Inorganic binders – benefits - state of the art - actual use

Thomas Steinhäuser
Universität Duisburg – Essen
Gießerei – Institut
Forsthausweg 2, 47057 Duisburg
thsteinhaeuser@aol.com

In 1995, the development of a new generation of inorganic core binders started at the University Duisburg. The main motivation for the development was to get rid of the unhealthy emissions caused by resin-bonded cores in the foundries. The first patents were established in 1996. About the year 2000 the first serial production of cylinder heads started (rotacast). From 2005 on several suppliers appeared with similar systems on the market. Today in the German foundry industry the OEMs and their main suppliers (BMW, VW, Mercedes-Benz) are running serial production for aluminium DC and LPDC parts (cylinder heads, Engine blocks etc.)
The benefits of the systems are:

- elimination of emissions in core making and casting
- better shake out
- reclaimability of core sand

also:

- lower cost for waste disposal
- reduced costs for exhaust air treatment

All the binder systems are based on sodium silicate and several different additives to optimize the process (curing time, fluidity of the core sand, storage stability, casting surface). The main process differences compared to existing core making technologies are:

- Hardening by physical elimination of water
- tool temperature 140-180°C
- microwave drying, alternative hot air drying in the core box

The binding process is shown in Figure 1:

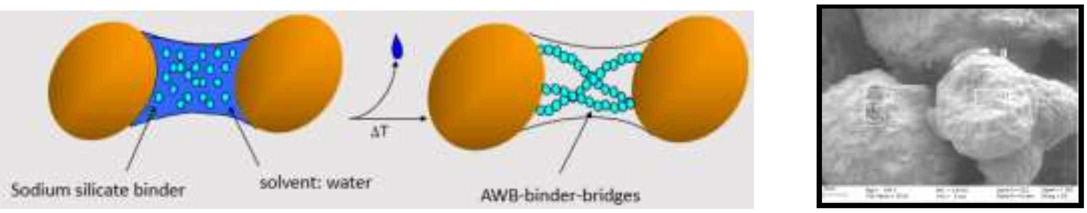

Figure 1: Inorganic binding process

The core are storable for several weeks under normal conditions if fully dried. The binder system do normally not contain organic material, that means there will be no emissions during the casting process, also there is practically no gas forming that could cause casting defects (see Figure 2).

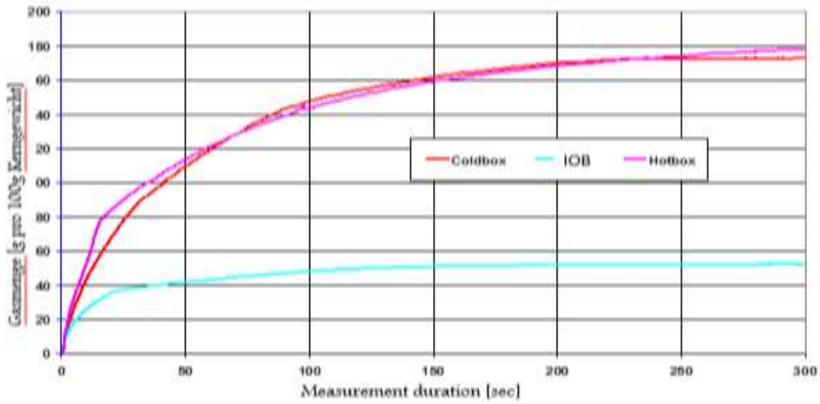

Figure 2: Results of Cogas-Test

Usually the inorganic core binders have excellent shakeout properties especially in light metal and bras castings. As shown in Figure 3 the strength of the cores depends on the temperature the cores have been exposed to. Up to 200°C free water evaporates and the strength grows to a maximum. At higher temperatures the bonded water (OH) disappears, that leads to shrinking and cracking of the binder bridges and strength drops to practically zero, so shake out is easy. At higher temperatures exceeding 750°C there may depending on type of binder (Na-contend) and amount of binder secondary glass phases be formed that could raise strength again.

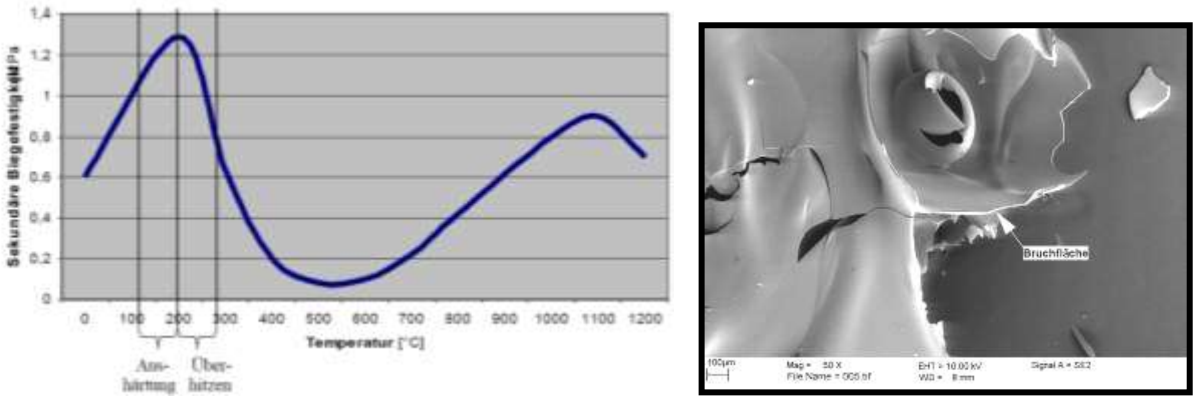

Figure 3: Bending strength subject to temperature

Reclamation of the core sand can be easily done by deagglomeration and dedusting. Some of the binder systems on the market may require an additional thermal treatment at 600-650°C because of reactive additives that have to be removed completely (see Figure 4).

