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

Steel pouring at the CTIF's experimental foundry

SUMMARY

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CTIF – Centre Technique des Industries de la Fonderie

Once the steel parts have been cast by the different partners of the Green Foundry Life project in order to compare the emissions generated in the foundry between organic and inorganic sand, CTIF carried out several works.

- For phase B3 of the project, concerning the impact of inorganic sand on the quality of steel castings:
  - ▪ Determination of roughness indices of the castings by the different partners,
  - ▪ Measurement of gas contents (on parts) that can be generated by the sand,
  - ▪ Structural investigations on samples taken from the parts to check the absence of defects due to exogenous gas generated by the sand.

- For phase B4.5 of the project, concerning inorganic sand waste:
  - ▪ Mechanical treatment tests,
  - ▪ Hydromechanical treatment tests,
  - ▪ Ultrasonic treatment tests,
  - ▪ Characterisations of sand samples carried out before and after treatment, to observe the impact of the different technologies on inorganic sands, and to select sand batches to be tested in leaching (sand batches before treatment, least treated sand batches and best treated sand batches).

- For phase B4.6 of the project, regarding options for reusing inorganic sand waste in geo-construction:
  - ▪ Leaching tests on inorganic sand waste,
  - ▪ Leaching tests on treated sands,
  - ▪ A synthesis of the results obtained in relation to the reference documents of the different countries taking part into this project (Germany, Spain, Finland, France, Italy, Poland).

Parts cast by the different partners of the project and characterized by CTIF

CTIF : Casting made of structural steel standard EN GS240,
INOTEC : Casting made of stainless steel ASTM A747 Cb7-Cu2 (Unified Numbering System 324 J92110),
GEOPOL and PEAK : Castings made of stainless steel ASTM A297 HH (UNS 401 J93503).

Roughness Indexes of Steel Parts Cast by the Project Partners

Parts	Roughness indexes measured on **moulding surfaces** **2S1 < standard < 8S1**	Roughness indexes measured on **finishing surfaces** **2S2 < standard< 5S2**	Results obtained compared to standard NF 1370 and the BNIF's RT n°359, for steel parts **Casting surfaces**	**Finishing surfaces**
CTIF Label O	External surface = 4S1 Internal surfaces = 2S1 to 6S1	*	Compliant with the standard Compliant with the standard	Compliant with the standard Compliant with the standard
CTIF Label I	External surface = 4S1 Internal surfaces = 2S1 to 6S1	*	Compliant with the standard Compliant with the standard	Compliant with the standard Compliant with the standard
GEOPOL	2S1 to 6S1	5S2	Compliant with the standard	Compliant with the standard
INOTEC	2S1 to 6S1	5S2	Compliant with the standard	Compliant with the standard
PEAK	2S1 to 5S1	5S2	Compliant with the standard	Compliant with the standard

