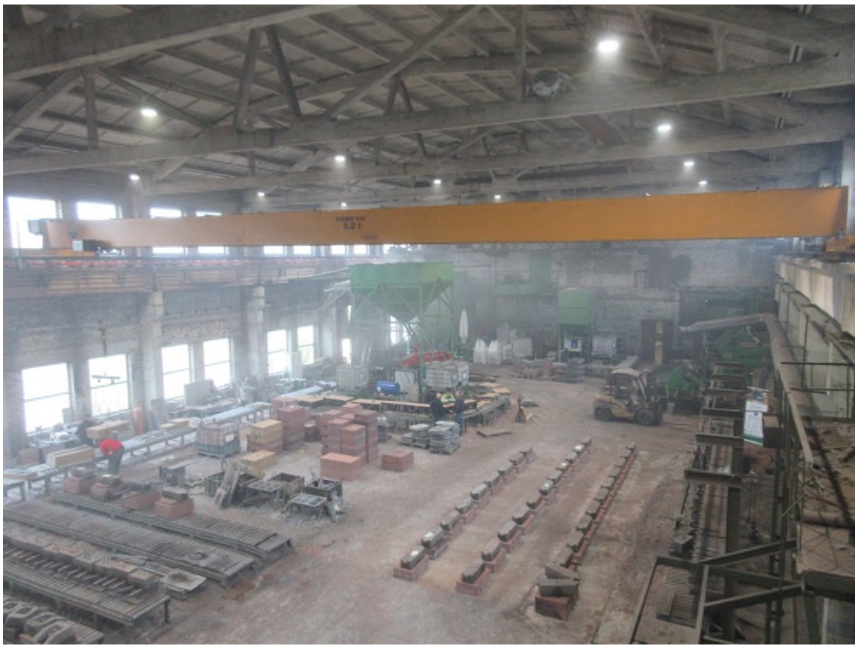
AX-Consulting

Green Foundry LIFE project (LIFE17 ENV/FI/173)

Action B2 Total emissions and indoor air quality measurements of pilot foundries

Emissions and indoor air concentrations of different binder systems during full-scale test casts

De2A Results of emission and indoor air measurements of organic and inorganic binder system test casts in Valumehaanika foundry in Estonia



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16.2.2022

Client	Valumehaanika AS Teguri 32 Tartu 51013 Estonia
Assignment	Measurement of emissions and indoor air concentrations from the casting mold
Measurement date and place	Tartu, 19.-24th of September 2021
Measurement staff	Pessi Suonpää and Seppo Heinänen
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T232 (EN ISO/IEC 17025)

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APPENDICES

1 Introduction

Valumehaanika AS (VM) is a small iron foundry locating in Tartu, Estonia. The foundry has been established in 1966 and it has been recently renovated.

