The ECOLOTEC process
German production foundry experience

The production of quality castings at minimal cost is a primary requirement for the foundry industry. Additionally, recognition has grown amongst foundrymen of the need to satisfy environmental legislation through minimising emissions and solid waste, and further improve working conditions. These requirements have led to development of the ECOLOTEC resin binder system.

Currently more than 30 German foundries use the ECOLOTEC process to produce cores for grey and ductile iron, steel and non-ferrous castings. This paper highlights why foundries have converted to this process in preference to other resin binder systems, and gives specific examples of the castings produced.

Practical experiences in coremaking

The hardening of ECOLOTEC resin progresses as follows:

$$\textit{Resin/KOH Solution} + CO_2\ \textit{gas} \rightarrow \textit{Hardened Resin} + K_2CO_3$$

The ECOLOTEC resin contains a cross linking agent which is inactive at high pH values. The resin's initial high pH value is achieved by the use of potassium hydroxide in the binder.

During the gassing cycle, the carbon dioxide gas reduces the pH value of the resin/sand mix. This causes the coupling agent to be activated and core strength to be developed. An additional increase occurs on standing as the binder continues to react with CO_2 retained in the core. Figure 1 shows the transverse strengths achieved immediately and after storing for 24 hours.

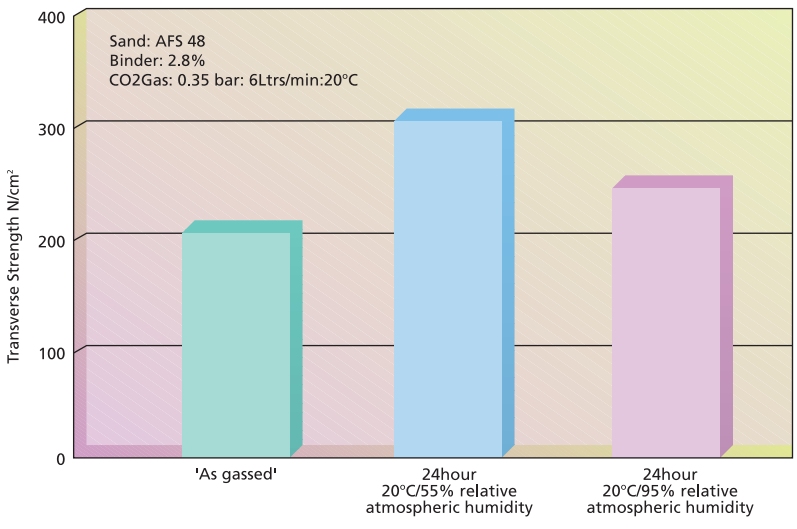


Figure 1: ECOLOTEC strength characteristics

The formation of the final strength is influenced favourably by heat or microwaves. Transverse strengths can increase to twice the initial value, whilst a significant strengthening of the core surface also occurs.

During hardening, care must be taken to ensure that the CO_2 gas is not forced through the core box at high velocity. The gas must react with the binder, and optimum strengths are not achieved if the binder is dehydrated by high gas velocity.

The volume of gas flowing through the core should be between 200 and 400 litres per minute depending on the configuration of the core. At such a flow rate, a CO_2 consumption of approximately 2.0% is obtained based on the weight of sand.

ECOLOTEC coremaking cycle times are of the same order as those of the amine-urethane process. Frequently the production times are faster if recommended purge times are used for the amine process.

Application

The application of the ECOLOTEC binder is for more compact amine-urethane cores, cores of the methyl formate process, and for 'problem' cores in the sodium silicate, hot-box and shell processes. More difficult cores such as water jacket or disc brake cores cannot yet be produced.

The reasons why foundries have introduced the ECOLOTEC process into the core shop include:

- Free phenol and free formaldehyde contents are typically 0.05% and 0.2% respectively.
- Lustrous carbon, nitrogen pinholing and veining defects are avoided whilst 'hot tearing' in steel castings has not been seen.
- Fume and emissions during core manufacture, casting and knock-out are reduced. As a result, working conditions are improved.
- CO_2 gas, with a MAK value of 5,000 ppm, is not considered a hazard and the use of scrubber units is unnecessary - thereby avoiding investment in plant.
- Water and alcohol based coatings can be used. Cores coated with water based coatings may be dried in circulating air or microwave ovens.