* No reference plate corresponding to a simple sandblasting operation

Synthesis of carbon, sulphur and gas content measurements

Samples	Content % C surface	Content % C inside	Content % S surface	Conten % S inside	Content % N surface	Content % N inside	Content % O surface	Content % O inside	Content % H surface	Content % H inside
CTIF O1	0,20	0,21	0,0037	0,0035	0,0080	0,0085	0,0082	0,0082	<0,0001	<0,0001
CTIF O2	0,22	0,22	0,0035	0,0040	0,0080	0,0080	0,0072	0,0062	<0,0001	<0,0001
CTIF O3	0,19	0,21	0,0040	0,0040	0,0080	0,0080	0,0063	0,0085	<0,0001	<0,0001
CTIF I1	0,20	0,21	0,0040	0,0040	0,0080	0,0080	0,0174	0,0075	<0,0001	<0,0001
CTIF I2	0,19	0,21	0,0038	0,0040	0,0080	0,0080	0,0084	0,0065	<0,0001	<0,0001
CTIF I3	0,18	0,21	0,0042	0,0040	0,0080	0,0080	0,0065	0,0106	<0,0001	<0,0001
GEOPOL W37-20/1	0,058	0,049	0,011	0,010	0,0380	0,0380	0,0200	0,0195	0,0008	0,0008
GEOPOL W37-20/2	0,058	0,046	0,011	0,010	0,0385	0,0390	0,0181	0,0206	0,0008	0,0008
GEOPOL W37-20/3	0,058	0,050	0,011	0,010	0,0385	0,0385	0,0179	0,0187	0,0008	0,0008
INOTEC 1	0,045	0,045	0,017	0,016	0,0165	0,0170	0,0085	0,0087	0,0001	0,0002
INOTEC 2	0,053	0,054	0,019	0,020	0,0170	0,0160	0,0089	0,0091	0,0001	<0,0001
INOTEC 3	0,052	0,051	0,019	0,023	0,0175	0,0160	0,0095	0,0087	0,0001	0,0003
PEAK W37/1	0,060	0,050	0,013	0,010	0,0360	0,0390	0,0205	0,0329	0,0007	0,0006
PEAK W37/2	0,054	0,051	0,011	0,010	0,0365	0,0380	0,0173	0,0196	0,0007	0,0009
PEAK W37/3	0,052	0,049	0,011	0,010	0,0365	0,0370	0,0180	0,0196	0,0008	0,0009

Theoretical thresholds for the occurrence of defects: H < 5 ppm, N < 100 ppm or several hundred ppm if high alloying element contents, S < 150 ppm, O < 150 ppm or more if high Cr content.

Exceedance / standard

Action B4.5 Treatment tests of inorganic sand waste

Summary of the characterization of the sands to be treated

Laboratory Inspections on the sand samples	Ref SN BE01	INOTEC before T	CTIF IE before T	W37-20 before T	W37 before T
Fineness index	46	49	46	46	46
Distribution 50-70-100 (%)	95,03	85,27	89,71	86,21	86,90
Distribution 200-270-bottom (%)	0,18	1,30	1,10	0,64	0,42
Residual aggregates (% sieve 6+12+20)	0,00	0,24	0,28	0,46	0,30
Theoretical specific surface (cm2/g)	159	169	157	161	159
Breakage of sand grains observed under the optical microscope (high/low/not)	No	Low	Low	Low	Low
Aggregates observed under optical microscope (yes/no)	No	Yes	Yes	Yes	Yes
Presence of fines (no/low/significant)	Low	Significant	Significant	Significant	Significant
Grain shape observed under the light microscope (general trend: spherical/angular)	Spherical	Sph+Ang	Sph+Ang	Sph+Ang	Sph+Ang
Appearance of grains observed under the optical microscope (general trend: smooth/rough)	Smooth	Smooth+Rou	Smooth+Rou	Smooth+Rou	Smooth+Rou
Amount of black grains (general tendency: no/low/significant)	No	Low	Low	Low	Low
Quantity of light-coloured grains with black spots (general tendency: not/low/significant)	No	Significant	Significant	Significant	Significant
Amount of light-coloured, unstained grains (general trend: no/low/significant)	Significant	No	No	No	No
Electrical conductivity of sand (µS/cm)	500 - 520	907	1357	1045	957
pH of the sand	8,30 - 8,40	10,07	10,36	9,70	9,79
Acid demand of sand (ml HCl)	1,2 - 2,0	28	38,1	16,2	15,5
Samples retained for leaching test		X	X	X	X
UPDATED on November 26th 2021					

