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Innovative techniques: Best available techniques (BAT) in selected industrial areas - Subproject 3 - Foundries

Volume 1: BAT candidates

For our Environment

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Innovative techniques: Best available techniques (BAT) in selected industrial areas - Subproject 3 - Foundries

Volume 1: BAT candidates

by

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Kurzbeschreibung

Die EU-Kommission organisiert auf Grundlage der IVU-Richtlinie (2010/75/EU, die die Richtlinie 2008/01/EG ersetzt) einen Informationsaustausch zwischen Industrie, Umweltverbänden und Mitgliedsstaaten über beste verfügbare Techniken (BVT) in den Industriebranchen, die im Anhang 1 der IVU-Richtlinie genannt sind.

Zunächst war vorgesehen, im Jahr 2012 mit der Revision des BVT-Merkblattes für die Gießereiindustrie zu beginnen. Inzwischen ist mit einem Beginn der Revision im Jahr 2016 auszugehen.

Für die Revision sind fundierte deutsche Beiträge wichtig, um einen hohen, den Entwicklungen in Deutschland gerecht werdenden Stand der Technik in dieses internationale Dokument einzubringen. Dafür mussten zunächst neue Entwicklungen sowie die momentanen besten verfügbaren Techniken in der Gießereiindustrie recherchiert und dokumentiert werden.

Die Erarbeitung dieser deutschen Beiträge erfolgt unter der Federführung des deutschen Umweltbundesamtes (UBA). Ziel des Projektes war es, die Grundlage für einen deutschen Beitrag für die Revision des Merkblattes zu den besten verfügbaren Techniken (BVT-Merkblatt) für die Gießereiindustrie zu erarbeiten, der für die internationale Diskussion auf Englisch verfasst wird.

Es wurde dabei ein Vorgehen gewählt, bei dem zu Verfahren und Techniken für die Herstellung von Gussprodukten aus Eisen und Nichteisenmetallen (Aluminium, Zink und Kupfer) solche Neu- und Weiterentwicklungen im Vergleich zum Stand im bestehenden BREF-Dokument von Mai 2005 identifiziert und evaluiert wurden, die den Stand der Technik in der Gießereiindustrie in Deutschland repräsentieren. Dabei wurden neu errichtete sowie erweiterte und modernisierte Altanlagen berücksichtigt. Die Auswahl der Referenzanlagen orientiert sich unter anderem auch daran, Datenlücken im bestehenden BVT-Merkblatt zu schließen.

Abstract

Based on the Directive on Industrial Emissions (IED, which replaced Directive 2008/01/EC) an information exchange about Best Available Techniques (BAT) between industry, Member States and Environmental NGO is organised by the European Commission for industry sectors mentioned in Annex 1 of the IED.

It was intended to start drafting and updating the BAT documents on foundries in 2012. Due to delays it is expected that the starting date is 2016.

It is seen as important to provide substantiated contributions to reflect the high standard of techniques in German foundries in that international document. Therefor new developments and the available information about BAT had to be investigated and documented.

The elaboration of the German contributions has been managed by the German EPA (UBA). The objective of the project performed by Ökopol GmbH, Hamburg, and by the Institute on Foundry Technology gGmbH, Düsseldorf has been to elaborate the basis for the German contributions to the document on BAT in foundries. Due to the international discussion context the document has been elaborated in English language.

An approach has been chosen where in a first step, compared to the BREF-document of 2005, new processes and techniques for the production of ferrous and non-ferrous (aluminium, zinc, copper) casting products have been investigated, which reflect the state of technology in the German foundry industry. By this new, upgraded and modernised installations have been considered. The choice of installation also reflects the intention to close data gaps of the 2005-BREF document.

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Abkürzungen

a	anno (year)
AG	Aktiengesellschaft (incorporated company)
BAT	Best Available Techniques
BDG	Bundesverband der Deutschen Gießerei-Industrie
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BREF	Best Available Technique Reference Document
BTEX	aromatischen Kohlenwasserstoffe Benzol, Toluol, Ethylbenzol und die Xylole (benzene, toluene, ethylbenzene, and xylenes)
BVT	Beste Verfügbare Technologie
C	Celsius
cm	Zentimeter (centimeter)
CO	Kohlenmonoxid (carbon monoxide)
CTO	Catalytic Thermal Oxidiser (Katalytisch Thermischer Oxidierer)
d	day (Tag)
dB(A)	Sound Pressure Level (Maß zur Beschreibung der Stärke eines Schallereignisses)
DFB	deep fluidized bed – spezific type of SandLion®
EUR	Euro
Fe	Chemische Abkürzung für Eisen
g	Gramm
GE	Geruchseinheit (odour unit)
GIFA	Gießerei-Fachmesse
GmbH	Gesellschaft mit beschränkter Haftung (similar to limited liability company)
h	hour (Stunde)
IED	Industrial Emission Directive (Directive 2010/75/EU of The European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast)
IfG	Institut für Gießereitechnig gGmbH (Institute on Foundry Technology gGmbH)
IVU	RICHTLINIE 2010/75/EU DES EUROPÄISCHEN PARLAMENTS UND DES RATES vom 24.November 2010 über Industrieemissionen (integrierte Vermeidung und Verminderung der Umweltverschmutzung) (Neufassung)
kg	Kilogramm (1000 grams)
kW	Kilowatt
kWh	Kilowattstunde (kilowatt-hour)

m	Meter
mg	Milligramm (1/1000 gram)
Mg	Megagramm (1000000 grams)
MW	Megawatt
NL	Netherlands
Ökopol	Institut für Ökologie und Politik GmbH (Institute for Environmental Strategies)
PAG	Polyalkylene Glycol
PCDD	Polychlorierte Dibenzodioxine (Polychlorinated dibenzodioxins)
PCDF	Polychlorierte Dibenzofurane (Polychlorinated dibenzofurans)
PSM	Precision Sand Mould (Prazisionssandform)
PU	Polyurethane (Polyurethan)
PVP	Polyvinylpyrrolidone
SME	Smal and Medium Sized Enterprise (Kleine und mittlere Betriebe KMU)
t	Tonne (metric tonne)
TA Luft	Erste Allgemeine Verwaltungsvorschrift zum Bundes–Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft – TA Luft) Vom 24. Juli 2002 (Technical Instructions on Air Quality Control)
TEQ	Toxic Equivalent Units
UBA	Umweltbundesamt (Federal Environmental Agency)
VDG	Verein Deutscher Giessereifachleute e.V.
VDMA	Verband Deutscher Maschinen- und Anlagenbau (German Engineering Federation)
VOC	Volatile Organic Carbon
yr	year (Jahr)

Kurzbeschreibung

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Zunächst war vorgesehen, im Jahr 2012 mit der Revision des BVT-Merkblattes für die Gießereiindustrie zu beginnen. Inzwischen ist mit einem Beginn der Revision im Jahr 2016 auszugehen.

Für die Revision sind fundierte deutsche Beiträge wichtig, um einen hohen, den Entwicklungen in Deutschland gerecht werdenden Stand der Technik in dieses internationale Dokument einzubringen. Dafür mussten zunächst neue Entwicklungen sowie die momentanen besten verfügbaren Techniken in der Gießereiindustrie recherchiert und dokumentiert werden.

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Die folgende Tabelle nennt die Techniken, die im Rahmen der Untersuchung zur Prüfung als BVT-Kandidaten identifiziert wurden. Dabei ist zu den Techniken jeweils der zugeordnete Bereich der Umweltentlastung genannt.

Techniques and areas of environmental benefit

Chapter of the report	Technique	Areas of environmental benefits						
		Air emission	Reduction diffuse	Water / waste water	Residues	Energy	Noise	Resources
	Reduction of metal per casting							
2.1	Construction of low-mass castings with bionic principles	X	X			X		X
2.2	Simulation of low-mass casting and feeder systems	X	X			X		X
	Melting, cupola							
2.3	Melting process with modern long-term cold blast cupolas	X			X			X
2.4	Drying of water-based paint by using waste heat from a cupola furnace		X			X		
2.5	External heat recovery of a cupola furnace					X		
2.6	Injection of additive powder for reducing organic /gaseous emissions	X						
	melting, induction furnace, other furnaces							
2.7	Control system for energy use in induction heated furnaces					X		
2.8	Waste heat recovery of the induction furnace cooling system	X	X			X		
2.9	Use of waste heat with water storage					X		
2.10	Furnace with heat recovery in aluminium foundry					X		
	Melting shop, ladle preheating							
2.11	Ladle preheating using porous burners	X	X				X	
2.12	Ladles preheating using natural gas-oxygen technology	X	X			X		
	Moulding, green sands or no bake sands							
2.13	Inorganic green sand additive	X			X			
2.14	Coating of resin-bonded moulds and cores with water-based coatings	X	X					
2.15	Emission-reducing coating material with adsorptive properties	X	X					
	Emission reduced binders							
2.16	Reduced emissions from organic binders	X	X					
2.17	Aluminium foundry using inorganic core binders	X	X			X	X	
	Pouring, cooling, shake out							
2.18	Enclosure of casting and cooling line	X	X				X	
2.19	Post combustion of emissions in lost foam process	X						
2.2 0	Use of bioscrubber with additives for odour reduction	X	X					
	Sand preparation and sand reclamation							
2.21	Waste minimizing green sand preparation				X			X
2.2	Sand reclamation & heat treatment of aluminium castings in one				X			X

Chapt	Technique	Areas of environmental benefits						
2	stage							
	Heat treatment							
2.2 3	Quenching of castings with polymer solution	X	X					

Weiterhin erfolgte eine Erhebung zum status quo der Emissionssituation in der Gießereiindustrie in Deutschland (Band 2 des Berichts). Dabei wurden 80 Emissionsdatensätze aus den Bereichen Abkühlen/Ausleeren, Sandaufbereitung/Regenerierung, Strahlen, Putzen, Kernmacherei, Nassguss, Gießen Kaltharz, Formen, Fe-Kupolofen und Fe-Induktionsofen zusammengetragen.

Band 3 des Berichts umfasst eine Erhebung zur Verbreitung von Verfahren der Fertigungs- und der Umwelttechnik in deutschen Gießereien.

Summary

Based on the Directive on Industrial Emissions (IED, which replaced Directive 2008/01/EC) an information exchange about Best Available Techniques (BAT) between industry, Member States and Environmental NGO is organised by the European Commission for industry sectors mentioned in Annex 1 of the IED.

It was intended to start drafting and updating the BAT documents on foundries in 2012. Due to delays it is expected that the starting date is 2016.

It is seen as important to provide substantiated contributions to reflect the high standard of techniques in German foundries in that international document. Therefor new developments and the available information about BAT had to be investigated and documented.

The elaboration of the German contributions has been managed by the German EPA (UBA). The objective of the project performed by Ökopol GmbH, Hamburg, and by the Institute on Foundry Technology gGmbH, Düsseldorf has been to elaborate the basis for the German contributions to the document on BAT in foundries. Due to the international discussion context the document has been elaborated in English language.

An approach has been chosen where in a first step, compared to the BREF-document of 2005, new processes and techniques for the production of ferrous and non-ferrous (aluminium, zinc, copper) casting products have been investigated, which reflect the state of technology in the German foundry industry. By this new, upgraded and modernised installations have been considered. The choice of installation also reflects the intention to close data gaps of the 2005-BREF document.

The following table specifies techniques, which have been investigated in the course of the research on BAT candidates. The area of potential environmental protection resulting from the techniques are shown in the last seven columns.

Techniques and areas of environmental benefit

Chapter of the report	Technique	Areas of environmental benefits						
		Air emission	Reduction diffuse	Water/ waste water	Residues	Energy	Noise	Resources
	Reduction of metal per casting							
2.1	Construction of low-mass castings with bionic principles	X	X			X		X
2.2	Simulation of low-mass casting and feeder systems	X	X			X		X
	Melting, cupola							
2.3	Melting process with modern long-term cold blast cupolas	X			X			X
2.4	Drying of water-based paint by using waste heat from a cupola furnace		X			X		
2.5	External heat recovery of a cupola furnace					X		
2.6	Injection of additive powder for reducing organic /gaseous	X						

Chapt	Technique	Areas of environmental benefits						
	emissions							
	melting, induction furnace, other furnaces							
2.7	Control system for energy use in induction heated furnaces					X		
2.8	Waste heat recovery of the induction furnace cooling system	X	X			X		
2.9	Use of waste heat with water storage					X		
2.10	Furnace with heat recovery in aluminium foundry					X		
	Melting shop, ladle preheating							
2.11	Ladle preheating using porous burners	X	X				X	
2.12	Ladles preheating using natural gas-oxygen technology	X	X			X		
	Moulding, green sands or no bake sands							
2.13	Inorganic green sand additive	X			X			
2.14	Coating of resin-bonded moulds and cores with water-based coatings	X	X					
2.15	Emission-reducing coating material with adsorptive properties	X	X					
	Emission reduced binders							
2.16	Reduced emissions from organic binders	X	X					
2.17	Aluminium foundry using inorganic core binders	X	X			X	X	
	Pouring, cooling, shake out							
2.18	Enclosure of casting and cooling line	X	X				X	
2.19	Post combustion of emissions in lost foam process	X						
2.20	Use of bioscrubber with additives for odour reduction	X	X					
	Sand preparation and sand reclamation							
2.21	Waste minimizing green sand preparation				X			X
2.22	Sand reclamation & heat treatment of aluminium castings in one stage				X			X
	Heat treatment							
2.23	Quenching of castings with polymer solution	X	X					

In addition the status quo of the emission situation in the foundry industry in Germany has been investigated (volume 2 of this report). 80 data sets of emission values have been collected from the areas cooling/empty, sand regeneration, blasting, cleaning, core making, green sands, no bake sands, mould production, ferrous cupola furnace and ferrous inductive furnace.

Volume 3 of the report covers a survey on processes and techniques in German foundries regarding production processes and environmental technologies.

1 Hintergrund und Ziele

Die EU-Kommission organisiert auf Grundlage der IVU-Richtlinie (2010/75/EU, die die Richtlinie 2008/01/EG ersetzt) einen Informationsaustausch zwischen Industrie, Umweltverbänden und Mitgliedsstaaten über beste verfügbare Techniken (BVT) in den Industriebranchen, die im Anhang 1 der IVU-Richtlinie genannt sind.

Entsprechend wurde im Jahr 2004 ein BVT-Merkblatt auch für die Eisen- und Nichteisen-Gießereiindustrie erstellt, da die Branchen laut Anhang 1 der IVU-Richtlinie betroffen sind, wenn die Produktions- bzw. Schmelzkapazität 20 t/d und bei Blei und Kadmium 4 t/d übersteigt (Nr. 2.4: Eisenmetallgießereien mit einer Produktionskapazität von über 20 Tonnen pro Tag und Nr. 2.5 b: Anlagen zum Schmelzen von Nichteisenmetallen einschließlich Legierungen, darunter auch Wiedergewinnungsprodukte (Raffination, Gießen) mit einer Schmelzkapazität von mehr als 4 Tonnen pro Tag bei Blei und Kadmium oder 20 Tonnen pro Tag bei allen anderen Metallen).[1]

Stranggießen wurde aus dem Umfang des BVT-Merkblattes ausgeschlossen, da es bereits im BVT-Merkblatt zur Eisen- und Stahlerzeugung behandelt wird.

Die IED in der Neufassung (2010/75/EU) ist am 6.1.2011 in Kraft getreten und muss binnen 2 Jahren also bis zum 6.1.2013 in nationales Recht umgesetzt werden.

Für Anlagen, die in den Geltungsbereich der IED fallen, müssen im Betrieb die Grundprinzipien des Artikel 11 erfüllt werden:

- Vorsorgemaßnahmen gegen Umweltverschmutzungen,
- Anwendung von BVT,
- Vermeidung erheblicher Umweltverschmutzungen,
- Vermeidung von Abfällen bzw. deren Bewirtschaftung entsprechend der Richtlinie 2008/98/EG,
- Effiziente Energienutzung,
- Verhinderung von Unfällen bzw. Begrenzung von Unfallfolgen,
- Vermeidung von Umweltverschmutzungen bei endgültiger Stilllegung.

Zur Erstellung und Aktualisierung der BVT-Merkblätter erfolgt ein Informationsaustausch, der entsprechend Artikel 13 IED insbesondere folgende Bereiche umfasst:

„a) Leistungsfähigkeit der Anlagen und Techniken in Bezug auf Emissionen, gegebenenfalls ausgedrückt als kurz- und langfristige Mittelwerte sowie assoziierte Referenzbedingungen, Rohstoffverbrauch und Art der Rohstoffe, Wasserverbrauch, Energieverbrauch und Abfallerzeugung;

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[1] In Deutschland wurden die gleichen Produktionsgrenzen genehmigungsrechtlich in die 4.BImSchV in Spalte 1 der Nummer 3.4 Anhangs übernommen (Verordnung über genehmigungspflichtige Anlagen, zuletzt geändert in 10/2007)

b) angewandte Techniken, zugehörige Überwachung, medienübergreifende Auswirkungen, wirtschaftliche Tragfähigkeit und technische Durchführbarkeit sowie Entwicklungen bei diesen Aspekten;

c) beste verfügbare Techniken und Zukunftstechniken, die nach der Prüfung der in den Buchstaben a und b aufgeführten Aspekte ermittelt worden sind.“ [IED Artikel 13(2)].

Anhang III der IED benennt Kriterien für die Ermittlung der besten verfügbaren Techniken:

„1. Einsatz abfallarmer Technologie.

2. Einsatz weniger gefährlicher Stoffe.

3. Förderung der Rückgewinnung und Wiederverwertung der bei den einzelnen Verfahren erzeugten und verwendeten Stoffe und gegebenenfalls der Abfälle.

4. Vergleichbare Verfahren, Vorrichtungen und Betriebsmethoden, die mit Erfolg im industriellen Maßstab erprobt wurden.

5. Fortschritte in der Technologie und in den wissenschaftlichen Erkenntnissen.

6. Art, Auswirkungen und Menge der jeweiligen Emissionen.

7. Zeitpunkte der Inbetriebnahme der neuen oder der bestehenden Anlagen.

8. Für die Einführung einer besseren verfügbaren Technik erforderliche Zeit.

9. Verbrauch an Rohstoffen und Art der bei den einzelnen Verfahren verwendeten Rohstoffe (einschließlich Wasser) sowie Energieeffizienz.

10. Die Notwendigkeit, die Gesamtwirkung der Emissionen und die Gefahren für die Umwelt so weit wie möglich zu vermeiden oder zu verringern.

11. Die Notwendigkeit, Unfällen vorzubeugen und deren Folgen für die Umwelt zu verringern.

12. Von internationalen Organisationen veröffentlichte Informationen.“ [IED Anhang III]

Weiterhin benennt Artikel 14 IED Genehmigungsauflagen

Artikel 17 IED (Allgemeine bindende Vorschriften für die in Anhang I aufgeführten Tätigkeiten) bestimmt, dass sich die allgemeinen bindenden Vorschriften auf die besten verfügbaren Techniken stützen, „ohne dass die Anwendung einer bestimmten Technik oder Technologie vorgeschrieben wird, um die Einhaltung der Artikel 14 und 15 zu gewährleisten“ [IED Artikel 17(2)].

Artikel 18 IED weist darauf hin, dass in den Fällen, in denen eine Umweltqualitätsnorm strengere Auflagen erfordert, „als durch die Anwendung der besten verfügbaren Techniken zu erfüllen sind, so werden unbeschadet anderer Maßnahmen, die zur Einhaltung der Umweltqualitätsnormen ergriffen werden können, zusätzliche Auflagen in der Genehmigung vorgesehen“ [IED Artikel 18].

Zunächst war vorgesehen, im Jahr 2012 mit der Revision des BVT-Merkblattes für die Gießereiindustrie zu beginnen. Inzwischen ist mit einem Beginn der Revision frühestens im Jahr 2014, aufgrund der Verzögerungen im Zeitplan der EU-KOM, auszugehen.

Für die Revision sind fundierte deutsche Beiträge wichtig, um einen hohen, den Entwicklungen in Deutschland gerecht werdenden Stand der Technik in dieses internationale Dokument einzubringen. Dafür müssen zunächst neue Entwicklungen sowie die momentanen besten verfügbaren Techniken in der Gießereiindustrie recherchiert und dokumentiert werden. Die

Erarbeitung dieser deutschen Beiträge erfolgt unter der Federführung des deutschen Umweltbundesamtes (UBA).

Ziel des Projektes ist es, einen deutschen Beitrag für die Revision des Merkblattes zu den besten verfügbaren Techniken (BVT-Merkblatt) für die Gießereiindustrie zu erarbeiten, der für die internationale Diskussion auf Englisch verfasst wird.

