MEEHANITE TECHNOLOGY

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Green Foundry

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DeB5.1A Content of the public Green Foundry project Workshop

Date	**Friday, April 22th 2022, 09:00-13:35 CET**
Participants	**Project partners and ca. 75 other invited participants. Total number of participants (whole time or part time) was ca. 100. The list of invited persons is in annex 1.**
Location	**TEAMS meeting**
Chair	**Dr.-Ing. Dirk Lehmhus, Fraunhofer IFAM, Bremen, Germany**
Presentations	**The copies of the presentations will be uploaded to the project website: www.greenfoundry-life@com**

Agenda

The webinar started at 9:00 CET

1. Overall project presentations (Sara Tapola/Meehanite Technology ltd, Tampere Finland)

Sara Tapola is the project coordinator.

She presented the main objectives of the project, the participating beneficiaries, and the main actions done in the project. The project started January 1st, 2018 and will end June 30th, 2022. The EU contribution is ca. 1,2 million €.

2. Results of test casts:

2.1 Karhula / Valumehaanika (Hannu Pöntinen/Pekka Kemppainen, Meehanite) at 9:20

Hannu Pöntinen and Pekka Kemppainen are working as consultants in Meehanite Technology Ltd.

The presentation dealt with the results of the production scale test casts with inorganic binder systems, done in Karhula Foundry in Kotka, Finland and Valumehaanika AS in Tartu, Estonia. Three different inorganic binders were evaluated in mould and core making. One of the inorganic binder systems required heating to temperature of 150…200 °C to harden. This system, consisting of binder and hardener/promotor material, is 100% inorganic. Two other systems harden at ambient temperatures ("self- setting"). These self-setting systems use organic ester solution as a hardener and thus contain low levels of organics. Pretests aimed at finding the optimum recipes for binder and hardener additions as well as other process parameters were carried out first. Thereafter, several full production scale test series were made using all three inorganic binder systems. Test castings in Karhula Foundry were stainless steels, in Valumehaanika gray cast iron. The weight range of the test castings in Karhula was 15…2500 kg, and in Valumehaanika 5…200 kg. The quality of the moulds, cores and castings made using inorganic binder systems was compared with the quality of the same products made using the currently employed organic binder system, i. e. phenolic Alphaset (for quality of casting, see also the respective presentation by CTIF).

In summary, the results were very promising. The emissions levels determined were remarkably smaller than with organic binder systems for all inorganic binder systems under scrutiny. Moulds, cores and ferrous castings produced using these binders showed similar quality and properties as their conventionally produced counterparts. A drawback is the need for elevated hardening temperatures in the case of the purely inorganic binder system. The temperature levels required in this case do not allow the use of current patterns and core-boxes, which are made of wooden or plastic material, due to the risk of deformations or breakage. The change of all patterns and core-boxes to heat resistant materials like metals would be technically possible, but afford very large investments.

While the experiments performed were technically successful, large scale implementation of inorganic binders in ferrous foundries requires a lot of information about the various systems available and many successful examples of the actual transformation, on industrial scale, from conventional to inorganic systems. This is due to the conservative nature of the foundry industry, but even more so because of potential investments associated with the change, which need to be well justified in a sector with notoriously small margins. To facilitate such a broad demonstration of inorganic binder systems in ferrous foundry, a new LIFE project proposal has been prepared for the 2022 LIFE programme: "Green Casting LIFE". If the proposal gets funded by the commission, six "flagship" foundries are committed to start production scale implementation of inorganic binders in some or all of their production and make the necessary investments. In addition, a minimum of 15 "follower" pilot foundries would benefit from the results and experiences achieved in the flagship foundries and start the implementation process during the project on this basis.

Discussion:

Q: Is the usage of inorganic binders a "mature" method in ferrous foundries?
A: Acc. to binder producers, ca. 1 % (ca. 40) of the European foundries are currently using inorganic binders, most of them are casting light metals (Al) (information received from company Foseco). We

are aware of only 5…6 ferrous foundries in Europe, which are using inorganic binders in every-day practice, partly or fully in their production lines. It can therefore be concluded that the introduction of inorganic binders in ferrous foundries is at an early stage.