Results of the sand characterization after mechanical treatment

Laboratory checks on the sand samples	Ref SN BE01	INOTEC	CTIF IE	GEOPOL W37-20	PEAK W37
Fineness index	46	50	49	52	55
Distribution 50-70-100 (%)	95,03	92,00	94,68	90,27	90,75
Distribution 200-270-bottom (%)	0,18	0,92	1,04	1,89	2,28
Absence of residual aggregate (%)	0,00	0,00	0,00	0,08	0,04
Theoretical specific surface (cm2/g)	159	176	170	184	195
Breakage of sand grains observed under the light microscope (high/low/no)	no	low	low	significant	significant
Aggregate removal observed under optical microscope (yes/no)	no	yes	yes	yes	yes
Amount of fines produced by the treatment (no/low/significant)	no	significant	significant	significant	significant
Grain shape observed under light microscope (general trend: spherical/angular)	Spherical	Sph+Ang	Sph+Ang	Sph+Ang	Sph+Ang
Appearance of grains observed under the light microscope (general trend: smooth/rough)	smooth	smooth+Rug	smooth	smooth	smooth
Amount of black grains (general tendency: not/low/significant)	no	significant	low	low	low
Quantity of light-coloured grains with black spots (general tendency: not/low/significant)	no	significant	significant	significant	significant
Amount of light-coloured unstained grains (general trend: not/low/significant)	significant	no	low	low	low
Electrical conductivity of treated sand (µS/cm)	500 - 520	863	1262	997	842
pH of the treated sand	8,30 - 8,40	10,01	10,17	9,57	9,44
Acid demand of treated sand (ml HCL)	1,2 - 2,0	27,5	35,9	20,9	17,1
Samples retained for leaching test		X	X	X	X
Updated on 26/11/2021					

Results of the sand characterization after hydromechanical treatment

Laboratory checks on the sand samples	Ref SN BE01	INOTEC	CTIF IE	GEOPOL W37-20	PEAK W37
Fineness index	46	49	47	48	49
Distribution 50-70-100 (%)	95,03	92,64	95,42	94,68	93,94
Distribution 200-270-bottom (%)	0,18	0,14	0,04	0,00	0,06
Absence of residual aggregate (%)	0,00	0,04	0,00	0,04	0,08
Theoretical specific surface (cm2/g)	159	172	160	169	172
Breakage of sand grains under the light microscope (significant/low/no)	no	low	low	low	low
Aggregate removal observed under optical microscope (yes/no)	no	yes	yes	yes	yes
Amount of fines produced by the treatment (no/low/significant)	no	low	low	low	low
Grain shape observed under the optical microscope (general trend: spherical/angular)	Spherical	Sph+Ang	Sph+Ang	Sph+Ang	Sph+Ang
Appearance of grains under the optical microscope (general trend: smooth/rough)	smooth	smooth	smooth	smooth	smooth
Amount of black grains (general trend: no/low/significant)	no	low	low	low	low
Quantity of light-coloured grains with black spots (general trend: no/low/significant)	no	significant	low	low	low
Amount of clear unstained grains (general trend: no/low/significant)	significant	significant	significant	significant	significant
Electrical conductivity of treated sand (µS/cm)	500 - 520	523	516	507	511
pH of treated sand	8,30 - 8,40	8,78	8,73	8,72	8,45
Acid demand of treated sand (ml HCl)	1,2 - 2,0	5,8	2,2	0,6	1,5
Samples retained for leaching test		X	X	X	X
Updated on 26/11/2021					

Results of the characterization of the sands after ultrasonic treatment

Laboratory checks on the sand samples	Ref SN BE01	InoEC	CTIF IE	GEOPOL W37-20	PEAK W37
Fineness index	46	50	47	49	50
Distribution 50-70-100 (%)	95,03	93,02	96,10	94,14	93,98
Distribution 200-270-bottom (%)	0,18	0,18	0,06	0,04	0,10
Absence of residual aggregate (%)	0,00	0,04	0,04	0,06	0,12
Theoretical specific surface (cm2/g)	159	176	162	171	175
Casse grains de sable observée au microscope optique (significant/low/no)	no	low	low	low	low
Sand grain breakage observed by optical microscope (significant/low/no)	no	yes	yes	yes	yes
Aggregate removal observed under optical microscope (yes/no)	no	low	low	low	low
Amount of fines produced by the treatment (no/low/significant)	Spherical	Sph+Ang	Sph+Ang	Sph+Ang	Sph+Ang
Appearance of grains under the optical microscope (general trend: smooth/rough)	smooth	smooth	smooth	smooth	smooth
Amount of black grains (general trend: no/low/significant)	no	low	low	low	low
Quantity of light-coloured grains with black spots (general trend: no/low/significant)	no	significant	low	low	low
Quantity of clear unstained grains (general trend: no/low/significant)	significant	low	significant	significant	significant
Electrical conductivity of treated sand (µS/cm)	500 - 520	525	521	515	518
pH of treated sand	8,30 - 8,40	8,76	8,77	8,79	8,58
Acid demand of treated sand (ml HCL)	1,2 - 2,0	7,5	4,5	1,5	1,6
Samples retained for leaching test					
Updated on 26/11/2021					