Es wurden Verfahren und Techniken für die Herstellung von Gussprodukten aus Eisen und Nichteisenmetallen (Aluminium, Zink und Kupfer) Neu- und Weiterentwicklungen im Vergleich zum Stand im bestehenden BREF-Dokument von Mai 2005 identifiziert und evaluiert, die den Stand der Technik in der Gießereiindustrie in Deutschland repräsentieren. Dabei wurden neu errichtete sowie erweiterte und modernisierte Altanlagen berücksichtigt und als Referenzanlagen beschrieben. Die Auswahl der Referenzanlagen orientiert sich unter anderem auch daran, Datenlücken im bestehenden BVT-Merkblatt zu schließen.

Die Beschreibung der BVT-Kandidaten erfolgt entsprechend den späteren Anforderungen für die Einspeisung in den Sevilla-Prozess in Englisch.

2 BAT candidates

The following section describes techniques to be considered in the course of defining BAT.

The table below provides an overview of environmental benefits related to the techniques described.

Table 1: Techniques and areas of environmental benefit

Chapter	Technique	Areas of environmental benefits						
		Air emission	Reduction of diffuse	Water/ waste water	Residues	Energy	Noise	Resources
	Reduction of metal per casting							
2.1	Construction of low-mass castings with bionic principles	X	X			X		X
2.2	Simulation of low-mass casting and feeder systems	X	X			X		X
	Melting, cupola							
2.3	Melting process with modern long-term cold blast cupolas	X			X			X
2.4	Drying of water-based paint by using waste heat from a cupola furnace		X			X		
2.5	External heat recovery of a cupola furnace					X		
2.6	Injection of additive powder for reducing organic /gaseous emissions	X						
	melting, induction furnace, other furnaces							
2.7	Control system for energy use in induction heated furnaces					X		
2.8	Waste heat recovery of the induction furnace cooling system	X	X			X		
2.9	Use of waste heat with water storage					X		
2.10	Furnace with heat recovery in aluminium foundry					X		
	Melting shop, ladle preheating							
2.11	Ladle preheating using porous burners	X	X				X	
2.12	Ladles preheating using natural gas-oxygen technology	X	X			X		
	Moulding, green sands or no bake sands							
2.13	Inorganic green sand additive	X			X			
2.14	Coating of resin-bonded moulds and cores with water-based coatings	X	X					
2.15	Emission-reducing coating material with adsorptive properties	X	X					
	Emission reduced binders							
2.16	Reduced emissions from organic binders	X	X					
2.17	Aluminium foundry using inorganic core binders	X	X			X	X	
	Pouring, cooling, shake out							

Chapt	Technique	Areas of environmental benefits						
2.18	Enclosure of casting and cooling line	X	X				X	
2.19	Post combustion of emissions in lost foam process	X						
2.20	Use of bioscrubber with additives for odour reduction	X	X					
	Sand preparation and sand reclamation							
2.21	Waste minimizing green sand preparation				X			X
2.22	Sand reclamation & heat treatment of aluminium castings in one stage				X			X
	Heat treatment							
2.23	Quenching of castings with polymer solution	X	X					

2.1 Construction of low-mass castings with bionic principles

2.1.1 Reference to BREF-May 2005

No Information on the subject of bionics as environmental protection method is present in the existing BREF.

2.1.2 Description

The term 'bionics' is a composition of the words biology and technology, and describes the implementation of requirements from nature to technology. The central goal is the production of components such as castings with a minimum mass of material.

With the help of the bionic concept, typically implemented by computer programs for topology optimization, the castings can be improved for all applications like e.g. castings for automotive, engineering and many more.

An example is the manufacturing of machining tools, which is subject to the highest design and manufacturing challenges. By using advanced optimization algorithms and computer programs more lightweight castings can be implemented having even better mechanical properties compared to their predecessors.

The specified design goal, high stiffness combined with low manufacturing costs, can be taken into account with natural growth structures (for example, the growth patterns of trees) [1].

Based on the illustrated machine bed, Fig.1 (material: EN-GJL-250, weight: 1 150 kg Dimensions: 1 765 x 1 120 x 1 100 mm) shows how economic, technical and ecological interests can be combined harmoniously.

Fig. 1: Machine bed with castings. The machine bed is the rigid base (Source: IfG)

2.1.3 Achieved environmental benefits

Achieved environmental benefits are:

- Reduced flows of metallic feedstock in the total production process including raw material storage, melting, casting / cooling / emptying and in casting treatment
- Reduced dust and gaseous emissions in these manufacturing sectors (at constant number of castings);
- Less energy use and CO_2 emissions, especially during melting and transport.

2.1.4 Operational data

The topology optimization is using a special calculation tool - the “finite element method” (FEM).The FEM software allows finding weaknesses in a constructive CA-design and an objective evaluation of design variants. So far, designers used it only as a tool to improve functionality in an iterative approach by repeated modifications of the CAD model, which was very time consuming. By combining FEM software with advanced optimization algorithms, it became possible to generate functionally convincing design proposals automatically by masking areas during the topology optimisation of the work piece which are not or only minimal stressed. Output is a structure, which provides minimal distortion with a given weight.

The software improves and accelerates finding of convincing work piece designs which is seen even more important due to increasing deadline constrains.

After the detailed design of the work piece mould can be optimised. Analogous to growth processes in nature it eliminates strength related vulnerabilities by automatically applying some material in heavily used areas [2].

2.1.5 Cross-media effects

None.

2.1.6 Applicability

Applicable to all cast components - regardless of casting materials and casting processes. Close communication with the customers is advised especially when low mass castings will be developed.

2.1.7 Economics

- Reduced raw part costs by saving material,
- Reduced melting costs,
- Reduced cost of core and mould production,
- Increased value of components in cases where value of components depends on weight and or costs per piece,
- Competitive advantages over competing materials and manufacturing processes (welding, forging, polymer concrete).

2.1.8 Driving force for implementation

- Reduction in weight of castings: in the example of the machine bed, the weight was reduced from 12 to 9 t; In general a range of reduction between 10% and 35% is expected [3],
- Maximum component stiffness by minimum material use,
- Accelerated finding of concepts for design of work pieces,
- Reductions of unit costs – in case of the machine bed described above: 50%.

2.1.9 Example

- CLAAS GUSS is using the software Hyperworks [4];
- Under the trade name BIOCAST® Heidenreich & Harbeck AG is developing material efficient premium cast parts with the help of bionic optimisation tools [5];
- GF Automotive is producing mechanically highly stressed components for the automotive industries with bionic guidelines that are based on the principle of growth of trees [6].

2.1.10 Reference literature

[1] BDG-paper „Energieeffizienter Gießereibetrieb“: GIFA 2011-presentation. Düsseldorf.

[2] VDG-paper „Inspiration Bionik – Von der Evolution in 21. Jahrhundert“: GIFA-presentation 2007.

[3] Dipl.-Ing. Ernst du Maire und Dr.-Ing. Thorsten Schmidt "Von der Natur lernen - kraftflussgerechte, neuartige Gestaltung gegossener Komponenten" 2. NEWCAST-Forum - Tagungsband, 21. und 22. April 2005.

[4] Information from CLAAS GUSS GmbH.

[5] Information from HEIDENREICH & HARBECK AG.

[6] Information from Georg Fischer Automotive AG.

2.2 Simulation of low-mass casting and feeder systems

2.2.1 Reference to BREF-May2005

Information about improvement in yield as a technical method is provided in chapter 3.10.1.3 of the BREF, but there is no information about simulations.

2.2.2 Description

The simulation of mould filling improves the quality, the recovery and productivity. The yield during a manufacturing process is the net weight generated, based on the spent gross casting weight.

The new casting process simulation technique , as shown in Fig. 2, compared with the previous model, lead to an improvement in yield of by about 18.5%. There is a front wheel fork in light alloy, which is manufactured by tilted die-casting.

Fig. 2: Optimisation of casting and die layout through process simulation of a front fork of aluminium (left: original casting and heat centre, right: optimised directional solidification casting)

2.2.3 Achieved environmental benefits

Achieved environmental benefits are:

- reduced consumption of metallic materials,
- reduced dust and gaseous emissions from melting, casting / cooling / emptying and casting treatment from reduced use of material,
- less energy consumption and related CO_2 emissions, particularly during the melting.

2.2.4 Operational data

Hardware and software for the simulation of cooling characteristics and properties of cast iron or cast parts.

2.2.5 Cross-media effects

No cross-media effects.

2.2.6 Applicability

Applicable for all industrial casting materials and casting processes.

2.2.7 Economics

License fees for the annual use of standard software MAGMA5 is about 25.000 €. The software is material-specific or process dependent and can be extended with additional modules.

Alternatively it is possible to use casting simulation as a service.

Economic benefits are:

- The increase in yield and reduction of rejection rate and the moulding cycle time can result in a reduction of the melting and material costs in the sum of 28 000 € in the first year (example), leading to a return of investment in approx. one year.
- An increase in the metal yield results in less consumption of energy, sand and additives per tonne of good casting.

2.2.8 Driving force for implementation

The casting process simulation

- increases the ability to process and avoid casting defects,
- increases the yield by reducing the amount of recycled material.

A reduction in wall thickness reduces the setting time and the moulding cycle time by 10%

2.2.9 Example

MAGMA GmbH, Aachen, Germany.

In Germany, about 180 simulation systems are in use. Systems for the simulation of casting and cooling processes are also available from other vendors.

Literature source [2] provides several exemplary cases for the application of simulations, like:

“Equipment manufacturer John Deere, Moline III., cut the scrap rate of gray-iron part from 10.3 to 1.4% and saved $66 936/year by modifying the part and gating system. The company also boosted its casting yield from 58 to 64% for an additional saving of $66 600/yr. “

“Simulation results encouraged pump manufacturer Otto Junker in Germany to cast a steel pump housing that had direct-pour top risers instead of the typical side risers. This lowered the amount of liquid metal needed by 81% reduced molding time by 79% and minimised the time needed to burn-off the risers by 87%. The company reduced its total production costs for the part by 12%.”

“A South American iron foundry increased the casting yield for a ductile-iron differential case housing from 62 to 67% by using simulation to develop a non-traditional gating system. The design lowered the overall scrap rate from 17 to 7%, saved 700 000 kW-hr/yr to produce 24 000 parts and slashed total costs by $500 000."

"Heidelberger Druck (Germany) relocated a mould gate based on simulation results and thereby significantly reduced the amount of repair welding it had to perform on a cover. Temperature losses in the original part had let to incomplete filling of a rib. Simulation let engineers see how material flow was affected by moving the gate to different locations" [2].

2.2.10 Reference literature

[1] Sturm,.J.C.: Energie- und Rohstoffeinsparung durch konsequente Nutzung der Gießprozesssimulation. GIESSEREI 98, 2011, Nr. 6, S. 82 ff.

[2] English online summary of the above article: http://digital-edition.machinedesign.com//?iid=0df839e7 (s. 70-73)

[3] BDG-paper „Energieeffizienter Gießereibetrieb“: GIFA 2011-presentation

2.3 Melting process with modern long-term cold blast cupolas

2.3.1 Reference to BREF-May 2005

Chapter 2.4.1.3 of the BREF describes a long-term cupola furnace operation.

The information in the following section describes further details.

2.3.2 Description

The cupola melting operation of the iron foundry Hermann Reckers GmbH & Co. KG consisted essentially of two furnaces with oxygen injection, which were operated in daily change. While one furnace was used for melting the iron, maintenance work has been carried out at the other one.

As part of the modernisation, both existing furnaces were dismounted and on the same place a long-term cold blast cupola was built which also has an oxygen injection. The adjustment of the amount of blasted air to the current operating conditions was done with the aid of a wind volume measurement and a wind control system and a frequency control for the wind fan. Unlike the old furnace, the molten iron is not continuously stored in the interior of the long-time cupola. For this purpose a non-heated forehearth has been installed, which absorbs the leaking melt.

In normal operation molten iron is continuously leaking. Here it is collected over iron gutters in the unheated tray forehearth with a crane ladle and then transported to the already existing, electrically heated furnace or heat-retaining memory furnace, or if necessary, transported directly to the mould system for casting. The slag is separated in the siphon and then flowing into a slag bucket below the furnace platform, which cools it and is given in the next step in solid form for recycling / disposal.

The main difference between the two former shaft furnaces whose feed had to be touched up every day, is that the long-time cupola furnace has a water cooling system for the blast furnace where the blast nozzles are extending into. The water cooling system prevents the nozzle from melting quickly due to high temperature in the furnace, which was linked in this area with a strong erosion of the furnace lining. This will prolong the life of the furnace lining considerably, so that the furnace can be operated over a period of several weeks before the food has to be relined.

The dust extraction consists of the radiator, two cyclones, the dry cleaning system and dust filter with radial fan, exhaust silencer and steel chimney. In the combustion process in a cupola furnace stack gas is produced in all phases of operation (start-up, normal operation, low-melting). The gas is fully captured in the furnace head and fed to the cupola dust extraction.

The deposited dust in the filter bags is cleaned by backwashing, then collected in the dust collection hopper and fed to a dust container and disposed therein. The cleaned air is discharged with a residual dust content of <10 mg / m³ in the atmosphere.

As an additional measure for improvement the warehouse and the charge makeup of the starting materials were built in a separate hall. This reduces the noise emissions and fugitive dust emissions greatly and in addition, the loss of quality of the starting materials can be avoided by the weather.

2.3.3 Achieved environmental benefits

Long-term cold blast cupola

- Protecting the environment by reducing the consumption of materials (furnace lining) and the amount of waste (furnace waste); Before changing furnace lining life time was at 1 day, after it was at more than 2 months. Fire resistant demand was before change of lining 25 – 30 kg/t Liquid iron and after 1.6 kg/t Liquid iron.
- Reduced dust emissions and waste volumes due to the start-up and shutdown, and the renewal of the furnace lining (Before: 1 day; After: more than 2 months),
- Reduction of odour emissions by 60 % (Before: 167 MGE/h; 4 400 GE/m^3 After: 65 MGE/h; 1 700 GE/m^3).

Feedstock storage in a warehouse

- Reduction of fugitive emissions during storage and charge makeup of the starting materials,
- Reduced moisture feedstock and coke,
- Reduction of noise at the delivery and in charge makeup of substances.

2.3.4 Operational data

Table 2: Operational data long-term cold blast cupolas

Operating times cupola furnace	Monday to Friday in 2-shift operation from 5:00 am to 22:00 pm
melting capacity (liquid iron)	Before: Up to 8 t/h After: Up to 12 t/h
Furnace lining lifetime	Before: 1 day After: more than 2 months
Fire resistant demand	Before: 25 – 30 kg/t Liquid After: 1.6 kg/t Liquid iron
Odour emissions	Before: 167 MGE/h; 4 400 GE/m^3 After: 65 MGE/h; 1 700 GE/m^3
Exhaust gas volume cupola furnace, coke, oxygen demand, the amount of dust (waste disposal)	No changes

2.3.5 Cross-media effects

No significant cross media effects (slightly increased power consumption from cooling equipment might occur).

2.3.6 Applicability

- Reconstruction requires a large amount of investment (reconstruction cupola furnace and warehouse).

- A long-term cold blast cupola should be operated at least two shifts, because during non-operating time (night shift) it is not completely shut down. This phase takes too long (one-shift operation) and the long-term cold blast cupola would be uneconomical.

2.3.7 Economics

Investment storage hall: ca. 900 000 €,

Investment long-term cupola: ca. 1 200 000 €.

Table 3: Economic aspects long-term cold blast cupolas

Operating costs:	old cupola	new cupola
lining material	3.61 €/t Fe	2.10 €/t Fe
disposal costs	1.23 €/t Fe	0.04 €/t Fe
labour costs	5.76 €/t Fe	4.38 €/t Fe
Sum:	10.60 €/t Fe	6.52 €/t Fe

2.3.8 Driving force for implementation

- Environmental benefits,
- Increase competitiveness by reducing costs related to refractory and furnace waste disposal,
- Possibility to extend the operating hours of the melting operation to three shifts,
- Improvement in workload and job security by significantly reducing physically stressful work in the hot and narrow furnace shaft.

2.3.9 Example

Hermann Reckers GmbH & Co. KG Eisengießerei, 48432 Rheine – Mesum

2.3.10 Reference literature

Given by the operator of the reference plant

2.4 Drying of water-based paint by using waste heat from a cupola furnace

2.4.1 Reference to BREF-May 2005

In section 4.5.2.2, the post-combustion of exhaust gases from hot blast cupolas and in chapter 4.7.3 the use of waste heat from hot-blast cupolas using thermal oil for core drying is shown.

Using waste heat from hot-blast cupolas for drying water-based paint is shown as a new procedure.

2.4.2 Description

A dip and spray primer paint system is operated with the use of water-based paint. The system has 4 dip pools, 2 spray levels and a drying tunnel, in an evaporation zone with a capacity of 13 tied rods at an air temperature of 50°C and an actual additional drying area with a capacity of 46 tied rods at an air temperature of about 140°C.

The transit time through the drying tunnel is 1 hour. Subsequently, cooling of the parts takes place in a corresponding tunnel with fresh air from outside with a cycle time of 40 minutes.

Compared with the former paint shop, which worked with solvent-borne paint systems, a considerable additional energy was required for drying of water-based paint. The entire drying area was designed with 5 gas burners, blower and an installed capacity of 2 250 KW.

Fig. 3: Dip priming (source: IfG)

Fig. 4 Spray primer paint system (source: IfG)

Fig. 5: Drying system (source: IfG)

In 2009, a thermal oil heat system to recover excessive heat from the stack gas has been installed at the cupola furnace. To use the waste heat, a secondary circuit (= recovery circuit) was constructed between the upper end of the zero-pressure collector of the primary circuit (= cooling circuit at the cupola furnace) and by a cycle line (DN-125 mm) and - via the roof - the area of the facility where painting drying is performed. In case that there will be additional consumption points for the waste heat, additional sockets have been integrated in the circuit. The hot oil in the secondary circuit reaches a temperature of about 210°C. To use some of this waste heat for a paint shop, 5 thermal oil heat exchangers were installed in the drying tunnel.

Fig. 6: Thermal oil pipes for water-based paint drying (source: IfG)

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2.4.3 Operational data:

Table 4: Operational data of water-based paint plant for priming with waste heat recovery for paint drying

Manufacturer	Heimer Lackieranlagen GmbH & Co.KG
Start date of operation	4th Quarter of 2009 (actual system) 2nd Quarter of 2010 (extension waste heat utilization)
Operation time	Monday to Friday in a three-shift operation
Area requirements	1 700 m3
Performance - flow rate castings	6 500 kg/h
Installed electric power	335 kW
Installed capacity of natural gas burner	2 250 kW
Power consumption	1 728 028 kWh in 2010
Gas consumption	118 078 m3/a resp. 1 315 400 kWh in 2010

Comment: The cupola operated in two shifts, the paint plant is three shift operated. In case of operating the cupola in three-shifts, the period of waste heat recovery is longer and the heat recovery potential rises.

2.4.4 Achieved environmental benefits

By application of the technique reduction of (partly diffuse) VOC emissions and odour can be achieved.

In case of waste heat recovery the gas consumption for drying is reduced by ca. 30% from ca. 25.5 m^3/h to 18.2 m^3/h. It is notable that the cupola is two shift operated and the paint plant is three shift operated. In case of a three-shift cupola operation, the period of waste heat recovery is longer and the heat recovery potential rises.

2.4.5 Cross-media effects

None.

2.4.6 Applicability

For the interpretation of the nominal furnace capacity a furnace curve must be developed, which is based on the casting program. Background to this is the ratio between convection and the object surface temperature (e.g. object surface temperature according to specification = min 100°C for 20 minutes holding time means 140°C circulating temperature for 45 minutes holding time.).

Applicability in existing installation is limited by the factors described above.

2.4.7 Economics

- The additional investment costs for the integration of waste heat for drying paint are approximately EUR 1.4 million. These costs have been considered only on a pro rata basis.
- By the use of waste heat for drying paint, the production costs can be reduced compared to a paint drying using exclusively natural gas burners to approximately 20 - 25%.
- Maintenance and repair costs are in the order of 20 000 €/a.

2.4.8 Driving force for implementation

Cost savings and the reduction of VOC emissions. By switching to water based products recovery of excess heat from the stack gas became economically.

