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WHITE PAPER

THE SUSTAINABILITY ADVANTAGE

05/2024

Ferrous Foundries

VESUVIUS

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EXECUTIVE SUMMARY

Sustainability is a defining theme of the modern industrial landscape, particularly in energy-intensive industries, such as iron and steel foundries, and is often associated with increased regulation and costs. But strong positive business cases can be made for adopting more sustainable technologies and practices, particularly as they impact energy and resource consumption. This white paper will discuss current best practice available to ferrous foundries that underline the advantages such sustainable business choices can bring to financial, environmental and social performance indicators.



INTRODUCTION

Sustainability

Financial sustainability is not incompatible with improving environmental sustainability, the two often go hand in hand.

Sustainability is a defining theme of the modern industrial environment. This is most often associated with the need to reduce atmospheric emissions of CO₂ in order to mitigate the negative effects of climate change. As important as this undoubtedly is, sustainability is a much broader topic that encompasses a range of environmental, social and economic actions.^{1,2}

Sustainability is also not a simple or linear process: progress in one area can create challenges in others. For example, goals to reduce poverty and its associated challenges are predicated on economic development through inclusive and sustainable industrialisation. UN Sustainable Development Goals therefore aim to increase manufacturing's contribution to GDP and employment in developing countries.³

With 90% of all manufactured goods relying on metal castings,⁴ this bodes well for the foundry sector. But it also means that foundries are likely to come under increasing pressure to make their processes as sustainable as possible in order to ensure a sustainable basis for manufacturing growth. And while the industry is a long-standing contributor to sustainability in some areas, most notably through the recycling of scrap iron and steel,⁵ in other



areas, such as energy and resource efficiency, there is still much room for improvement.

The good news is that there are solutions available today for the most pressing sustainability challenges. In the remainder of this white paper, we will consider some of these under the themes of energy efficiency, resource intensity, pollution control and, finally, Foundry 4.0. We do so, while recognising that financial sustainability is not incompatible with improving environmental sustainability.^{6,7} Indeed, by optimising energy and resource use, the two often go hand in hand.

IMPACT AREAS



ENERGY EFFICIENCY

Metal casting is known for its high energy consumption, low energy efficiency and high CO₂ emissions.

According to one study, “on average, the energy consumed by a foundry shop far exceeds that which it is predicted to use based on theoretical calculations [...] due to inefficiencies associated with the activities of metal melting and casting [...] Opportunities to improve energy efficiency of a foundry operation, significantly [reduce] environmental impact while maintaining the sector’s competitiveness in the process.”⁸ Such opportunities may be grouped into three broad categories: improving the efficiency of casting processes; reducing rework and recycling via improved melt quality; and reducing process heat loss.

Although discussed separately below, it is important to note that these opportunities are interlinked. Lowering process heat loss will often result in cleaner casting by reducing the occurrence of temperature-related defects. Meanwhile, reducing rework and recycling through cleaner casting will by default also improve process efficiency, as castings will move more quickly through the cleaning room and consume less energy on the way.

Improving process efficiency

Melting accounts for 30% of energy consumption in the foundry. Improving the efficiency of this process is therefore a key concern.⁹ This can be achieved in a number of ways. For example, by improving yield, output is maintained but less material is melted. Improving thermal efficiency by reducing heat losses shortens melt times, reducing the energy input required per melt. High thermal efficiency also reduces the energy required to hold a continuous supply of liquid metal of consistent composition and quality for casting, another major area of energy consumption in the foundry.⁹

Solutions to these challenges take a range of forms. Pattern redesign with FEEDEX VAK sleeves, for example, helped improve metal yield at one manufacturer of liner castings for large compressors from 40% to 70%, resulting in a reduction in CO₂ emissions of 2.62kg per casting. This was achieved because FEEDEX sleeves are able to operate efficiently within a small surface area and under complex application conditions. This means they can be used even in moulds where space limitations would usually preclude the placement of a feeding system to improve metal yield.

In addition to improving yield, other processes are simplified and costs lowered by the FEEDEX VAK sleeves. The feeders are delivered ready to

use and, due to the smaller neck of the feeder, the contact area with the cast is 45% smaller, significantly reducing the need for post-casting fettling. This latter benefit is significant, as post-casting processes consume additional energy. Reducing or eliminating such rework thus improves energy efficiency; it also reduces costs and improves productivity (see discussion below).

