In foundries, the requirements placed on castings production have risen significantly over the past few years. The components are becoming ever more complex while the wall thickness is reduced and core intensity as well as the demands on the core binder systems used are rising. Further trends in recent years have been the ever increasing level of automation and introduction of new alloys. On the other hand, the foundry environment has become increasingly difficult. Environmental laws and regulations have been and will be further tightened up. These processes are pursued at national, but also at European level. Compliance with emission limit values is becoming increasingly difficult. In addition, many foundries suffer from a lack of acceptance on the part of the local residents who often lodge complaints in relation to air and noise pollution. Against the backdrop of having to reduce greenhouse gas emissions and take part in trading CO₂ emission allowances, the foundry industry is also invited to reduce the overall emissions of CO₂. This is why the foundry industry and their supplier industries have renewed their efforts to use low-carbon products wherever possible. Working in this area of seemingly conflicting priorities, the foundry industry must prove its worth. State-of-the-art, low-emission binding agents play an important role in improving the overall situation.

The core production with low-emission binding agents plays an important role in improving the overall situation of foundries (Photos: Hüttenes Albertus)

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The cold box process – a bridging technology

By combining the advantages of the cold box process and the inorganic method the new cold box system from Hüttenes-Albertus is a bridging technology towards inorganic core production
The task set for foundry chemistry

To meet these requirements, the goal of both foundry chemistry and the foundries is to reduce the use of organic materials. As a matter of principle, for reasons of ecology and economy the lowest possible dosage of binder should be used. In order to avoid and/or minimize cost intensive secondary measures such as exhaust gas purifiers or thermal afterburning, there are principally two primary measures that can be taken to reach the improvement goals set by the foundries:

» use of inorganic binder systems;
» use of organic binding agents with inorganic constituents.

Inorganic binder systems

The foundry industry has been using inorganic binder systems for a long time. Back in 1947, the Czech researcher L. Petrzela filed a patent for the waterglass-CO₂ process. Besides various other inorganic methods (e.g. on the basis of salts and phosphates), especially waterglass-based binder systems have established over the past few years. Modern inorganic binder systems are mainly two-component systems, consisting of a modified silicate solution and a mineral additive. So many problems that a foundry faces, like the reduction of fumes, odour, pollutants and condensates, can certainly be countered by using inorganic binder systems. The entirely inorganic Cordis binder system has already demonstrated its benefits in many applications (Figure 1).

Due to the technological and economic prerequisites the changeover to inorganic binder systems cannot yet be implemented on a large scale. The cold box process is still the dominating coremaking technique due to its many different applications, its efficiency and its technological advancements.

![Figure 1: Inorganic binder system – Cordis](image)

![Figure 2: Diagram comparing inorganic methods and cold box process](image)
Cold box process versus inorganic methods – a comparison

The diagram (Figure 2) shows the technological differences between the cold box process and the inorganic production method.

Inorganic method – Cordis

Strengths:
- prevention of odour emission
- low emission of fumes during the pouring process
- no emission of noxious matter
- low level of condensates in the die
- reduced gas behaviour
- good collapsibility

Weaknesses:
- hot core boxes (high energy costs)
- die costs
- long hardening times for bulky core geometries
- shorter shelf life than cold box cores
- reclaimability (work in progress)

Organic method – Cold box process

Strengths:
- cold core boxes
- variable core box material
- short production cycles
- good reclaimability
- good collapsibility
- robust method

Weaknesses:
- emissions (noxious substances, fumes, odour)
- high level of condensates
- gas formation
- disposal of used sand (phenol index)

The Cordis process shows its major strengths in the field of environmentally related properties. There are process-related benefits, such as rarely occurring condensation and all its positive aspects in production, a property especially appreciated in gravity die casting. On the other hand, the cold box process offers several technological advantages, including the use of cold core boxes or the very good sand reclaimability. In the future, each foundry will have to follow a decision-making process to determine which process is most suitable for individual application. To put it in a nutshell: The strengths of one process are the weaknesses in the other, and vice versa.

Figure 3: Chemical formula TEOS (tetraethyl orthosilicate)

Figure 4: Schematic representation of the new cold box technology

Figure 5: Reduction of C-content and increase in silicon oxide in the cold box binder
The cold box process – a bridging technology

As an innovative foundry supplier, Hüttenes-Albertus Chemische Werke (HA), Düsseldorf, Germany, soon started to develop cold box binder systems with improved properties. In 1999, the first cold box systems with silica-based solvents (TEOS) were used in foundries. Compared to the aliphatic and aromatic solvents that had been used in the cold box process until then, the use of tetraethyl orthosilicate (Figure 3) was the first step towards an inorganic cold box system.

Now the research objective was to gradually increase the fraction of these inorganic components in the cold box system. To this end, a new generation of binders was developed on the basis of tetraethyl silicate. In this new generation (i.e., the Si-modified system) the Si units are not only contained in the solvent but are also integrated in the resin molecule (Figure 4). HA’s new, patented solution is a milestone in the development of novel cold box systems because, for the first time, it combines the advantages of both the cold box process and the inorganic method. The integration of inorganic silicon dioxide units is achieved through a substitution reaction during which the hydroxyl groups of the resin molecules are made to react with ethyl silicates. In the process, the size of the resin molecules increases, so that the amount of activator can be reduced in relation to the resin content. Surprisingly, the viscosity of the basic resin is reduced despite the higher molecular weight. As a result, significantly less solvent is required than with the cold box binding agents used previously.

Due to the high percentage of inorganic constituents, this new development can be described as a bridging technology towards inorganic core production. Compared to aromatic cold box systems, the carbon content was reduced by 23%. Through a consistent use of siliceous components the latest binder generation has already reached the significant proportion of silicon dioxide of 12.4% (Figure 5).

The new generation of cold box binding agents leads to further improvements in regard to environmental compatibility and reduction in pollution (Figure 6).

There has also been significant progress regarding the reduction of condensate production and gas pressure. Condensates are a particularly important issue for gravity die foundries. Since the introduction of the cold box process, this aspect has been an important criterion for the development of binding agents. Condensates are generated in the pouring process by the release of core gases and/or decomposition products of the binding agents. The released volatile components condense in the colder zones of the die (gravity die) and core. The level of condensate (Figure 7) has an impact on the cleaning time, die life, die temperature and, finally, productivity and cost effectiveness in production.

The reduced level of condensate can be put down to the fact that no volatile products are formed during the combustion of silicon. An SiO₂ network is formed instead that contributes to thermal stability. After combustion, this network shows a high degree of brittleness, which again promotes collapsibility. The benefits of this new binder generation were confirmed in various practical applications. Some foundries from the non-ferrous metals sector (aluminium) as well as the ferrous metal field have already used this new binder generation successfully in serial production.

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