2.4.9 Reference literature

Gießerei Heunisch GmbH, http://www.heunisch-guss.com, Germany

Enzenbach, Thomas: Giesserei 96 (10/2009), S. 68-74

2.5 External heat recovery of a cupola furnace

2.5.1 Reference to BREF-May 2005

In section 4.5.2.2, the post-combustion of waste gases from hot blast cupolas and in chapter 4.7.3 the use of waste heat from hot-blast cupolas using thermal oil for core drying is described.

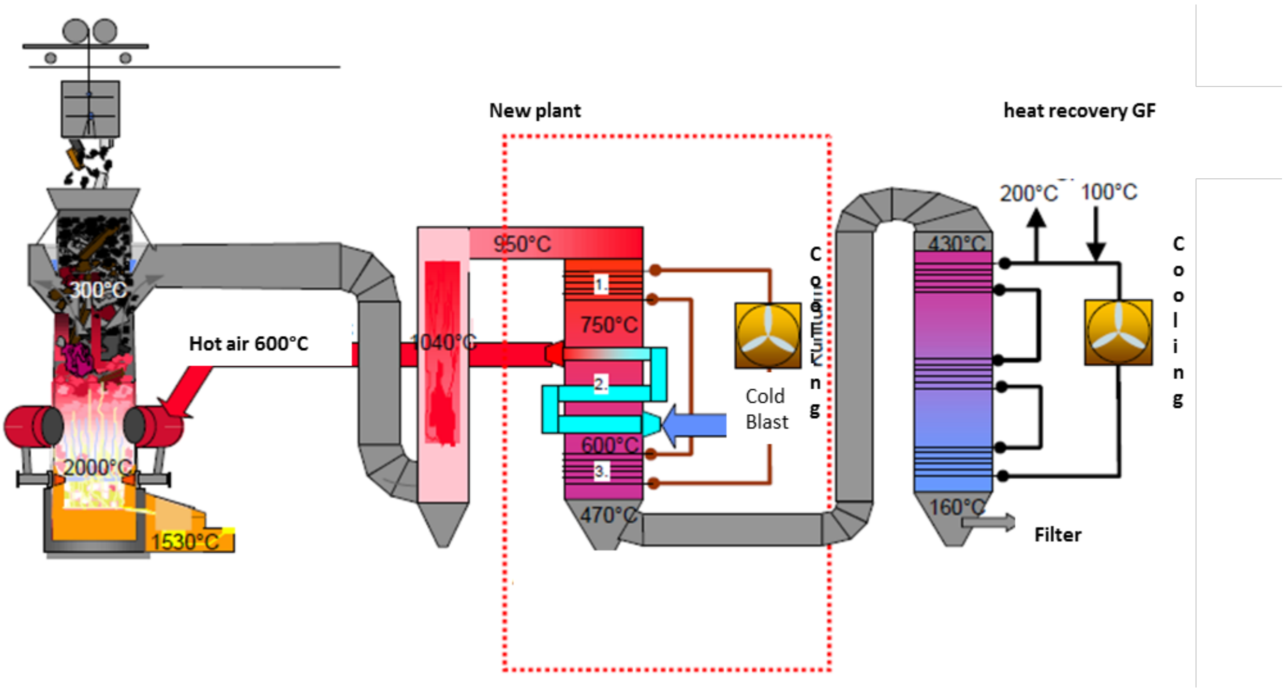
Using waste heat from a hot-blast cupolas to produce food-grade steam, which can be used in food production, is a way to improve environmental performance of the casting.

2.5.2 Description

The Georg Fischer Automotive AG in Singen produces ductile iron castings for cars and trucks. 200 000 tons of metals are casted per year from a hot blast cupola furnace. The CO rich off gas is post combusted and temperatures up to 900°C are achieved. The off gas must be cooled before entering the cleaning system.

In the described foundry, waste heat is discharged to a nearby food processing plant of the company “Maggi”.

Fig. 7: Heat exchanger (source: IfG)Fig



2.5.3 Operational data

Georg Fischer Automotive replaced the existing recuperator by a 2.5 times more efficient one in 2008. The excess heat is used to heat thermal oil, which is pumped through a 400-meter-long pipeline system in the boiler house about 200 meters away from the food processing plant of Maggi. The 280°C hot thermal oil is used there in a heat exchanger to produce a food grade steam. This steam is used for sterilization of wet ready-made dishes such as ravioli or for drying processes in the manufacture of dry soups and sauces. Maggi expects to substitute two-thirds of the natural gas previously consumed to produce food-grade steam.

Fig. 8: Schematic representation of the waste heat from the Georg Fischer AG and the Maggi factory (source: [2])

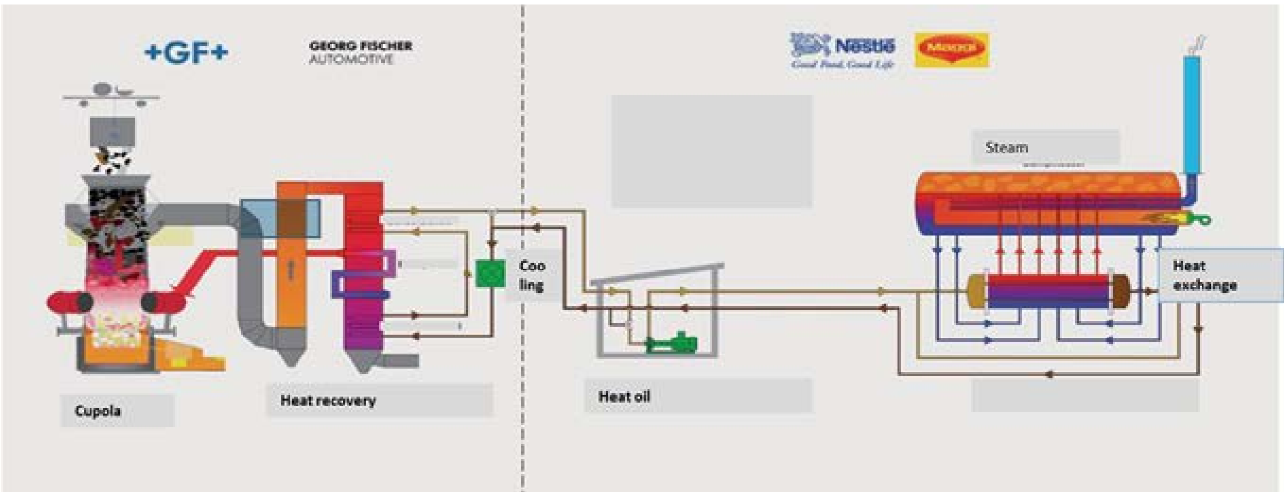


Table 5: Comparison of potentially usable energy with actually used energy

		Situation before reconstruction	Situation after reconstruction
maximum energy for recovery		25 MW	30 MW
used energy			
	hot blast	7 MW	7 MW
	hot water	6 MW	6 MW
	external use	0 MW	10-14 MW
	total	13 MW	23-27MW

2.5.4 Achieved environmental benefits

- Reduced primary energy consumption of 50 000 MWh/yr (at the plant using heat from the foundry),
- Reduction of about 11 000 tons of CO_2 emissions per year.

2.5.5 Cross-media effects

None.

2.5.6 Applicability

- The excess energy of the foundry meets the needs of the buyer of waste heat,
- Short distance between production and use of heat is crucial. The maximum distance must be determined case by case. In the described example, the distance is around 600 m.

No information is available regarding the agreements and technical equipments in case of downtime of the furnace.

2.5.7 Economics

Capital expenditures for Georg Fischer Automotive AG were about 3.5 million €. Maggi plant investment was at around 1.5 million €.

In the theoretical case of costs for primary energy of 5ct/kWh amortisation time of the overall investments will be less than 3 years.

2.5.8 Driving force for implementation

Economic and environmental benefits and climate protection.

2.5.9 Reference literature

[1] Bettinger, Frank; Kenzler, Markus. Abwärmenutzung bei einem Kupolofen, Umweltbundesamt (UBA-FB AP 20119, Abschlussbericht im Rahmen des Umweltinnovationsprogramm des BMU), 2009;

[2] http://www.georgfischer.com/2/11/124/8196/8212.asp, Stand Mai 2011;

[3] BDG-Schrift „Energieeffizienter Gießereibetrieb“: GIFA 2011-Sonderschau

[4] BDG/VDMA-Tagung „Energieeffizienz in Gießereien“ Frankfurt 2010.

[5] Energieeffizienz durch externe Abwärmenutzung GEORG FISCHER AUTOMOBILGUSS GMBH, SINGEN; Information sheet of the German Federal Environmental Protection Agency on the environmental investment program, Dessau, no year

2.6 Injection of additive powder for reducing organic and gaseous emissions from cupola flue gases

2.6.1 Reference to BREF - May 2005

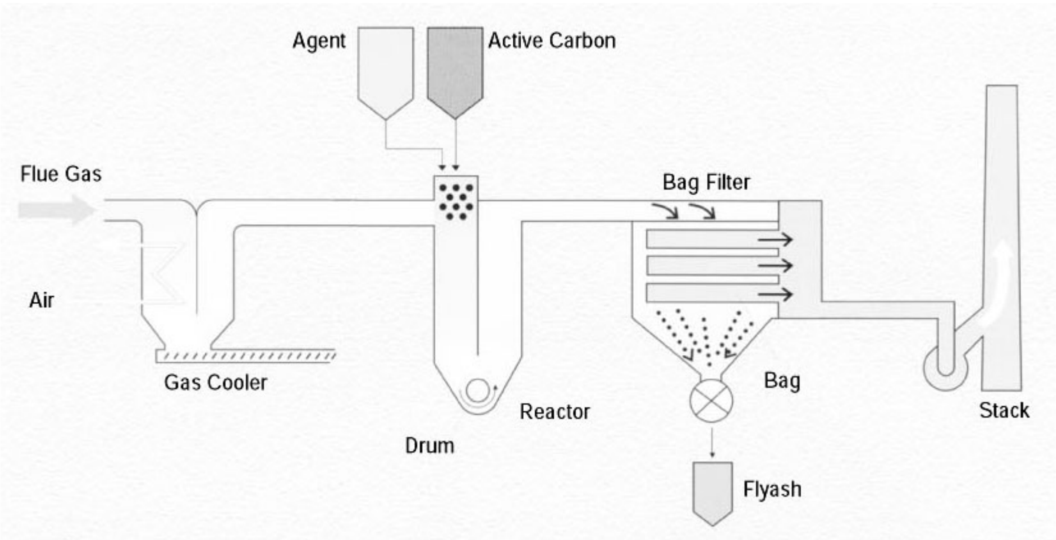
Topic of chapter 3.8.2 of the BREF is dioxin emissions of foundries. In chapter 4.5.1.4 injection of additive powders is described as a measure for dioxin emission reducing.

Information on details and an example plant is missing in the existing BREF document and provided in the following section.

2.6.2 Description

Adsorbents can be injected directly into the flue gasses upstream of a bag filter. Fig. 9 shows such a plant [1]. In case of an iron foundry in Germany the adsorbents are a mixture of activated carbon and calcium hydroxide [2].

Fig. 9: Injection of adsorbents (source: [1])



The injection system consists of a hopper with a dosing screw, which regulated the amount of adsorbent dosed to the gases. To facilitate the installation, the dosing system will be placed at ground level. By means of a small blower and a flexible pipe the adsorbents are transported into the flue gas (Fig. 10).

Fig. 10: View of an installation (source: IfG)

2.6.3 Achieved environmental benefit

The injection of additives into flue gases of a cupola furnace results in a significant reduction of organic substances in the off gas. In addition concentration of other hazardous substances like heavy metals is reduced due to the subsequent dust filter system [1; 2].

The dose of additives during the measurements in the project DIOFUR [1] (Table 6; 7) was fixed at 150 mg/Nm^3(dry). Dioxin emission was measured after the heat exchanger (before the injection) and at the stack (after injection).

Table 6: comparing the two measurement points for injection of active carbon

	13/11/2007		14/11/2007		15/11/2007	
Parameter	After heat exchanger	Stack	After heat exchanger	Stack	After heat exchanger	Stack
Total PCDD/PCDF ng I-TEQ/Dry Nm3	6.7064	0.1099	2.7108	0.0441	11.9247	0.2081
Dust mg/Dry Nm^3	/	32	/	107	/	106

The injection of inorganic adsorbents did not result in a similar reduction of PCDD/F concentrations in the off gas (see also the following table).

Table 7: comparing the two measurement points for injection of zeolite

	03/06/2008		04/06/2008		05/06/2008	
Parameter	After heat exchanger	Stack	After heat exchanger	Stack	After heat exchanger	Stack
Total PCDD/PCDF ng I-TEQ/Dry Nm3	3.202	3.451	1.753	5.260	0.007	1.069
Dust mg/Dry Nm^3	8 520	7.5	3 627	8.6	5 322	6.0

An adsorbent has been developed in the DIOFUR project [1], which is based on coke but has a high mineral content. By this, effective adsorbing can be achieved by minimising safety concerns from using organic substances in high temperature off gases.

2.6.4 Operational data

A German iron foundry runs a cold blast cupola with a capacity of 12-14 t liquid iron per hour. The injection of additive is 0.1 to 0.4 kg additive per t liquid iron.

The energy consumption is 4 kW for blowing 500m^3/h air with adsorbents into the raw gases of the cupola [2].

2.6.5 Cross-media effect

There is a higher cupola dust volume for disposal with a higher content of hazardous substances. In case of the German foundry described in section 2.6.4 the amount of dust for disposal rises by 0.1 to 0.4 kg per t of liquid iron. The DIOFUR project concluded that the contribution of adsorbents to the overall dust amount from of gas cleaning is negligible. “This means that the disposal costs for filter dust do not rise significantly from the use of adsorbents” [1]

2.6.6 Applicability

It is a cupola flue gas cleaning technique, which is compact, efficient and can be easily integrated in existing and new installations when space requirements are fulfilled. Applicable in hot and cold blast cupola.

2.6.7 Economics

In a feasibility study [1] the investment costs for a unit (prizes of 2009) are estimated at 35 000 € for an installation with a production of 45 000 t per year . Not included are:

- Work of civil engineering like the concrete bases, mural drilling etc.,
- Protection of the material (electric instruments, detections etc.),
- The access for the crane and the elevators (nacelles) on the building site,
- The cable of power for electrical equipment box.

The disposal costs are higher (see Cross-media effect”)

2.6.8 Driving force for implementation

Reduction of organic and other hazardous gases in cupola emissions.

2.6.9 Example plant

An iron foundry with a capacity of roughly 5 000 t good castings per year in Germany.

2.6.10 Reference literature

[1] Good Practice Guide on Minimizing Dioxins and Furans emission in foundries. EU funded project DIOFUR. Part 1, 2009.

[2] Information by German plant operator.

2.7 Control system for energy use in induction heated furnaces

2.7.1 Reference to BREF-May 2005

Chapter 4.2.3.1 of the BREF discusses to facilitate effective induction melting with the recommendation to minimize the holding time.

Energy control systems are a way to optimise energy consumption.

2.7.2 Description

When several furnaces are operated at the same time, peak load limitation is one way to reduce energy costs. In addition, modern energy management systems also reduce the specific energy requirement.

Energy-intensive companies pay in addition to the energy rate a demand charge that is based on the peak load. This is the highest measured power consumption in a given period.

Peak demands result usually from simultaneous use multiple consumers of electrical energy. The energy supplier must ensure availability of this maximum amount of electrical energy (peak) permanently due to its random occurrence.

In the discussions about the network load, peak loads are a crucial point. They cause additional supply costs at the energy supplier, which are invoiced, to the purchaser of electrical energy. By reducing the peak demand, the energy costs can be reduced.

When peak loads are reached modern load management systems do not cut off the furnace from the main supply but decrease for a certain time the performance of individual furnaces. This is achieved by an intelligent process technique.

Using multiple simultaneously operating melting aggregates results in characteristic data curves of the melting process. They represent the energy demand of the melting units in a given period. The processor attempts to coordinate the demands of the individual melting aggregates and thus to improve continuously the overall characteristic curve resulting from the energy demands of the sum of furnaces. The energy amount, resulting from the overall harmonisation and optimisation process, is then assigned to the individual furnaces. Priority can be given to individual furnaces manually.

Fig. 11: Principle of control of electric furnaces

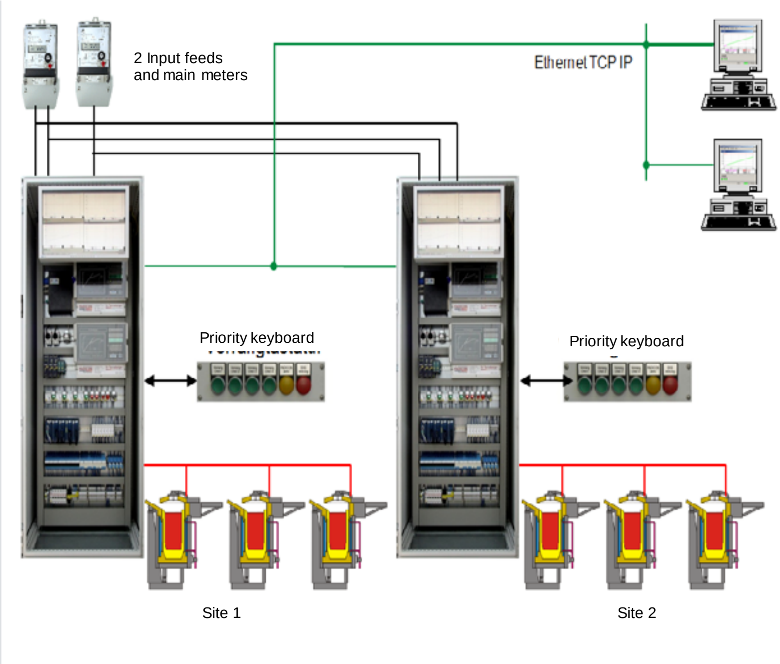
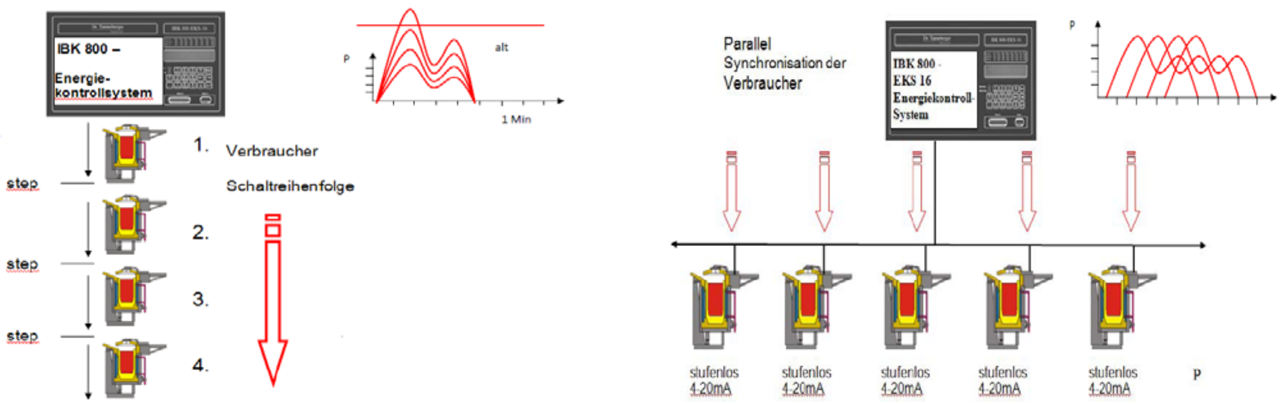


Fig. 12: Left: serial load shedding following the trend calculation method, right: parallel dedicated control for each furnace with its own load management



2.7.3 Achieved environmental benefits

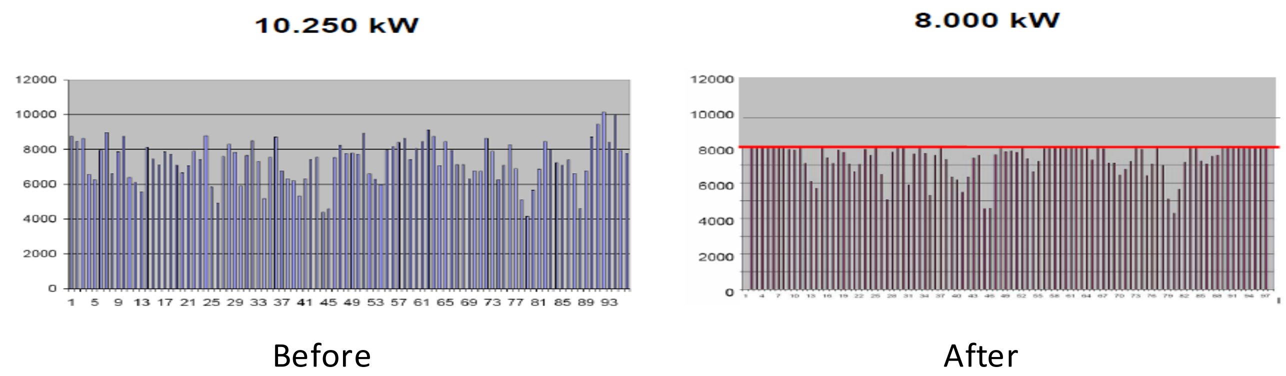
- By avoiding peak demands provision of energy at the supplier can be balanced and use of peak-load electricity generation plant – and with this environmental burden from starting such plants- can be avoided,
- Reduction of CO_2 emissions[2].