- Even with the use of uncoated cores, the casting surface is improved.
- Fettling and scrap in the fettling shop is reduced.
- Productivity is increased due to reduced fettling and partial elimination of the core coating.
- No explosive or flammable materials have to be stored.

Case Studies

- A major foundry selling to a particular market segment, has converted its core production of about 800 t/month from the amine-urethane process to the ECOLOTEC process. By this change, significant investment in plant for the reduction of amine and benzole emissions, was avoided.

- The foundry of Messrs Georg Fischer at Mettmann avoided the coating and drying of cores by replacing part of their amine-urethane production with the ECOLOTEC process. Additionally, the castings are now free from veining defects.

- The steel foundry of Reinhard Tweer in Bielefeld avoided building an extension to their gas washing plant following the introduction of the ECOLOTEC process.

- Figure 2 shows a ductile iron (GGG-40) valve body (cast weight of approximately 3.2 kg) which was manufactured by Stock Guss in Neumünster. By converting this core from amine-urethane cold box to the ECOLOTEC process, these castings are now free from veining defects.

- Figure 3 shows a ductile iron (GGG-60) connecting rod (weight 10.2 kg) manufactured in the Mannheim works of John Deere. By converting core manufacture from shell moulded cores to cores bonded with ECOLOTEC resin, a cost saving of 30% per casting has been obtained. The reasons are:
  - Shorter cycle times.
  - Elimination of the coating and drying process steps.
  - A reduction in moulding material and cleaning costs.
  - Faster throughput.
  - Better working conditions, less absenteeism.
  - Reduced emissions.

