IMPROVE THE USE OF NATURAL RESOURCES: INORGANIC BINDERS IN IRON AND STEEL FOUNDRIES CASE OF THE GREEN FOUNDRY LIFE PROJECT.

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Introduction

The foundry industry plays a key role in the overall industrial sector and its environmental impact in not negligible: high gas emissions and waste generation make it one of the most environmentally polluting section. Therefore the increasing need to have environmentally friendly industrial sectors, leads to a continuous research on technologies that guarantee not only compliance with technological parameters but also environmental ones.

In particular in the foundry industry most of the contaminants originate from combustion of organic binders in sand moulds after coming to contact with liquid metal in temperatures of over 1200° C. This causes hazardous emissions evaporation to the ambient air and indoor air. Remarkable part of contaminants condensates back into moulds making the sand used for the moulds also contaminated. If the surplus foundry sand is disposed in landfills the binder residuals begin to degrade and causing some GHGs to ambient air. The use of inorganic binders is a solution to eliminate emissions problems and to use the foundry sand more efficiently, leading to lower consumption of natural resources such as natural sand, water and energy. Moreover the inorganic binder reducing some technological problems such as the poor knocking out, elasticity and reclamability **(Izdebska-Szanda et al., 2013).**

Green Foundry LIFE project (LIFE17 ENV/FI/000173) introduces novel technologies for sand-moulding systems to cut emissions, improve indoor air quality and support the circular economy through re-use of foundry sand that is normally landfilled.

State of art

In modern foundry engineering the trend regarding the use of molding sands are towards lower and lower levels of environmental impact. One of the main impact is the VOCs, Volatile Organic Compounds, origin during the casting process. Such emissions can be dangerous not only for the environment, but also for the workplace safety. Hence, the trend is to replace older production processes that worked well for long times, with newer processes more ecological. In the case of molding sand with bentonite and coal dust (green sand), for example, the effort is to substitute coal dust, or to introduce substances to reduce harmful emissions. In the case of protective coatings, the effort is to use water based solvents instead of alcohol based solvents (**Major-Gabrys, 2019**).

More recently moulding sand is hardened with technology Hot-Box or Warm-Box with hot air or microwaves.

INOTEC can be used to make cores (Conev et al., 2016) with a water content around 60-65%. The production process use heated core boxes with air purging, to minimize moisture content. In particular, as shown in Figure 1, mould lifetime is quite short, depending on temperature and relative humidity. Cordis binder (Hosadyna-Kondracka et al., 2018) is based on hydrated sodium silicate with high temperature hardening.

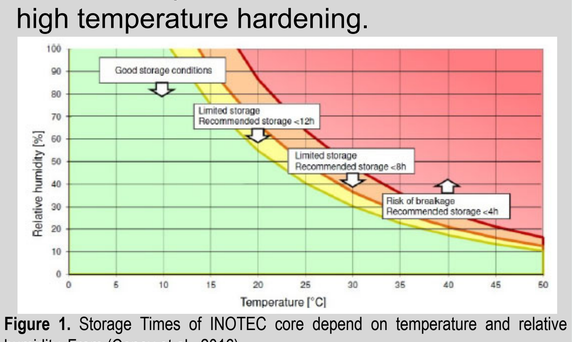

Figure 1. Storage Times of INOTEC core depend on temperature and relative humidity. From (Conev et al., 2016).

Green Foundry Project

The Green Foundry project has as a main objective the decrease of the European foundry industry environmental impact by introducing novel technologies for sand molding systems. In particular the use of inorganic binders in ferrous foundries applied in sand molding systems improves the environmental and economic impact leading to increased competitiveness of the industry. Replacing the currently used organic binders with new inorganic binders, one goal of the project is the reduction of hazardous air emissions, casting fumes and fine particles like binder aerosols from the casting process. The indoor air quality is improved. Moreover the use of inorganic binders would allow foundries to use the foundry sand more efficiently, improving the use of natural resources. The Green Foundry Project aims to demonstrate different methods for purification and re-use of surplus sand. As a further objective the project has the role of being an example for other foundries: introducing the inorganic systems in iron and steel foundries, the project aims to provide encouraging examples for the industry on an EU level, producing the necessary practical and information tools that will allow a systemic use of inorganic binders and technologies in ferrous foundries.

To achieve the objectives, several actions are to be implemented. Small scale test casts are made to measure the emissions of the casting processes, using both organic and inorganic binder molds. Total emissions of five pilot foundries will be measured and compared: one iron and steel foundry using organic binder system; one iron foundry using organic binder system and two aluminium foundries using inorganic binder system; one steel foundry using water glass binder system. Also indoor air quality will be measured and compared in four of the foundries mentioned above. Moreover foundry sand recycling options will be tested and compared for inorganic and organic binder sands.

Inorganic binders use in some European countries

The data of Polish foundries that produce casting in sand moulds are listed in Table 1.