[2] Quantitative information about potential reduction of energy consumption is not available.

2.7.4 Operational data

The Reinhard Tweer GmbH is, inter alia, a supplier of machinery and transport equipment. The annual production volume of the foundry is 27 000 t of cast steel and cast iron with spheroid graphite. In melting operation six medium frequency furnaces are used which have a significant influence on the energy costs of the foundry. The following illustration shows harmonisation of energy demands by reduction of peak demands.

Fig. 13: Without peak energy management peaks has been up to 10 250 kW; With load optimization maximum peaks are at 8 000 kW (source: IfG)



2.7.5 Cross-media effects

None.

2.7.6 Applicability

In foundries with a plurality of electrically powered furnaces.

2.7.7 Economics

Reduced power purchase costs can be analysed by considering shift operations. The calculation below based on electricity costs of:

- in 1-shift operation at 13.1 cents / kWh,
- in 2-shift operation at 12.4 cents / kWh and
- in 3-shift operation at 11.1 cents / kWh.

Table 8: Economic data

Installation	Savings
Walzengießerei Coswig	160 000,-€ / year
Klaus Kuhn Edelstahl - Radevormwald	120 000,- € / year
Jürgens Gießerei Emsdetten	60 000,- € / year
Flender Siemens – Chemnitz	80 000,- € / year
Affilips V.N. – Tienen / Belgium	100 000,- € / year
Gießerei und Glasformenbau - Radeberg	80 000,- € / year
KM Europa Metal AG - Osnabrück	90 000,- € / year
Intermet / Sakthi - Neunkirchen	180 000,- € / year
Eisenwerk Hasenclever & Sohn GmbH - Battenberg	130 000,- € / year
Meuselwitzer Guss Eisengießerei GmbH	80 000,- € / year
Technoguss Tangerhütte GmbH	50 000,- € / year

Information about payback periods is not available.

2.7.8 Driving force for implementation

- Reduced energy costs for electricity between5% and 23%,
- Shorter holding times by just in time – melting.

2.7.9 Example

Refer to section “Economic aspects”

2.7.10 Reference literature

BDG-paper „Energieeffizienter Gießereibetrieb“: GIFA 2011-presentation

Zak, B.,: Industrial Heating, The International Journal of Thermal Technology, Cut Costs and Stay Competitive with Advanced Energy Management, June 2011

http://www.tanneberger.de

Presentation at BDG-VDMA-conference 2010 in Frankfurt

2.8 Waste heat recovery of the induction furnace cooling system

2.8.1 Reference to BREF-May 2005

The waste heat recovery of an induction furnace for preheating of scrap is presented as a concrete example in section 4.7.2.

To increase energy efficiency, there is a new technique for using the waste heat of an induction furnace for underfloor heating.

2.8.2 Description

Electrically heated furnaces must be cooled with water. To increase the energy efficiency the foundry Böhmfeld GmbH & Co. is using the waste heat for the heat supply of

- underfloor heating in a newly built production hall;
- the new offices and restrooms.

In 2009, a new production hall was built on the factory site in which a new melting facility and a hand moulding facility were established. The new melting facility includes a medium frequency induction furnace.

The system for induction furnace water-cooling is a typical air-cooling system and a typical water circuit. The new technique is the heat recovery system. This waste heat recovery has the following advantages:

- Improvement and simplification of the procurement and storage and control of chemical binders of cold resin systems by eliminating so-called winter resins (for storage of resins and hardener in the hall),
- Improved setting process of the moulds, especially in winter, which are resulting in higher process safety and fewer rejects of moulds,
- Improved working conditions of employees in the winter due to more uniform, higher temperature without additional airflow.

2.8.3 Achieved environmental benefits

- Reduced energy consumption; Typically the demand for heating in the moulding facility is reduced by about 80%;
- Reduced natural gas consumption, which is associated with a corresponding reduction in CO_2 emissions by 80%;
- Avoidance of the use of winter resins.

2.8.4 Operational data

The following table shows the production data of the electrically operated melting furnace.

Table 9: Data of the electrically operated melting furnace

Manufacturer / type of heat exchanger	Funke FP 10-25-1-NH-0 10bar
Manufacturer / type of underfloor heating	830 m Rehau Rautherm-S 20 x 2mm auf 120 m^2
Temperature supply flow furnace cooling	20 to 35°C
Temperature of furnace cooling	45 to 60°C
Temperature supply flow floor heating	Ca. 40 °C
Temperature return flow floor heating	25 to 30 °C
Fuel (additional)	No additional burners for underfloor heating are required. Gas burner for room heating and hot water in the sanitary area are required.
Fuel savings	Year 2008: Social rooms consumption: 8 237 litres of heating oil (= 72.4 MWh at 8.79 kW/l) Year 2010: Social rooms consumption: 2 494 litres LPG (= 14.1 MWh of 5.66 kWh/l)

2.8.5 Cross-media effects

None.

2.8.6 Applicability

A general weakness in the use of waste heat from an induction furnace-cooling system is often the low temperature level of its return water, which seldom reaches more than 60°C. Anyhow, in the described application return water temperature and required temperature for floor heating fits very well.

The installation of an underfloor heating is ideal for a newly built hall. It must be ensured that the load of the floor does not result in damage to the floor heating. The distance between heat source and heat sink should not be too large.

For upgrading an underfloor heating system in an existing production facility, the hall must be empty and the floor needs to be replaced.

2.8.7 Economics

Costs of the new underfloor heating for a production hall:

- Investment costs 8 000 €
- Operating costs negligible
- Maintenance costs negligible
- Energy costs: permanent reduction in annual consumption of 8 237 litres heating oil in 2008 and 2 494 litres LPG in 2010
- Changes are representing a cost decrease of nearly 80% based on the heat of combustion

- Production costs In addition permanent cost reduction of about 25 to 30% from shorter setting times and reduced waste of the moulds can be achieved.

In several cases, such advantages cannot be achieved by conventional floor heating systems without use of excess heat due to economic reasons.

2.8.8 Driving forces for implementation

- Improve and simplify storage and control of chemical binders,
- Higher process safety and fewer rejects through an improved setting process of the moulds, especially in winter,
- Reduction of the heating demand of the moulding facility,
- Improved working conditions of employees in winter,
- Reduction in natural gas consumption, which is associated with a corresponding reduction in CO_2 emissions and costs,
- Avoiding the use of winter resins.

2.8.9 Example plant

Gießereigesellschaft mbH Böhmfeld & Co 59590 Geseke, Germany

2.8.10 Reference literature

Information from the operating company Gießereigesellschaft mbH Böhmfeld & Co,

http://www.boehmfeld.de

2.9 Use of waste heat with water storage

2.9.1 Reference to BREF May2005

In chapter 4.7.2 of the BREF the use of waste heat by induction furnace is described - but without the use of water tanks for heat storage.

2.9.2 Description

In the iron foundry two plants for heat recovery are installed:

- in the cooling system for the MF induction furnace coils,
- in the compressed air plant.

The waste heat is used:

- Heating for moulding shop, core shop and offices, altogether approx. 5 500 m^3,
- for hot water.

For the storage of waste heat a water reservoir was integrated in the system with a capacity of 65 m^3. The heat is supplied from various sources and can be stored. Waste heat for various users is distributed from this water reservoir.

It is planned to install an additional heat exchanger in the first stage of the cooling sand system . The waste heat obtained will also be directed into the water reservoir.

2.9.3 Achieved environmental benefits

- Reduction of heating energy consumption by about 50% or 1 000 000 kWh/a,
- Reduced heating demand for shower water.

2.9.4 Operational data

Table 10: Heat recovery of induction furnace

Manufacturer / type	Inductotherm
Power of the cooling plant of the furnace	2 140 kW
Flow / return line temperature	45 °C / 65 °C
Water circulation rate	68 m^3/h
Max. heating power for feeding into the water storage	1 300 kW

Table 11: Heat recovery of the compressed air plan

Manufacturer / type	Atlas Copco
Compressed air system performance	1 x 75 kW and 2 x 90 kW
Flow / return line temperature	55 °C / 70 °C

Manufacturer / type	Atlas Copco
Water circulation rate	3.8 m^3/h

Table 12: Operating data of the water reservoir waste heat recovery

Manufacturer / type	Atlas Copco
Amount of water	65 000 l
Flow / return line temperature	45°C / 65°C
Water circulation rate	Adaptable up to max. 68 m^3/h
Max. heating power for feeding into the water storage	900 kW

2.9.5 Cross-media effects

No cross-media effects.

2.9.6 Applicability

The efficiency of waste heat recovery is generally dependent on the following parameters:

- Temperature level of the waste heat,
- Heat transfer medium of the waste heat,
- Flow rate,
- Possible use of the waste heat:
    - Temporal correlation between waste heat accumulation and demand,
    - Spatial closeness between waste heat accumulation and demand,
    - Match of the temperature level,
    - Storage space for waste heat.

To retrofit a waste heat recovery, the space required for heat exchangers and associated equipment must be available.

2.9.7 Economics

- Saving energy costs approx. 60 000 Euro/a,
- Amortisation approx. 3 years.

2.9.8 Driving force for implementation

Increased energy efficiency and corresponding reduction in operating costs.

2.9.9 Example

HegerFerrit GmbH Junkerstraße 4, 67681 Sembach, Germany

2.9.10 Reference literature

Information provided by the plant operator.

2.10 Furnace with heat recovery in aluminium foundry

2.10.1 Reference to BREF-May 2005

No description of a fuel fired furnaces in an aluminium foundry, which has similar intense post-combustion and heat recovery is described in chapters 3.3.6 and 4.7 of the BREF.

2.10.2 Description

In an aluminium foundry, the fuel-fired furnaces are connected to a heat exchanger system, which heats the premises and the water for the casting cleaning facility. When closing the direct line to the chimney, the exhaust gases flow through a bypass to the heat exchanger, which transfers the process heat to the water circuit.

In this furnace, high resource efficiency and good insulation was realised to be able to make use of as much melt heat as possible. At the same time the facilities of the furnace builder ZPF therm Maschinenbau GmbH cause low amount of exhaust gas due to the special design of the combustion chamber. The principle of reverse airflow is used, hence gases formed during the melting process are not directly discharged through the chimney, but remain longer in the oven (Fig. 14,15).

About 300 000 castings parts are produced annually by JURA CAST GmbH in Beilngries (Bavaria) for automobile and truck manufacturers, international engineering as well as for medical technology. The medium-sized company currently employs around 200 staff.

Fig. 14: The exhaust systems of the four furnaces on JURA CAST are connected with heat exchangers. These transmit the heat of the hot gases from the melting process to the heating circuit (source: IfG)

Fig. 15: The largest furnace is lowered into the ground, making it easier to clean. To drain the system, it flips into a ladle into the provided recess (source: IfG)

2.10.3 Achieved environmental benefits

Pollutants are burned by the heat produced by the casting. Particulate matter content in emissions is less than 3 mg/m^3 and hydrogen fluoride concentration is only 0.4 mg/m^3. This technique has an additional advantage: waste gas heat can be used to heat the exhaust gases of the holding basin, resulting in a reduction of fuel consumption and CO_2 emissions and thus a climate protection effect.

At the time of the study, no calculation of the amount of heat re-used was possible, yet.

2.10.4 Operational data

With two heat exchangers, one for the large melting furnace and one for the three small systems, a 30 000 litre storage reservoir is heated which supplies 80 percent of the company building with heat. In addition the washhouse system for finished castings is heated with from this reservoir. The big furnace has two burners, each with 1 000 kW power, the flow of heat energy after the melting process is about 35 to 40 percent of the heat exchanger. The heat exchanger is able to transfer about 75 percent of heat into the reservoir.

2.10.5 Cross media effects

None.

2.10.6 Applicability

The technique is applicable to new plants and existing plants if space requirements are met.

2.10.7 Economics

Investment costs for heat exchangers, piping, structural measures, connection to the central heating system: about 100 000 €.

2.10.8 Driving force for implementation

Climate protection is combined with minimisation of operating costs

In addition in the concrete case of the exemplary plant cleaning was simplified. Since the furnace was about 70 cm deeply embedded in the ground, it is easy to clean without pedestals, and other resources from both sides. Over the large holes can be achieved all areas while cleaning. To empty all the melt, the furnace tilts into a recess in the floor, in which there is a transport ladle . This moves subsequently hydraulically upwards.

2.10.9 Example

JURA-GUSS GmbH, Beilngries

2.10.10 Reference literature

Unveröffentlichte Angaben von ZPF Therm Maschinenbau GmbH, Siegelsbach

www.jura-guss.de

www.zpf-therm.de

2.11 Ladle preheating using porous burners

2.11.1 Reference to BREF-May 2005

Chapter 4.7.4 of the BREF deals with the preheating of ladles.

For ladle preheating using porous burner, there is no information.

2.11.2 Description

A modified technique of gas-air burner is the so-called volume burner or gas porous burners. This process modification is available for use in foundries since the year 2008.

In a gas porous burner (volume burner), the combustion takes place in a porous high-temperature ceramic, the combustion reactor. The result is a flameless, volumetric combustion in the form of a glowing ceramic foam. This can be used as both a radiating surface, as well as a homogeneous heat source. That combustion is limited to the numerous pores of the ceramic, which can be seen as small reactors. Porous burners can achieve power densities of more than 3 MW/m^2.

Serving as combustion reactor the ceramic foam body can be produced in almost any geometric shape. Adapted to the particular application, the round, square, or line-shaped ceramic body provides the heat exactly where it is needed in the process.

Due to the customized form and flameless combustion, more homogeneous heating can be achieved in particular at larger objects, such as transportation and casting ladles or crucibles of furnaces.

The following figure depicts the process.

Fig. 16: Scheme of the ladle preheating (source: [5])

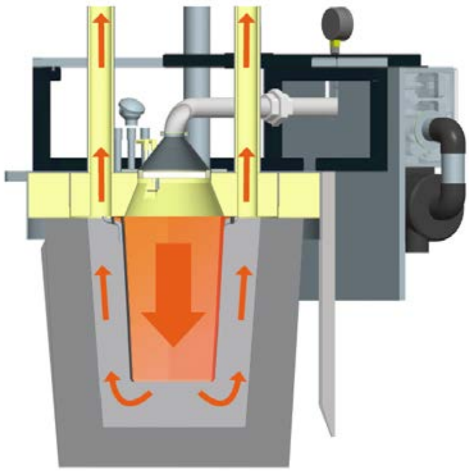


Fig. 17: Ladle preheating (source: [5])

In principle this technique could also be applied in other heating areas than ladle preheating.

2.11.3 Achieved environmental benefits

- Reduction in gas consumption of up to 60%, In the example of [5] gas consumption could be reduced by 60 000 m^3/yr and related CO_2 emissions by 115 t. Excess heat could be used for heating of the production facilities [6].
- Increased energy efficiency,
- Corresponding reduction in emissions of CO_2 and NO_x emissions,
- Reduction of noise emission by low noise combustion.

2.11.4 Operational data

Table 13: Operational data ladle preheating

power density	continuously adjustable from 150 – 3 000 kW/m^3 with an adjustable burner size at a reactor depth of 15 mm
performance	from 2 kW to over 1 000 kW
flame free combustion	Heat source instead of open flame, i.e.: no contact of a product with the flame, no combustion interference by external convection, or outer atmosphere, No drafts or motion sensitivity, direct transfer of heat by hot gas and radiation heat,
Controllability	control range up to 1:20 at lambda 1.3, quickly adapt to changing process conditions, radiation and hot gas temperature controllable, precise controllability of 900 to-1 400°C to plus/minus 3 K in a few seconds,
Homogeneity	targeted, flat heat input at any desired location, gentle product treatment, homogeneous temperature distribution,
Design/Form	any shape as a line or surface burner,
Emissions	minimal emissions of CO and NOx in the entire power range,
Fuels	all gases according to EN 483, Oil vapour mixtures, low calorific gases, insensitive to varying gas pressure.

2.11.5 Cross-media effects

None.

2.11.6 Applicability

The following factors may affect the feasibility:

- When high temperatures are required, for example >1 100°C, the heating time can be longer than that of conventional burners. This is important to ensure the required power density of the burner (e.g. steel casting);
- If the burner can be moved manually and the geometry requires exact and careful handling the burner can be damaged if handled carelessly.

The technique is applicable in small and large foundries.

2.11.7 Economics

Cost savings of up to 60% can be achieved by substituting conventional burners by porous burners due to exact controllability and uniformity of the heat input. In conjunction with the high power modulation, the whole system improves efficiency and brings productivity gains of up to 50%. In the case of [5] ladle durability had been doubled.

The following statements of investment costs, operating costs, maintenance costs and energy savings are based on information provided by a user of porous burners.

- Ladle size 15 t
- Investment costs: 70 000 €
- Operating costs: 20 000 €/a in gas costs
- Maintenance costs: 5 000 €/a
- Energy cost savings: 8 000 €/a

Information about amortisation time is not available and depends on numerous individual factors. In the case of [5] and [6] the following cost-benefit equation (Reference Values) has been made: "With a saving of natural gas amounting to € 23 286 /p.a., a minimized ladle-lining abrasion of € 7 000 and an increase in productivity of approx. € 10 000, a static calculation states that a reflux of capital results after 5.8 years" [6].

2.11.8 Driving force for implementation

- Longer life of the lining by uniform heating;
    - Reduction of the refractory material consumption
    - Reduction of waste refractory material
- Economic benefits through energy savings and environmental benefits through reduced CO_2 and NO_x emissions.

2.11.9 Example

HegerFerrit GmbH, 67681 Sembach

Stahlwerke Bochum GmbH, 44791 Bochum

Edelstahlwerke Schmees GmbH, 40764 Langenfeld

2.11.10 Reference literature

[1] Presentation at BDG-VDMA-conference 2010 in Frankfurt

[2] BDG-paper „Energieeffizienter Gießereibetrieb“: GIFA 2011-presentation

[3] Stahlwerke Bochum GmbH, http://www.stahlwerke-bochum.com

[4] Promeos GmbH, www.promeos.com

[5] Energiesparende Pfannenaufheizstation: Halbierung des Gasverbrauchs Edelstahlwerke Schmees GmbH Langenfeld,

[6] BMU-UMWELTINNOVATIONSPROGRAMM Abschlußbericht zum Vorhaben: Einsatz einer energieeffizienten Pfannenaufheizstation bei der Herstellung von Edelstahl 20182, Dessau, 2011

2.12 Ladles preheating using natural gas-oxygen technology

2.12.1 Reference to BREF-May 2005

Chapter 4.7.4 of the BREF deals with the preheating of ladles.

There is no reference for preheating ladles using natural gas-oxygen burners.

2.12.2 Description

Natural gas-oxygen diffusion burners can be used to warm up for example transport ladles. The warming of the transport ladle takes place by an open flame. The flame burner fires from top into the ladles. In addition, these burners (Fig. 18) are also used in foundries for special applications (Fig. 19).

Fig. 18: Control of the oxy-fuel diffusion burner (source: IfG)

Fig. 19: Oxy-fuel diffusion burner with cooling water, used here for the feeder heating during the casting of a ship propeller in a bronze alloy (source: IfG)

2.12.3 Achieved environmental benefits

In oxy-fuel diffusion burners, the gas-oxygen ratio is approximately 1:2. When using natural gas-air diffusion burners, the gas-air ratio is approximately 1:10. Higher flow rates for the combustion result from the use of natural gas-air diffusion burners compared to natural gas-oxygen diffusion burners.

The reduced nitrogen content from using oxy-fuel diffusion burners leads to a reduction in fuel consumption and it is expected that generation of NO_x is reduced[3]. Assuming that during the combustion of natural gas about 1.95 kg CO_2/m^3 is released, the total amounts of CO_2 emissions in the example described in section "Economics" is:

- to 58.5 kg/h for one ladle, heating 3 ladles to 175.5 kg/h,
- to 78.8 kg/h for one ladle, heating 3 ladles to 263.3 kg/h.