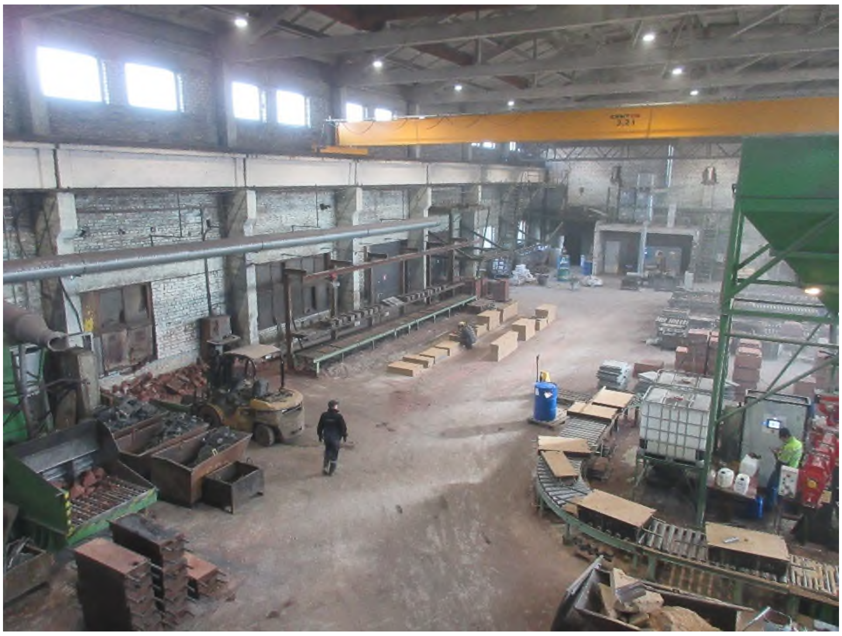

Figure 1. Overview of the foundry. At the back is the induction furnace and on the right the sand mixer.

VM has modern equipment, including a 3 years-old induction furnace with the melting capacity of 750 kg (figure 2) and a continuous mixer line, (figure 3).

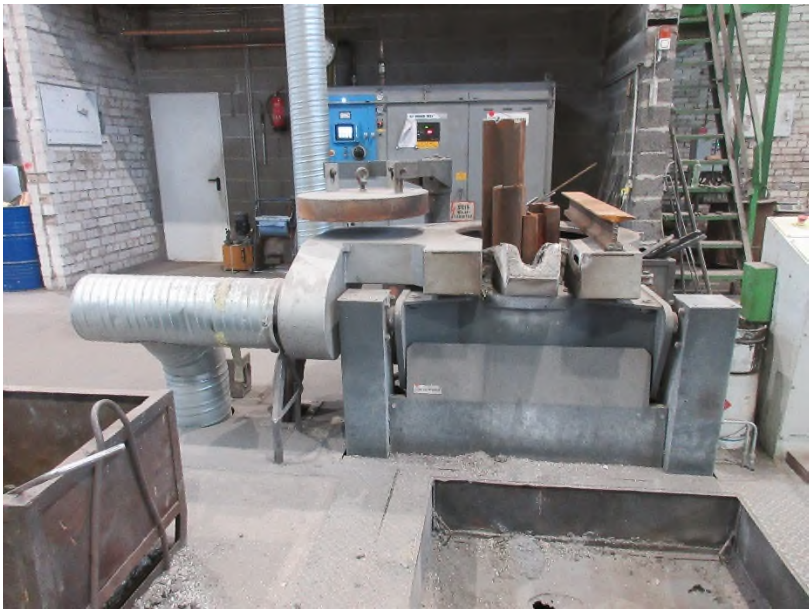

Figure 2. Induction furnace

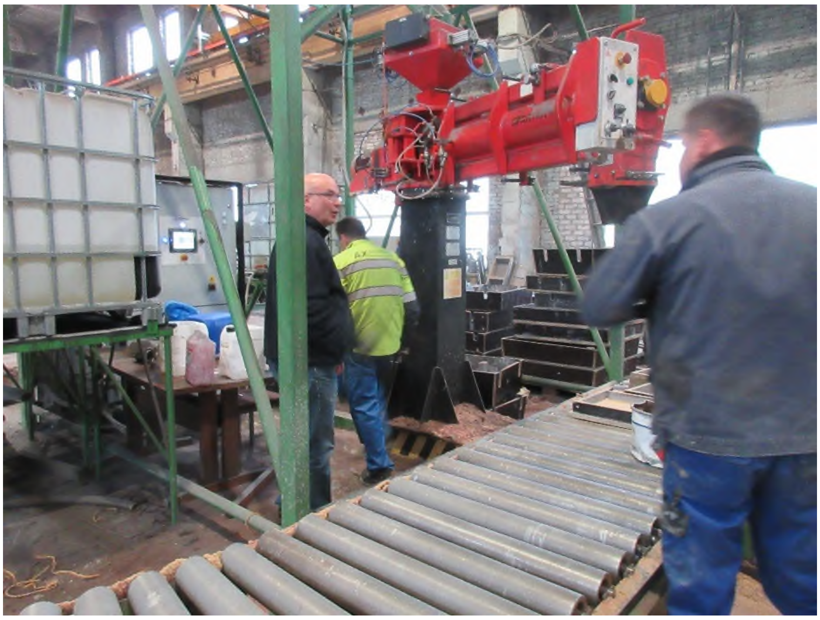

Figure 3. Modern continuous mixer.