Q: Is it still possible to join the new LIFE project proposal?
A: The core project consortium is already fixed, but the project needs numerous "follower" pilot foundries. As soon as we get a positive response from the Commission, we will be in touch with the potential pilot foundries. Participants of the present meeting are invited to declare their interest in joining the proposal in this role.

Comment by Pekka Kemppainen: One possibility of using inorganic binders would be to produce cores by metallic core boxes which tolerate the higher temperatures needed by the 100% inorganic binder system but manufacture the moulds themselves using the self-setting "semi" inorganic binder systems. As most of the gaseous emission are emitted from the cores, and as even the "semi" inorganic systems provide a significant improvement in this respect when compared to the fully organic ones, harmful emission levels would still be effectively reduced & investment needs lowered.

2.2 FA, Fonderie di Assisi (Stefano Saetta/UNIPG) at 9:40

Stefano Saetta is a professor in University of Perugia, Department of Engineering.

He presented the results of casting experiments based on cores which were produced using inorganic binder systems at the pilot foundry Fonderie di Assisi (FA). FA produces demanding castings for the automotive industry (mainly engine components) from steel and cast iron. The core chosen for the tests was a complicated and difficult, which has caused some problems in production when produced using the current organic (phenolic) cold-box method. The cores were produced by a sub-supplier, which already had experience in producing cores with inorganic binders for aluminum foundries. Two different, 100 % inorganic binder systems requiring heating to 150…200^{o}C for hardening were used. The cores were delivered to FA in boxes tightly covered by plastic foil to avoid potentially detrimental effects of humidity during transportation and storage. The cores were inserted into green sand (bentonite) moulds. The casting material was gray cast iron. The quality of cores based on inorganic binder systems was found to be equal to the current organic cores. The quality of the test castings was also comparable with current production castings. Gas formation was significantly reduced compared to Cold-Box cores, resulting in less emissions and better indoor air quality in the foundry.

Discussion:

Q: Did you use a coating for the cores?
A: Most of the cores were painted with an alcohol-based Zr coating, except for a few which were uncoated as a basis for comparison. No big difference in casting quality or in shake-out properties was found between coated and uncoated samples.

3. Results of emission reduction chamber tests with different inorganic and organic binder systems (Rafal Danko/AGH) at 10:00

Rafal Danko is a professor in AGH University of Science and Technology in Krakow, Poland. AGH is 100 years old university, with ca. 25000 students and 2500 professors. AGH is known for the research and education eg. in foundry technology.

Rafal Danko presented the results of emission measurements made with two different chamber test methods. Laboratory scale tests were performed at AGH and somewhat bigger chamber tests at Hardkop pilot foundry. Test arrangements can be seen in the presentation available via the project website. Three different inorganic binders were used in the tests, among them two fully inorganic binder systems and one “semi” inorganic binder system, where the hardener is an organic ester solution. In comparative measurements, three different organic binder systems were used: Furan, phenolic Alpaset and green (bentonite) sand system. In the green sand system the organic material is the coal powder which is added to improve the surface quality of the castings.

In the summary of results it was stated that emissions of PAHs, as well as BTEX in case of moulding sands with furan and alphaset organic binders, is several dozen times higher than the emission of these compounds from moulding sands with all inorganic binders. Green sand was situated between organic and inorganic binder systems in terms of PAHs emissions, but comparable in BTEX emissions to the inorganic binders. The emissions of green sand can be reduced by substituting coal dust with more environmentally friendly additions.

As a conclusion, sands with inorganic binders are less harmful for both environment and employees than moulding sands with organic binders.

Discussion:

Q: Do the lower emissions allow the workers to work without masks?
A: This depends on national regulations. The results of the experiments must be compared to these to decide on a case-by-case (i.e. country-by-country) basis.

Comment: Lower emissions generally reduce the need for ventilation. The cost of ventilation is high in cold climate areas, such as eg. central and Northern Finland, where introduction of inorganic binder systems could thus constitute a significant additional benefit.

4. Tested surplus foundry sand recycling and reuse methods

4.1 Thermal reclamation (Juhani Orkas, Association of Finnish Foundry Industry) at 10:20

Juhani Orkas is professor of casting technology in Aalto University, Department of Mechanical Engineering in Espoo Finland. He is also working in Association of Finnish Foundry Industry, which is the beneficiary partner in this project.

