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Casting of the uncoated core

Casting without coatings – vision or reality?

The demands on the foundry industry become more exacting every day. Globalization not only opens up new markets and opportunities, but it also creates an enormous squeeze on costs. Only those who succeed in enhancing productivity can withstand this growing cost pressure, however, only if they do not neglect aspects such as emission control and responsible care. Foundries have increasingly become the focus of public attention as a result of growing environmental awareness and the more stringent interpretation of environmental regulations.

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* If not stated otherwise the percentages refer to mass fractions

In spite of all limitations, the casting quality must not suffer, as it is the key to the success of the foundry industry. There is much need for action – constructive ideas are required to be able to realize the above mentioned goals. An optimal value chain is one of the key preconditions. The use of plant technology and production materials must be optimized. Here collaboration between suppliers and foundrymen plays an important (if not the central) role in establishing innovative and more advanced systems on the market.

Casting without coatings – Pros and cons

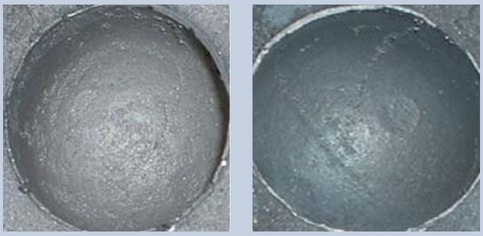
The cold box process might offer the possibility of producing castings without use of coatings. On the one hand, this would increase productivity and, on the other hand, it would guarantee a very high casting quality. But what exactly does casting without coatings mean and which advantages – and disadvantages – does it provide?

Casting without coatings primarily means the use of a system of additives and suitable binders intended to improve the surface of a casting such that the coating process can be dispensed with.

In the following we will discuss the question as to under which circumstances and in which areas of iron casting it seems feasible to dispense with coatings.

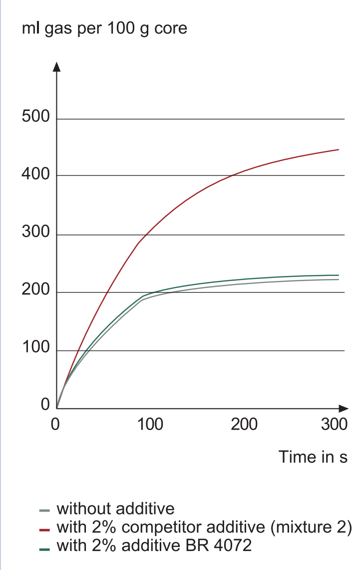
Advantages of casting without coatings. Casting without coatings provides the possibility of saving material costs, both in terms of input material and in terms of peripheral equipment (drying oven equipment, coating bath, etc.).

Figure 1



Casting test with dome core and additive BR 4048 (GJL, 1425 °C): a) uncoated, b) coated

Figure 2



COGAS measurement: Influence of additives on gas generation during casting (0.7 % cold box per unit)

However, the most important argument in favour of casting without coatings is that one or even two process steps can be eliminated: the coating process proper and the subsequent drying process, which both require time and personnel. Therefore an increase in productivity can be expected from eliminating these production steps.

Dispensing with the coating process also reduces energy costs, because the costly drying of the coated cores in ovens is no longer necessary.

In foundries a special safety risk comes from alcohol-based coatings. If these materials were no longer used, the safety risk would be drastically reduced.

Although coatings are important for the achievement of a good casting quality, they can also be a source of failures within the process chain which must be taken into account when problems in the production chain occur. The problem might disappear as soon as production is changed to casting without coatings. Coating-specific casting defects, such as scabbing or inclusions, can thus be avoided.

Last but not least, the logistical effort required to transfer of the cores to the coating bath / drying oven, the provision of a coating bath and drying oven, the installation of explosion-proof work places and the personnel requirement can be reduced.

Advantages of casting with coatings. But on the other hand, using coatings also provides a series of major advantages: e.g. coated cores can usually be produced with lower binder rates. The cores are thermally more stable due to the coatings' thermal insulation effect. Coatings reliably prevent finning and other casting defects, such a metal penetration and vitrification. The use of coatings generally produces very clean casting surfaces which only require little reworking and fettling.

Another, not to be denied advantage is that the coating process can cover irregularities from coremaking. This is particularly important with a view to guaranteeing quality in critical areas, i.e. those where a system reacts highly sensitively to smallest variations in the production parameters, for example, variations in the sand quality.