2.12.4 Operational data

Technically, the process of combustion of gaseous fuels with pure oxygen has the effect that due to the reduced exhaust losses, the combustion temperature and gas radiation are increased.

With oxy-fuel diffusion burners usually temperatures of 1 200°C – 1 300°C can be reached. By modifying a conventional oxy-fuel diffusion burner, for example with water cooling, temperatures around 1 500°C can be reached. In addition to the heating of the already mentioned ladles, oxy-fuel diffusion burners are used for sintering and heating of:

- of E-furnaces and for e-hearths,
- of troughs, casting dies and converters,
- of specific feeders and
- for slag emptying into the furnaces.

2.12.5 Cross-media effects

Production and transport of oxygen is related to additional environmental burdens compared to use of ambient air.

2.12.6 Applicability

The focus of the application of gas-oxygen diffusion burners is on iron and steel foundries (mainly due to the achievable temperatures). The technology is also potentially applicable for non-ferrous metal foundries.

[3] No measuring data are available regarding the reduction of NO_x.

2.12.7 Economics

Costs of the application of natural gas-oxygen diffusion burners can be described by an exemplary case where 3 ladles with 8 tons per day are heated. A gas-oxygen diffusion burner is used. After about 1 hour, a ladle temperature reaches about 1 200 ° C.

- Natural gas demand is about 30 m^3/h per plant + oxygen demand 60 m^3/h per plant,
- Costs for heating a ladle: Natural gas demand is about 30 m^3/h x 1 h results in about 30m^3 + oxygen results in about 60 m^3,
- Costs natural gas: 0.35 €/m^3,
- Costs oxygen: 0.20 €/m^3,
- Total direct costs for natural gas: 0.35 €/m^3 x 30 m^3 = 10.50 €,
- Total direct costs for oxygen: 0.20 €/m^3 x 60 m^3 = 12.00 €,
- Total cost: 22.50 €,
- Total cost per day: 22.50 € x 3 ladles = 67.50 €.

Cost per year: 67.50 €/d x 22 d/month = 1 485 €/month x 12 months/y = 17 820 €/y.

To compare the economic differences between natural gas-air diffusion burners and gas-oxygen diffusion burners an example is provided below:

Per day (single layer), the heating of 3 ladles with 8 tons takes place . Three natural gas-air burners are used, which also run constantly to keep the temperature. After about 1 hour, a ladle temperature of about 800°C to 900°C is reached.

- Natural gas demand is about 45 m^3/h per plant + air requirements (fan) is about 450 m^3/h per plant,
- Costs for heating of a ladle: Natural gas demand is about 45 m^3/h x 1 h results in 45 m^3 + air consumption (fan) is approximately 450 m^3,
- Costs natural gas: 0.35 €/m^3,
- Costs for providing air: 0.04 €/m^3,
- Total direct costs for natural gas: 0.35 €/m^3 x 45 m^3 = 15.75 €,
- Total direct costs for air (fan) 0.04 €/m^3 x 450 m^3 = 18 €,
- Total cost: 33.75 €,
- The cost of continuous operation to preheat the ladles must be added, exemplary set with 80 €. After all, in many foundries the ladles are under continuous heating to keep them in case of need immediately ready for use.
- Total cost per day: 33.75 € x 3 ladles/d = 101.25 €/d + 80 €/d =181.25 €/d.
- Cost per year:181.25 €/d x 22 d/month =3 987.5 €/month x 12 months/y = 47 850 €/y.

2.12.8 Driving force for implementation

- Reduction of energy costs and emissions (CO_2 and NO_x),
- Increase of the energy efficiency of thermal processing systems,
- Increase in the availability, for example, by melting units and transport ladles,
- Improved product quality by reducing temperature differences between the melt and transport ladle.

2.12.9 Example

Mecklenburger Metallguss GmbH – MMG, Waren/Müritz, Germany

2.12.10 Reference literature

Engineering consulting Josef Weschenbach, http://www.ingenieurbuero-weschenbach.de/oxy.html

Pfeifer H. et al.: Energieeffizienz und Minderung des CO2-Ausstoßes durch Sauerstoffverbrennung. Firmeninformation.

BDG-Schrift „Energieeffizienter Gießereibetrieb“: GIFA 2011-Sonderschau

2.13 Inorganic green sand additive

2.13.1 Reference to BREF - May 2005

This is a new process. It is not mentioned in chapters 3.9.4 and 4.3.2 of the BREF.

2.13.2 Description

Carbonaceous materials are substituted to reduce emissions and create better working conditions in foundries, which apply sand moulds.

Moulding sand additives consisting of bentonite (clay binder) and Lustrous Carbon Formers, in which to Lustrous Carbon Former e.g. coal, gilsonite, hydrocarbon resin, is replaced by alternative products. Supplier can blend or process with graphite, stress buffering minerals or other minerals. Product examples: ENVIBOND, GEKO LE , NAYVOC.

2.13.3 Achieved environmental benefit

Reduction of emissions and odours. The reduction ratio depends on the core sand inflow.

The positive effect regarding emissions relies on some factors:

- Reduced or no use of lustrous carbon formers (coal),
- Enhanced adsorption of emerging casting gases that result mainly from core binders,
- Filtration measurements of operating moulding sands from core intensive greensand systems. Comparing no coal based products with traditional moulding sand additives show a reduction of condensates and dust formation during casting can be over 50 %

Resulting environmental benefits are

- Cleaner working place: less smoke; carbon monoxide concentrations at working place are reduced by approx. 50%,
- Benzene emissions are reduces by approx. 40%,
- Blends have a higher percentage of bentonite than traditional blends with coal. Consumption is related to bentonite, so less blend (not bentonite) is used, resulting in less truck loads needed. (5 – 10%),
- Increased possibilities of moulding sand reuse, due to lower content of pollutants and condensates,
- Smaller air extraction and filter installations and less cleaning / maintenance.

2.13.4 Operational data

In general inorganic coal replacements do not emit organic, hydrocarbon volatiles during heating / casting. Due to this they cannot generate lustrous carbon (graphite film from pyrolysis) and carbon residues. Coal replacements are in general graphite, specially treated graphite, coke flour, porous minerals and swelling minerals. Each producer can have different composition depending on his or her research and experience. Products are customized and can be blended with traditional coal containing products.

Bentonite binder should be of high quality, high clay / montmorillonite content to reduce accumulation of accompanied non clay minerals.

Bentonite preference: 85 % Montmorillonite, durability 50 % after heating the clay for 2 hours at 550°C, compression strength according to VDG P69, above 8 N/cm^2 and wet tensile strength above 0.25 N/cm.

Product classification: not dangerous and no auto ignition, if not blended with coal.

2.13.5 Cross-media effect

None.

2.13.6 Applicability

The technique is applicable as a pure inorganic binder system or as a blend in combination with classical products (coal). It is added to the moulding sand like a traditional moulding sand binder or blends. Applicability depends on quality. It is not classified as hazardous substance or dangerous good.

The application can be partial because of less good shake out behaviour(separation casting and mould) and occurrence of specific casting defects.

2.13.7 Economics

Coal free blends have higher raw material costs. This can be partly compensated by reduced consumption and by less operation cost for air extraction, such as smaller installation, less cleaning and maintenance. The moulding sand waste contains fewer pollutants making it easier to reuse it in other applications and industrial sectors. Savings transport costs can be achieved due to coal replacement by minerals of which less is needed.

2.13.8 Driving force for implementation

- No smoke and less carbon monoxide at working places,
- Significant reduction of Benzene (BTEX) and Carbon Monoxide (CO) emissions,
- Normal moulding sand practice,
- Less / no penetration defects , grey iron casting,
- In case of coreless production no air extraction is required,
- Waste sand is cleaner.
- Example plant

Iron foundry *Componenta* in Heerlen/NL;

Other Foundries in Germany and other European countries.

2.13.9 Reference literature

Grefhorst, C.,Senden, W., Ilman, R., Podobed, O., Lafay, V., Tilch, W.: Reduction of greensand emissions by minimum 25 % - Case study chinese, China Foundry November 2010.

Grefhorst, C.,Senden, W., Ilman, R., Podobed, O., Lafay, V., Tilch, W.: Reduzierung von Grünsandemissionen um mindestens 25 % - Fallstudie, Giesserei Rundschau Heft 1/2 2011.

Grefhorst, C. & Lemkow, J.: Greensand without Organic Additives for the Production of Iron Casting. Proceedings of 66th World Foundry Congress Vol. 1, S. 489-501. The development of this process started in the year to 2000 by the GOAPIC project supported by 5th Framework program of the European Union.

Grefhorst C, Lafay V, Richardson N, Podobed O. Challenges of introducing inorganic mold- and core making processes. Casting plant and technology 2012 / 01

Neue Konzepte zur Emissionsminderung aus bentonitgebundenen Formstoffen; Engelhardt , T.: GIESSEREI PRAXIS 2010/04, S. 93-100.

Toward a green greensand Nayström, P.:Foundry Trade J. 2007, Nr. 181, S. 211.

http://www.ikominerals.com/index.php?id=75&L=ajnjvmap

2.14 Coating of resin-bonded moulds and cores with water-based coatings

2.14.1 Reference to BREF-May 2005

Section 4.3.3.5 of the BREF informs about benefits and difficulties of applying water-based coatings.

The following information on the use of aqueous coatings is more recent.

2.14.2 Description

The carrier liquid forms a suspension with the base material. In this way, the coating material can be processed. Such carrier liquids are generally water or alcohol.

Before the cores or mouldings can be combined to complete sand moulds they must be completely dry. The drying process depends on the size and geometry of the parts to be dried. Large parts or parts with varying formats, which have been typically made from furan or phenolic resin bonded moulding materials (cold resin process), must be dried several hours or days in the hall. Smaller parts with unvarying shapes drying oven can be used.

If drying is supported by using heat energy consumption and energy efficiency might be an issue. A newly developed drying oven, which is used in foundries by now, shows increased energy efficiency. In this drying oven, the airflow is optimised in a way that the air jet can be guided directly to the coated mould surface. With this airflow, the air temperature can be set below 90°C.

2.14.3 Achieved environmental benefits

Main advantage of using aqueous coatings and drying in the ambient air are reduced diffuse alcohol emissions. No additional energy is needed for drying in ambient air.

If this technique is combined with the use of newly developed drying ovens energy consumption and related CO_2 emissions are reduced.

2.14.4 Operational Data

The following table describes operational data of newly developed drying ovens and compares it to the previous technique.

Table 14: Operational data coating of resin-bonded moulds and cores with water-based coatings

	Previous technique	New technique
Thermal processing power [kW]	400	225
Electrical power input [kW]	30	55
Drying time [h], castings with 10 tones	3,5	1,9
Drying time [h], castings with 5 tones	2,7	1,4
Drying time [h], castings with 3.5 tones	2,8	1,4
Mean specific energy consumption [kWh / t]	303	79

2.14.5 Cross-media effects

None, if drying in ambient air is done. Higher energy consumption and related CO_2 emissions when conventional drying ovens are used compared to alcohol-based coatings. Energy consumption can be reduced by using drying ovens with improved energy efficiency.

2.14.6 Applicability

Aqueous coating can be dried at the ambient air or using a drying oven. Generally, the drying of aqueous coating requires a longer drying time than alcohol-based coatings.

Aqueous coatings do have a wide range of application, but cannot replace all alcohol-based coatings. In certain applications alcoholic coatings are still needed. These applications can be given as:

- Large or complicated forms / cores in which there are drying problems due to difficult penetration of the drying air,
- The use of water glass bonded sands,
- In magnesium casting: water causes $Mg(OH)_2$, which leads to technical problems,
- In the production of manganese steel with MgO coating.

The use of aqueous coating and their drying by appropriate storage time requires consideration of certain aspects of the production process:

- Size of the cores or moulds and their increasing drying time with greater size,
- Processing times;
- Space in the foundry for the storage of forms / cores.

In the planning of a new foundry, these three variables should be taken into account.

In particular, in existing foundries, area and space requirements can be limits, which are not able to overcome.

2.14.7 Economics

The drying of mouldings coated with water-based coatings requires more space and increased production time.

The table below compares economic aspects of the application of a newly developed drying oven with the previously applied technique.

Table 15: Expenditure in drying ovens

	Previous technique	New technique
Investment (10 year amortization) [€]	420 000	500 000
Maintenance costs per year [€]	4 200	5 000
Casting capacity per year [t]	4 000	7 000
Energy costs per ton of casting [€]	16.00	4.80
Total cost per ton of casting [€]	27.55	12.66

2.14.8 Savings sum up to 54% when applying the new drying technique.

In case drying in ambient air is done no energy costs result. Costs for space requirements are variable.

2.14.9 Driving force for implementation

- Avoiding of solvent-based emissions in the work areas of the core facility and the moulding facility,
- Improved safety (no fire risk).

2.14.10 Example

Air-dry

- Stahlwerke Bochum GmbH
- 44791 Bochum, Germany
- Heger Ferrit GmbH
- 67681 Sembach, Germany
- C. Grossmann Stahlguss GmbH
- 42719 Solingen, Germany

Drying in Oven

- AVA GmbH, Magdeburg (see [1])

2.14.11 References

[1] GIESSEREI 98, 06/2011, p. 56 ff.;

[2] Information from facility operators

2.15 Emission-reducing coating material with adsorptive properties for outer mould surfaces

2.15.1 Reference to BREF-May2005

Information about methods to reduce emissions and odours is described in chapter 4.5.9.

The reduction process presented here is new.

2.15.2 Description

The "Clean Top" technique is shown schematically in the following figures:

Before casting, a coating material with absorbent properties is applied on top of the moulds. A possible composition of the coating material can be:

- calcium carbonate
- aluminium silicate (coarse)
- activated carbon
- lime
- water

Fig. 20: Exemplary application of clean top (source: IfG)

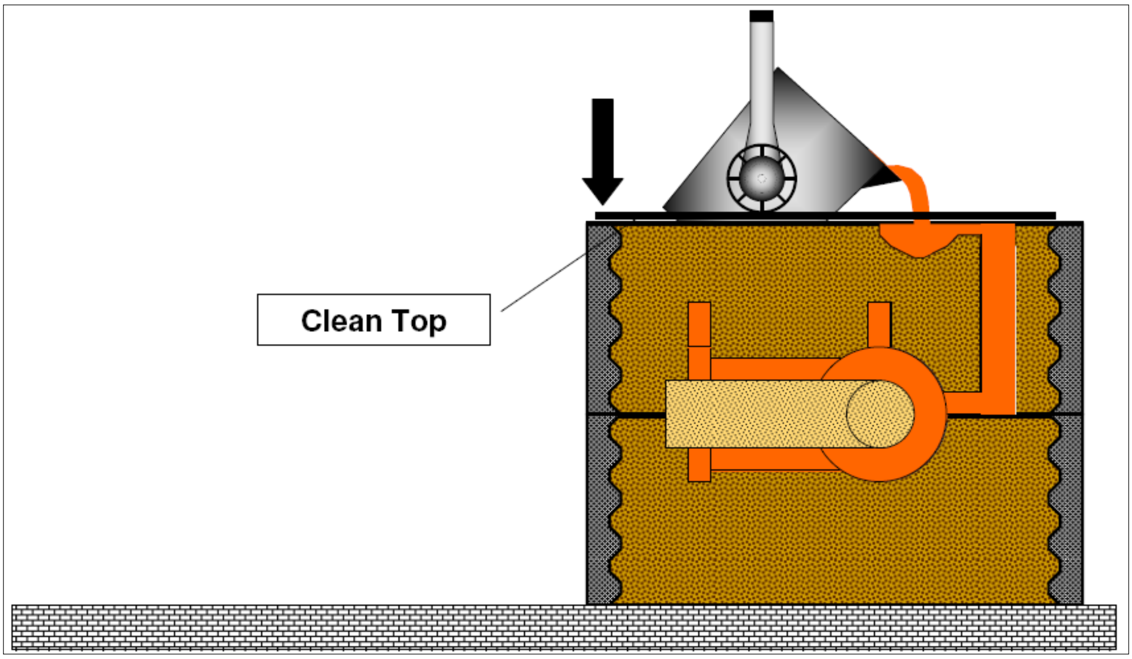
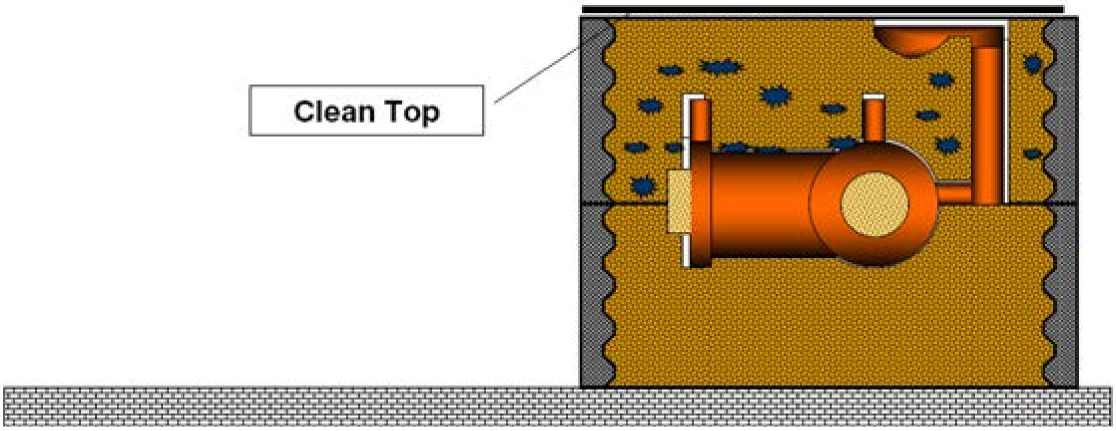


Fig. 21: Exemplary application of clean top (source: IfG)



2.15.3 Achieved environmental benefits

The applied coating material has the following properties:

- Absorption of the emissions generated during the casting process like inorganic and aromatic volatile pollutants such as benzene, toluene, xylene and sulphur dioxide,
- Adsorption of fine dust or fumes.

By this, diffuse emissions can be reduced.

BTX and SO_2 emissions of the casting process were measured in the iron foundry in Bocholt Hulvershorn. The following charts show the results of the measurements:

Fig. 22: Exemplary application of clean top (source: IfG)

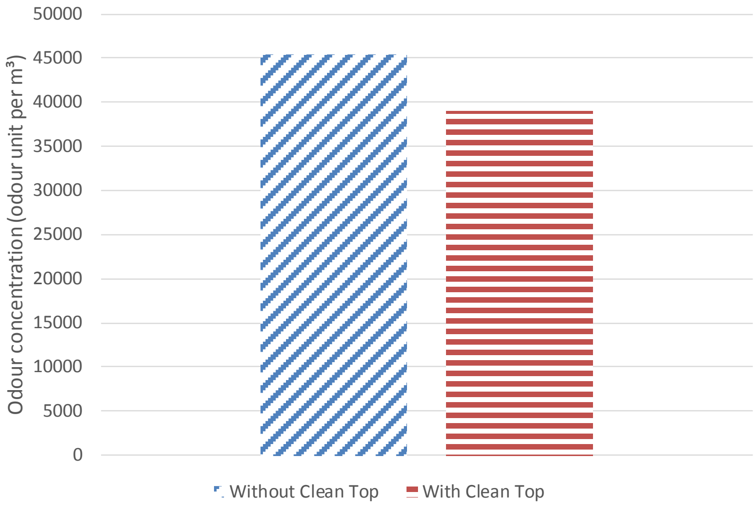
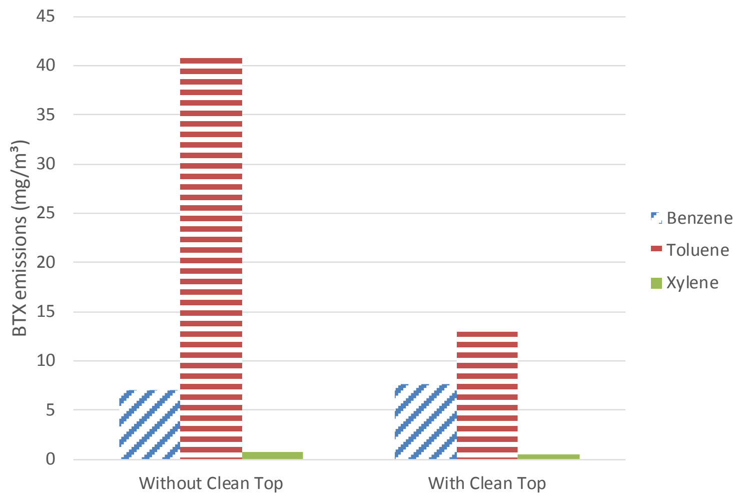


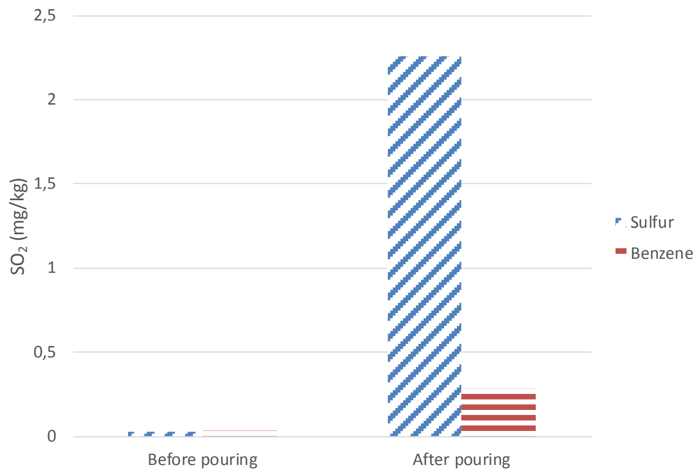
Fig. 23: Reduction of emissions from use of furan resin bonded sands by using clean top (SO2) (source IfG)

Fig. 24: Reduction of emissions from use of furan resin bonded sands by using clean top (BTX) (source IfG)



To examine the effect of the coating material "Top Clean", the sulphur and benzene concentration was determined in the Clean Top layer before and after casting. The result is shown in the following diagram:

Fig. 25: Effect of the coating material "Top Clean" (source IfG)



2.15.4 Operational Data

Detailed operational data are not available.