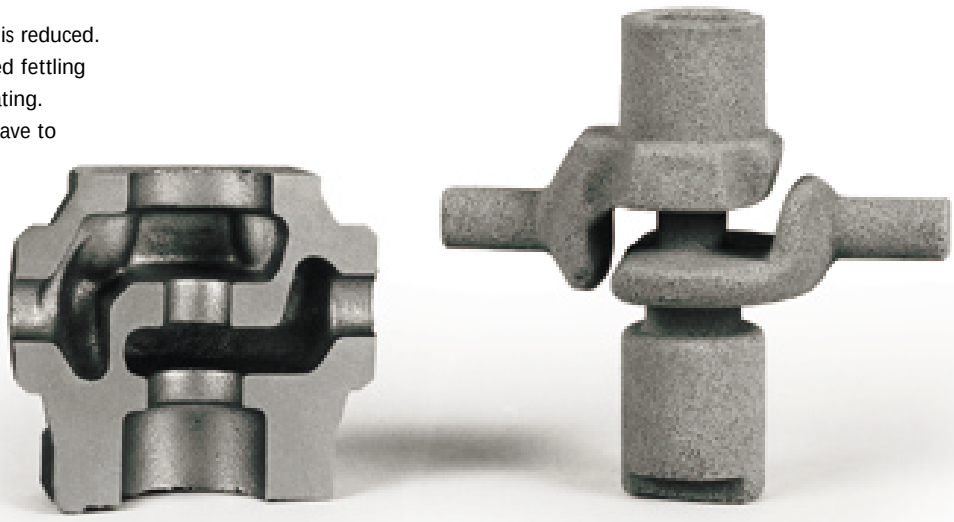


Figure 2: Valve body

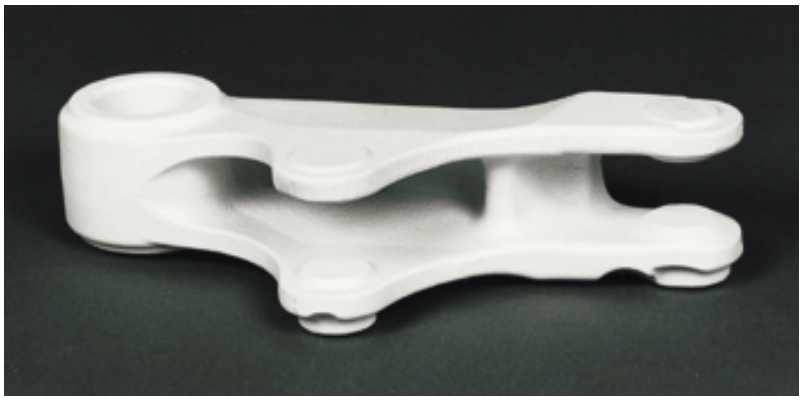


Figure 3: Connecting rod

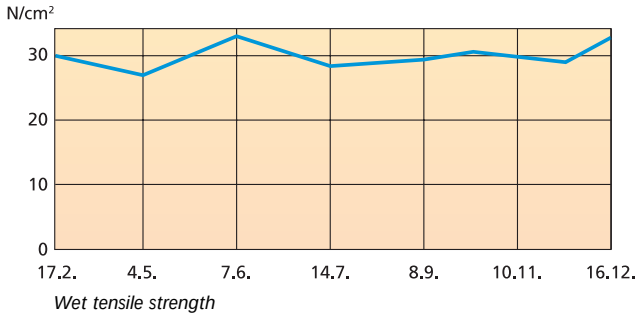
Core production with reclaimed sand

ECOLOTEC bonded sand is not usually recycled as a single system. For this reason there is little experience to date on the reclamation of ECOLOTEC bonded unit sands.

The most important factor when rebonding greensand with ECOLOTEC resin for coremaking is the content of residual bentonite. Good results have been achieved by bonding a regenerated greensand where the residual bentonite content is approaching zero. The transverse strengths obtained were greater than those obtained with new sand.

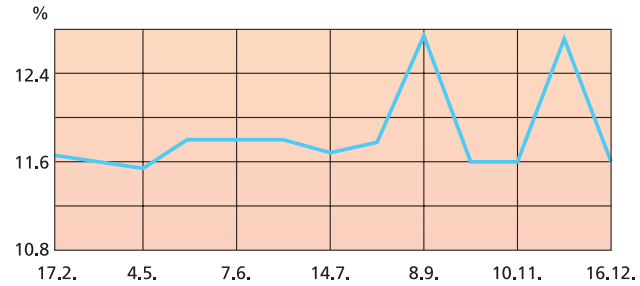
Regenerated sand from an acid hardened furan-phenolic binder system can be blended at the rate of 10-20% (80% new sand) with ECOLOTEC bonded sand. Because of the pH value of 10 to 11 in the residual moulding materials from the ECOLOTEC system, its introduction into a sand to be hardened by acid is not recommended.

