administrative and techniques

- **650** professors

AGH-UST research and education structure



Action B1: Emission of different binder systems during small - scale test cast. Mathot 1. Testing foundry at AGH – UST - laboratory test.



materials

MDPI

Article

Environmental Impact of the Reclaimed Sand Addition to Molding Sand with Furan and Phenol-Formaldehyde Resin—A Comparison

Mariusz Holtzer [1,*], Rafał Dańko [1], Angelika Kmita [2,*], Dariusz Drożyński [1], Michał Kubecki [3], Mateusz Skrzyński [1] and Agnieszka Roczniak [1]

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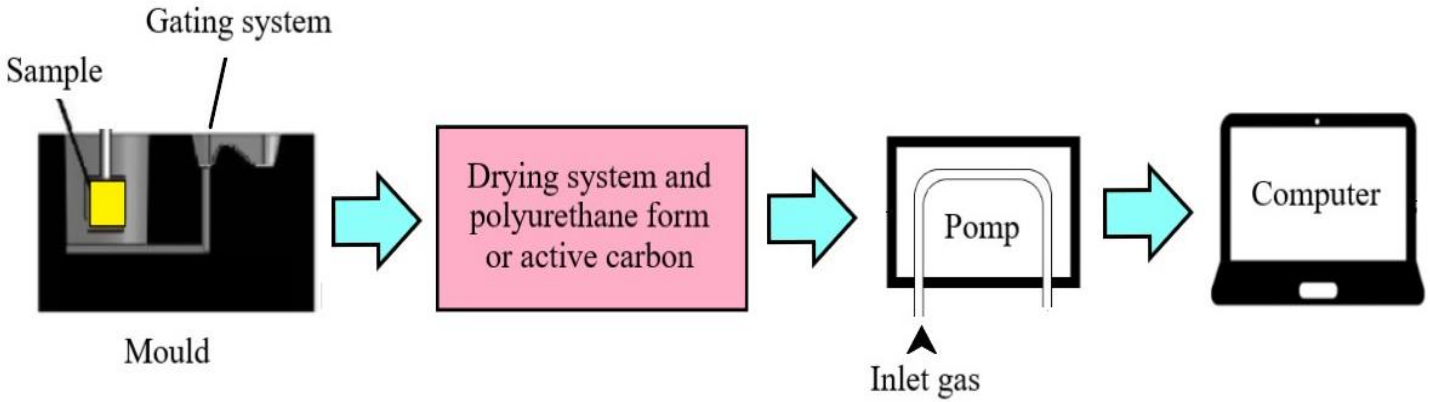
Received: 8 September 2020; Accepted: 29 September 2020; Published: 1 October 2020

Methodology and apparatus used



Scheme of the stand for measuring of the gas volume and BTEX and PAHs emission.

Methodology and apparatus used

Samples provided for the determination of compounds from BTEX group and PAHs were extracted with dichloromethane in a gas-tight vials for headspace analysis.

BTEX analysis were performed using a headspace sampler.
For chromatographic separation HP-5MS column was used.
The commercially available BTEX MIX standard in methanol was used for the quantitative analysis.

PAHs analysis were performed using S/SL injector port in splitless mode
For chromatographic separation ZB-PAH column were used.
The commercially available PAHs MIX standard in acetonitrile/acetone/toluene mixture was used for the quantitative analysis.

Materials and theirs characteristic

Furan resin: Kaltharz X 850 TN011 + Aktivator 100 T 3 (Hüttenes-Albertus) (code MF):.
composition of molding sand: silica sand – 98,5%; resin - 1%; hardener – 0.5%.

Phenol-formaldehyde resin (ALPHASET): Sinotherm 8255 + Aktivator J 120 (Hüttenes-Albertus) (code MA):
composition of molding sand: silica sand – 98.5%; resin - 1.2%; hardener – 0.3%.

CORDIS inorganic binder system for cores (Hüttenes-Albertus) (code MC):
composition of molding sand: silica sand - 96.7%, binder CORDIS 8593 - 2%, Anorgit 8610 - 1.3%;

INOTEC inorganic binder system for cores (ASK CHEMICALS) (code MI):
composition of molding sand: silica sand – 96.4%, binder Inotec – 2.3%, promotor Inotec – 1.3%.