2.15.5 Cross-media effects

Pollutants adsorbed in the coating material end up in the moulding material. Compared with the amount of moulding material, the amount of coating material is low. If moulding material is recycled, enrichment of pollutants in the moulding material could occur. However, it is assumed that fine-grained coating mass separated and discharged with dust from de-dusting during the regeneration of used sand. Data is not available.

2.15.6 Applicability

The Clean Top method can be used for hand moulding procedure and in the cold resin moulding procedure.

2.15.7 Economics

The use of the emission reducing binder requires no investment.

The material cost of the feed material depends on the specific nature of the binder and the volume purchased by the foundry.

The costs of Clean Top are relatively low, compared to other downstream measures to reduce pollutant emissions: 1 €/m^2 form surface, resulting in 100 000 €/a in the reference plant.

2.15.8 Driving force for implementation

The main advantages of Clean Top

- Reduction of pollutant emissions and exposures (diffuse sources),
- Reduction of odour emissions,
- The foundry does not provoke problems with the neighbourhood

- Relief from pollution control licensing procedures

2.15.9 Example

Hulvershorn Eisengießerei GmbH & Co. KG,

46395 Bocholt, Germany

System developers:

Ashland-Südchemie-Kernfest GmbH,

40721 Hilden, Germany

2.15.10 Reference literature

Gieniec A., Helber J., Pohlmann U., Weigl M.: Entwicklung umweltfreundlicher Gießereiprozesse, gestützt auf ein zentrales Transferzentrum. BMBF gefördertes Vorhaben. Düsseldorf, Hilden, München 2008.

2.16 Reduced emissions from organic binders

2.16.1 Reference to BREF-May 2005

Information on low-emission chemical binders is described in chapters 3.9.4, 4.3.3 and 4.5.9 of the BREF.

The binder systems described below were developed after 2005.

2.16.2 Description

Several types of organic binders are used in iron, steel and aluminium foundries. Typical materials in casting gases that are generally responsible for the odour of these mixtures, are the binder systems like PU coldbox, warmbox, shell moulding and furan-resin based cold resin. These binder systems were modified to achieve reduced emissions. The new binders were tested in the laboratory and in foundries.

2.16.3 Achieved environmental benefits

The manufacture of cylinder heads from a cast aluminium alloy shows that the change of the binder system in the cold box process from a biosystem to a silicate system can achieve an odour reduction of approximately 60%. Additionally, the process was changed to the inorganic Cordis method, leading to an almost complete elimination of the odour emissions (-99%). The new binder systems also reduce the BTX emissions from the aluminium foundry.

Fig. 26: New binder system for odour and BTX reduction in an aluminium foundry – part A (source IfG)

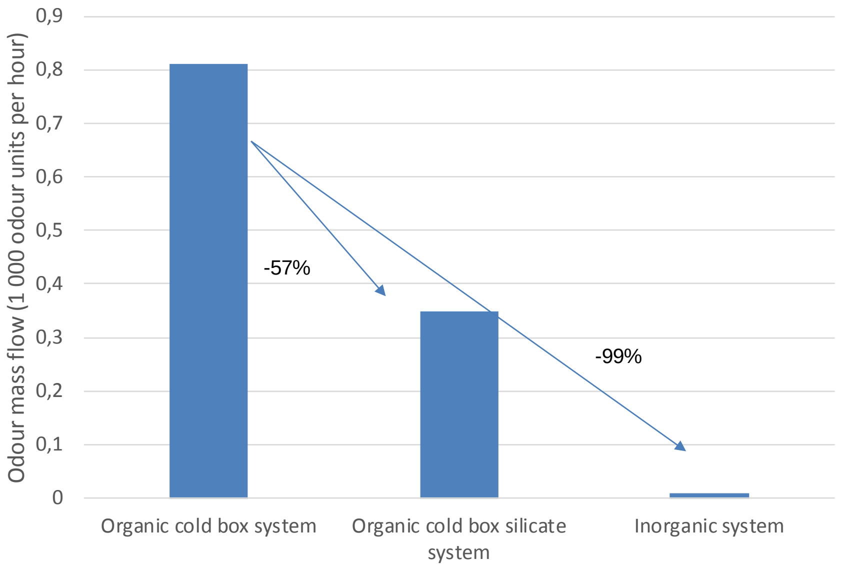
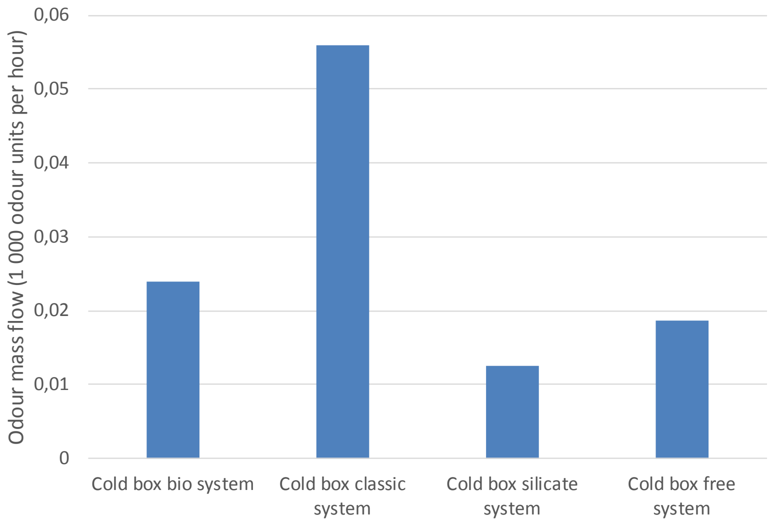


Fig. 27: New binder system for odour and BTX reduction in an aluminium foundry – part B (source IfG)



When using a silicate system in combination with an inorganic additive instead of a classic series system in combination with a wood flour additive, the odour emissions from the production of gear houses in an iron foundry are reduced by 46%.

When replacing the hexa-hardened shell moulding sand by resol-hardened sand test result showed reduction of odour emissions above 70%, similarly achieved at Harzguss Zorge and at Halberg Guss in Brebach (crankshaft masks) reference plant.

Fig. 28: New binder for odour and BTX reduction in an iron foundry – part A (source IfG)

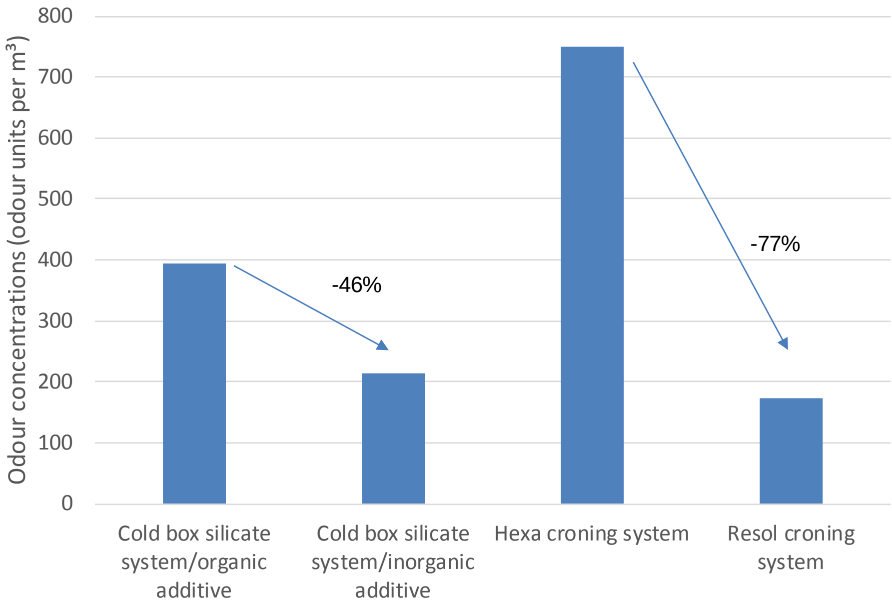
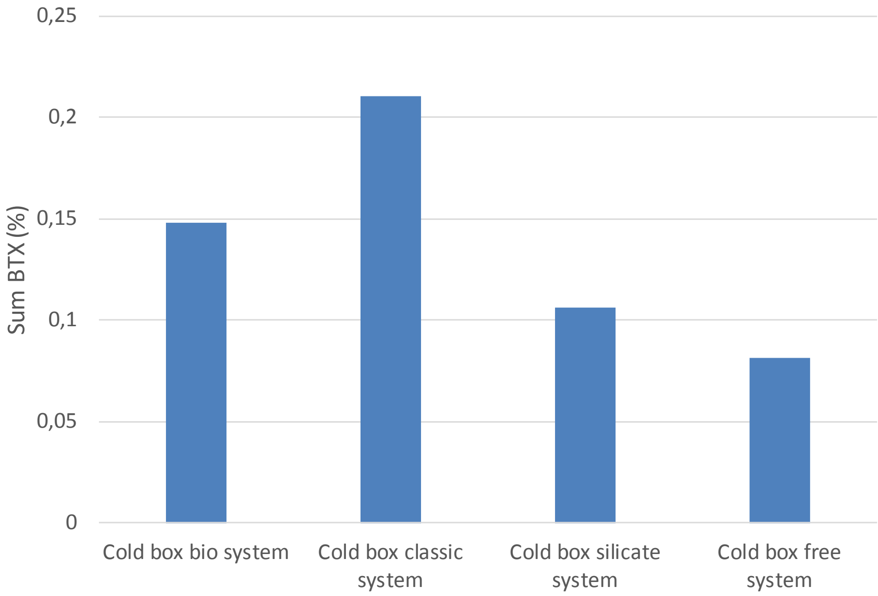
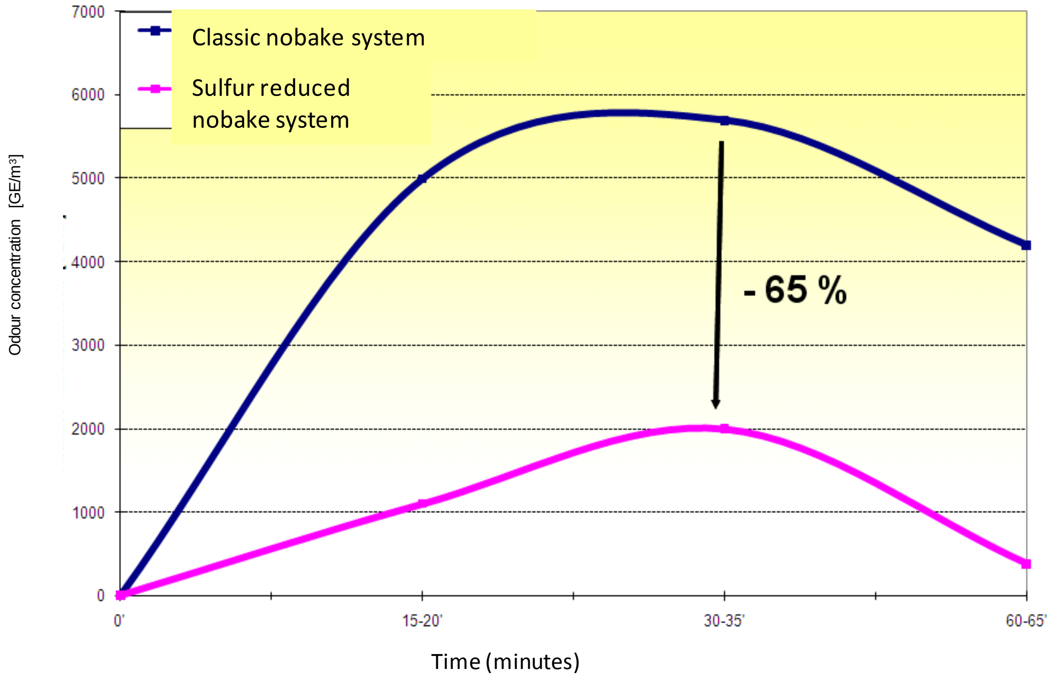


Fig. 29: New binder for odour and BTX reduction in an iron foundry –part B (source IfG)



Applying a sulphur-reduced bake system, the smell emissions in a steel foundry (Fig. 27) are reduced by 65% when using new sand moulds and new sand cores.

Fig. 30: New binder to reduce emissions of sulphur compounds (odours and pollutants) in a steel foundry – from pouring until 60 minutes after pouring (source IfG)



2.16.4 Operational data

The material consumption and the processing of new emission-reducing binders corresponds to the production technology, as it is described in BREF May 2005 in Chapters 2.5.6 and 4.3.3.

2.16.5 Cross-media effects

None.

2.16.6 Applicability

The emission-reducing binders are used for mass production of sand cores and for core and mould production in the hand form method or in the bake process.

2.16.7 Economics

The use of emission-reducing binders requires no investment.

The material costs for the new vehicle will depend on the specific nature of the binder and the volume purchased by the foundry.

The costs of the innovative binders are typically higher than for the previously used binders.

2.16.8 Driving force for implementation

The advantages of the new binder:

- Reduction of odour emissions,
- Reduction of pollutant emissions and exposures (diffuse sources),
- The foundry does not provoke problems with the neighbourhood,
- Relief from pollution control licensing procedures.

2.16.9 Examples

Foundries:

VW-Gießerei AG Nutzfahrzeuge, Hannover

Eisenwerk Brühl GmbH , Brühl

Harzguss Zorge GmbH, Zorge

Edelstahlwerke Schmees GmbH, Pirna

Binder developers:

ASK Ashland-Südchemie-Kernfest GmbH, Hilden

Hüttenes-Albertus Chemische Werke GmbH, Düsseldorf

2.16.10 Reference literature

Gieniec A., Helber J., Pohlmann U., Weigl M.: Entwicklung umweltfreundlicher Gießereiprozesse, gestützt auf ein zentrales Transferzentrum. BMBF supported project. Düsseldorf, Hilden, München 2008.

2.17 Aluminium foundry using inorganic core binders

2.17.1 Reference to BREF - May 2005

This is a new process. It is not mentioned in the chapters 3.9.4 to 4.3.3 of the existing BREF.

2.17.2 Description

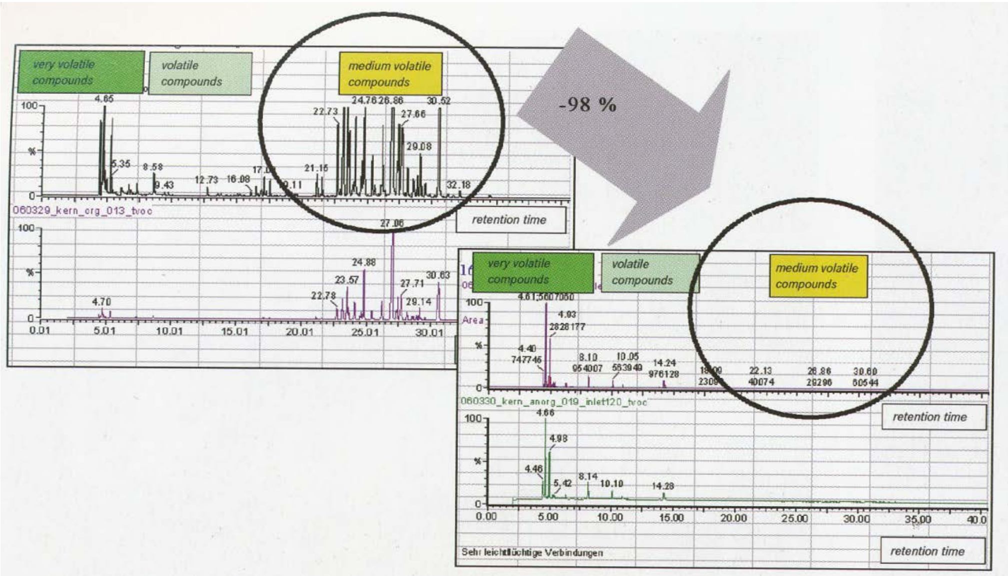
In the aluminium foundry the Inotec inorganic binders system is used. It combines a liquid component (a modified sodium silicate solution) with additives known as promoters, which contain high concentrations of minerals. The system is cured by use of heated tools. Flushing the system with hot air removes moisture and helps to optimise curing times and storing ability of the cores.

The new binder Inotec in core making at the BMW foundry is made by ASK Chemicals GmbH, Hilden.

2.17.3 Achieved environmental benefit

- Prevention of amine emissions in core making,
- Reduction of 98% of the organic C emissions and smell emissions after pouring, compared to organic cold box binders,

Fig. 31: Reduction of organic emissions (source: BMW)



- Reduction of energy consumption and related CO_2 and air pollutant emissions: 20% of die-casting compared with die-casting using urethane cold box cores or hotbox cores. Specific energy consumption per t of mixed sands:
- 0.089 kWh per t mixed sand (quartz sand, 2.95 % inorganic binder & promoter),
- 1.723 kWh per t mixed sand (quartz sand, 1.2 % urethane cold box binder, part 1 & 2)
- Reduction of noise (less tool cleaning),

2.17.4 Operational data

Aluminium serial production of automotive castings:

- 5 000 to 150 000 castings per year,
- BMW foundry in Landshut/Germany (in 2010):
    1. foundry processes using sand cores: gravity die casting, low pressure die casting,
    2. 45 000 t aluminium and magnesium castings (only high pressure die casting): cylinder heads, motor blocks,
    3. turnover: 235 Mio €,
    4. employees: 1 280.
- Adapted core shooting machine, gassing equipment and sand reclamation plant,
- Core box temperature: 180°C,
- Curing air temperature: 150°C,
- Gravity die casting, low pressure die casting,

2.17.5 Cross-media effect

Energy consumption for curing of inorganic binders with heat (drying process). Note: For urethane cold box process curing is without heat by using the catalyst amine.

Thermal sand reclamation (600°C to 700°C) is performed with a reclamation efficiency of 90 % to 95 %.

2.17.6 Applicability

The technique is applicable in foundries with aluminium gravity die-casting and low-pressure die-casting and serial production, with short-term core storage in case of hot and wet climate situation.

The conversion of an existing foundry line needs many process stages (see Economics). It also needs heated core boxes made of metal; many SME foundries use core boxes made of wood or plastics.

In the die casting process there is only one kind of sand, which is a precondition, using inorganic binders in serial production. In iron or steel foundries e.g. there is a self-curing no bake sand system or there are green sands with cores. In both processes there is no alternative to organic binders.

