HÜTTENES-ALBERTUS
Chemische Werke GmbH
Wiesenstr. 23
40549 Düsseldorf, Germany
Tel: +49 211 50 87-0
Fax: +49 211 50 05 60
E-Mail: info@huettenes-albertus.com
Internet: www.huettenes-albertus.com

Used Sand Reclamation: Environmentally Beneficial and Economically Sensible

Intro:
After air and water, silica sand is the third most common, high volume raw material used in many industries. This includes the foundry industry. In Germany alone, foundries use an estimated 2.5 million tons of new silica sand per year as a basic moulding material in the production of cores and moulds. It is foreseeable that silica sand will not always be available worldwide in the required quantity and quality that we are used to today. And there will also be bottlenecks in the landfilling of waste sand from foundries. Against this background, it is both environmentally beneficial and economically reasonable to keep this valuable material, sand, in a recycling loop.

Good, mature plant technology to reclaim most moulding materials already exists. Depending on the casting process and the binder system employed, mechanical, thermal or thermal-mechanical reclamation methods are used. At the "Altsand" conference from 3 to 4 April 2017, Martin Dahlmann, graduated engineer, from Hüttenes-Albertus presented two successful practical examples of thermal and thermal-mechanical reclamation of used sand.

Practical example 1: Thermal reclamation at HA in Braunschweig

The HA production site in Braunschweig was founded in 1979 as Sandtechnik Pohl GmbH & Co. KG. The company initially produced resin-coated sands for the shell moulding process. A short time later, they also took up make-to-order production of cores. With the commissioning of a first FATA reclamation plant in 1985, followed by a lump breaker and a second FAT reclamation plant in 1987, the prerequisites for thermal used sand reclamation were created. In 1989, the plant was taken over by Feslente (later Hepworth PLC), then Sibelco. It has belonged to Hüttenes-Albertus since 2003. Today, HA produces resin-coated sands at the Braunschweig site and reclaims organically bound core sands on behalf of its customers.

With its facilities in Braunschweig, HA is able to reclaim up to 20,000 tons of used sand per year. The plant processes core sand and broken cores, but not used sand mixtures of core sand and clay-bonded sand. During thermal reclamation, the organic binding agents burn at a temperature of about 700°C. Moulds with bentonite buildup cannot be used in this process, as the clay particles would sinter on the silica sand grains during the thermal treatment. As a result of increased alkalinity and very high electrical conductivity, the sand would then no longer be suitable for use with the usual organic binder systems. Braunschweig primarily reclaims core sand and broken cores from the cold-box process. **(Fig. 1)**

Fig. 1 Used and reclaimed sand offloading silo at the HA works in Braunschweig.

Incineration of organic components

The raw material for thermal reclamation is used core sand, which is delivered by silo truck. Six silos, with a storage capacity of 350 tons, are available for storing used sand. In addition to this used sand, it is also possible to process broken cores. They are first crushed in a lump breaker with a capacity of 6.5 tons per hour. Ferromagnetic metal parts are removed by means of a magnetic separator. A conveyor screw then continuously moves the used sand into a fluidized-bed furnace heated to 700°C, at a throughput speed of 20 minutes. During this time, the organic components are completely burned.

Classifying the reclaimed material plays an important role after this thermal treatment. During this separation process, free-flowing fine particles, i.e. dust, are removed by a stream of air. In addition, classification can be carried out via a tumbler screen system, in which the fine particles in the reclaimed material are further reduced. **(Fig. 2)**

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Sample designation	QS 42	Reclaimed mat., screened	Reclaimed mat., classified
Mesh size	in [%]	in [%]	in [%]
1,000mm	0,2	0,0	0,0
0,710mm	2,7	2,0	2,1
0,500mm	11,8	10,5	15,1
0,355mm	26,0	29,8	55,7
0,250mm	38,9	36,2	24,7
0,180mm	16,8	17,6	1,8
0,125mm	2,9	3,9	0,6
0,090mm	0,4	0,0	0,0
0,063mm	0,2	0,0	0,0
< 0,063mm	0,1	0,0	0,0
AFS grain fineness number	43,49	43,36	36,24
Medium grain size [mm]	0,361	0,356	0,421
Theor. Surface area S_{th}[cm²/g]	72,0	71,6	56,9
Loss on ignition [%]	0,12	0,01	0,01
Sludge content [%]	0,13	0,12	0,12

Fig. 2 Comparing thermally reclaimed material screened and classified with silica sand AFS 42: The removal of fines and the lower loss on ignition in the reclaimed material have a positive effect on the gas pressure of test cores.