Use of special minerals. Frequently other auxiliary and fill materials are used in addition to coatings. The use of so-called special sands, such as chromium ore sands, J, zirconium or chamotte sands, have a positive effect on the surface properties of the castings. Also special minerals, such as andalusites or ceramic microballs, are frequently used. However, a drawback of all these materials is that they are rather costly. Even if added to the moulding material in very small quantities, the associated costs could be considerable.

Use of additives. The use of additives could make the addition of special minerals to the moulding material superfluous. The advantages of additives include easy dosing (by screw feeders, etc) and the possibility of running the process fully automatically. It might even be possible to completely substitute expensive fill or auxiliary materials. Generally, a rise in productivity and a more cost-effective production chain can be expected. But the use of additives may also have disadvantages. Some of the additives, especially organic ones, are additional emission carriers. The strength level of the produced cores may be reduced, which in turn may require slightly higher binder rates. Furthermore, the casting surface properties might slightly differ from those of castings produced with coated cores.

Preconditions for casting without coatings

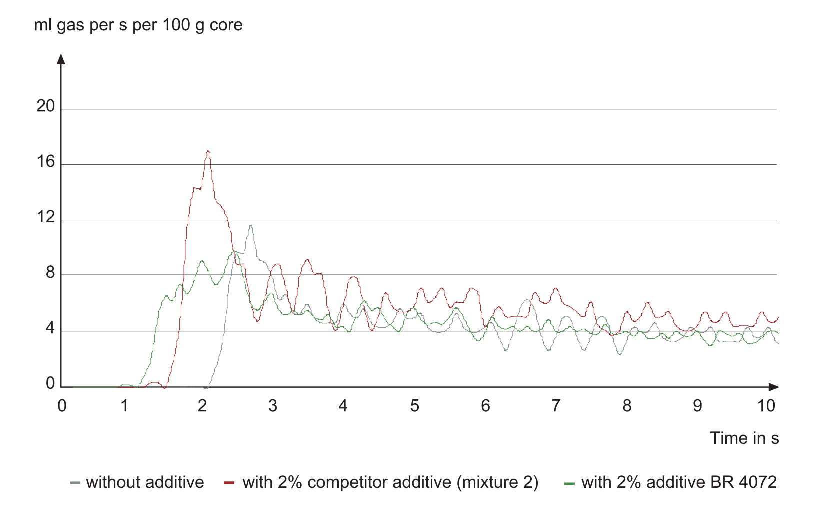
Casting without coatings is certainly only feasible under certain metallurgical preconditions. Whereas casting of grey cast iron without coatings appears to be problematic, however feasible, casting of ductile iron without coatings seems to be much more promising. Steel casting without coatings seems to be extremely difficult. This differentiation results above all from the different surface tensions of the metals or alloys. A higher surface tension facilitates casting without coatings. The absence of substances that reduce the surface tension of the metal/the alloy, such as sulphur or phosphorus, is therefore a desirable precondition.

Another important aspect is the casting temperature. The higher the temperature, the smaller the chances for casting without coatings become.

Also the section thickness and core geometry play an important role, because the thermal effect on the core must naturally not be too strong.

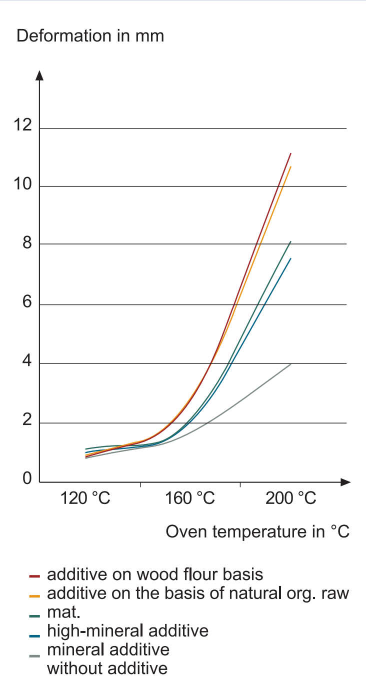
The fineness of the basic moulding materials is another relevant factor, as well as the metallic head pressure and the compacting method.

Figure 3



COGAS measurement: Influence of additives on the gas shock during casting (0.7 % cold box per unit)

Figure 4



Deformation test: Behaviour of cold box mixtures with additive during oven drying (0.8 % CB per unit, 1.5 % additive, 400 g load acting on the flat bar for 30 min)

Certainly, a number of castings will not be suitable for being cast without coatings in the future. These include castings to be used as hydraulic or engine components, thick-walled castings and brake disks. But there are other castings which are likely to be produced without the use of coatings in the future, e.g. casings for rear axles and differential gears, manifolds and callipers.

