Action B3 Test series of molds, cores and casts produced by inorganic and organic binder systems

Deliverable DeB3A Test casts produced by inorganic binder systems in Valumehaanika AS in Estonia

Date: 31.12.2021

Authors: Meehanite Technology Oy

Foundryteam Oy

Contents

1. Background

These tests are part of the Action B.3. “Test series of moulds, cores and casts produced by inorganic and organic binder systems” and they are a continuation to the tests made in Karhula Foundry in Finland. Karhula Foundry had to the withdraw from the project 23rd October 2020 due to economic problems, caused by drastic drop in order intake during Covid-19 pandemic. Remaining test casts were produced at Valumehaanika AS in Estonia. First test casts were carried out I 19-24.9.2021 and the foundry continued until mid - December 2021. In total 19,7 tons of test castings were made by using inorganic binders.

2. Valumehaanika AS

Valumehaanika AS (VM) is small iron foundry locating in Tartu, Estonia. The foundry has been founded already in 1966 but is has been recently renovated. VM has now modern equipment, including 3 years old induction furnace with the melting capacity of 750 kg, figure 1, and continuous mixer line, figure 2.

Figure 1. Induction furnace

Figure 2. Modern continuous mixer.

The current binder system is the same as in Karhula Foundry, phenolic Alphaset system.

The used foundry sand is silica sand and it is from Estonian origin. The datasheet of the sand is in Annex 1. The moulds and cores are made by hand. Typical casting sizes vary between 5…100 kg, and they are used eg. in machines, generators, furnaces and other heating equipment. Total annual production is ca. 200 tons of castings, and work force is ca. 10 employees.

3. Tested inorganic binder systems

The currently used organic binder system, phenolic Alphaset, is so called self-setting. It means that the hardening happens at ambient temperature, without any need for heating or gas blowing. VM has no equipment for heating or gas blowing of moulds and cores. Therefore the only feasible inorganic binder systems are self-setting or “no-bake”. These systems harden at ambient temperature because the used hardener is organic ester.

Tested two no-bake systems were:

Cast Glean S 27 binder and Cast Clean K4…K6 hardeners, made by Peak Deutschland GmbH, see figures 3 and 4.

Geopol 618 binder and SA73 hardener, made by SandTeam, see figure 5.

Figure 3. Peak’s binder **Figure 4. Peak’s hardener**

Figure 5. SandTeam's binder and hardener

3.1 Test moulds made by Peak's inorganic binder system

Peak Deutchland GmbH in Nossen, Germany is producing a variation of sodium silicate solution binding and ester based hardening agents. Cast Clean S27 is designed for ferrous castings. Combined by ester hardener (catalyst) Peak's inorganic system is self-setting. This means that this binder + hardener reaches the required strength levels at normal room temperature and moisture without additional drying or heating.

Typical composition is 2…3% binder of the sand volume. The amount of the hardener is 10...12% of the binder, accordingly 0,2…0,3% of the sand volume. The hardener being mainly ester, the combination is not 100% inorganic. Based on Peak's experience, the gas formation is, however, expected to be only 10…15% compared to alpha set type phenolic binder system. The chamber test made in Karhula Foundry in autumn 2020 proved that this is true.

There are 7 types of hardeners K1…K7. The bigger the number, the faster is the hardener. Working times are 30 (with K1) …2 (with K7) minutes. The stipping time is 2…2,5 times the working time.

The tests were made in the production line using the continuous mixer. In the mixer, there are four pumps, one for the binder, two for different "speed" hardeners and one for water (for cleaning). Peaks binder and hardener can be connected to the pumps, which normally are pump Alphaset binder and hardener, without any changes or modifications. The binder and hardener are injected to the sand stream continuously in the mixer. Two different recipes of the binder and hardener were tested. Different recipes were tested.

Figure 6. Hand moulding.