Avoiding finest fractions

When using reclaimed sand for the production of cold-box cores, fines have a negative impact on gas permeability. Gas pressure measurements with test cores have demonstrated that already the substantial reduction of fine particles to < 0.125 mm via sifting had a considerable influence on the gas pressure within the core. Compared to “natural” silica sand, the loss on ignition of the reclaimed material is reduced by at least 0.1%, which, again, also lowers the gas pressure. The low gas pressure helps avoid gas defects such as gas pressure scabs or gas bubbles in the casting. **(Figures 3 and 4)**

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The elimination of finest fractions is also desirable with regard to binder application. Smaller particles have larger surfaces, so that more binding agent is required to achieve full wetting. In order to maintain the high sand quality after reclamation, the reclaimed sand should then be treated “gently”. Rapid acceleration with pneumatic conveying systems is not recommended, as this leads to deterioration of the sand and the formation of dust. The positive effects of classification would thus be lost. Conveyor belts or bucket elevators should be used instead.

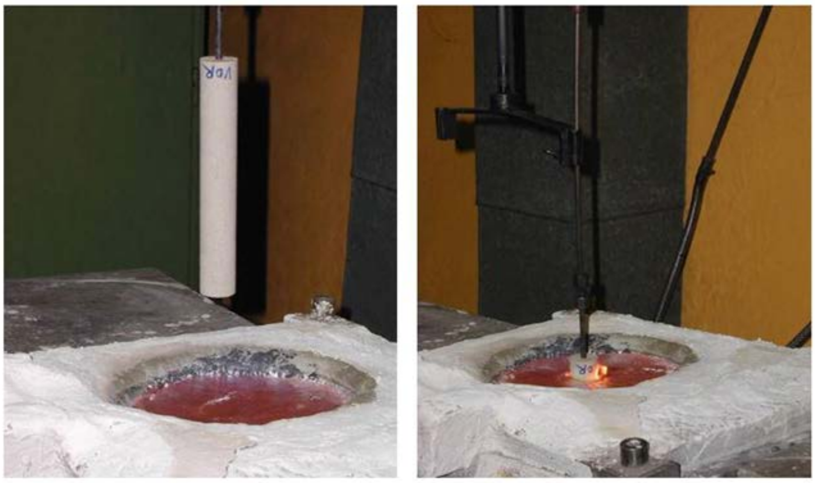

Fig. 3 For the gas pressure measurements, a measuring probe was used to immerse test cores in grey cast iron and aluminium melt. Here: aluminium melt

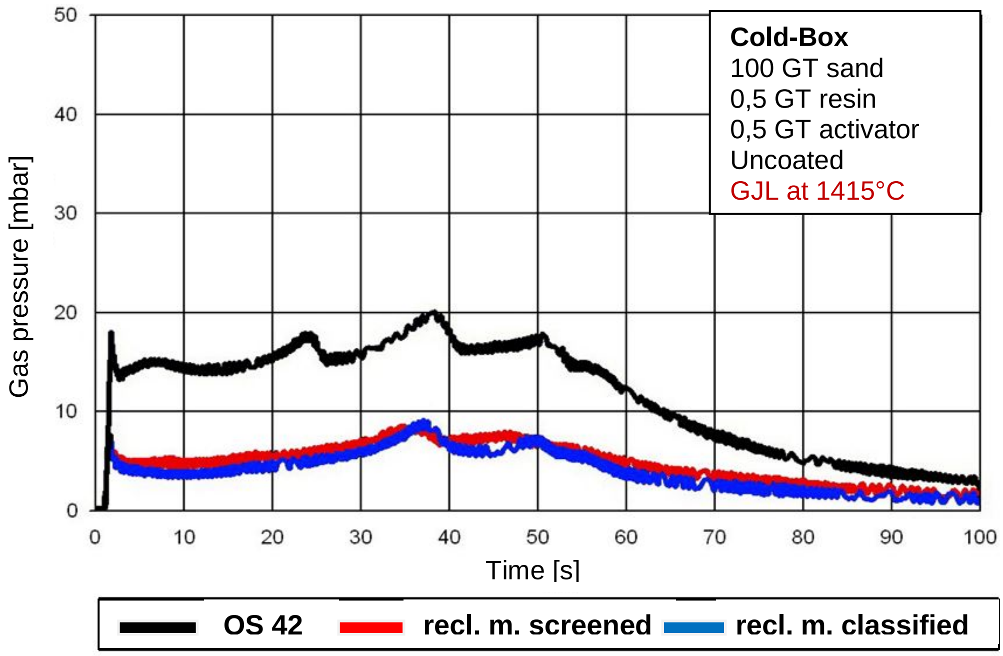

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Fig. 4 The reclaimed material (red line: air-classified, blue line: classified) has a better gas permeability than QS 42 new sand. This results in significantly reduced gas pressure in the core.