Casting without coatings also calls for a specifically adapted cold box system. In addition to the basic requirements, like best possible strength properties, good resistance to humidity and long sand life, above all qualities such as high dimensional accuracy and minimum deformation tendency are of decisive importance. Another aspect, which should not be neglected especially in view of productivity improvements, is good core box cleanliness which makes for high machine availability.

Laboratory investigations

Casting tests. Casting tests with dome cores are highly suitable to check the potential of additives for improving the surface properties of castings. Examples of the results of such casting tests are given in **Figure 1**. The test dome cores were produced using 0.85 %* cold box per unit and 1.5 % additive BR 4048. The castings were produced with coated and uncoated cores (GJL, 1425 °C). **Figure 1b** shows the casting produced with the uncoated core. There are hardly any differences to the surface properties of the casting produced with the coated core **(Figure 1b)**. Besides these properties in practical operation the use of additive BR 4048 provides distinct advantages in terms of machine availability because tool contamination could be appreciably reduced.

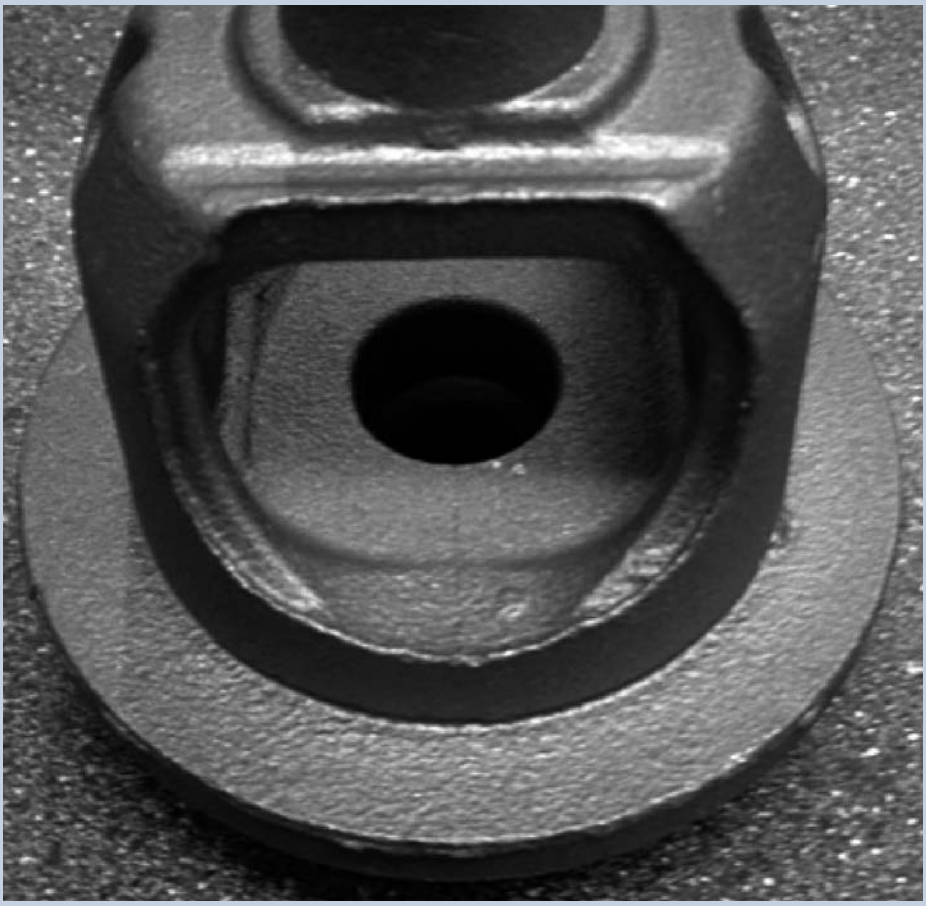
Emission measurements. As already mentioned above, also environmental aspects should be taken into consideration, i.e. emissions measurable as BTX values or odours should be reduced to a minimum.