2.17.7 Economics

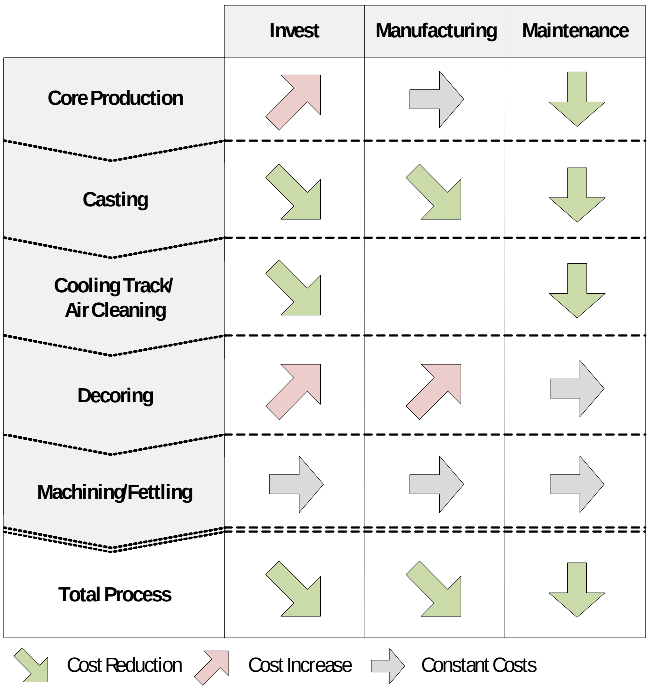
Conversion of an existing foundry or production line:

When using inorganic binders all stages of an aluminium foundry process has to be adapted: die design, core box design, sand mixer, heated core box, core shooting machine, gassing (hot air) equipment, core handling and storage (climate-dependent), thermal sand reclamation.

Building of a new foundry or production line:

Investment and running costs: there is an advantage compared to a foundry or a production line with urethane cold box process.

Fig. 32: Depiction of economic aspects



- Productivity increase +10%
- Tool maintenance -50%
- Tool cleaning -75%
- Manufacturing cycle time (casting -10%
- Thermal post-combustion of the exhaust air -100%

The economic effects of the application of this BAT candidate depends on numerous factors and can not be described in general in more detail.

2.17.8 Driving force for implementation

Sustainability within production:

- Reduction of emissions, exposure and fire risk.
- Improving of aluminium casting quality: lower temperature of the die (< 200°C) → smaller dendrite arm spacing in Al castings → higher strength.
- Higher productivity and less maintenance (-50%) compared to a foundry process with urethane cold box cores.

2.17.9 Example plant

BMW AG, Landshut, Leichtmetallgießerei.

Users of other kinds of inorganic binders with heat hardening: VW Nutzfahrzeuge Gießerei, Hannover and Posnan, DC Foundry.

2.17.10 Reference literature

Emmerich Weissenbek, Thomas Kautz, Jörg Brotzki, Jens Müller:

Zylinderkopffertigung der Zukunft – Ökologie, Ökonomie und Werkstoffoptmierung im Einklang. MTZ 2011, 72. Jahrgang, Nr. 6, S.484-489.

Thomas Kautz, Emmerich Weissenbek, Wolfgang Blümlhuber: Anorganische Sandkernfertigung: ein Verfahren mit Geschichte. GIESSEREI 2010, Nr. 9, S.76-79.

Harald Schwickal, Hartmut Hoffmann, Wolfgang Blümlhuber, Emmerich Weissenbek: Regenerierung von anorganisch gebundenen Gießereikernsanden. GIESSEREI 2009, Nr. 11, S. 40-44.

Johann Wolf, Wolfgang Blümlhuber, Jörg Willimayer, Emmerich Weissenbek: BMW light-metal foundry counts on inorganically bonded cores. Casting Plant and Technology 2008, Nr. 3, S. 8-11.

Emmerich Weissenbek, Jörg Willimayer, Johann Wolf: BMW-Leichtmetallgießerei setzt auf anorganisch gebundene Kerne. GIESSEREI 2008, Nr. 6, S. 32-35.

Jens Müller: Anorganisches Bindersystem im Sandwich zwischen „Technology Push“ und „Market Pull“. GIESSEREI 2012, Nr. 2, S. 52-58.

2.18 Enclosure of casting and cooling line

2.18.1 Reference to BREF-May 2005

In section 4.5.9.2 of the BREF it is noted that an enclosure of casting and cooling lines and the extraction of fumes is recommended. A concrete plant technology is however not mentioned.

The following information is more recent.

2.18.2 Description

The foundry produces over 3.5 million cast parts with a total tonnage of 33 000 tons per year. Production site is in Gutersloh, Germany.

An evacuation system is operated at the primary cooling area of the box-less moulding plant, type DISAMATIK. The area of the secondary cooling section, which comprises the separation of sand and castings, the conveying in the cast cooler and the blasting of the castings has been enclosed completely.

2.18.3 Achieved environmental benefits

The achieved environmental benefits are:

- Reduction of dust and CO in the work area,
- Reduction of diffuse dust emissions to air by around 50 % (based on the assumption of a 95 %-99 % cleaning efficiency of a bag filter),
- Reduction of overall emissions.
- Reduction of noise emissions by 3 – 9 dB(A),

By expanding the noise enclosure the average sound level (L_{eq})[4] has been lowered. The noise situation before the enclosure is shown below:

- 14.09.1999 In front of DISAMATIK, side of the holding furnace L_{eq} 87 dB(A)
- October 1999 Sorting places before the radiation plant L_{eq} 91 dB(A)
- 16.11.1999 Outflow of the noise protection cabin L_{eq} 92 dB(A)

By enclosing the casting a cooling line in 2009, the noise level has been reduced to the following levels:

- In front of DISAMATIK, side of the holding furnace L_{eq} 81 dB(A)
- Sorting places before the radiation plant L_{eq} 88 dB(A)
- Within the extended noise protection cabin L_{eq} 83 dB(A)

[4] The L_{eq} describes the average noise pressure level determined by noise level meters.

It can be seen that the L_{eq} for example at the sorting stations was lowered by 3-9 dB(A).

The table below depicts the evolvement of the reduction of dust and CO concentrations in the indoor air. The dust concentration at the sorting stations was 6.5 mg/m^3 before installation of the enclosure.

Table 16: Dust and CO concentration in the working area (2-hour averages)

Year	Dust [mg/m^3]		CO [ppm]
	Type of dust		Part of the installation where measurement has been performed
	alveolar	quartz	sorting station
2009	1.0	0.09	< 26
2010	0.5	0.02	< 11

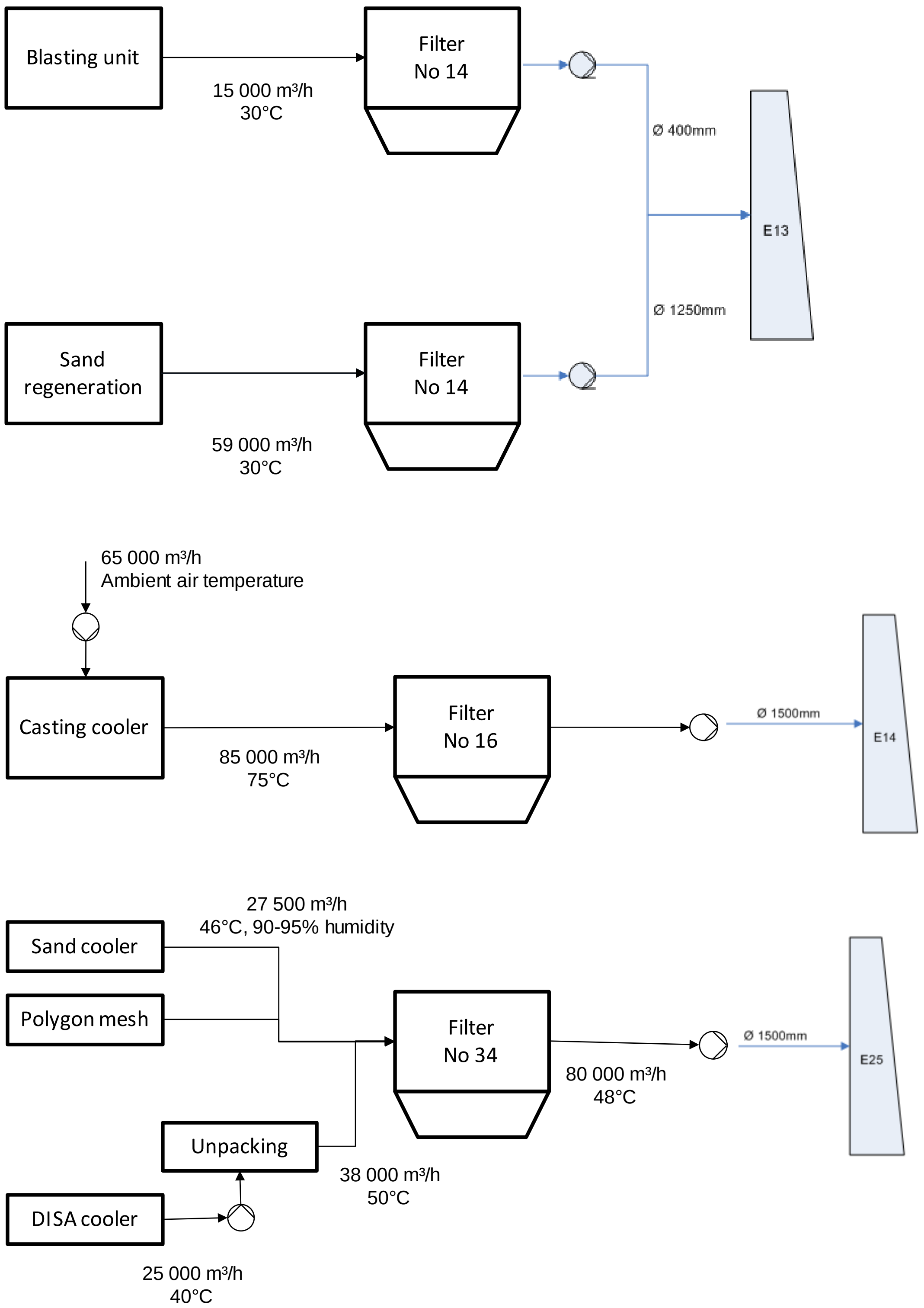
The dust concentrations, which may be released as diffuse emissions from the hall, have been roughly halved.

Remark: The total amount of CO emitted from the foundry to the environment remains unchanged, since the dust filters do not effect CO.

2.18.4 Operational data

From the blasting unit 15 000 m^3 are extracted to filter No. 14, from sand treatment 59 000 m^3 to filter No. 22. Most off gas results from the cooling of the cast (85 000 m^3 to filter 16). From cooling of sand and the polygon mesh 27 500 m^3 and from the DISA cooler and the unpacking unit 38 000 m^3 are extracted to filter 34.

Fig. 33: Examplary process scheme and volume flows (source: Miele)



2.18.5 Cross-media effects

Previously emitted dust must be disposed of as waste.

2.18.6 Applicability

In principal applicable to new and existing installations but spatial conditions must be suitable to set up an enclosure.

2.18.7 Economics

The implemented technical measures of enclosure caused an investment of approximately 180 000 € for the reduction of noise, dust and CO emission in the hall.

Efforts for maintenance of the exhaust hoods could be reduced by changing the supply air.

Information on the level of operating costs is not available.

2.18.8 Example

Miele & Cie KG, Gütersloh, Germany

2.18.9 Reference literature

Krimpmann, M., Giesserei-Erfahrungsaustausch, 12/2006,

http://www. zuwis.de/de/publikation/zuwis_erfolgsdoku.pdf

Information from plant operator

2.19 Post combustion of emissions in lost foam process

2.19.1 Reference to BREF - May 2005

In chapter 3.9.6.1 of the BREF no reference to a site and plant is given.

2.19.2 Description

Exhaust gas capturing using vacuum and a catalytic post combustion system is used for treatment of waste gases in the lost foam process. A description of the lost foam process is given in chapter 3.9.6.1 of the existing BREF.

In the Catalytic Thermal Oxidiser (CTO) volatile organic pollutants are burnt. The catalyst reduces the amount of energy needed to crack the pollutants. The raw gas loaded with pollutants is lead into the heat exchangers of the CTO by the process fan. Here the raw gas is pre-heated by the hot clean gas. When required the blower heats the exhaust gas in the combustion chamber until the ignition temperature of the catalyser is reached. In the catalyser the pollutants contained in the raw gas are converted mainly into CO_2 and H_2O. After the catalyser the clean gas is lead into the heat exchanger tubes[5]. A compensation tank can be used to equalise concentrations of the gases.

2.19.3 Achieved environmental benefit

The benefit of the post combustion is the reduction of emission of organic pollutants (BTEX, Total Organic Carbon).

2.19.4 Operational data

GussStahl Lienen GmbH & Co. KG, Lienen/Germany:

- foundry processes: lost foam process and no bake moulding,
- 1 300 to 1 600 t (500 t lost foam castings) per year, steel castings, heat resistant steel ,
- weight per part: 1 kg to 1 t,
- turnover: 15 Mio € ,
- employees: 75 ,
- two-shift operation

2.19.5 Catalytic post combustion:

- the air cleaning system has been built by Pflock & Meckler (today: Venjakob Umwelttechnik, Sarstedt/Germany),
- Volume: 1 300 Nm^3/h,
- the air cleaning system is operating roughly 15 min/day; the catalyst is preheated all day,

[5] No diagram of the system is available.

- after pouring there are emissions for some seconds; the ventilation system is operated for a minute.

Table 17: Operational data post combustion

Compound	Emissions, without post combustion	Emissions, with post combustion
Benzene	596 mg/m³; 320 g/h	0.04 mg/m³; 0.047 g/h
Toluene	129 mg/m³ ; 70 g/h	not measured
Etylbenzene	23 mg/m³; 13 g/h	not measured
Xylene	43 mg/m³; 23 g/h	not measured
Styrene	863 mg/m³; 466 g/h	not measured
Methyl methacrylate	2 157 mg/m³; 1165 g/h	not measured
Total organic carbon	not measured	95 mg/m³, 0.111 kg/h
Parameters		
Air pressure	1 000 hPa	988 mbar
Gas flow	540 m³/h	1 167 m³/h
H20 content	21 g/m³	25.6 g/m³
02 content	*	18.9 Vol.-%
Gas temperature	24 °C	not measured
Catalyst temperature	not measured	394 to 626 °C
Clean gas temperature	not measured	255 to 370 °C
Burner temperature	not measured	420 to 437 °C

Explanation: * The measuring protocol gives a value of 0.0 Vol. %, which is implausible.

2.19.6 Cross-media effect

Consumption of 400 m^3 natural gas per month.

2.19.7 Applicability

Post combustion can be applied in new and existing plants. It is advantageous in case of exhaust gas with relative high organic content, e.g. after pouring in lost foam process.

2.19.8 Economics

Investment costs for catalytic post combustion plant: 250 000 €,

Running costs (maintenance etc.) – post combustion plant: 5 000 €/year.

2.19.9 Driving force for implementation

Reduction of emissions and complying with the German regulation TA Luft

2.19.10 Example plant

GussStahl Lienen GmbH & Co. KG, Lienen/Germany

Other users of lost foam process with post combustion:

BMW AG, Landshut/Germany,

2.19.11 Reference literature

http://www.gsl-lienen.de/service/downloads/

http://www.venjakob.de/en/

2.20 Use of bioscrubber with additives for odour reduction

2.20.1 Reference to BREF-May 2005

The use of a bioscrubber with additives for odour reduction is not mentioned.

2.20.2 Description

In bioscrubber, pollutants are absorption by washing fluids, which are subsequently regenerated by microorganisms, which convert the pollutants.

The metal works at Franz Kleinken GmbH operates a bioscrubber micro cyclone system[6]. Ambient air from the rooms passes in the cleansing installation at first a spray chamber / water atomization. The exhaust air (raw gas, a mixture of air and odour molecules) is treated with a water mist. The mist (fresh water with additives based on vegetable fatty acids) is produced by high-pressure nozzles. The active substance in the medium reacts with part of the odorous substances (sulphur compounds) and binds them.

At the same time, the water of the bioscrubber is sprayed into the air stream. The water, which is in a closed loop, contains natural enzymes and microorganisms as active compounds, which produce in the bioscrubber additional enzymes, and breaks down organic matter and biological odours.

The enzymes provide an improved transfer of the odour molecules into the water phase. A natural, herbal fragrance in the media is responsible for the change of plant-specific odour, without increasing the total odour load.

In a micro cyclone drops and gaseous substances are separated from the gas stream. The separated liquid phase is collected in a where biodegradation of aromatic substances and media takes place. By added microorganisms, the organic ingredients are degraded mainly to CO_2 and water.

In the demister unit remaining drops are separated by the centrifugal deposition principle from the gas stream. They are then fed into the water circuit.

[6] No system diagram is available.

2.20.3 Achieved environmental benefits

In an exemplary case of measuring directly above a casting mould the odour minimisation efficiencies have been in the range between 60% and 80%. The odour quality is thereby altered so that the plant-specific odour of the foundry is no longer perceivable.

A long-term olfactometric measurement before installation of the system and during the plant operation (> 6 months) confirmed the achieved environmental benefits.

2.20.4 Cross-media effects

- Generation of waste water,
- Energy consumption for exhaust technology.

2.20.5 Operational data

In the iron foundry products are made from gray and ductile iron with a weight up to 30 t. The foundry is divided into a hand moulding for large cast and a hand moulding for small castings (up to 4 tons weight). Both moulding facilities are supplied by its own core shops. The melting process consists of 2 MF induction furnaces, with a capacity of 2 and 4 tonnes and in 2 cupola furnaces with a melting capacity of 6 t/h.

The extracted exhaust per reference foundry plant is 25 000 m^3/h.

2.20.6 Applicability

In principal bioscrubbers can be applied in new and existing plants. The required operating system depends on two conditions: the smell load and the hall suction. When the application of bioscrubbers is technically evaluated

- the planned water flow and the amount of additives must be adapted to the smell load;
- up time of the casting facility must be considered due to its consequence for energy consumption.

When no odours are generated (e.g. when no casting is done or during production downtime), it is possible to turn off the system manually. A time limit for downtime of the bioscrubber does not exist. The plant can operate continuously 24 hour per day.

It has to be considered that the microorganisms require relatively constant environmental conditions.

2.20.7 Driving force for implementation

- There are large volumes of air with relatively low loads, but strong-smelling substances. By using a bioscrubber, the use of comparatively little additives is sufficient.
- Odour nuisance in the neighbourhood,
- Permitting requirements.

2.20.8 Economics

- The investment cost of air conditioning systems like indoor air extraction and indoor cleaning techniques amount to each plant about 150 000 to 200 000 €. It should be considered in the evaluation of the economics whether the indoor air extraction and indoor cleaning techniques, which might be necessary anyhow, must be redesigned to the needs of a bioscrubber system.
- The operating costs for the bioscrubber are between 6 and 10 € per hour of operation.

2.20.9 Example

Metallwerk Franz Kleinken GmbH, Germany

2.20.10 Reference literature

Information from Metallwerk Franz Kleinken GmbH, Germany http://www.kleinken.de

2.21 Waste minimizing green sand preparation

2.21.1 Reference to BREF - May 2005

A vacuum mixer for preparation of green sands is described in chapter 4.3.2.1 of the BREF.

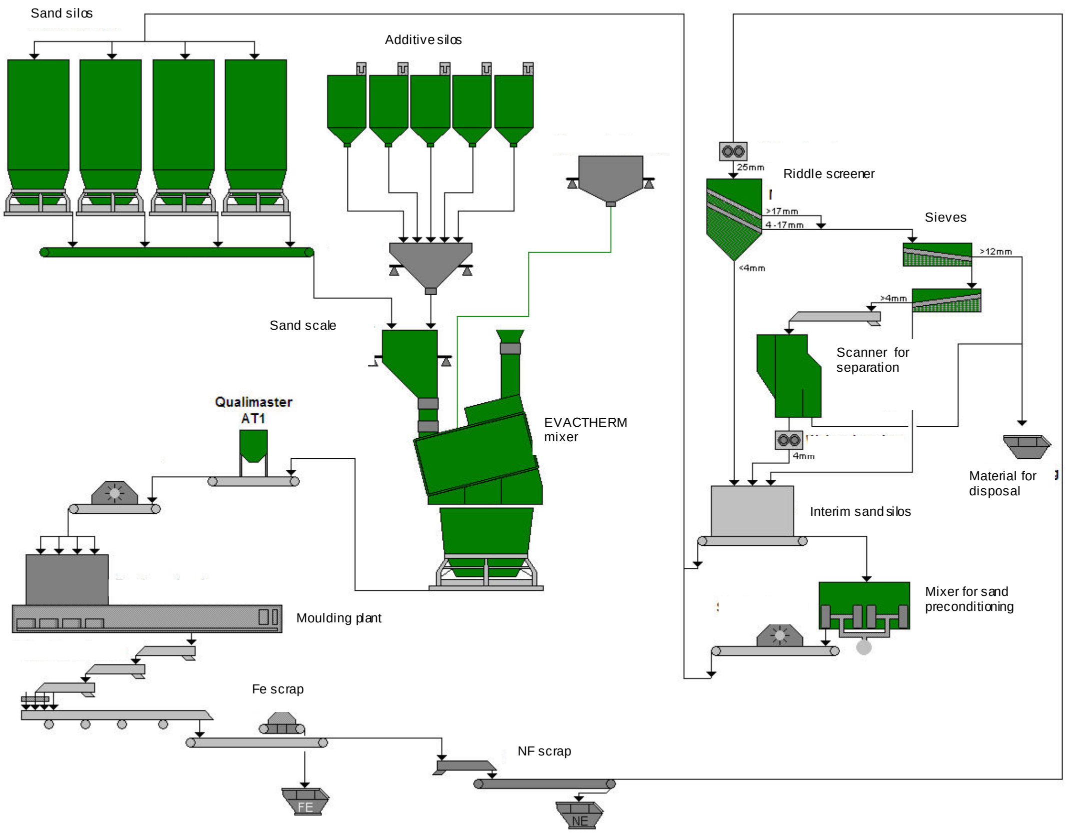
The following section describes an innovative installation.