The sand system at Valumehaanika is the organic phenolic Alphaset binder system. The used silica sand is from Estonia. The moulds and cores are made by hand. Typical casting size varies between 5...100 kg, and the products are used in machines, generators, furnaces and other heating equipment. Total annual production is ca. 200 tons of castings, and work force is ca. 10 employees.

Emission measurements were carried out with different binder systems (one organic phenolic binder and two inorganic binder systems) in order to compare the results between different binders. Same production volumes, products and process conditions were used for each of these three emission measurements. Each binder system was used for castings for the whole day and emission were measured. Same was repeated with other tested binder systems in following days. Measurements were carried out at Valumehaanika on 19.-24.9.2021. The aim of the measurements was to find out the concentration of components, emissions and concentrations in indoor air.

Following binder systems were tested:

1) Alphaset = organic phenolic Alphaset binder
2) Peak = inorganic Cast Clean S 27 binder and Cast Clean K4...K6 hardeners, made by Peak Deutschland GmbH
3) Geopol = inorganic Geopol 618 binder and SA73 hardener, made by SandTeam

2 Measurement results

Emission measurement results are presented in APPENDIX1 and the indoor air concentrations in APPENDIX 2. Trends from the measurements are presented in APPENDICES 3-6. Test parameters are presented in the project deliverable DeB3A Inorganic binder system test casts in Valumehaanika Foundry in Estonia".

3 Conclusions

The weight of the iron castings were 800 kg in each measurement and the sand amount was about 5000 kg. Measurement arrangements were principally same in each three measurement. However, it has to be noticed that there were background concentrations in the foundry hall which effected the results All unit process emissions were mixed in the room air because the foundry processes were in the same hall. The ventilation system was very primitive containing only a general ventilation (roof fans only). The binder system influence in the indoor air quality was affected by the unit processes (shake-out or demolishing activities) carried out in the same hall, and therefore the results were unillustrative and unclear. Based on the results of the test carried out with iron castings and using inorganic binder system, the total emission measurements demonstrated about 50% less emission concentrations compared to the organic binder. Emission measurement results from both the tested inorganic binders were similar. As a conclusion, emissions in the foundry were clearly reduced when implementing inorganic binders. All measurement results are presented in this report.

3.1. Emissions

3.1.1. Particles

Particulate matter emissions were about two times higher on organic Alphaset binder than on inorganic binders.

3.1.2. Carbon monoxide (CO)

Results show that there was a short-term high concentration of CO when the melt was poured and afterwards the concentrations started to reduce rapidly. Measured CO emissions were almost same with all binder systems.

3.1.3. Volatile Organic Compounds (VOC)

Highest VOC concentration was unexpectedly measured on Geopol inorganic binder and lowest on organic phenolic Alphaset binder. This is mainly due to ethanol and 2-propanol, which come from the coatingnot from binder systems.

3.1.4. BTEX

Emissions of BTEX compounds were approximately three times higher on Alphaset resin than on inorganic binder systems.

3.1.5. Sulphur dioxide (SO_2) and nitrogen oxides (NO_X)

During the measurements no significant concentrations of sulphur dioxide or nitrogen oxides were detected.

3.1.6. Phenols and cresols

During the measurements no significant concentrations of phenols and cresols were detected. The low phenol concentrations when using organic Alphaset binder system may result of the fact that the hall doors were occasionally left open during the measurement because of the transportation in the foundry hall.

3.1.7. Formaldehyde

Formaldehyde concentration was tree times higher on organic Alphaset binder than on inorganic binders.