GEOPOL – inorganic self-hardening binder system, (code MG):
composition of molding sand: silica sand – 98.2%; GEOPOL 618 – 1,6%, hardener 73 – 0.24%.

Green sand – ECOSIL SLE84 9 (CLARIAD)–activated bentonite with dust coal and carbon additive (code MB)
Composition of molding sand: silica sand – 93% bentonite – 7%, water – 55 cm^3. Samples were dry at 100^oC for 4 h.

Methodology

Collected samples with adsorbed gases were kept at 3-7^{o}C until they were analyzed. Samples for the determination of compounds from the BTEX group and PAHs were extracted with dichloromethane.

In the case of BTEX, activated carbon constituting the adsorbent and dust retained on the quartz filter was analyzed.

For PAHs, polyurethane X-2 foam and dust retained on the quartz filter were analyzed.

The obtained quantitative results were included in Tables presented on next slides.

To compare the tested molding sands in terms of BTEX and PAHs emissions, two indicators: were introduced : one calculated for 1 kg of moulding sand and the other calculated for 1 g of components included in the binder.

Results

MF – furan
MA – Alphaset
MG – Geopol
MC – Cordis
MB – Green sand
MI – Inotec

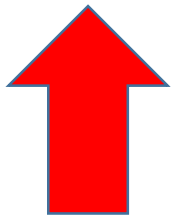
CODE	Per 1 g of binder, µg		Per 1 kg of molding sand, mg	
Compounds	Total BTEX	Benzene	Total BTEX	Benzene
MF	**43 852**	40 158	**658**	602
MA	**32 994**	30 911	**495**	464
MG	**3342**	2 837	**60**	51
MC	**715**	496	**24**	16
MB	**2 510**	2 293	**170**	161
MI	**860**	556	**22**	14

Total emission BTEX and benzene calculated per 1 g of binder and 1 kg of molding sand.

Results

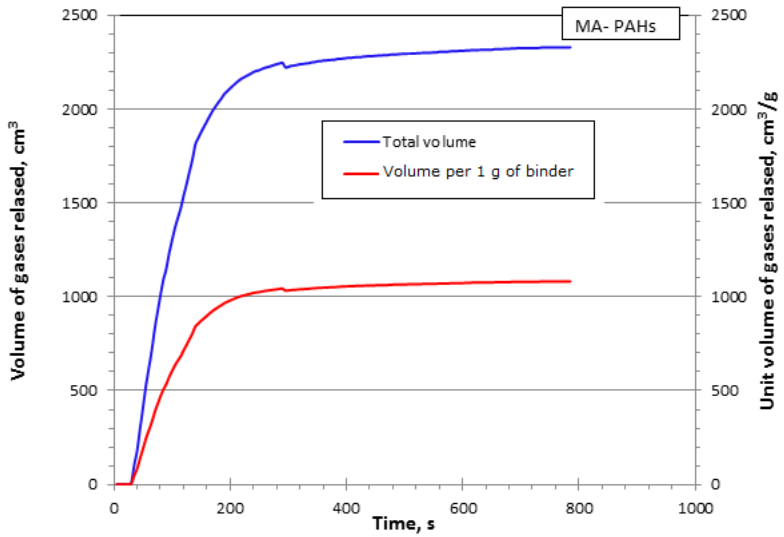
MF – furan
MA – Alphaset
MG – Geopol
MC – Cordis
MB – Green sand
MI – Inotec

CODE	Per 1 g of binder, µg		Per 1 kg of molding sand, mg	
Compounds	Total PAHs	Benzo(a)pyrene	Total PAHs	Benzo(a)pyrene
MF	5.98	0.12	12.09	0.24
MA	4.58	0.08	9.87	0.17
MG	1.37	0.03	3.14	0.06
MC	0.44	0.00	2.18	0.01
MB	0.62	0.02	5.80	0.15
MI	0.52	0.00	1.99	0.02