Juhani Orkas presented the results of thermal reclamation demonstrations. The demonstrations were made in an old Nuutajärvi glass plant, where the rotating drum dryer has been turned into a waste foundry sand reclaiming furnace. FinnRecycling Oy has developed the machinery and process and they now can serve all foundry customers no matter of the sand type.

During the project two types of used inorganic binder sands were treated (one fully inorganic and one “semi” inorganic having ester solution hardener) by thermal reclamation. The results were compared to those obtained for used sands based on organic furan, phenolic Alphaset and green sand methods. The temperature in the drum during thermal reclamation was

As conclusion it was stated that the thermal reclamation gives best results with used Alphaset sand; the bending test results are even better than with new sand in this case. Good results are also achieved with used furan sand, while for fully and “semi” inorganic used sands thermal reclamation improves the bending test results at least to some degree. For green sand it was found that there is a need of mechanical treatment following thermal reclamation. For such a process, a new mobile treatment unit has been developed. Foundries can buy or lease the equipment and place it on their own premises to lower transportation costs.

Discussion:

Q: How many cycles of thermal reclamation can be applied?
A: The typical process in the foundries is to use 30% new sand and 70% recycled sand. This means that sand is recycled 3…4 times. Because sand is becoming a disappearing resource, this should be improved. When using the Alphaset method, 10% new sand and 90% recycled sand may already be possible, which means ca. 10 recycling rounds.

Comment by Pekka Kemppainen: With ceramic sand (instead of normally used silica sand) it should be possible to recycle as many times as needed. The sand gets finer in the process, but this may even be beneficial: It would be worth testing whether coatings might be avoided in this case. Juhani Orkas promised to study this.

Comment by Theo Kooyers: Theoretically 5% new sand and 95% recycled sand is the maximum, because some sand is always lost in the process. This has been already tested with olivine and ceramic sands.

4.2 Composting tests (Sara Tapola/Meehanite) 10:40

Sara Tapola is the coordinator of the project. Besides coordinating the project, Meehanite Technology is also responsible for some actions.

Sara Tapola presented the results of the composting tests. Meehanite has gained experience in composting waste foundry sands in earlier LIFE projects and owns the patent for this method. The goal is to avoid landfilling of waste foundry sands by cleaning them via composting and in turn reusing them as additive in soil material.

In the present project, 500 tons of composting material were cleaned in Finland and Spain, containing 20…30% waste foundry sand and dust. Both organic and inorganic binder system waste sands were tested. Good cleaning results have been achieved with organic furan, phenolic Alphaset and bentonite waste sands. Harmful organic substances (DOC, TOC, BTEX) and fluoride were degraded by 70...90% during composting. Inorganic binder waste sands are also suitable for composting, but they contain only small amounts of harmful substances, so in this case, use in composting remains an option for avoiding landfill, but the cleaning capability of the composting process is not needed in this case.

In the presentation, an example of building a composting site was presented. The most effective way for using this method would be if foundries co-operated with current composting sites owned eg. by local waste management companies. Benefit for the latter would be that the waste foundry sand would replace sand which today has to be bought by operators of composting sites as mineral additive.

Discussion:

Q: Is composting decreasing the amounts of heavy metals in waste foundry sands?
A: No.
Q: How should waste sands containing heavy metal contaminations be treated?
A: The only known commercial method is separation, typically by magnets. The reuse of waste foundry sand with high concentration of heavy metals is still a problem and it is normally landfilled.

4.3 Washing tests (Patricia Caballero/Tecnalia) at 11:00

Patricia Caballero is director of foundry technologies at Tecnalia, in Spain.

She presented the results of laboratory scale washing tests. Distilled water and 5M HCl acid were used. The waste sands were first washed using distilled water and filtered repeatedly until pH 9,35 was achieved. Then the sand was mixed with HCl at a ratio of 1:5 in a flask which was then placed in a magnetic agitator for 8 hours. The sand was then rinsed with water and afterwards dried at 105°C. Both green sand and inorganic silicate binder system waste sands were tested. The washing method decreased the amounts of metals (Ba, Cr, Fe, Mo, Ni, Zn) in waste sand by 11..51% and the amounts of hazardous elements in green sand (fluorides, phenols, DOC, TOC, BTEX) by 36…99%. The method is effective but at the moment there is no commercial applications.