The hardening times with this binder system are dependent on ambient temperature: the lower the temperature, the slower is hardening. The ambient temperature was only 12 °C, and hardening time with this recipe was too slow for the normal production rate. The stripping could be made 45…60 minutes after moulding, and the roller track filled with moulds waiting for stripping. Examples of the moulds after stripping are shown in figure 7.

Figure 7. Examples of the moulds made by Peak's binder system

The moulds were coated by alcohol-based zircon coatings, Foseco's TENO®tec 5800 B. The coatings were dried by flame burning. The examples of the coated mould are shown in figure 8.

Figure 8. Coated moulds made by Peak's binder systems.

Normally the aimed stripping time with organic Alphaset binder system is 15…30 minutes. Therefore a "faster" recipes were also tested. 7-8 recipes and combinations were tested.

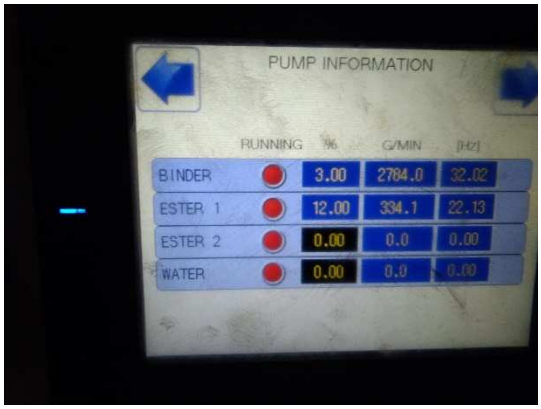

Figure 8. Setting values for the recipe nr. 2.

The hardening with the recipe nr.2 was somewhat faster. The stripping times were 30…45 minutes, but still longer that the aim is with organic Alphaset.

3.2 Test castings of the moulds made by Peak's binder systems

Test cast was made next day and accordingly the moulds had 18…24 h time to harden.

The composition of the melted iron: C: 3,3%, Si 1,7%, Mn 0,9%.

The grade of this gray cast iron type corresponds to the norms EN GJL-250 and GG25 in DIN 1691. The casting temperature was 1450 °C.

The figures 9. show the test cast.

Figure 9. Test cast of the moulds made by Peak's binder system.

Practically no fumes were emitted from the mould after pouring the melt into the moulds. The moulds were broken next day by hand hammering and cleaned by shot blasting machine, figure 10. In figures 11 and 12 are shown some of the test castings before and after shot blasting.

Figure 10. Shot blasting machine.

Figure 11. Test castings made by Peak's binder system before shot blasting.

Figure 12. Test castings made by Peak's binder system after shot blasting.

The surface quality of the test castings was comparable with the castings made by organic Alphaset moulds. The sticking of the sand to surface was, however, slightly stronger with test castings, and somewhat longer shot blasting times were needed.

3.3 Tests moulds made by SandTeam inorganic binder system

Geopolymers are purely inorganic materials; they belong among alkaline aluminosilicates. These materials contain silicon, aluminium and an alkaline element such as sodium or potassium. In nature, such materials occur as zeolites. Geopol, however, is not formed by geological processes, but is artificially prepared. Geopol is called geopolymer because its composition is close to the composition of natural rocks.

The hardening material is similar as with Peak,s binder system, ester, and Geopol binder system is also self-setting ie. “no-bake”.

SandTeam has developed different modifications of Geopol and SA hardeners. The tested binder is Geopol 618, which is recommended for ferrous castings. SA hardeners are classified so that SA 71 is the slowest and SA 76 is the fastest.

The hardening time is dependent on ambient temperature also with Geopol binder systems. The measured ambient temperature was very low, only 8…11 ^{o}C, during the moulding with Geopol binder system. Therefore the fastest hardener available SA 75 was only used.