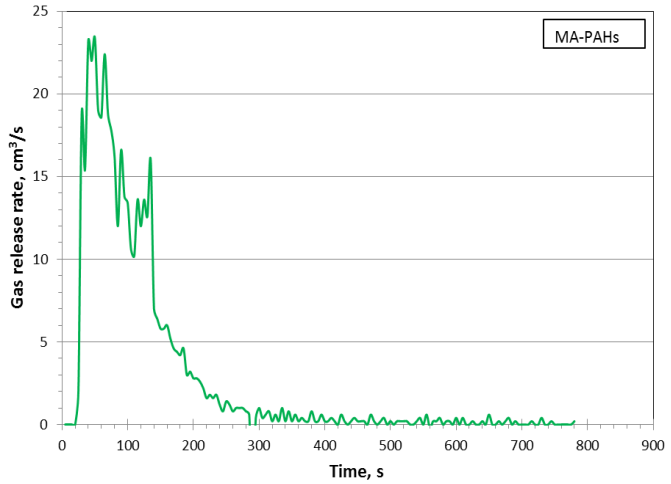


Total emission PAHs and benzo(a)pyrene calculated per 1 g of binder and 1 kg of molding sand

Results



Emissivity of gases in time, from the investigated moulding sands MA during PAHs measurements: blue line – total volume from sample, red line – volume calculated per 1 g of binder.

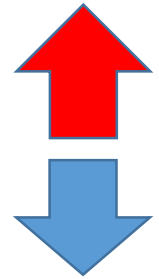


Gas release rate in time, from the investigated moulding sands MA during PAHs measurements.

Results

MF – furan
MA – Alphaset
MG – Geopol
MC – Cordis
MB – Green sand
MI – Inotec

Moulding sand code	Realized gases from moulding sands during tests / 100 g of moulding sands		
	from BTEX test [ml]	from PAHs test [ml]	Average, [ml]
MF	1931	2014	1973
MA	2614	2380	2497
MG	1395	1356	1376
MC	1273	1011	1142
MB	2762	2459	2610
MI	862	914	888



Results of volume measurements of gases release during tests

Results

MF – furan
MA – Alphaset
MG – Geopol
MC – Cordis
MB – Green sand
MI – Inotec

Moulding sand code	Dust realized from moulding sands during tests / 100 g of moulding sands			Average
	from PAHs test [g]	from BETX test [g]	from SO_2 test [g]	[g]
MF	0.009	0.004	0.004	0.006
MA	0.003	0.006	0.004	0.004
MG	0.003	0.002	0.001	0.002
MC	0.002	0.002	0.002	0.002
MB	0.040	0.011	0.006	0.019
MI	0.003	0.001	0.001	0.002

Dust realized from moulding sands during tests.

Results

MF – furan
MA – Alphaset
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MB – Green sand
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Moulding sand symbol	Amount of: SO_2, NO_x, CO, CO_2 emitted in experiment[1] and calculated per kilo of molding sand[2]							
code	SO_2 $[cm^3]^1$	SO_2 $[cm^3/kg]^2$	NO_x $[cm^3]^1$	NO_x $[cm^3/kg]^2$	CO $[cm^3]^1$	CO $[cm^3/kg]^2$	CO_2 $[cm^3]^1$	CO_2 $[cm^3/kg]^2$
MF	1.4	10.5	0.011	0.08	98	738	6.7	50.4
MA	1.4	10.3	0.007	0.05	119	872	5.4	39.6
MG	0.11	0.82	-	-	53	394	7.2	53.6
MC	0.2	1.3	-	-	41	273	3.9	25.9
MB	1.9	13.7	-	-	134	965	10.1	72.7
MI	0.3	2.0	-	-	43	282	3.9	25.6

Emission of SO_2, CO, CO_2 and NO_x from molding sands.

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Conclusions

On the basis of the research, it can be concluded that:

- the highest total BTEX emissions were found in organic binders (MA and MF) and green sand;
- the molding sands with inorganic compounds, hardened with hot gases (MI, MC), showed emission BTEX several times lower, whereas for molding sands with inorganic binder, but hardened by organic hardener (MG), BTEX emission increases slightly;
- the main component of the released gases from the BTEX group was benzene (even above 90%);
- moulding sands with organic binders (MA and MF) release up to 10 times more compounds from the PAHS group than moulding with inorganic binders;
- significant amounts of PAHs are released by green sand due to carbon-containing additives.