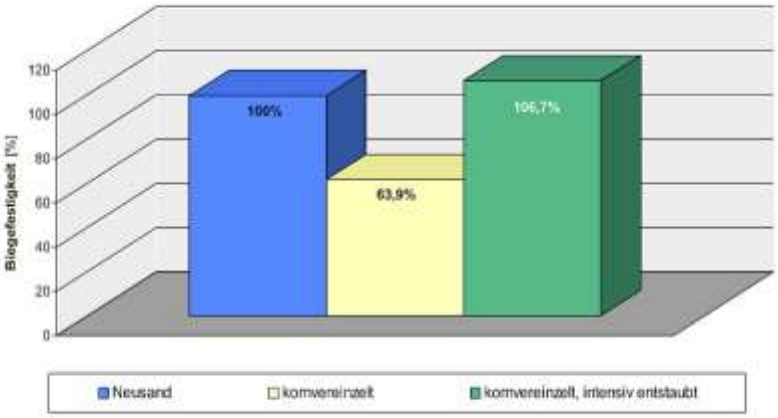

Figure 4: Comparison bending strength reclaimed new sand

The flow chart of the complete process is shown in Figure 5:

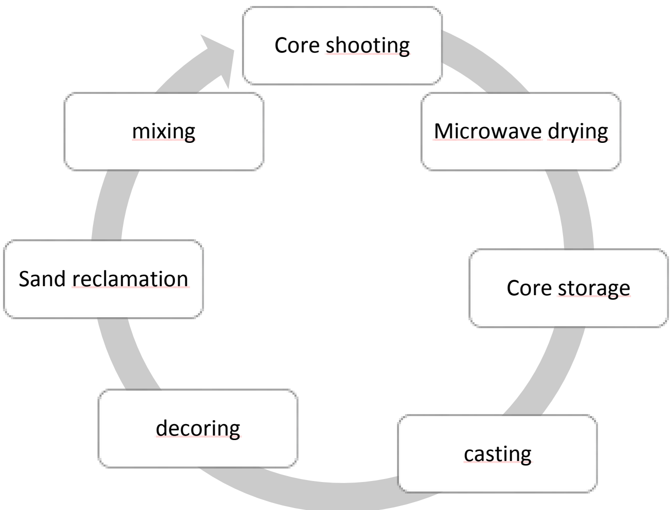

Figure 5: Flow chart of the complete process

One problem, which occurs with inorganic binders, is the quality of casting surface. As there is no gas emission from the core, metal easily wets the silica sand that causes rough casing surfaces. There are different ways to avoid wetting:

- coating
- addition of gas formers as additive
- substitution of silica sand by non-wetting material (olivine, Al_2O_3 based minerals)
- modification of sand wettability by additives (silica fume)

The following figures show the effect of silica fume additive on casting surfaces.

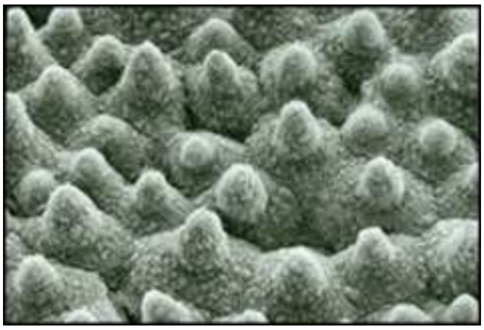

Figure 6: SEM-picture: Surface lotus leaf

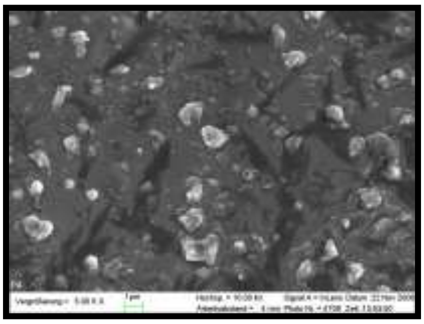

Figure 7: SEM-picture: Surface silica sand

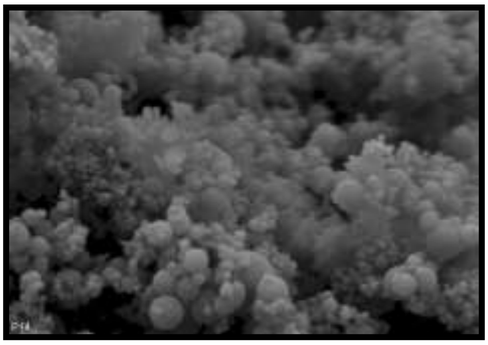

Figure 8: SEM-picture: nano particles

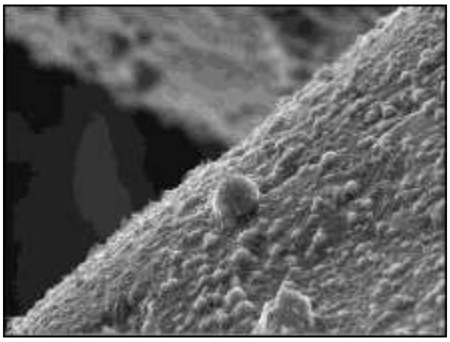

Figure 9: SEM-picture: silica sand with nano particles

without nano-particles

With nano-particles

Figure 10: casting without / with nano particles

Meanwhile a great variety of castings are produced under serial conditions with inorganic core binders.

Literature:

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