Figure 4a



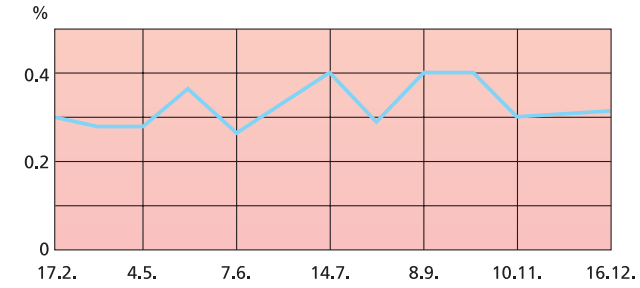
Wet tensile strength

Figure 4b



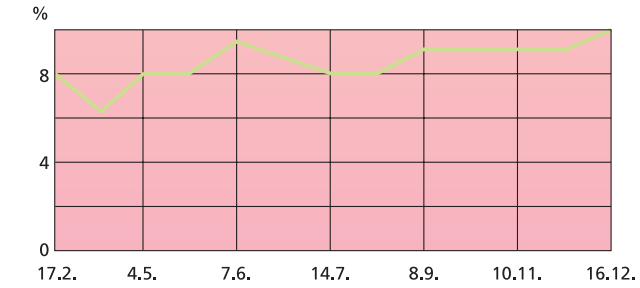
Content of fines

Figure 4c



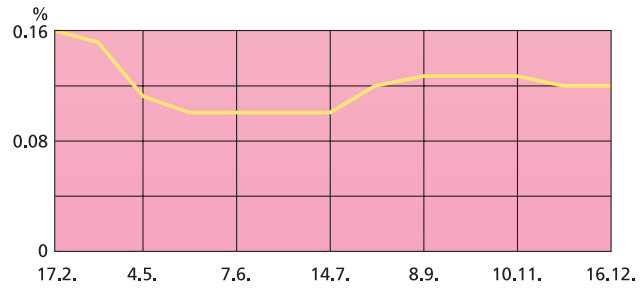
Bentonite additions

Figure 4d



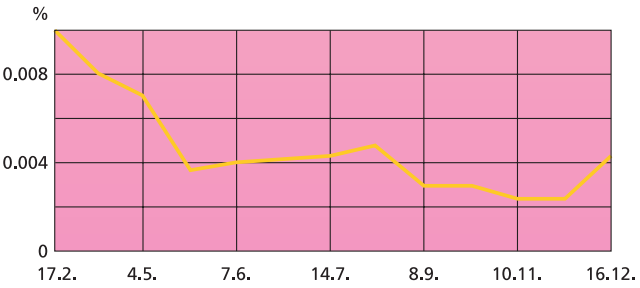
Active clay content

Figure 4e



Total potassium content

Figure 4f



Water soluble potassium content

Greensand Compatibility

Over a one year period, greensand systems have been monitored and thermally affected and unaffected ECOLOTEC core sand regularly run into the system at approximately two per cent. Wet tensile strength, fines level, bentonite additions, active clay content and changes in the potassium content (total and water soluble) were all measured, see figures 4a - 4f.

The following conclusions were drawn from these investigations:

- When using a fully activated bentonite, addition of ECOLOTEC core sand can lead to a reduction in green tensile strength. The reason is that salts contained in the core sand can lead to an over activation of the bentonite. Changing the bentonite to one of normal activation will return the wet tensile strength to the original level, see figure 4a.

- Active clay content and characteristic greensand properties, were maintained without any increase in bentonite addition levels, see figures 4c and 4d.

- The ECOLOTEC binder contains potassium, see figures 4e and 4f. Different references (see bibliography items 1-6) point to damage to bentonite in circulating sand due to the introduction of potassium from an alkali system. All these publications are based on laboratory investigations or measurements of industrial water added to circulating sand during its preparation.

  However these results have not been confirmed in practice during large scale commercial use of alkali binder systems (including methyl formate cured binders).

Figures 4a - 4f: Characteristic data for a production greensand system over a 12 month period:

Environmental Aspects

Emissions

Emissions occur when any organic component is subjected to elevated temperatures. Particularly important are emissions of benzole, phenols, polycyclic aromatic hydrocarbons and total carbon.

The measurement of emissions in foundries using ECOLOTEC binders has shown that the critical values for these materials are significantly below the limiting values of technical guidelines for air quality. Because the quantity and type of emissions in a casting process are strongly dependent on the thermal stress put on the binder, the filtration effect of the sand and other factors, absolute emission values if needed, must be measured.

Sand Disposal

Disposal sites for foundry waste are in short supply and sand dumping is becoming increasingly expensive. For this reason the recycling of waste sand has become of prime importance.

To establish the disposal options for ECOLOTEC core and moulding sands, samples were examined which had been both "stressed" and "unstressed" by heat during the casting process.

ECOLOTEC sand which had been heat-affected during the casting of both iron and aluminium alloys complied with the criteria for Disposals (Class 1 Mineral Disposals), according to the 'Technical Guidelines for Domestic Waste'. The elute from these samples also complied with regulations, allowing the waste to be disposed of, if required, in earth work, road construction, etcetera.

Core sand unaffected by heat, for example core scrap, did not comply with the criteria for domestic waste. However these materials, as they arise, can be introduced quite easily into a circulating sand system at controlled addition rates as necessary.

All samples examined were within the allowable values for polycyclic aromatic hydrocarbons according to drinking water regulations (1).

Summary

The ECOLOTEC resin binder offers a technically developed, environmentally acceptable and economic alternative to the methyl formate and amine-urethane processes for compact cores, and can also be used in the area of sodium silicate bonded, problem cores.

The process is already being used in a number of iron and steel foundries for the mass production of cores. There are also users in the light alloy casting sector.

Acknowledgement

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