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Green Foundry LIFE project (LIFE17 ENV/FI/000173)

AGH –UNIVERSITY OF SCIENCE AND TECHNOLOGY ACTIONS
Action B1: Emissions of different binder systems during small – scale test casts.
Method 2. Tests in foundry plants – small scale chamber

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materials

MDPI

Article

Research on the Release of Dangerous Compounds from the BTEX and PAHs Groups in Industrial Casting Conditions

Mariusz Holtzer [1], Rafał Dańko [1,*], Sylwester Piasny [2], Michał Kubecki [3], Dariusz Drożyński [1], Agnieszka Roczniak [1], Mateusz Skrzyński [1] and Angelika Kmita [4,*]

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Life

Materials

Furan resin: Kaltharz X 850 TN011 + Aktivator 100 T 3 (Hüttenes-Albertus) (code MF):.
composition of molding sand: silica sand – 98,5%; resin - 1%; hardener – 0.5%.

Phenol-formaldehyde resin (ALPHASET): Sinotherm 8255 + Aktivator J 120 (Hüttenes-Albertus) (code MA):
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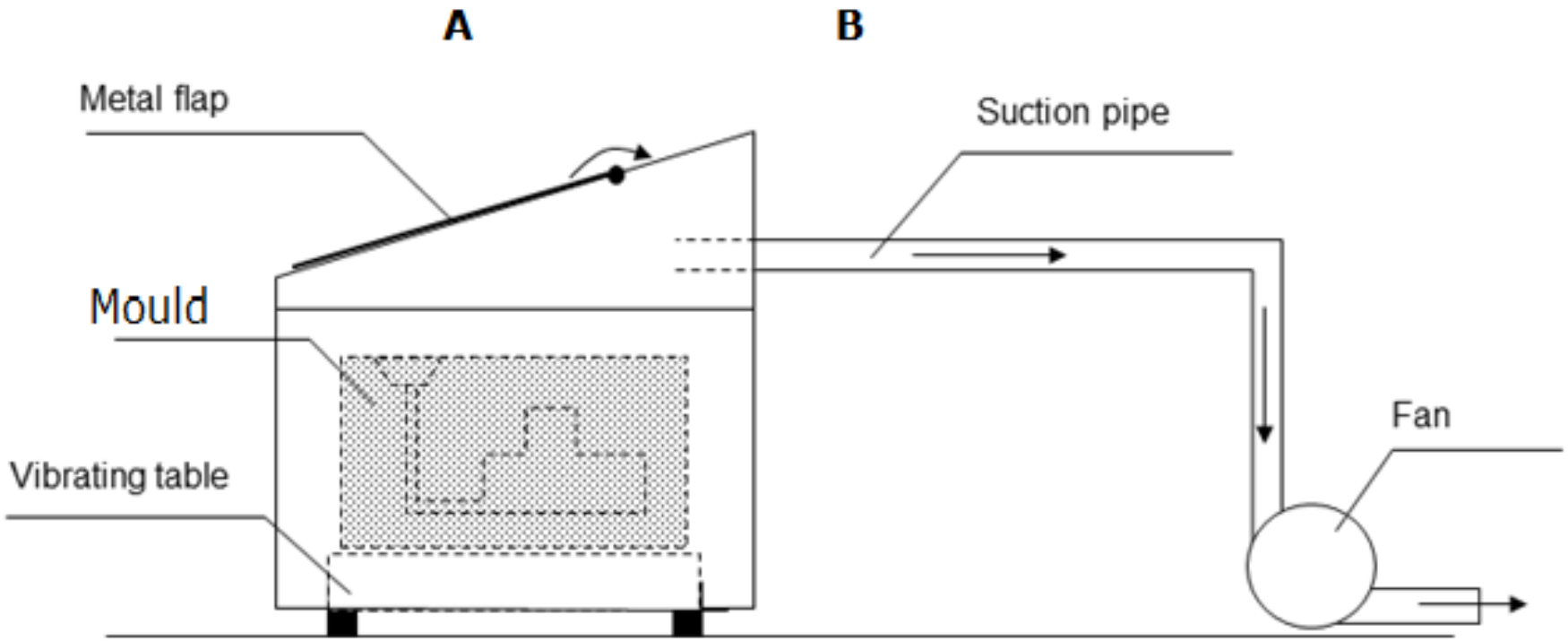
Methodology and apparatus used

