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Innovative Binder and Refractory Coating Solutions for Highly Complex Castings

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1. Introduction

A key element for the reduction of exhaust gas emissions is the so-called downsizing concept that enables to increase the specific performance of combustion engines along with reduced volumes. Light-weight, compact and small aggregates are growing ever more complex and pose new challenges to the foundry engineer. Today's engine components, such as cylinder crankcases and cylinder heads, enable several functions to be combined that previously needed additional aggregates. The new challenges in the manufacture of castings that have become very core intensive (Figure 1) have led to a specific increase in gasifiable substances and, hence, to the risk of gas-related casting defects.

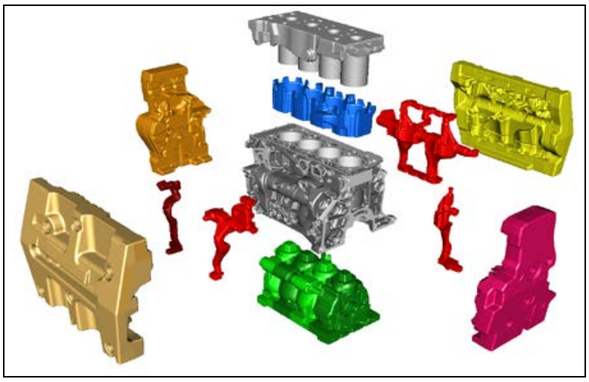

Figure 1: Core Package setting thin wall casting Eisenwerk Brühl

With the binding agents and coatings used, these new castings need new concepts. The conventional polyurethane process that is traditionally used in production lines due to its high productivity, however, fulfils the new requirements only very insufficiently and therefore requires a fundamentally new concept.

2. New Binder Concepts

The development of a new, innovative binder concept that incorporates inorganic components in its molecular structure and therefore contains less carbon provided an adequate solution to this problem. On the one hand, the result of this modification reduces the viscosity and, consequently, the quantity of solvents used. On the other hand, the new binder has a higher moleculare weight than the previous formulations, which results in a high thermal stability of the cores. This feature is especially important for the need to cast increasingly fragile cores without deformation. In addition, due to its structure, application of the new binder leads to a significant decrease in CO_2 emissions. In 1999, the first Cold Box system with silicium-based solvents (TEOS) has been 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 2) was the first step towards an partly inorganic Cold Box system.

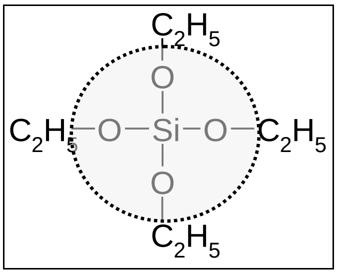

Figure 2: Formula TEOS (tetraethyl orthosilicate)

Now the objective of research was to gradually increase the fraction of these inorganic components in the Cold-Box system. To this day, a new generation of binder has been developed on the basis of tetraethyl silicate. In this new generation of binder the silicium units are not only contained in the solvent of the Cold-Box resin but are also integrated in the moleculare structure of the resin. Hüttenes-Albertus new, patented solution is a milestone in the development of novel Cold-Box systems. For the first time, it combines the advantages of both the Cold-Box process and certain properties of inorganic cores. 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. The viscosity of the base 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. With these new binder concepts it is possible to reduce the gas evolution (reducing gas related defects), the emissions (pollutants, smell and fume) and also the amount of condensates.

3. Coating Concepts

The manufacture of thin-walled, complex castings using the core package process requires the use of special coatings that besides good gas permeability, provide improved protection against sand expansion defects with reduced coating layer thickness. The novel coatings from Hüttenes-Albertus are designed with innovative refractory combinations that allow for controlled gas permeability to avoid gas defects. At the same time, their high ductility during pouring prevents the formation of expansion defects.

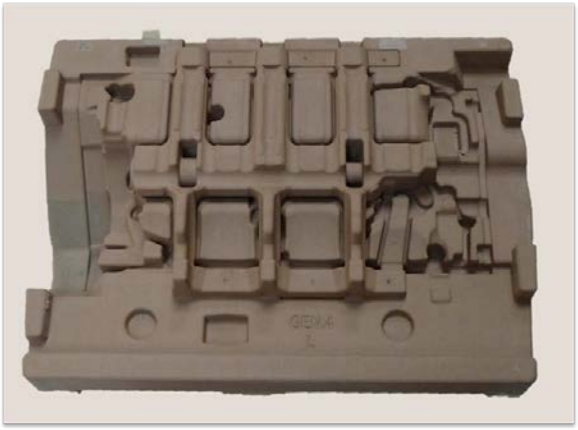

Figure 3: Coating Application core package process Eisenwerk Brühl Germany

The thin wall casting technology creates a lot of new challenges. The wall thickness of a conventional engine block in the past was 4 – 5 mm with a tolerance of ± 1 mm. The engine blocks of today have a wall thickness of 3 mm with a tolerance of ± 0,5 mm ! And the trend to reduced wall thicknesses is continuing. To manufacture thin walled engine blocks with a constant quality the system silica sand - sand additive – binder - coating has to fit the conditions. A big challenge is to avoid expansion and gas related defects (pinholes, scabbing etc.). Very important to avoid gas related defects is the gas pressure in the system sand – binder – coating. If a sand additive is used, this is also a very important substance to consider. If the gas pressure out of the core is higher than the metalostatic pressure the risk of gas defects is high. For the development of binder, additives and coatings or the examination of casting defects it is important to have a tool to examine the gas evolution and the gas pressure of the core sand system. In our technology center in Hannover we use a device to measure the gas pressure under conditions close to reality.

4. System - Sand-Additive-Binder-Coating

In order to reach the best results it is important to understand the crosslinking relations between the silica sand –sand additive-binder and the coating. The reason for using Sand additives is to minimize the effect of silica expansion and contraction behaviour. To choose the right sand additive it is important to know and understand the differences and the functionality of additives in the casting process in detail. There are different types of sand additives available, organic additives (burnout), inorganic additives and mixed forms. Organic additives are the traditional way of reducing the expansion rate of a core sand mix. These additives are relatively cost effective and easy to use. But organic additives create a lot of emissions like pollutants and smell. They increase rapidly the gas pressure in the core or core package and therefore can create gas related defects. That is the reason why the use of inorganic additives has become more in common, especially for thin wall applications. Inorganic additives create no additional gas evolution and no additional emissions. The impact on the core strength level is relatively small. Typical addition rates are 3 – 5 %. The inorganic additives reduce the sintering point of the silica core sand mix. It is basically a controlled manipulation of the sintering behaviour. The functionality of the sand additives also have a big impact on the performance of the coating. The unique properties especially of the inorganic additives can additionally open up new ways of designing a new generation of coatings.