3.2. Indoor air

3.2.1. Particles

Organic Alphaset binder particle concentration in indoor air was two times higher than on inorganic binders.

3.2.2. Volatile Organic Compounds (VOC)

VOC concentrations were almost the same with inorganic Geopol binder and with organic Alphaset binder and lowest with inorganic Peak binder. This is mainly due to ethanol and 2-propanol, which come from the coatingnot from binders.

3.2.3. BTEX

Emissions of BTEX compounds were approximately three times higher on organic Alphaset binder than on inorganic binders. Striking is the significantly higher benzene content on organic Alphaset binder.

3.2.4. Phenols and cresols

During the measurements no significant concentrations of phenols and cresols were detected.

3.2.5. Formaldehyde

Formaldehyde concentration was tree times higher on Alphaset resin than inorganig resins.

3.2.6. Quarts

Table 1. Measured quarts concentrations in indoor air

Binder	Measurement			Measured concentration	Part of limit(8h)-value
	date	start time	stop time	*mg/m³*	*%*
Alphaset	21.9.2021	11:00	12:49	0,18	358
Peak	22.9.2021	11:14	12:48	0,07	135
Geopol	23.9.2021	12:09	13:39	0,08	152

4 Procedure

4.1 Particles

Particle concentrations from the exhaust air were measured from samples taken with sond and pump in accordance with SFS-EN 13284-1 and SFS 3866 standards. Size of the sond and absorption rate were set so that the speed of the sample rate was as isokinetic with the speed of the exhaust air as possible. Uncertainty of concentration is ±15 %.

4.2 O_2, CO_2, CO, NO_x and SO_2

Sample from the exhaust air for the measurement of O_2, CO_2, CO, NO_x and SO_2 were taken with to the analyzers.

Uncertainty of the concentration is ±15 %.

4.3 Volatile Organic Compounds (VOC)

VOC measurement was made with the adsorption samples. Quantitative analysis from the hydrocarbon compounds was done one by one. Measurement was carried out in accordance with the SFS 3861 standard.

Tenax tube samples were analyzed by an accredited laboratory: Eurofins Environment Testing Finland, Lahti (FINAS T039)
Uncertainty of concentration is ±15 %.

4.4 Phenols

Phenols in the gas phase were collected from the exhaust air with the pump into the XAD-2-Supelco adsorption tubes. The analyses were carried out at an accredited laboratory: Eurofins Product Testing Denmark A/S (ISO 17025 DANAK) by Solvent Desorption/Gas Chromatography method.

4.5 Aldehydes

The aldehyde samples were taken from the exhaust air with the sample pump to the SepPAK-DNPH tubes. The analyses were carried out at an accredited laboratory: Eurofins Environment Testing Finland, Lahti (FINAS T039) by High Performance Liquid Chromatography (HPLC) method. Uncertainty of concentration is ±15 %.

4.6 Flow rate

The flow rate of the exhaust air was measured continuously with the pitot tube and the micromanometer. The result was calibrated with measuring the flow rate randomly from the exhaust air, using multi-point method with the micromanometer and the pitot tube, according to the SFS 5512 standard. The dry and wet temperatures were measured with the instant thermometer. Uncertainty of concentration is ±5 %.

The temperature was measured continuously with the thermoelement and the datalogger. Uncertainty of temperature is approximately ±1 °C.

5 Measurement equipment

The analyzer equipment and used standards and guidance, according to the measurements of the different components that were carried out, are presented in table 2.

Table 2. The measurement equipment, standards and guidance that were followed in the measurements.