The COGAS plant (developed by mk Industrievertretungen GmbH, Stahlhofen a. W./Germany) provides a good basis for the development of low-emission additives and/or new cold box systems. In the COGAS plant test cores are dipped into liquid aluminium and arising gases and condensate are collected. It is a well known fact that gas – due to its overall volume or due to the intensity of the gas shock – may cause casting defects. Moreover, larger quantities of gases and condensate are also undesired as they contain hazardous substances (e.g. BTX). **Figure 2** shows the result of a COGAS examination in graphical form. The differences in the gas volumes are salient. Whereas the gas volume of the cold box mixture containing a mineral additive is at the same level as a mixture without additive, mixture 2 – containing 1.5 % of an additive which is not emission-reduced – has generated twice as much gas. This result is also reflected in the intensity of the gas shock **(Figure 3)**. Mixture 2 produces a markedly stronger gas shock, which remains at an elevated level over the complete measurement period.

Deformation measurements. As explained above, dimensional accuracy and minimum deformation tendency are of decisive importance for the quality of a cold box system. Laboratory examinations performed for a customer provided interesting results in this respect **(Figure 4)**. The subject of the investigation was the study of the behaviour of cold box mixtures containing different additives during drying in the oven. The deformation of a 10-min-old flat bar (0.8 % per CB unit, 1.5 % additive), loaded for 30 min by a weight of 400 g, was measured

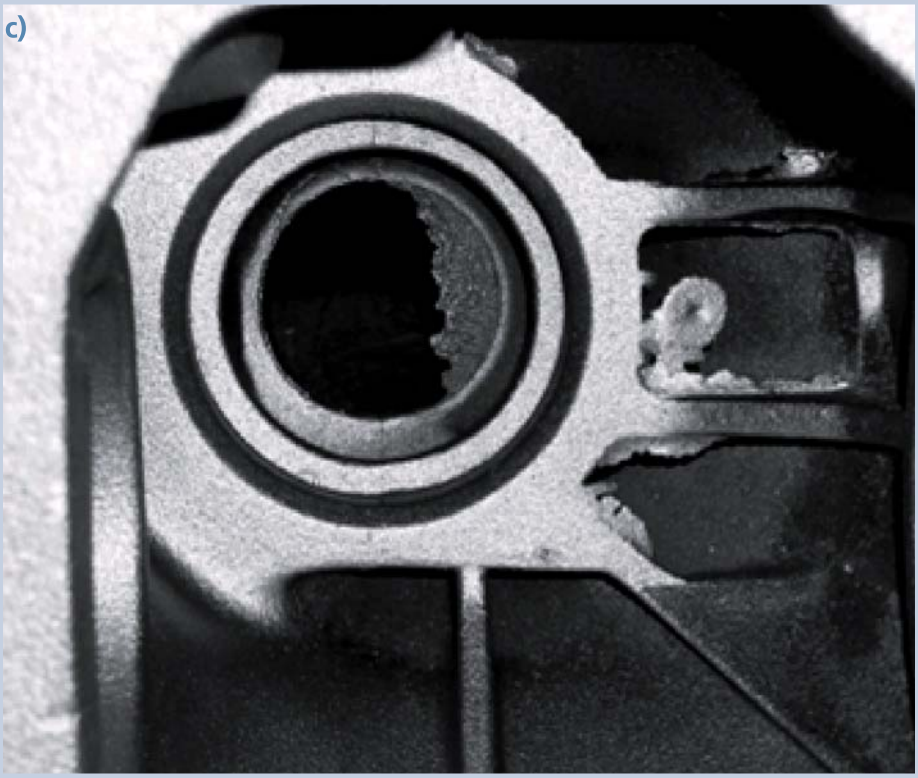
Figure 5

a)