Moving to the mould shop, a number of coatings have been developed to improve the efficiency of mould production. For example: SEMCO FD fast dry water-based coatings are – as the name implies – designed to cure more quickly than standard coatings, and so reduce the consumption of energy consumed in the drying process. At a foundry specialising in wind turbine castings, for example, the use of SEMCO FD shortened core/mould drying cycles by 50%, improving energy consumption by 50% with a consequent improvement in CO₂ footprint. Handling was also made easier and safer due to the application of a lighter filler combination and the removal of zircon from the foundry.

Meanwhile, SEMCO CC coatings are formulated to change colour when dry, providing a clear visual indication of mould readiness to operators. This prevents over-drying and the excess energy consumption this entails. The colour change is also reversible, helping avoid the use of wet moulds for casting – with the implications for casting quality that this entails.

Cleaner casting: reducing rework and recycling¹⁰

All inclusions pose a challenge when it comes to cleaner casting, but oxide bi-folds are particularly pernicious.¹¹ Bi-folds are caused when the oxide film, formed on the surface of the liquid metal on exposure to the atmosphere, is included into the melt. Bi-folds float only very slowly through molten metal and are thus difficult to remove via traditional slagging methods. Remaining thus in the melt, they form larger agglomerations of non-metallic material during solidification.

To avoid this, foundries may opt to increase pouring temperature to encourage the bi-folds to float to the surface more quickly for easier removal. But a higher pouring temperature can itself result in casting defects; it also increases the overall energy input into the system.

The combination of the ROTOCLENE rotary melt treatment process and HOLLLOTEX shroud provides an effective solution to this bi-fold challenge. The ROTOCLENE process involves purging the molten metal with argon, while the melt is stirred.¹² The argon is thus dispersed through the melt, forming curtains of micro-bubbles that float to the surface, picking up oxide films and other inclusions on the way, and resulting in a cleaner cast. The HOLLLOTEX shroud then protects the metal from further contact with the atmosphere during pouring, and thus the potential for reoxidation and further bi-fold formation. The bottom of the shroud also incorporates a filter box with STELEX ZR *ULTRA* filter to remove any remaining inclusions.

Filters – such as the STELEX range – are a solution in themselves when talking not only about melt quality, but also improving the pouring process. This is because they reduce turbulence and improve flow into the mould, in addition to removing inclusions, producing a higher-quality cast and reducing the need for post-cast reworking.

At the same time, the ROTOCLENE process also homogenises melt temperature, preventing premature metal solidification at the ladle and eliminating the risk the stopper will freeze, while the HOLLLOTEX shroud reduces heat loss during pouring. The combination thus allows foundries to reduce pouring temperatures – with clear benefits when it comes to energy efficiency.



Reducing process heat loss

A further opportunity to improve the energy efficiency of casting systems lies with solutions that reduce process heat loss. These mean less overall energy has to be put into the system to achieve the same results.

One solution here is the use of insulating lining systems, such as the KALTEK range of products for ladle lining, which lower heat loss and reduce preheating times. For example, at Fonderei Venissieux in France the use of KALTEK ISO 60 BF linings halved ladle lining time, reduced drying time from 9 hours to just 1 hour, and shortened the preheat from 4 hours to just 1 hour – while improving lining lifetime by 35%. The KALTEK lining was also lighter, allowing 1150 tons of metal to be treated, compared to only 750 tons previously.

KALTEK linings – in the form of board ladle linings – also form a key component of the Foseco warm start ladle package for bottom four ladles, alongside an innovative warm start VISO stopper and VAPEX nozzle (more on which below). The resulting solution requires little (if any) preheating, reduces temperature loss from the ladle, and enables lower tapping and holding temperatures. These benefits have an additional knock-on impact when it comes to both casting quality and process efficiency. The use of the warm start ladle package results in fewer temperature-related defects and thus a reduction in rework/recycling. Castings therefore move more quickly through the cleaning room, increasing process efficiency.

RESOURCE INTENSITY

Improving yield not only impacts the energy efficiency of the process, it also improves resource efficiency, the second critical element in foundry sustainability.



Improving yield not only impacts the energy efficiency of the process; it also improves resource efficiency, the second critical element in foundry sustainability, when you consider that new steel products contain only 30% recycled steel.¹³

The abovementioned technologies for optimised pouring are again important here in that they lower the occurrence of casting defects and thus the need to clean casts, as well as reducing non-productive or wasted metal. But so too are technologies that extend meantime between replacement of components and consumables.