Measurement method	Device mark	Measurement	Standard
CO SO2	Testo 300	Chemical cell	SFS 3869 SFS 5412 ISO 12039:2001
NOx	Testo 300	Chemical cell	SFS 3869 SFS 5425 SFS EN 14792:2005
SO2	Testo 300	Chemical cell	SFS 3869 ISO 7935:1992
Flow rate	Micromanometer and pitot-tube	Pressure difference	SFS 3866 SFS 3869 SFS EN 132844:2001
Temperature	Thermoelement	Voltage difference	SFS 3866 SFS 3869 SFS EN 132844:2002
VOC	Adsorption equipment	Adsorption	SFS EN 1948 SFS 3869
Phenols Aldehydes	Adsorption equipment	Adsorption	SFS EN 1948 SFS 3870
Particles	Particle measurem	Gravimetric	SFS EN 13284 SFS 3866 (adjusted)
H2O	Dry/wet temperature	Voltage difference	SFS 3866 SFS 3869 SFS EN 132844:2002

Binder type		Alphaset	Peak	Geopol
Casting quantity (kg)		800	860	800
Sand quantity (kg)		4800	5160	4800
Binder quantity (kg)		77,4	173,4	102,0
Exhaust air flow (Nm^3/s)		2,22	2,22	2,22
Concentration (mg/Nm^3)	Particles	7,23	3,62	3,22
	Total VOC	1,24	1,30	1,39
	BTEX	0,00	0,00	0,00
	Ethanol	0,15	0,15	0,16
	2-Propanol	<0,07	0,08	0,08
	Phenols	<0,04	<0,04	<0,05
	Cresols	0,08	0,08	0,08
	Asetaldehyde	0,38	1,27	1,19
	Formaldehyde	0,10	0,19	0,18
	Carbon monoxide	44,4	50,0	45,5
	NO_x	0,14	0,73	0,74
	SO_2	0,07	0,96	0,94
Emissions (g/h)	Particles	57,8	29,0	25,7
	Total VOC	9,9	10,4	11,1
	BTEX	0,00	0,00	0,00
	Ethanol	1,16	1,22	1,31
	2-Propanol	0,58	0,61	0,66
	Phenols	0,34	0,35	0,38
	Cresols	0,67	0,65	0,63
	Asetaldehyde	3,04	10,18	9,51
	Formaldehyde	0,79	1,48	1,47
	Carbon monoxide	355	400	364
	NOx	1,13	5,79	5,94
	S02	0,56	7,68	7,55
Emissions per casting quantity (mg/kg)	Particles	72,2	33,7	32,1
	Total VOC	12,4	12,1	13,9
	BTEX	0,0	0,0	0,0
	Ethanol	1,5	1,4	1,6
	2-Propanol	0,7	0,7	0,8
	Phenols	0,4	0,4	0,5
	Cresols	0,8	0,8	0,8
	Asetaldehyde	3,8	11,8	11,9
	Formaldehyde	1,0	1,7	1,8
	Carbon monoxide	444	465	455
	NOx	1,4	6,7	7,4
	S02	0,7	8,9	9,4
Emissions per sand quantity (mg/kg)	Particles	12,0	5,6	5,4
	Total VOC	2,1	2,0	2,3
	BTEX	0,0	0,0	0,0
	Ethanol	0,2	0,2	0,3
	2-Propanol	0,1	0,1	0,1
	Phenols	0,1	0,1	0,1
	Cresols	0,1	0,1	0,1
	Asetaldehyde	0,6	2,0	2,0
	Formaldehyde	0,2	0,3	0,3
	Carbon monoxide	73,9	77,5	75,8
	NOx	0,2	1,1	1,2
	S02	0,1	1,5	1,6
Emissions per binder quantity (mg/kg)	Particles	746	167	252
	Total VOC	128	60	109
	BTEX	0	0,0	0,0
	Ethanol	15,0	7,1	13
	2-Propanol	7,5	3,5	6,4
	Phenols	4,3	2,0	3,7
	Cresols	8,7	3,7	6,2
	Asetaldehyde	39,3	58,7	93,2
	Formaldehyde	10,2	8,5	14,4
	Carbon monoxide	4 586	2 306	3 565
	NOx	14,6	33,4	58,2
	S02	7,2	44,3	74,0