Different recipes were tested. Geopol binder and SA hardeners can be used with the same mixer pumps as Alphaset binder and hardener, without any modifications and adjustments. The Geopol 618 binder and SA 75 hardener were connected by pipes to mixer pumps similarly as with Peak’s binder and hardener, without any problems. Only the setting values were set to give the abovementioned recipe.

The hardening happened very slowly, mainly because of the low ambient temperature. Some of the bigger moulds broke during or after stripping, due to too slow hardening, figures 13 and 14.

The Geopol moulds were made during two days, and the test casts were made in the second day, ca. 3 h after the producing the last mould. In second day, only smaller moulds were produced. Totally 19 successful moulds were made by Geopol binder system, but the stripping times were too long for normal production rate. According to them the hardening should have happened faster. One factor in hardening rate is foundry sand quality. Before the tests in Karhula Foundry, a sample of 10 kg foundry sand was sent to SandTeam’s laboratory, and they cave the recommendations of the recipe based on laboratory studies. It was now assumed, that Valumehaanika’s sand quality is similar as the sand quality in Karhula Foundry, and the recipe recommendation was made accordingly.

Figure 13. Mould made by Geopol, broken during stripping.

Figure 14. Mould made by Geopol, broken after stripping.

The Geopol moulds were also coated by alcohol-based zircon coatings, Foseco's TENO®tec 5800 B. The coatings were dried by flame burning, figure 15.

Figure 15. Drying of the coating with flame burning.

3.4 Test castings of the moulds made by SandTeam binder system

The test casts were made 3…27 h after the producing the moulds. The iron quality was the same as with Peak's moulds, gray cast iron type corresponding to the norms EN GJL-250 and GG25 in DIN 1691. The casting temperature was 1451 °C.

In sone moulds there were small leakages between the mould parts, see figure 16. It was expected to be caused by unproper sealing of the mould parts, not by breakage of the moulds.

Figure 16. Test cast of Geopol moulds. Small leakage in one mould, left.

The fume emissions were negligible also with Geopol moulds, see figure 17.

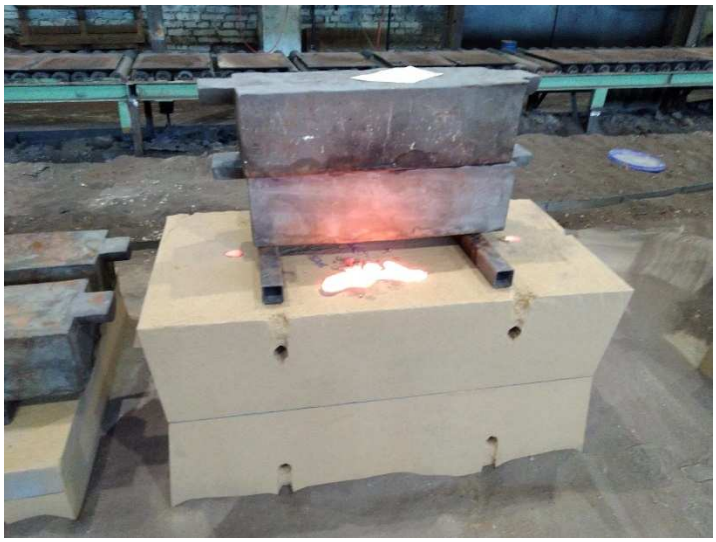

Figure 17. Geopol test mould. No visible fumes were emitted. Photo was taken 5 minutes after pouring.

The moulds were broken next day by hand hammering and test castings were cleaned by shot blasting machine, similar way as with Peak's test castings. Surface quality was comparable with castings made by Alphaset moulds. Due to slightly stronger sand sticking longer shot blasting times were needed. Figure 18 shows examples of the test castings made by Geopol binder system.

Figure 18. Test casting made by Geopol binder system.

4 Continuation of the tests

During the supervision on the tests, totally 2,9 tons of test castings were produced by using these two inorganic binder systems. At the same time totally 4,5 tons of comparison castings were produced by using organic Alphaset binder system. The sizes of the test castings were 20…550 kg.

