

POSSIBILITIES OF BURRS ELIMINATION FROM CORES PRODUCED WITH COLD-BOX-AMINE TECHNOLOGY

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Abstract

Actual problem of all foundries that produce core castings with the Cold-Box-Amine methods are surface defects. Most common surface defect are burrs. Therefore it is needed to specify the possibilities for preventing the burrs, or make their occurrence as low as possible. According to the knowledges, the best way of eliminating the burrs is using of additives. Experiments were executed on two types of gray cast iron castings, where during preparation of mould mixture for first casting additive EP 3767/2 had been used and additive Spherox had been used for second casting. These chosen additives showed good results, surface of castings was clean, without surface defects. Given the effectiveness of selected additives only for specific types of castings, it is necessary to define the effects of these additives on the quality of the castings. For further production of flawless cast, it is necessary to describe all the possibilities of eliminating burrs.

Keywords: casting, grain boundary defects, interface defects, internal stresses, thermal conductivity

1 Introduction

Cold-Box-Amine (CBA) method was founded in 1965 by Ashland company and in year 1968 it was introduced to the European foundry industry. After 35 years, this method finds its worldwide place and become most important method of cold hardening with gas. In Germany, the share of this method in comparison to other methods of core production is cca 60%. The share on all methods using the hardening with gas is cca 77% [1, 2].

Cold-Box-Amine method makes it possible to produce fast machine production up to middle sizes. This fast, cost-effective and automatic production provides good possibilities for on-line production. Just after production, the cores can be put into die or sand moulds which can be casted. This fast flow of production is only possible, when after painting of the cores with water paint are these cores immediately dried in the oven. Core production with the CBA method can be two times faster than the other methods [1, 3].

Highly actual problem in foundries which produce CBA cores during casting production are surface defects of gray cast iron castings are called burrs. Burrs are characterized according to the STN 42 1240 norm as a rib or vein – meshing of growth on surface of casting, which are created with the act, that metal flows into cracks created from dilatation of moulding materials. They occur mainly on cylindrical surfaces and curved edges of cores (moulds) [4, 5].

During pouring, the cracks or meshing of cracks is formed in places of curved surface, where molten metal flows [6]. From analysis of creation process of burrs comes out, that compression strength of resin mixtures is 4 – 5 times higher than tensile strength. Formation of burrs is more likely in rounded edges of non-cylindrical shapes than by cylindrical cores, where dilating layer increases compressive stress.

As a criteria for susceptibility of mixture with different composition to the error formation, index of heat conductivity can be used [6, 7]. Heat conductivity is the degree of material plasticity. Mixtures with artificial resins have high strength in cold, which is suddenly decreased in narrow temperature interval of thermodestruction of resin and without plastic state will collapse by heating. These errors occur also by ductile cast iron castings. With a survey it was found out, that most of foundries have problems with burrs, 71% foundries are trying to solve this problem with anti-burrs additives into core and moulding mixtures, but only 29% is taking their „anti-burr“ method as satisfactory and successful [8]. Eventhough that CBA method is widely spread and every foundry which uses this method has problems with burrs, there is just very few scientific literature and published articles are mostly the tries of foundries or suppliers of materials for this method to solve this issues. For foundry industry and its external suppliers are characterized by strict protection of technological knowledge and material data sheets.

There are some ways of eliminating these surface defects of castings, mainly using of additives which are added to moulding core mixture [6, 9]. With new type of casting, with the change of technology or shape of casting, the usage of checked additive does not have to function. Therefore foundries must experiment and try to find the most efficient additives for their castings. Even usage of the best additive to eliminate the burrs could not secure its 100% removal. Therefore it is needed to take into account all the factors acting to the formation of this surface defect of castings. If it is not possible to eliminate the burrs formation by adding of additive into moulding mixture, other types of opening material could be used. All of this leads to the overpricing of production and lower competitiveness in casting price formation [9].