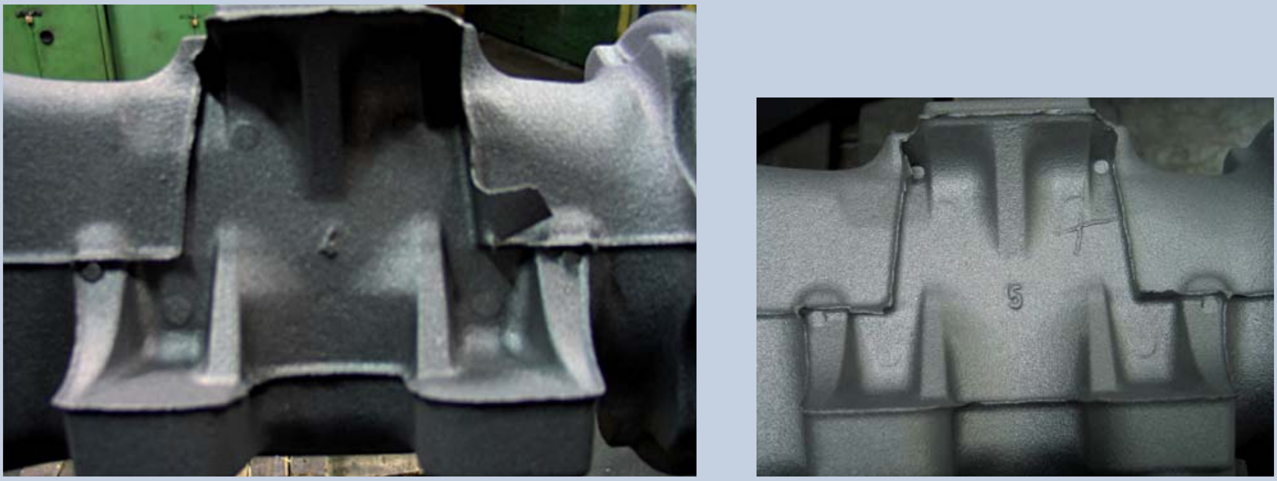
b)

c)



Examples of castings produced with uncoated cores: a) and b) casings for differential gears, each with 0.7 % CB per unit, 7 % additive BR 14000; c) casing for rear axle, 0.7 % CB per unit, 7 % additive BR 14000

Figure 6



Coated – uncoated comparison: a) casting of axle inset core with (alcohol-based) coating, 0.8 % CB per unit; b) casting of the uncoated core, 0.8 % CB per unit, 2.0 % additive BR 4048

in relation to the oven temperature. Up to a temperature of approx. 150 °C no peculiarities were found between the various cold box mixtures, no matter whether they contained organic or (high-)mineral additives. However, at temperatures above 150 °C major differences occurred. Cores with additives on wood flour basis and on the basis of natural organic raw materials exhibited a very strong tendency to deformation. The deformations of flat bars produced with cores containing (high-)mineral additives was less strong by approx. 30 %.

For practical foundry operation this means that when using additives and coatings at the same time special attention has to be paid to the oven drying process. Should there be problems with deformed cores, the drying temperatures must be reviewed and, if necessary, reduced. Another, though less convenient, option would be to use another, less deformation-prone additive. Ideally, the coating process can be dispensed with and with it the complete oven drying process.

Practical examples

Casting without coatings is already practiced today in connection with the cold box process. Figure 5 gives some examples of castings produced without coatings. As mentioned above, casings for differential gears and rear axles, calipers and manifolds can be produced without coatings, if appropriate additives are used. The use of a special additive, in this case BR 14000, in combination with a low binder rate has produced a casting surface quality which to date was only achievable by coated cores. Both the two differential gear casings and the rear axle casing do not show any traces of casting defects.

Figure 6 shows another example of a casting produced without core coatings. The casting is an inset core for an axle produced at a renowned car and engine producer. The core coming from the coremaking machine had to be manually coated, requiring one unit of manpower. The used alcohol-based coating was to be done away with to comply with the applicable hazardous substance regulations. The use of additive BR 4048 provided a viable solution. Worth of mention is the fact that despite the use of the additive it was not necessary to increase the binder addition rates. The original recipe could be retained. Also the pictures show that there are no differences between the castings produced with and without coated cores.

The shift to casting without coatings has reduced the risk potential, material costs and manpower and has enhanced productivity – while retaining the high casting quality standard.

Conclusions and outlook

Casting with uncoated cores is certainly a somewhat hot issue. On the one hand, there are the many advantages, especially in terms of productivity, and on the other hand, there are the uncertainties associated with the implementation of this casting method in the foundry environment.

There is definitely no generally applicable solution. A more differentiated view is required. Successful implementation depends on a number of different parameters. These include metallurgical parameters, such as the surface tension of the metal, casting temperatures or metallic head pressure, and other aspects such as core geometry or moulding material composition.

The investigations have shown that there is potential for optimizing the overall system comprising binders, additives and coatings. In many cases, where already today the use of specific additives has led to the application of very thin coating layers, a further reduction in coating layer thickness or even the complete elimination of the coating process seem feasible.

Already today it is possible to use uncoated cores in certain areas and under favourable conditions, as has been proved by first results from practical operation.

Against the background of ever stricter environmental regulations, one key objective should never be overlooked when developing new processes, namely the reduction of emissions (condensate, BTX, odours).