Discussion:

Comments by Patricia: The washing method has been previously utilized commercially for green (bentonite) sands in Spain. Unfortunately, the company ceased operations just before the project started in 2018. The foundry industry is important for recycling especially of metals, and it should recycle and reuse also sands as efficiently as possible. Which treatment method is best for the environment and economy is not yet fully clear. Composting is feasible and applied in Spain, too.

4.4 Mechanical, hydromechanical and ultrasonic treatment tests of inorganic waste sands (Jean-Bernard Virolle/CTIF) at 11:20

Jean-Bernard Virolle is head of Experimentation and Prototyping at CTIF.

He presented the results of the different laboratory scale sand recycling methods. The used sands were four different inorganic binder sands from demonstrations in Karhula Foundry and in CTIF's own foundry. The basic principles of different methods were presented on "sand grain" scale.

As a conclusion it was stated that mechanical treatment alone is not sufficient to clean inorganic binder sands. Hydromechanical method is the best option, and the recycled sand works as well as new sand in core making. An alternative is the ultrasonic method, which also performed well in small scale tests. Similar bending test results were received compared to hydromechanically recycled sand. An important next step would be the scaling-up of the method to meet industrial requirements.

4.5. Leaching tests and identifying reuse options (Jean-Bernard Virolle/CTIF) at 11:40

Jean-Bernard Virolle also presented the results from the leaching tests of untreated and recycled inorganic binder sands. Different reuse options were addressed for all tested sands.

As a conclusion it was stated that all hydromechanically treated sands can be reused in road or geo constructions. Some of the waste sands (from fully inorganic binder systems) can be used in these reuse options without any treatment. Mechanical recycling is not effective method to increase the reuse options.

Discussions of presentations 4.4. and 4.5:

Comment by Theo Kooyers: Peak's Cast Clean binder systems does not contain any fluorides. Thus the fluorides identified by the leaching tests must stem from some other source. This does not only apply for Peak's, but also for the other inorganic binder systems investigated. The fluoride source must be something else than binder or hardener. Discussion hinted at risers as the most probable source.

Discussion about the cost of new sand and sand disposal:

- **Juhani Orkas**: virgin sand + dumping fee 100…300 €/ton
- **Timo Kronqvist:** deposit fee in Finland is now 100 €/ton
- **Comment from a Polish foundry**: dumping fee is "enormous" in Poland

Q: Are silica sand dust emissions measured and what are the results?
A: (by the author) Dust results are presented in the total emission and indoor air quality reports, to be uploaded later on the project's web site.

5. BAT report will be presented (Dirk Lehmhus/IFAM) at 12:00

Dirk Lehmhus is senior researcher in the department of Casting Technology and Lightweight Construction at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) in Bremen, Germany.

He presented an outline of the Best Available Techniques Reference Document (BREF) process plus additional information on the relevance of the Best Available Techniques (BAT) and Emerging Techniques (ET). Purpose of the BREF document is to define the state of the art in terms of technologies contributing to the reduction of emissions and pollution, typically in one specific industrial sector. Techniques identified as BAT set the benchmark for the permission of new industrial installations in EU member states. The current BREF for the smitheries and foundries industry dates from 2005, the process for defining a new BREF has been started with a KickOff-meeting in September 2019. A first draft of the new document has been published in February 2022 and is available through https://eippcb.jrc.ec.europa.eu/sites/default/files/2022 02/SF_BREF_D1_web.pdf.

Prerequisite for a technological approach to be considered as BAT is its commercial availability.

Findings of the Green Foundry LIFE project are meant to be fed into the BREF process either as BAT or as ET: The aim of the present workshop is to discuss the selection made by project partners with external stakeholders. Green Foundry LIFE suggests inclusion of the following techniques in the upcoming BREF document:

<u>As BAT:</u>

- Use of inorganic binders for moulds in iron and steel casting
- Use of inorganic binders for cores in iron and steel casting

- Thermal reclamation of foundry sands primarily for organic binder waste foundry sands
- Composting of waste foundry sands

As ET:

- Washing of waste foundry sand
- Ultrasonic treatment of waste foundry sand
- Hydromechanical treatment of waste foundry sand

6. Discussion and gathering of information/feedback (Dirk Lehmhus/IFAM) at 12:30

Remarks from the general discussions.