High quality of the reclaimed material

Thermal reclamation produces sand with application properties that differ only marginally from those of new sand. Used in a cold-box process, the reclaimed sand achieves very good strength values and also meets all other expectations placed on high-quality foundry sand.
In addition to the ecologically desirable conservation of resources, a comprehensive cost analysis of thermal from procurement to transport to disposal is worthwhile. In many cases, this will clearly show the economic advantages provided by reclamation.

Global perspective

While in Germany the foundry sand situation is relatively relaxed, things are quite different in other countries. While in Germany, high-quality sand is available at affordable prices, in Italy, for example, silica sand has to be imported at high costs. In India and China, the quality of the sand is often insufficient, or the processing technology is substandard. In these countries, sand reclamation has traditionally played a greater role than in Germany, due to the scarcity of silica sand. In China, foundries are "forced" to reclaim sand by regulatory measures. Companies are only allowed to supply sand if they are able to take the used sand back.

Practical example 2: Thermal-mechanical reclamation in a Chinese plant

An exemplary case study for sand recycling is the thermal-mechanical reclamation in a Chinese plant. This plant is able to process core sand mixed with clay-bonded sand. After a thorough preparation and pre-mixing, the used sand flows through a vertical furnace that has been designed in a very energy-efficient way, at a throughput speed of four hours. **(Fig. 5)** Following thermal treatment, the organic components are burnt and the bentonite is oolithised. After cooling, the sand is subjected to mechanical treatment by means of so-called "flashers", which remove the deposits of the fired clay in one or two treatment steps. **(Fig. 6)**

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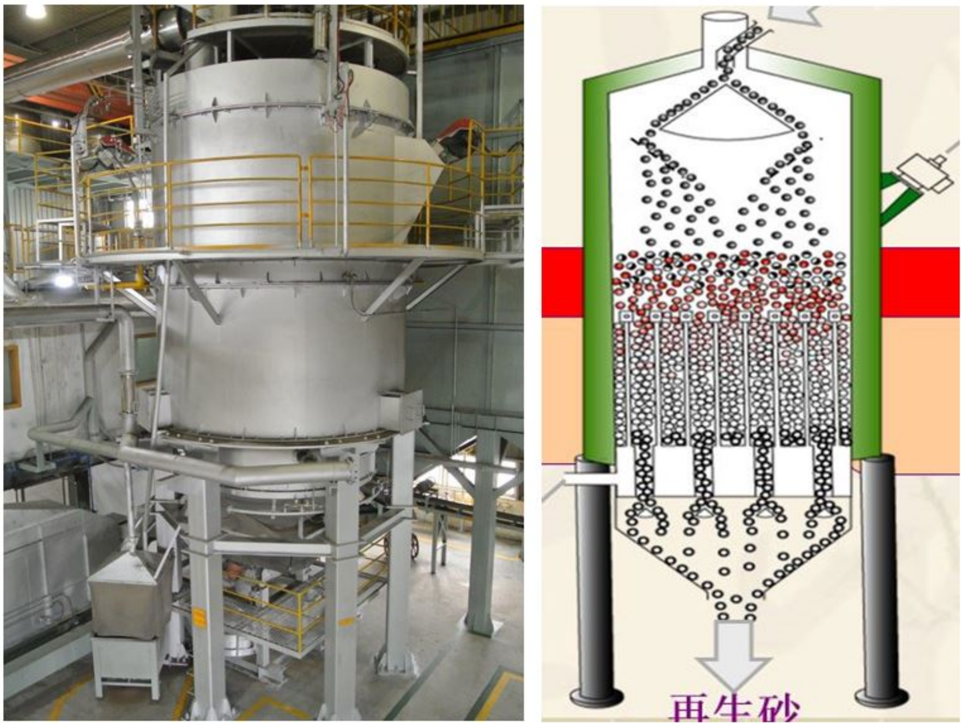

Fig. 5 The vertical furnace plant for the thermal treatment of the core sand / green sand mixture in China is extremely energy efficient.