Action B4.6 Options for reusing inorganic sand waste

Identifying options for reusing inorganic sands

Process	Options	Accepted in center	Use of the material in geo-contruction (document from Finlande)						
	Samples tested	waste inert	Roadway covered[1)]	Roadway paved[1)]	Field covered[1)]	Field paved[1)]	Embankment	Floor structure of industrial or storage building	Crushed stones and ash[2)]
Untreated sands	INOTEC	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	CTIF IE	No	No	No	No	No	No	No	No
	GEOPOL W37-20	No	No	No	No	No	No	No	No
	PEAK W37	No	No	Yes	No	No	No	Yes	No
Mechanical processing	INOTEC	No	Yes	Yes	No	Yes	Yes	Yes	Yes
	CTIF IE	No	No	No	No	No	No	No	No
	GEOPOL W37-20	No	No	No	No	No	No	No	No
	PEAK W37	No	No	Yes	No	No	No	Yes	No
Hydro mechanical processing	INOTEC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	CTIF IE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	GEOPOL W37-20	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	PEAK W37	Yes except in Italie	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MAJ du 12.01.2022									

Process	Options	Accepted in center	Use of the material in road ingeneering (2019 Cerema guide France)		
	Samples tested	waste inert	Alternative material for type 1 use	Alternative material for type 2 use	Alternative material for type 3 use
Untreated sands	INOTEC	No	Yes	Yes	Yes
	CTIF IE	No	Yes	Yes	Yes
	GEOPOL W37-20	No	No	No	No
	PEAK W37	No	No	No	No
Mechanical processing	INOTEC	No	Yes	Yes	No
	CTIF IE	No	Yes	Yes	Yes
	GEOPOL W37-20	No	No	No	No
	PEAK W37	No	No	No	No
Hydro mechanical processing	INOTEC	Yes	Yes	Yes	Yes
	CTIF IE	Yes	Yes	Yes	Yes
	GEOPOL W37-20	No	Yes	Yes	No
	PEAK W37	Yes except in Italie	Yes	Yes	Yes
MAJ du 12.01.2022					

Conclusion

The laboratory work carried out during this project made it possible to verify the impact of an inorganic sand on the quality of small steel castings.
It was found that the condition of the casting and finishing surfaces of the parts complied with the NF1370 standard according to BNIF technical recommendation no. 359 (Bureau de Normalisation des Industries de la Fonderie).
The contents of carbon, sulphur, nitrogen, hydrogen and oxygen measured on the part samples did not reveal any major problem.
The structural investigations carried out on the samples taken from the parts also confirmed that inorganic sand would apparently not have a major impact on the occurrence of defects (for the small steel parts tested in this project).

Treatment trials carried out on inorganic sand waste have shown that hydromechanical and ultrasonic technologies are particularly effective in obtaining an inert sand waste after treatment, or in allowing the treated sand to be reused in foundry, geo-construction or road engineering.

Nevertheless, these hydromechanical and ultrasonic treatment processes need to be tested on an industrial scale to verify whether these emerging technologies would be viable, compared to solutions using conventional technologies (mechanical, thermal, thermomechanical).

In this context, it would be interesting to develop a pilot capable of treating 250 kg of sand per cycle to check the feasibility and determine the consumption ratios, the production/maintenance ratios and the sand treatment costs in €/t, and to compare the results obtained with those of conventional installations.
The study of this (these) industrial pilot(s) would also enable a representative life cycle analysis and carbon impact calculation to be carried out, to find out whether the hydromechanical and ultrasonic technologies can be transferred to industry for the treatment of used foundry sand.