Produced castings (alloy)	Year Production (castings) [tons]	Sand used/year [tons]	Inorganic sand used/year [tons]
Steel	50.000	~ 223.000	~ 33.000
Iron	659.000	~ 2.504.200	~ 75.000
Non-ferrous	150.000	~ 450.000	~ 45.000

Table 1 Polish foundries

Most of the steel castings are produced in moulds prepared in AlpHaset technology (Vasková et al., 2008), while only few castings are produced in moulds prepared in ester waterglass technology.

Most of the iron castings are produced in green sand moulds and only a small number of foundries is still using inorganic sands. As regards non-ferrous foundries, the automotive sector is the one most interested in inorganic binders. In Germany there are 297 foundry companies, including 120 iron foundries and 34 steel foundries. There are currently 11 foundries (10 aluminum foundries and one brass foundry) which use inorganic binders in production. There are 470 foundries in Spain, 120 non-ferrous, 20 steel and 90 iron. Only 8 foundries use inorganic binders: 6 foundries use silicate binder for steel casting and 2 foundries Ecocure Blue and Inotec for aluminium cores.

The Italian foundries situation is reported in Table 2. Some tests have been made by new inorganic binders such as test in core making line at one foundry but the test did not lead to permanent usage due to problems in fettling.

Foundries [number]	Year 2016
Iron	147
Steel	38
Light metal	512
Other non-metal	347

Table 2 Italian foundries

In France there are about 300 foundries, 200 ferrous and 100 non-ferrous. In ferrous-alloys foundries, inorganic binders are not used in normal production. Three ferrous foundries are interested and have made trials, but they were stopped because of the lack of solution for the check-out issue. In three of the 4 foundries where the inorganic binders are used, they are at a research or development stage and only in the permanent mould process used for aluminium parts (inorganic binders are only used for the production of cores).

The number of foundries in Finland is 29, 15 of them ferrous and the rest 14 is non-ferrous. There has been one test with new inorganic binders in a brass foundry, but tests did not lead to further usage. There is big interest to tests inorganic binders in 5 ferrous foundries.

The number of foundries in Sweden is 99, 38 of them ferrous and the rest 61 is non-ferrous. There is still quite big usage of old type inorganic binders, i.e. water class type. About 600 tons of such binders are used in 10 foundries; in 5 ferrous, in 3 brass and in 2 aluminium foundries. However, there are no foundries in Sweden using new type inorganic binders.

The number of foundries in Denmark is 15, 8 of them ferrous and the rest 7 is non-ferrous. There are no foundries in Denmark using new type inorganic binders.

The number of foundries in Norway is 11, 5 of them ferrous and the rest 6 is non-ferrous foundries. There is no info about foundries using new type inorganic binders.

The usage of new type of inorganic binders in Europe is still very limited. Some aluminium foundries in Poland and Germany making castings for automotive industry are already using them, especially in core making lines. Similar foundries in France are testing them for research purposes, but the production applications are planned to be made first in their subsidiary foundries in Brazil, China and Mexico. The usage of new inorganic binders in ferrous foundries has not really started.

First tests in Finland and future tests in Italy

Full production scale test with inorganic binder system molds is starting at Karhula foundry in Finland.

Figure 2. Chamber tests (source http://greenfoundry-life.com/)

This foundry is demonstrating stainless steel castings in the range from 4 to 20 tons testing several types of inorganic binders and sand types. Binder-sand combinations based on the recommendations from the binder suppliers is pretested using test sample molds. Figure 2 show the chamber test made by using Inotec inorganic binder. First test results show that gas formation was drastically smaller than in the chamber test made in another foundry using organic binder and only small amount of CO was detected right after pouring. The quality of the casting surface was good, even if no coating was used.

Figure 3. Cores with inorganic and organic binders

Interest for inorganic binders in FOM Tacconi, one Italian foundry, is based on two potential benefits:

- minimal gas formation should improve quality by diminishing the risk for casting defects and make moulding simpler due to less need for ventilation pins
- emissions from the foundry would decrease and indoor air quality would improve.In the past FOM Tacconi has once tested cores made by using inorganic binders. The results of the trial were not satisfactory: core sand sticked to the castings and finishing of the castings was difficult. Figure 3 shows 2 cores, one obtained with inorganic binder (in the upper part) and one with organic binder (in the lower part).

Conclusions

The foundries industry will play an important role in the next future in many sectors (automotive, buildings, mechanical, etc.) for the high level of technological and the economic performances. But its competitiveness will depend also on the sustainability. From the environmental point of view VOCs emission during casting process is the main issue. The most promising technology to face this issue is the use of inorganic binders. While these binders are commonly used in aluminium sector, in iron and steel casting their use is still at testing level. Even if several solutions are already in the market, there are not applied in the daily production. It is important to support the industrial implementation of these technologies. This is the aim of the Green Foundry Life project described in the paper. The tests are still at the beginning but main difficulties seem to be the initial investments in these new technologies. In the next steps of the project the aspect concerning the implementation of the industrial process will be investigated.

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http://greenfoundry-life.com/

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