In present situation it is very important to deal with the question of using the additives with the aim of burrs removal. Using of additives leads to elimination of the tension between grains of silica sand SiO_2 . Additives can be divided based on their acting in mixtures. First group is formed with additives on the wooden saw-dust basis. During heat exposition the admixtures burn-out and places between the sand grain occur. The second group are iron scales (ferrous oxides and ferrous hydroxides). When using these additives is their reaction with silica sand influenced by heat exposition, where substances with lower melting temperature are formed. For example the creation of fayalite with the reaction of SiO_2 and FeO (melting point 1490 K). The result is decrease of dilatation of SiO_2 . Here belongs the ferrous oxides or artificial opening materials on aluminosilicate basis. Into third group the reclaim of mixture with phenolic or furane resin or reclaim from green sand mixtures could be placed. The reason of using these reclaims is the once coated or oolitized grain, which has greater place for relaxation of creating tension. But all alcalic substances which come into the mixture are disturbing the Cold Box process, which is caused by introduction of amines. Therefore returning mixtures, which have these highly alcalic binding materials (e.g. water glass hardened by CO_2) are being excluded. Up to 70% of reclaim of green sand mixtures could be used for Cold Box mixtures without significant increase of binding material [10]. Important factor is the lowest possible humidity of additives and reclaim, because activator – substance 2 – polyisocyanate of binding system reacts with humidity and decomposes [10-13].

Developments in the foundry is also characterized by the need to analyze the impact of use of additives on the properties of different types of castings - even within different technologies.

With the way of chemical analysis, granulometric composition, microscopical analysis and laboratory results it is the aim of next period to define these additives. There are few types of additives on the market: additive EP3767/2 (additive on mineral substances basis with wood meal and ferrous oxides), additive BR14000 (additive on mineral substances basis), additive HS (additive on ferrous oxides basis). German company FOSECO offers Noracel M75 against burrs – additive on mineral substances and ferrous oxides basis [14].

Austrian company Furtenbach GmbH offers additive Furtol VP 150 against the burrs which consists of soft-milled resin and plastificator [15]. Other used additives are Antifin No2, additive X05, BR-W 39, Feranex and Veinseal I35.

It is now necessary to address the complex issue of elimination burrs. One option is to optimize the properties of the silica sand, and the current consumption reduction of expensive additives. By minimizing the amount of additives without further careful optimization of process parameters, however, the economic cost foundry production may also increase as a result of removing burrs [16, 17]. Based on the literature, theoretical knowledges and experiments on castings where some of these additives were tested, the elimination of burrs would be discussed.

2 Experimental materials and methods

To eliminate burrs in the production of the casting was tested EP additives 3767/2. Cast was made of cast iron with flake graphite according to German standards GG25 entitled HOUSING cottage with a characteristic shape with internal ribs.

For casting production with cold-box technology, the moulding mixture consisting of opening material (mostly silica sand), binding material (compound 1 and compound 2) and additives is used. This moulding mixture is shot in cold-box equipment into prepared core boxes, where it is blown by the gas called amine. After production of cores, all of these are painted.

CBA method for cores production consisted of following:

- Waterless dried silica opening material (parameters are in **Table 1**).

Table 1 Parameters of silica opening material used for experiment

Quarta grog	1K 0,20/0,315/0,16 Poland
Medium grain	$d_{50} = 0,25\text{mm}$
Content drifting substances	max. 1 %
Content units smaller than 0,1 mm	max. 1 %
SiO ₂	min. 98,0 %
Fe ₂ O ₃	max. 0,50 %
carbonates	max. 0,30 %

- Fluid compound 1, which is product of condensation of phenol and formaldehyde to benzyl-ether resin in solvent (parameters are in **Table 2**).
- Fluid compound 2, which is polyisocyanate component in solvents, which was difenylmethandiisocyanate in organic solvent for Cold Box system, type: ECOcURE 60 in amount 4,5 weight%
- Catalyst, which are tercial amines, which significantly influence the speed of reaction. Catalyst named Katalysator DMI – fy. Murexin – Furtenbach had been used.