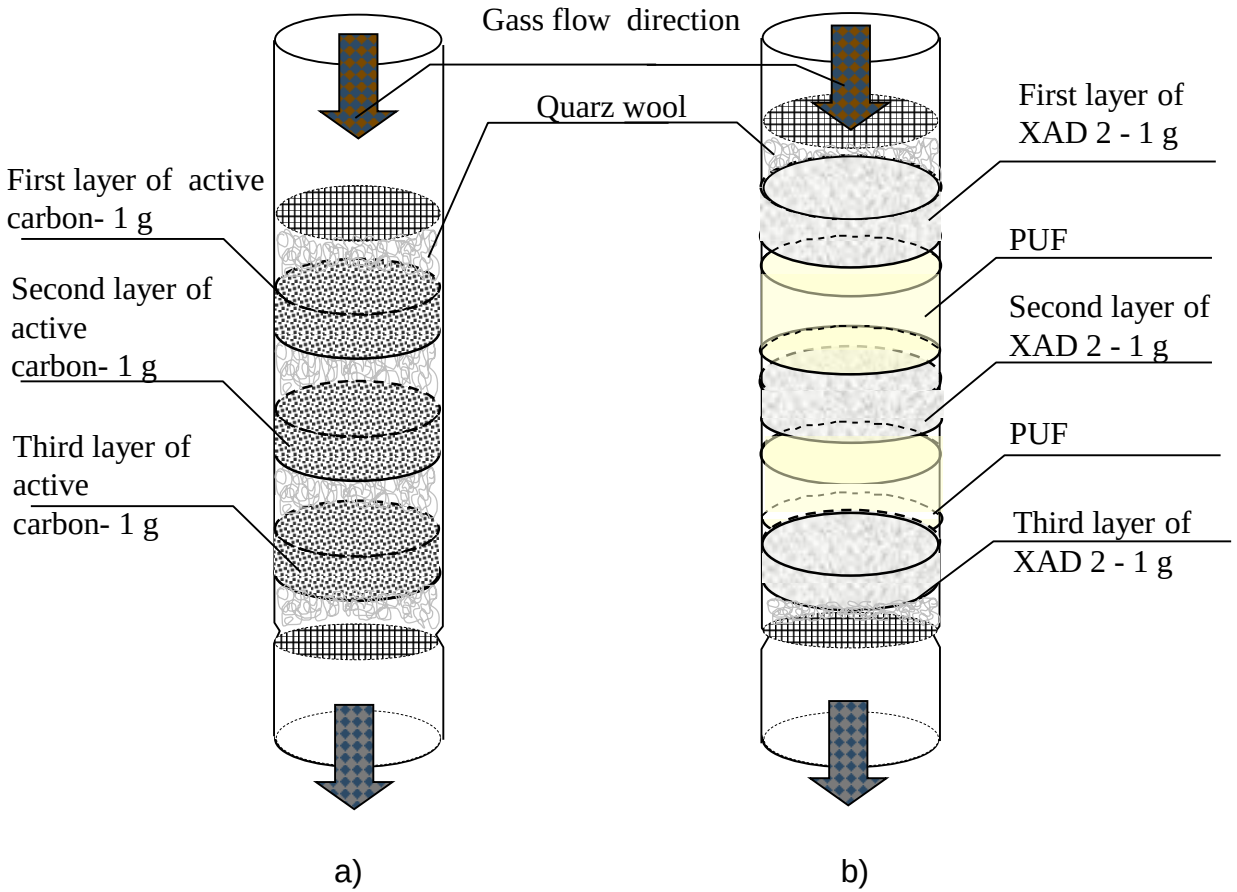


The scheme of the stand for pouring, cooling and shaking-out:

a) pouring stand,
b) suction system

Methodology and apparatus used

Methodology and apparatus used



Scheme of sorption tube:
a) to collect compounds from the BTEX group,
b) to collect compounds from the PAH group