Comment by Erkki Karvonen: The binder system is the “key” factor in the processes of the foundries using sand moulds and cores. No foundry manager will change the binder system easily! A lot of testing and demonstrations must be made to prove that all processes (moulding, core making, pouring, knock-out, sand reclamation etc.) are working well with the new binder systems. The proposed new LIFE project “Green Casting LIFE” is therefore extremely important as basis for implementation of such changes, as it facilitates the required scope of production scale demonstrations with inorganic binders in different ferrous foundries and makes the experiences and results gathered in the course of these experiments available to all foundries and other stakeholders.

Discussion around BAT and BREF process:

Nicolas Creon is a member in BREF working group. He described the requirements for a new BAT. The technique must be available, economical and technically viable. When a new BAT is accepted, the limit values for emissions and indoor air quality will be set accordingly, and these limit values are then mandatory for all foundries which apply the BAT in question!
In order to get enough and reliable measurement data, any BAT must be applied in a minimum of 10…20 foundries before the related limit values can be fixed.
Question by Sara Tapola: The implementation of the inorganic binder systems will most probably happen step-by-step, so that foundries start to utilize inorganic binders first only in some part of the production. What kind of limit values are applied in this transition phase?
Nicolas Creon: Local authorities will decide. It may be that old limit values are applied in such cases.
Comment by Benjamin Laulier: Any BAT must be a commercialized technique and economically viable. Before approving any technique as BAT, a thorough LCA should be performed.
Question by Pekka Kemppainen: Are the BAT rules the same in all EU countries, and who will enforce them in the various member states?
A: The rules are the same, local authorities have the responsibility to monitor that the rules are being followed.
Nicolas Creon informed that new BREF will be ready in 2023.
Juhani Orkas stated that the CAEF has gathered a lot of comments related to the initial draft of the BREF. Criticism has been directed especially at the proposed extent of mandatory monitoring, which would be very costly for the foundries! Further comments from more than 200 foundries address the new limit values proposed, which are felt to be very tight.
Maciej Krolikowski commented that the new limit value for dust would mean that his foundry OPSA would have to invest a lot for air conditioning, eg. for renewal of all filters.

Discussion around the competition from foundries outside EU.

Pekka Kemppainen asked if the foundries outside EU are obliged to follow the same rules when they import to EU?
Nicolas Creon responded that this was not the case as BREF is only applicable to foundries in the EU**.**
Rafal Danko said that one proposed way to protect EU production would be a tax based on CO_2 emissions, eg. due to extra transportation, and potentially an additional tax based on heavy pollution/environmental impact.
Sandra Gaspar commented that eg. in Asia there are also very “clean” foundries, so that all foreign foundries couldn’t be treated similarly.
Timo Kronquist requested EU to set rules for the import. In calculating CO_2 emissions transportation should be taken into account!

Discussion about the current and future environmental problems and challenges of the foundries

Questions from the Green Foundry LIFE consortium to stimulate the discussion:

- What are your foundries biggest environmental problems and challenges?
- Are customers and/or authorities putting pressure on your foundry to solve these problems?
- Do your customers choose their suppliers based on questions of environmental impact?
- Are your customers willing to “pay extra” in return for “greener” production processes?
- Does your foundry have experience with inorganic binder systems? If so, what kind of experiences (pros and cons)?

Answers and comments by Sandra Gaspar: Our foundry FMGC get pressure to solve environmental problems and challenges by authorities and customers. Some customers are willing to pay extra for “cleaner” processes. Main environmental problem is CO_2 emissions caused by melting process. Waste sand disposal is also problem - some part of the waste sand is used in road and other geo construction, some is landfilled. At FMGC, this has led to a new moulding line, maybe using inorganic binders, being considered. Composting of waste sand is also a possible option.

Sandra Gaspar suggested the formation of a research group working on sand regeneration issues. **Timo Kronquist** and **Maciej Krolikowski** declared their interest in such a group.

Rafał Dojka stated that customers are indeed not willing to pay more for green processes. Furthermore, he asked whether a distinction might be made in the BREF between diffferent products, e.g. based on product size. This could make the transition easier, as an overnight change for all production lines would not be feasible.

Comment from Maciej Krolikowski: Dust limit values as proposed in the current draft of the BREF will put foundries under significant pressure (see also comment above).

Closure of the webinar at 13:35 CET