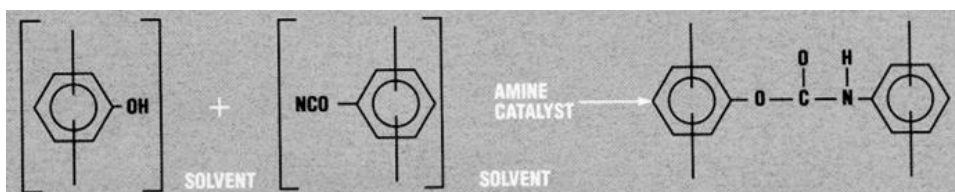
Table 2 Parameters of fluid compound 1 in binding material

Title	Ecocure 30 Ashland-Sudchemie
Isophorone	2,5-10 %
Phenol	2,5-10 %
Formaldehyde	< 2,5 %
The amount added to the sand mixture	1,5 hm%

Second analyzed casting was rotary shaped gray cast iron casting EN GJL 250 with name Reibscheibe, braking disk with diameter 642 mm, respectively 652 mm.

In this experiment also silica opening material 1K0,20/0,315/0,16 Poland was used and Cold-Box system from company ASK – Chemicals was used. As binding compound, ASKOCURE 366 (compound 1) and ASKOCURE 666 (compound 2) were used. Additive with the name Spherox was added as a ferrous oxides. Catalyst used was Katalysator DMI – fy. Murexin-Furtenbach. The amount of binding compound was 0,66 weight% for compound A and B. Weight of new sand was 136 kg/mixing. This additive was heavy, into mixture was added 6 weight % - 8 kg of additive. During this experiment, combinations with 6; 4,5 and 3 weight %, respectively 8; 6 and 4 weight % were examined.

Both compounds create core mould mixture with opening material, which is hardened with the gas catalyst. Specific characteristics of phenolic acid is its benzyl-ether structure. Summary chemical equation (**Fig. 1**) is additive polymerization, which advantage is, that no new fissile products are formed [18].

**Fig. 1** Chemical reaction [18]

Next were used:

- Coatings: TENO Sil 301 MPX in thickness 0,8 mm
- Coating graphite paste: GRAPEX – fy. Grapa
- Distinctively denaturated alcohol for diluting of coatings – STN 660860 (19)

2.1 Helping materials for core production

- Separators:
 - separating products on alupigment and wax basis in the solvent mixture
 - types: PARTI gel alu 2,6 – fy. FOSECO
ZIP SLIP LP 89 – fy. Ashland-Sudchemie
- Corrective and sealing material:
 - corrective paste on refractory filling basis (magnesium silicate)
 - type: Specotin Flick masse – fy. Speform
- Acid for chemical liquidation of used amine:
 - phosphoric acid
 - type: H3PO4 – technical (75%) – fy. Neuber-Chemika [19].

3 Results and discussion

Mostly used way of eliminating of burrs is the use of additives into moulding core mixture. Effect of added additives had been experimentally proven. First analyzed casting was gray cast iron casting with characteristic shape of housing and inner ribs. Example of casting with burrs occurrence can be seen on **Fig. 2**.

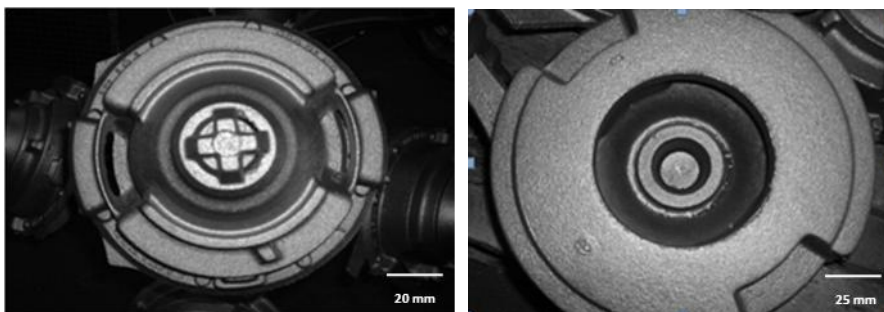


Fig. 2 Gray cast iron casting with characteristic shape of housing with inner ribs

The burrs are showed on **Fig. 3**, where castings were cut for better identification of the errors.