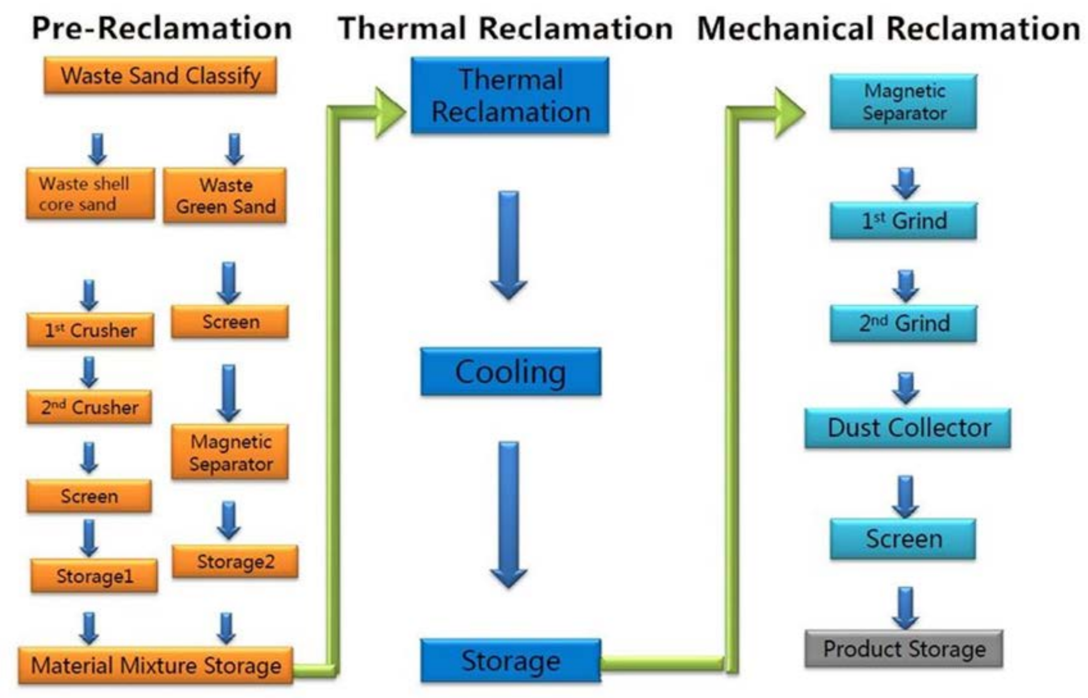

Fig. 6 Flow chart of thermal-mechanical reclamation.

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New sand versus reclaimed material compared

The Hüttenes-Albertus laboratory carried out several sand analyses in order to compare the composition and properties of new sand from Germany and Mongolia with Chinese used sand containing bentonite, and with reclaimed material both from China and from a European foundry. In addition, Cold-Box bending test bars were produced and their strength values were determined. **(Figures 7 and 8)**

As a result, it can be said that both the reclaimed material from China and the material from Europe have satisfactory properties, allowing their trouble-free use in core production.
The thermal-mechanical reclamation process used in China thus makes a valuable contribution to the conservation of resources. The logistics of new and used sand is improved, and the amount of waste sand sent to landfill is significantly reduced. A comprehensive cost analysis will surely result in showing economic benefits.

	New sand H 32	New sand Mongolia	Reclaimed material China	Reclaimed material EU
Reclaimed material		100 %	100 %	100 %
Quartz sand H32	100 %			
Bending strength during imm. processing of the CB mixture [N/cm²]				
15 s	240	230	190	190
1 hour	430	420	320	320
24 hours	520	490	360	360
Bending strength after 1 hour storage of the CB mixture [N/cm²]				
15 s	220	230	170	170
1 hour	430	390	250	270
24 hours	530	440	310	300
Bending strength, coated cores [N/cm²]				
Air drying, 1 hour	420	250	320	310
Furnace, 1 hour 150°C	590	590	520	490
Bending strength, coated cores [N/cm²]				
24h at 100% rel. humidity	460	240	350	330

Fig. 7 Comparison of strength values of test bars made of new sand and of reclaimed material from Europe and China.

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Fig. 8 Visual comparison of the sands at 200x magnification.

Info box:

Re-usable reclaimed sand should meet the following key parameters:

- As neutral pH as possible
- Low and uniform electrical conductivity
- Low loss on ignition
- Low fine-particle content
- Low sludge content
- Uniform and low degree of oolithisation
- Uniform grain distribution

About HA:

Hüttenes-Albertus is a leading international manufacturer of chemical products for the foundry industry, with head office in Düsseldorf, Germany. Almost 2,000 committed employees in more than 30 countries develop and produce foundry chemical solutions for all common core and mould-making processes for customers around the world. Parts cast using HA binder systems are the core components in a wide range of products, including car engines, wind turbines and industrial machines.

Reprint free of charge/specimen copy requested

Düsseldorf, September 2017

How to contact us:

Product Manager Special Sands:	**Martin Dahlmann** mdahlmann@huettenes-albertus.com Phone: +49 211/5087-370
Media:	**Sabine Umla-Latz** sumla-latz@huettenes-albertus.com Phone: +49 211/5087-142