Production personnel of Valumehaanika continued the tests with these two inorganic binder systems during the autumn of 2021. Totally 19,7 tons of test castings were made by using inorganic binders. This volume includes the test castings made during supervision. Totally 16,5 tons of comparison castings made by using organic Alphaset binder system. The total volume of test castings with inorganic and organic binder systems is 36,2 tons. The size range of the test castings was 20…870 kg.

5 Findings and conclusions

Both Peak's Cast Clean and SandTeams Geopol inorganic binder systems are suitable for Valumehaanika's current production line equipped with modern continuous mixer. The mixer pumps can be used without any modifications with both inorganic binder systems, instead of the current phenolic organic Alphaset binder system hardening rate with both inorganic binder systems was slower that with Alphaset low ambient temperature, 8…12 ^{o}C, was the main reason for slow hardening rate. Also Alphaset hardens slower in cool temperatures, but the rate can be adjusted by using faster hardeners both inorganic binder systems have also fast hardener types. However, the hardening rates with the fastest hardeners available were slower than anticipated by the binder producers one factor of the slow hardening rate could be the used sand quality. The Valumehaanika's sand sample must be sent to SandTeams's laboratory for studying it's effect on hardening rate the quality of the test castings was comparable with current Alphaset castings (samples of tests castings made by both inorganic binder systems, and samples of typical Alphaset

castings are available for further studies, if needed). Some moulds broke during or after stripping, due to too slow hardening ca. 50 moulds were also produced by Alphaset binder system for comparison (total emission and indoor air quality measurements were made during the test casts).

Annex:

KuivLiiv®

CE

TOIMIVUSDEKLARATSIOON nr 0,1-0,6 EN 13139

1. Tootetüübi identifitseerimiskood: **Kuivatatud ja sõelutud liiv 0,1/0,6**

2. Identifitseerimise märk: **0,1/0,6**

3. Kasutusotstarve: **kasutamiseks hoonetes, teedeehituses ja muudes ehitistes kasut. mõrt**
4. Tootja:EMG Kuiv Liiv OÜ
Vana-Narva mnt.11b, Kiiu alevik
74604 Harjumaa
Reg nr. 11306794
Tel/fax: 5247474; e-mail: info@kuivliiv.ee
Tootmiskoht: Vana-Narva mnt 11a, Kiiu alevik, Harjumaa

5. Ehitustoote toimivuse püsivuse hindamise ja kontrollimise **süsteem 2+**
Ühtlustatud standard: **EN 13139:2002+AC2004**

6. **Teavitatud asutus:** Tallinna Tehnikaülikooli Sertifitseerimisasutus reg. nr. 1504

7. Deklareeritud toimivus

Põhiomadused		Toimivus	Harmoneeritud tehniline kirjeldus
Tera kuju, suurus ja tihedus	Tera suurus	0,1/0,6	EN 13139:2002+AC:2004
	Peenosised	kat. 1	
	Puistetihedus	1,44 Mg/m³	
Koostisosad/ sisaldus	Huumuse sisaldus	Heledam etalonist	
	Kloriidide sisaldus	≤0,01%	
Ohtlikud ained	Radioaktiivne kiirgus	Ic1	

8. Punktides 1 ja 2 kindlaksmääratud toote toimivus on kooskõlas punktis 7 osutatud deklareeritud toimivusega. Käesolev toimivusdeklaratsioon on välja antud punktis 4 kindlaksmääratud tootja ainuvastutusel.

9. Eespool kirjeldatud toote toimivus vastab deklareeritud toimivusele. Käesolev toimivusdeklaratsioon on väljaantud kooskõlas määrusega (EL) nr.305/2011 eespool nimetatud tootja ainuvastutusel.

Tootja poolt ja nimel allkirjastanud:

Marek Klais
Juhatuse liige

Kiiu,
16.10.2019