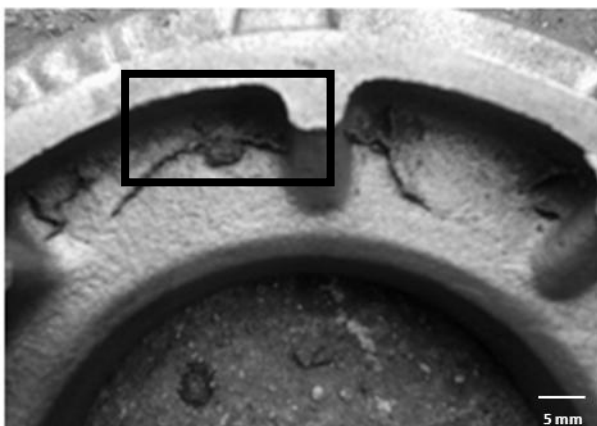


Fig. 3 Detail look on burr occurrence

Problematic places were mainly inner surface from cores, where burrs occurred – non acceptable for customer. Cleaning of this places is very difficult and laborious. The castings without burrs are cleaned in one shift, castings with such burrs needed to be cleaned during 6 shifts.

Experiments were done under working conditions in factory, each combination of opening material, binding material, additive and coating was mixed based on results from previous production. It was needed to check the influence of these materials for burr removal. After doing the experiments with given materials, castings were formed without burrs. Castings were clean inside with smooth surface, **Fig. 4**.

To check the influence of additive, next experiments on rotary gray cast iron casting EN GJL 250 were done. Name of this casting is Reibschleibe, it is a brake disc with diameter 642, respectively 652 mm.

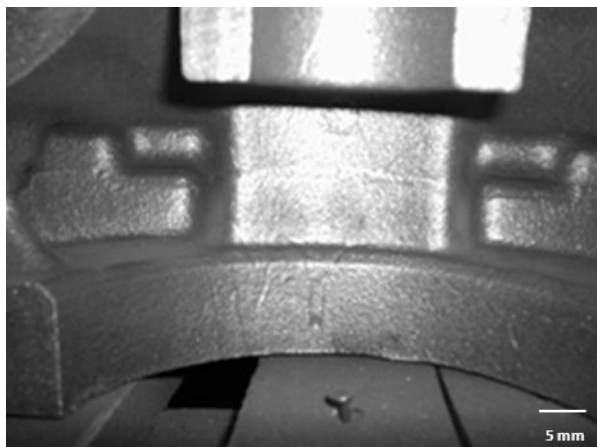


Fig. 4 Look at inner side of the casting Housing without burrs

In this experiment, new additive Spheroox on ferrous oxide basis was added. Produced cores were strong, abrasion was minimal. Cores were produced without problems, processability of the mixture was good, same as the fluidity of the mixture.

Using of additive Spheroox showed minimal occurrence of burrs on castings. By 6 weight % of additive, castings were without burrs, checking was done visually on cut castings, so the places were visible and accessible to precise checking. Surface of casting was clean, without error. **Fig. 5a** shows the cast before using additives with the occurrence of burrs and **Fig. 5b** is cast upon the use of additives Spheroox without surface defects.)

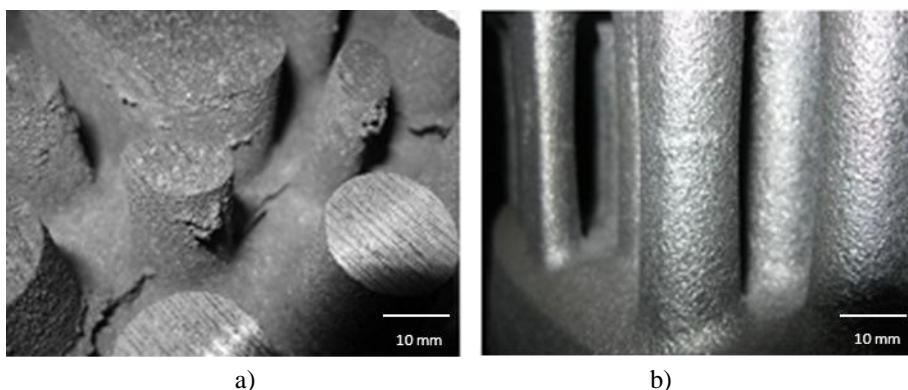


Fig. 5 Casting Reibscheibe before (a) and after (b) use of Spheroox additive.