2.21.2 Description

Ohm & Häner is a family owned business for aluminium sand casting operating as a jobbing foundry with a total production of 4 500 tons of aluminium castings.

Process related factors are causing an accumulation of impurities in the moulding material in sand casting. In standard sand regeneration systems these impurities (core sand, insulating material, metal scrap) cannot be separated sufficiently from the moulding material. Significant agglomeration of impurities is causing the necessity to dispose comparatively high amounts of moulding material and refresh the system with new silica sand and clay binder. The new sand regeneration technique at Ohm & Häner achieves a more complete separation of impurities from the moulding material (Fig. 34).

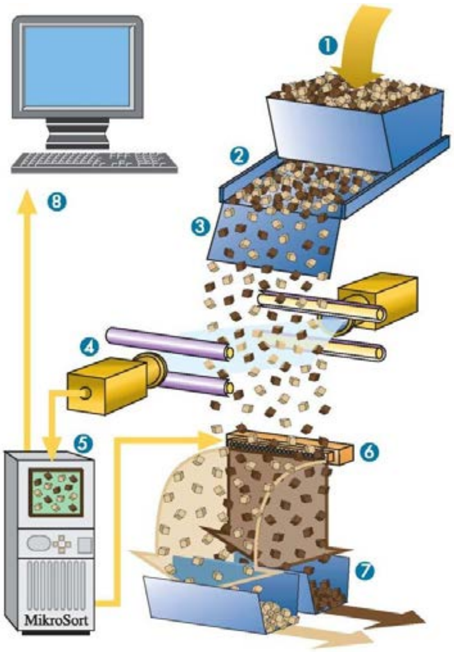
Fig. 34: New green sand regeneration plant at aluminium foundry Ohm&Häner (key components in green) (source: [3])



Key components are mixers, silos, riddle screeners and a scanner for separating impurities from green sand based on brightness/colour of the material (Fig. 35).

Fig. 35: MikroSort device for optical detection and separation of impurities from green sand (source: [3])

Fig. 36: Process scheme MikroSort device (source: [3])



Legend:

1: Input feed (mixture),

2: Vibration chute to widen input material,

3: Falling distance,

4: Camera system for identification of components,

5: Computer system for image processing and steering of separation process,

6: Blast pipe band for separation of detected component via blast impulse,

7: Separation boxes,

8: Visualisation.

Organic bonded sands are kept separately from inorganic bonded sands.

2.21.3 Achieved environmental benefit

Environmental benefits resulting from application of this technique are:

- Minimisation of waste sand,
- Reduction of raw material consumption (resource conservation for silica sand and bonding clay),
- Significant reduction of heavy-duty transports.

Table 18: Reduction potentials

Parameter	Potential in case of full capacity operation
Reduction of used sand for disposal	12 650 t/a
Reduction of raw material consumption: silica sand	13 800 t/a
Reduction of raw material consumption: clay binder	92 t/a
Reduction of CO_2 emissions due to reduction of transport	140 t/a

Table 19: Operational data (in case of full capacity operation)

Maximum licensed operating hours:		8 760 h
Operating hours:		6 570 h
Capacity sand preparation plant:	70 t/h	460 000 t/a
Without new technique:		
- amount of new sand:	ca. 3 %	13 800 t/a
- amount of disposed sand:	ca. 3 %	13 800 t/a
With new technique:		
- amount of new sand:	0.25 %	1 150 t/a
- amount of recycling sand (no disposal):	0.25 %	1 150 t/a
Reduction of new sand consumption:		12 650 t/a
Reduction of disposal of contaminated sand:		13 800 t/a

2.21.4 Cross-media effect

No effects.

2.21.5 Applicability

All aluminium foundries with green sand system and moulding plant.

2.21.6 Economics

Table 20: Economic aspects green sand preparation

Total investment:			4.44 Mio €
Cost reduction per year: ca.			1.18 Mio €:
- New sand costs	12 650 t	45 €/t	569 250 €/a
- Disposal sand costs:	13 800 t	43 €/t	593 400 €/a
- Total sand costs:			1 162 650 €/a*
- Bentonite costs:	92 t	228 €/t	21 000 €*

(* including transportation costs and in case of full capacity operation)

2.21.7 Driving force for implementation

Besides resource efficiency improvement also technical advantages were achieved by means of the new sand preparation system, which are of great importance in the foundry production:

- Significant consumption reduction of bentonite binders and water in the moulding material,
- Fine-grained moulding sand composition achieved resulting in smooth surfaces in the castings,
- Reduction of surface defects from impurities accumulated in the moulding material.

2.21.8 Example plant

Ohm&Häner Metallwerk GmbH & Co KG, Drolshagen

2.21.9 Reference literature

[1] Ohm L., Dieckhues, G.: Sandaufbereitung in einer Aluminium-Sandgießerei. Olpe 2011. BMU–UMWELTINNOVATIONSPROGRAMM, No.: ZG II 4-42155 – 5/224.

[2] BMU –UMWELTINNOVATIONSPROGRAMM: Sandaufbereitung in einer Aluminium-Sandgießerei Förderkennzeichen: ZG II 4-42155 – 5/224, Abschlussbericht

[3] Ressourcenschonung durch innovative Sandaufbereitung OHM & HÄNER METALLWERK GMBH & CO KG, OLPE, Information sheet of the Federal Environmental Protection Agency on the Environmental Investment Program, Dessau, no year

2.22 Sand reclamation and heat treatment of aluminium castings in one stage

2.22.1 Reference to BREF - May 2005

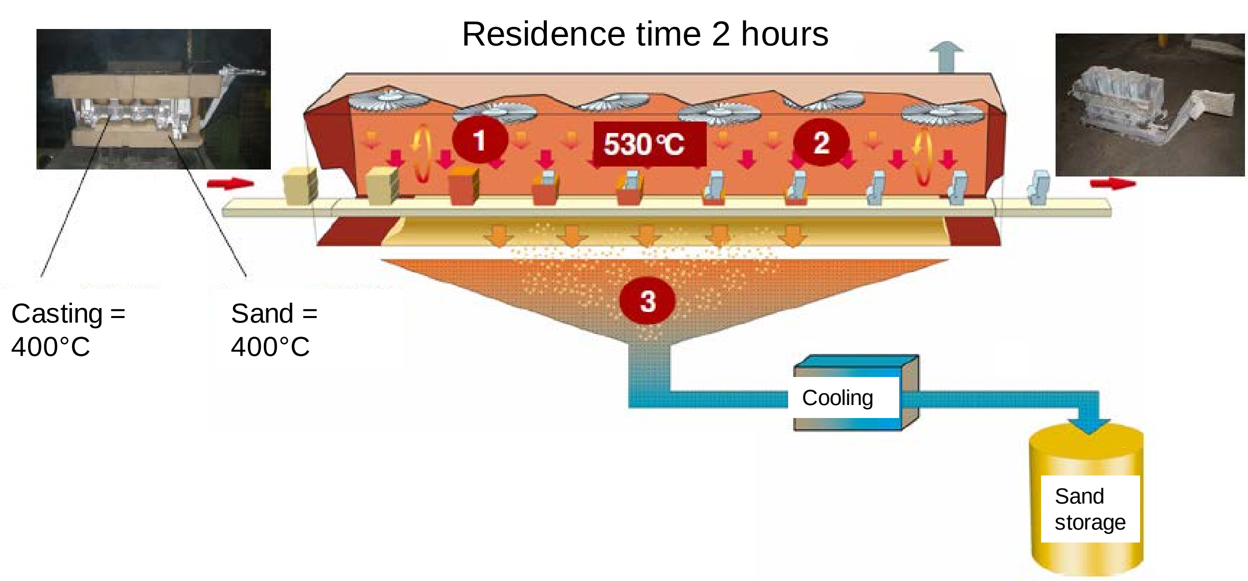
This process is not mentioned in the BREF – May 2005.

2.22.2 Description

The CEC Sand Lion® 3-in-1 Process (Fig.35) does carry out three foundry steps simultaneously in one automatic system

- Thermal de-coring / sand – casting separation,
- Thermal sand regeneration,
- Solution heat treatment.

Fig. 37: The CEC Sand Lion® 3-in-1 Process: 1: separating: castings and sand; 2: annealing; 3: sand reclamation



Immediately after pouring and solidification, the castings are loaded into the furnace for heat treatment. Foundries load the castings within 15 minutes and moulds within 20-25 minutes into the furnace. No cooling, no mechanical sand removal and/or de-coring, no riser cutting are needed.

Binder is burned as a fuel: Only the presence of heat above 420°C and oxygen causes the organic binder to burn and the mould/core will disintegrate. Special axial fans create a pressure drop across the castings (negative pressure) which results in turbulences inside the castings. This allows rapid sand removal from horizontal internal passages such as water jackets, oil passages and other thin cores.

Sand falls to the bottom of the furnace for final cleaning in a heated fluidized bed and will be released to the sand collecting vibratory conveyor underneath the furnace. Sand will be cooled for pneumatic transport back to the core shop. No further treatment needed before being re-used in the core sand mixer. L.O.I. of the reclaimed sand < 0.07%.

Castings are thermally processed (solution heat treatment) at temperatures between 485°C and 535°C (as specified by customer) and quenched after treatment.

Sand Lion® systems are available as

- roller hearth furnace (batch type and continuous),
- deep fluidized bed (DFB) ('continuous' batch type) or
- chain type furnace (continuous).

Waste gases will be thermally treated in an afterburner at 820°C to burn nitrogenous gases. Hot exhaust runs through a heat exchanger, pre-heating fresh air for fluidizer, air knives, and burners, before being led to the bag house.

2.22.3 Achieved Environmental Benefit

Reduced waste and reduced resource consumption by sand Recycling

- It is a closed circuit 'core shop – pouring – thermal de-coring – sand reclamation – core shop'. About 97% of the used sand loaded with the castings into the Sand Lion® furnace will be transported back to the core shop as clean, regenerated sand.
- All sand from the foundry can be regenerated. Waste sand from the core shop, broken cores can be loaded into the furnace for reclamation as well.
- Only the loss (only about 3% per hour; broken grains, and fine particles) will be separated and need to be replaced.
- Reduced waste amounts.
- Another environmental benefit is the reduction of truck transports between sand mine and foundry and/or between foundry and landfill.

Use Of Recovered Heat

- Loading of hot castings into the furnace; heat for melting the metal is also being used for sand reclamation and heat treatment.
- No cooling of castings; the cooling process would use energy (e.g. electric blowers) to destroy energy.
- Organic binder creates heat when burned. This heat inside the furnace is being used for sand reclamation and heat treatment.
- Binder chemicals are burned inside the furnace.
- Some foundries use heat of exhaust for providing hot water or heating the building.

Waste gas treatment

- Minimised emissions

Emissions

- Emission of CO_2 is reduced

Table 21: Emission levels at 12 % O_2

	Maximum emission levels allowed	With 3 in 1 (customer´s report)

	Maximum emission levels allowed	With 3 in 1 (customer´s report)
CO	80 mg/ m^3	60.9 mg/ m^3
VOC	20 mg/ m^3	7.9 mg/ m^3
NO_x	250 mg/ m^3	230 mg/ m^3
Dust	10 mg/ m^3	6 mg/ m^3

2.22.4 Operational data

Capacities casting treatment: Existing systems treat between 33 and 180 engine block and cylinder head castings per hour, based on customer's specifications. The furnaces (as a modular construction) are engineered to specification thermal systems. Depending on number of castings/hour, size of castings/moulds, temperature, heat up and soak time, etc. the furnaces will be designed as a number of modules.

Capacities sand reclamation: The installations provide the capacity to reclaim between 1 ton and 30 tons of used sand per hour. The hopper shaped bottom of the furnace is also designed to buffer a certain amount of sand during production stops in the sand system downstream the furnace; means the furnace can continue to heat treat castings.

Utilities estimate the consumption of gas, electricity, and compressed air based customer's process specification. Gas consumption for example depends very much on temperature of castings during loading, treatment time and temperature, quantity of sand and binder content, etc. The share of recovered energy can be in a range of 47%. In general, operating such a plant it can reduce the energy consumption by 25 – 30%.

2.22.5 Cross-media effect

One may see it as an indirect disadvantage when risers and feeders are heat treated as well before being cut-off. It may use more energy in the furnace. On the other side, loading of hot risers and feeders increases the heat loaded into the furnace.

'Heat treated' risers and feeders can be easier cut-off. This saves costs for cooling.

2.22.6 Applicability

This process can be applied for

- Castings in aluminium alloy,
- Castings with sand,
- Core and mould sand with organic binders,
- Castings made in any casting process where sand (Silica, Zircon, etc.) is used for forming,
- the outer and/or inner contour of the casting (e.g. gravity die casting process, low pressure die casting process, Precision Sand Moulds, Croning, No-bake),
- Casting heat treatment capacities between ~30 and 180 castings/hour,
- Sand removal and reclamation capacities up to > 35t/hour.

2.22.7 Economics

Savings can be achieved by

- Reduced treatment time (energies),
- Reduced space requirements,
- Reduced personnel costs,
- Less equipment, no stand-alone machinery,
- Less handling operations, less damage,
- Reduced emissions,
- Recovery of energies,
- Less inventory (work in progress).

Customer reported a saving of

- Labour costs by 46%,
- Energy costs by 25%,
- Gas consumption by 64%,
- Operating costs by 55%.

Reported share of energies:

- Gas 42%,
- Electric power: 11%,
- Energy recovery 47%.

No data on investment costs are available.

2.22.8 Driving force for implementation

- Reduction of operating costs.
- Efficient and environmentally friendly treatment process.

2.22.9 Example plant

Total 37 of those 3-in-1 roller hearth and chain type systems were installed world-wide and are used mainly for treatment of gasoline and diesel engine block castings (low pressure die casting, Precision Sand Mould and gasoline and diesel cylinder head castings (gravity die casting, low pressure die casting, Precision Sand Mould).

Hydro Aluminium Dillingen (now Nemak Dillingen), Germany

- 4 lines for engine blocks and heads
- total capacity about 480 castings/hour
- this installation (whole foundry) in Dillingen is one of the best foundries using PSM

Daimler Benz Mettingen, Germany

- 2 lines for cylinder heads

- Availability 98%

2.22.10 Reference literature

VDG/VDMA Conference “Energy Efficiency in Foundries”, Frankfurt, March 2010

Information by plant operators

GIESSEREI 98, 11/2011

2.23 Quenching of castings with polymer solution

2.23.1 Reference to BREF-May 2005

Chapter 3.12 of the BREF deals with quenching and emissions. Chapter 4.5.11.2 describes emission recording of oil quenching baths.

Quenching of castings with a polymer solution is a new procedure.

2.23.2 Description

To establish certain metallurgical properties, steel castings are subjected to heat treatments. It may be necessary that the parts must be rapidly cooled. Usually liquid or gaseous substances like water, oil or compressed air are used for quenching of castings.

The system described here has a quenching baths filled with a polymer solution. The polymer solution consists of an aqueous polyvinyl concentrate with anti-rust, anti-foam additives and preservatives. It contains no hazardous ingredients and is non-flammable.

By changing the concentration of the polymer solution, different cooling curves can be realized. This is particularly inspired by similar oil-cooling curves, where the disadvantages of quenching in oil emulsions such as oil fumes, odour nuisance and fire hazards can be avoided.

By using polymer solution with a concentration between 12% and 15% similar hardness and delay results can be achieved compared to an intense high-quenching oil.

Usually aqueous solution at concentrations between 5% and 15% are used. Polymer basic materials are usually products based on Polyvinylpyrrolidone (PVP), polyalkylene glycol (PAG).

2.23.3 Achieved environmental benefits

Advantages of using polymer solution compared to the use of oil-water emulsion are

- favourable emission characteristics,
- lower odour nuisance,
- not combustible.

In terms of emissions, the use of polymer solutions offers significant advantages over the use of quenching oil. Thermal stress of the quenching oil at a temperature range between 120°C and 300°C results in increasing oil vapour rates. Higher temperatures may lead to formation of cracked gases. In case of incomplete combustion, flue gases may result containing carbon monoxide, hydrocarbons, oil vapour, aldehydes, carbon black, partly also aromatic or polycyclic hydrocarbon compounds.

By using polymer solution vapour is minimised and no dip flame are produced so that no fumes are released.

2.23.4 Operational data

The following table summarises operational data for quenching with polymer solutions.

Table 22: Operational data quenching

Pool size	Ca. 30m³
Content	30 000 litres
Rec. concentration	10 – 30 %
Application temperature	20 – max. 50 °C

2.23.5 Cross-media effects

Due to the extreme thermal stress of the polymer components during the quenching process formation of thermal degradation products, such as short-chain hydrocarbon compounds, carbon dioxide can be expected. Anyhow, the total amount of emitted organic substances is lower compared to the use of oil. No measuring and analytical data are available.

2.23.6 Applicability

The following factors may influence the applicability:

- Check whether the required cooling curves can be realised. Possibly, certain cooling curves are not possible.
- Technically, an existing oil quenching baths (pools, tanks for oil emulsion) can be usually converted for application of polymer solution without problems.
- Possibly, the quenching baths of polymer solution require more space.

2.23.7 Economics

Application of this technique does not require additional installations. Significant changes in the operating, maintenance and disposal costs are also not to be expected.

2.23.8 Driving force for implementation

- Favourable emission behaviour with respect to organic substances in comparison to an oil bath,
- Simple control of the concentration which is responsible for the quenching effect,
- Occupational Safety: No risk of fire.

2.23.9 Example plant

Stahlwerke Bochum GmbH 44791 Bochum, Germany

2.23.10 Reference literature

Details given by the operating company of the reference plant

Details given by the manufacturer of the polymer solution, BURGDORF GmbH & Co. KG, Stuttgart, Germany

3 References

2.1.10 Reference literature

[1] BDG-paper „Energieeffizienter Gießereibetrieb“: GIFA 2011-presentation. Düsseldorf.

[2] VDG-paper „Inspiration Bionik – Von der Evolution in 21. Jahrhundert“: GIFA-presentation 2007.

[3] Dipl.-Ing. Ernst du Maire und Dr.-Ing. Thorsten Schmidt "Von der Natur lernen - kraftflussgerechte, neuartige Gestaltung gegossener Komponenten" 2. NEWCAST-Forum - Tagungsband, 21. und 22. April 2005.

[4] Information from CLAAS GUSS GmbH.

[5] Information from HEIDENREICH & HARBECK AG.

[6] Information from Georg Fischer Automotive AG.

2.2.10 Reference literature

[1] Sturm,.J.C.: Energie- und Rohstoffeinsparung durch konsequente Nutzung der Gießprozesssimulation. GIESSEREI 98, 2011, Nr. 6, S. 82 ff.

[2] English online summary of the above article: http://digital-edition.machinedesign.com//?iid=0df839e7 (s. 70-73)

[3] BDG-paper „Energieeffizienter Gießereibetrieb“: GIFA 2011-presentation

2.4.9 Reference literature

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Enzenbach, Thomas: Giesserei 96 (10/2009), S. 68-74

2.5.9 Reference literature

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[2] http://www.georgfischer.com/2/11/124/8196/8212.asp, Stand Mai 2011;

[3] BDG-Schrift „Energieeffizienter Gießereibetrieb“: GIFA 2011-Sonderschau

[4] BDG/VDMA-Tagung „Energieeffizienz in Gießereien“ Frankfurt 2010.

[5] Energieeffizienz durch externe Abwärmenutzung GEORG FISCHER AUTOMOBILGUSS GMBH, SINGEN; Information sheet of the German Federal Environmental Protection Agency on the environmental in-vestment program, Dessau, no year

2.6.10 Reference literature

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