Code	Benzene	Toluene	Ethylbenzene	m+p -xylene	o-xylene	Total
	[mg/kg]a	[mg/kg]a	[mg/kg]a	[mg/kg]a	[mg/kg]a	[mg/kg]a
	[mg/kg]b	[mg/kg]b	[mg/kg]b	[mg/kg]b	[mg/kg]b	[mg/kg]b
MF	18	63	0.46	2.1	0.46	**84**
	52	178	1.3	6.1	1.3	**238**
MA	23	7.2	0.31	3.1	0.46	**34**
	65	20	0.87	8.7	1.3	**96**
MB	2.6	1.7	0.15	0.46	0.15	**5.1**
	7.4	4.8	0.43	1.3	0.43	**14**
MI	1.1	0.46	0.15	0.31	0.15	**2.2**
	3.0	1.3	0.43	0.87	0.43	**6.0**
MG	1.1	0.31	0.05	0.15	0.01	**1.6**
	1.0	0.87	0.13	0.43	0.04	**3.5**
MC	0.15	0.06	0.01	0.03	-	**0.25**
	0.43	0.17	0.04	0.09	-	**0.73**

a) mg / 1 kg of sand b) mg / 1 kg metal

Amounts of compounds from BTEX group emitted during pouring, cooling and knock - out (total)

MF – furan
MA – Alphaset
MB – Green sand
MI – Inotec
MG – Geopol
MC – Cordis

Results

Amounts of compounds from PAH group emitted during pouring, cooling, and knock-out (total)

MF – furan
MA – Alphaset
MB – Green sand
MI – Inotec
MG – Geopol
MC – Cordis

Code	Naphthalene t_b = 217.9°C	Acenaphthylene t_b = 280 °C	Acenaphthene t_b = 279 °C	Fluorene t_b = 295 °C	Phenanthene t_b = 340 °C	Anthracene t_b = 319.3 °C	Fluoranthne t_b = 384 °C	Pyrene t_b = 40 4 °C	Total
	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a	[mg/kg]^a
	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b	[mg/kg]^b
MF	0.12	0.001	0.003	0.008	0.011	0.006	0.003	-	**0.15**
PAH	0.33	0.004	0.009	0.022	0.030	0.017	0.009	-	**0.42**
MA	0.51	00.031	0.012	0.032	0.031	0.015	0.006	0.005	**0.64**
PAH	1.43	0.087	0.035	0.091	0.087	0.043	0.017	0.013	**1.8**
MB	0.13	0.011	-	0.006	0.012	0.006	0.003	0.005	**0.16**
PAH	0.36	0.030	-	0.017	0.035	0.017	0.009	0.013	**0.48**
MI	0.015	-	-	0.001	0.003				**0.019**
PAH	0.043	-	-	0.004	0.009	-	-	-	**0.056**
MG	0.073	0.012	0.054	0.009	0.003	0.001	0.001	0.001	**0.15**
PAH	0.21	0.035	0.15	0.026	0.009	0.004	0.004	0.004	**0.41**
MC	0.009	0.001	0.001	0.003	0.001	0.001	0.001	0.001	**0.018**
PAH	0.026	**0.004**	0.004	0.009	0.004	0.004	0.004	0.004	**0.059**

[mg/kg]^b per 1 kg of mould sand , [mg/kg]^b per 1 kg of metal, t_b = boiling point

Conclusions

The following conclusions can be drawn on the bases of tests performed under the small scale chamber conditions:

1. Emissions of PAHs, as well as BTEX in case of moulding sands with organic binders is several dozen higher than the emission of these compounds from moulding sands with inorganic binders.
2. Green sands in respect of the PAHs emission are in the intermediate sphere, while in respect of the BTEX emission are comparable with moulding sands with inorganic binders.
3. From the comparison of moulding sands with organic binders it results, that the BTEX emission from the MA sand is more than two times lower than the emission from the MF sand, while benzene and toluene predominate in the composition of gases emitted from both sands.
4. Moulding sands with inorganic binders are comparable in terms of the emission amount of substances from the BTEX and PAHs groups. Higher values of the unitary emission from moulding sands with MG binder are the result of using the organic liquid hardener for this binder hardening, while for the hardening of the remaining two binders (MI, MC) high temperatures were used.
5. Moulding sands with inorganic binders (MG, MC and MI) are characterised by lower harmfulness for the environment and employees than moulding sands with organic binders.
6. Relatively environment friendly were green sands (MB), in which a part of coal dust was substituted by additions able to produce lustrous carbon.

Thank You very much for your attention

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