There exist few ways how to eliminate the burrs formation, respectively minimizing their occurrence. From above stated experiments it is clear, that the best way to eliminate burrs is the usage of additives. For Housing casting, the additive EP3767/2 showed best results and for Reibscheibe casting, the additive Spheroox by 4,5 weight % showed best results. Castings were formed without burrs, with smooth surface. Other way for burrs elimination is to use opening material, heat-resistant grain material with grain size over 0,02 mm, which forms the main volume of mixture and in cold-box process has specific meaning. Mostly in CBA method, silica

sand is used (also during these experiments), which has discontinual heat dilatation. This is very disadvantageous, therefore it is needed to decrease the criteria of susceptibility to stress error formation of the mixture by changing the silica sand with opening material with lower temperature dilatation [20].

Other important factor is binding material, which total volume in the mixture was cca 1,6%, were amount of compound 1 and compound 2 is chosen proportionally, with their change some properties of mixtures could be changed [20]. By excess of compound 1 (resin component) actual strength increases, maximal strength decreases, the lifetime of mixture gets little bit worse, resistance against humidity worsens, susceptibility to burrs formation is reduced, thermal resistance decreases.

By excess of compound 2 – polyisocyanate: actual strength decreases and could be reduced to elasticity, maximal strength does not change, lifetime of mixture gets little bit worse, resistance against humidity does not change, susceptibility to burrs formation increases, thermal resistance increases [21].

The mostly used way to stop the burrs formation when using additives belong ferrous oxides (powder and grain state). Their effect is explained by increasing of heat conductivity of mixtures, formation of low-melting silicates (fayalite) and so on. To experimentally proven effects belong increase of strength in high temperatures, e.g. by selfhardened furane mixture with the addition of powder ferrous oxides increases the temperature of mixture decomposition for 393,15 K and formation of burrs is pushed down [21].

4 Conclusions

Based on theoretical knowledges, literature, provided experiments and experiences from foundry it is very important to define the possibilities of prevention the burrs formation on castings produced with CBA technology. In this technology the aim is to produce strong and stabile cores, to remove the most defects during pouring, so that the occurrence of foundry errors is as little as possible. It is possible to eliminate the burrs in different ways, respectively with their combination.

- Most common way to eliminate burrs is the use of additive in the moulding core mixture. For casting Housing, additive EP3767/2 and for casting Reibscheibe, additive Spherox by 4,5 weight % showed best results. Castings were formed without burrs with smooth surface.
- In case that it is not possible to change the silica opening material with opening material with continual thermal dilatation, it is important that silica opening material fulfills these requirements: highly mineralogically clean, highly regular, lowest coefficient of angularity, have the highest grain shape factor, ie close to the shape of a sphere when $f_t = 1$, active surface of grains, clean without coatings, minimal concentration of fine parts. One possibility is to change the silica opening material for other location.
- By keeping the right amount of opening material it is possible to eliminate burrs formation with increasing binding material amount in mixture or by modification of binding materials to higher strengths in hot, with which the plasticity would increase.
- Ferrous oxides between grains increase the strength of mixtures, even when the resin is already burned-out. With the fineness of ferrous oxides increases also their efficiency, but strength characteristics of hardened mixture decrease. Usage of addition of powder ferrous oxides is in common cca 1 – 2,5 % into core mixture.

- Except for above mentioned ways, burrs formation can be eliminated with different additions as wood saw-dust, dextrin, special minerals, returning reclaimed mixtures, when using mechanical reclaim (60-70%) it comes to significant push-out of burrs formation, protective painting with amount of ferrous oxides and relaxing compound.

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