Longer equipment lifecycles reduce both the amount of waste produced by foundries (and therefore contribute to the aim of Zero Waste), as well the overall quantity of raw material consumed by equipment and consumables suppliers, such as Foseco. There are also health and safety benefits gained by reducing the need for maintenance and so limiting the exposure of workers to man-machine interactions.

Linings are particularly relevant when it comes to extending lifetimes and reducing waste, as the following examples demonstrate:

- A TRIAD Z 160 lining with VESBOND binder applied to the iron transfer ladle at an Italian automotive foundry improved service life from 16 to 25 days – or from 4032 tons to 5600 tons of metal handled. It was also possible to repair the lining and re-use the ladle for a second run.
- A TRIAD Z 189 lining applied to a launder at a high-volume American foundry producing ductile iron castings extended service life to six days initially, compared to three days under the previous practice, with subsequent launders used for two weeks with periodic cleaning.
- The use of KELLUNDITE 859 dry vibratable lining for coreless induction furnaces increased the lifetime of a 30 ton capacity furnace at Voestalpine Linz by 25% over previous solutions, while also improving the consistency of lifetime.

Meanwhile, VAPEX multi-life nozzles overturn the tradition of replacing the nozzle with each shot. The new zoned nozzle for multiple uses can be used as often as the VISO stopper. VISO stoppers and VAPEX nozzles can also be supplied in reusable clipcrates or metal boxes, again helping to reduce waste.

A final innovation of note here is the development of concentrated inoculants, which allow foundries to use less inoculant, without compromising quality. This is because – as the name implies – concentrated inoculants have been developed to include more of the active ingredient. Importantly, they are also low-silicon and so help mitigate the risk of silicon overdose in alloys with critical silicon level requirements.



POLLUTION CONTROL

Regulation of air pollutants is constantly evolving and tightening, requiring similarly constant innovation to enable foundries to continue to meet the requirements.

This can be via equipment, such as gas treatment systems. But there is also a growing range of solutions that remove these harmful elements at source.

For example, water-based coatings, such as the SEMCO range of coatings, replace solvent-based offerings, while inorganic binders, such as SOLOSIL binders, replace organic binders.

Both remove harmful chemicals from the foundry and help eliminate potential emissions, without the need for expensive and potentially complicated investments in gas treatment systems.

Advances in one area can create challenges in others and the use of water-based coatings is an example of this. Water-based coatings are vulnerable to attack by micro-organisms, which leads to deterioration of the coating. This threat is commonly neutralised by the addition of a biocide that slowly releases formaldehyde. But with tightening of formaldehyde emissions regulations, notably in the EU, there is growing demand for coatings that are both water-based and formaldehyde-free, such as the SEMCO FF coating.

Fluoride is another element facing increased scrutiny.¹⁴ Fluoride compounds have been used to initiate exothermic reactions in exothermic feeder sleeves since the 1950s. However, their use is becoming problematic as regulations on the disposal of fluoride-containing materials tighten, due to the environmental impact of water-leachable fluorides. This can have a significant impact on foundry sand disposal costs. A range of fluoride-free feeding systems has thus been developed, such as FEEDEX FEF (fluoride emission free) spot feeders and KALMINEX FF sleeves.

- FEEDEX FEF spot feeders feature a new formulation for high-density ram-up feeder sleeves, which eliminates the conventional fluoride-based initiator for the exothermic reaction.
- The KALMINEX 2000 FF product is a fluoride-free exothermic slurry formulation for production of free vacuum-formed insert sleeves.

Both FEEDEX FEF and KALMINEX 2000 FF formulations deliver similar performance and benefits as their traditional fluoride-containing counterparts. FEEDEX sleeves are also designed to improve casting yield and feed performance (improving casting process efficiency, see above discussion), while

KALMINEX feeder sleeves have been shown to be highly effective at reducing riser size and providing consistent feeding performance in both iron and steel applications.

A further challenge related to the use of harmful materials within the foundry is posed by mould release agents.¹⁵ Applied between the mould and the pattern, these agents are traditionally petroleum based, being manufactured from low-quality oil and classified as harmful, toxic, or dangerous under EU legislation. They also have relatively low flash points, which has resulted in a number of foundry fires in recent years. PARTISAL ECO release agents tackle both these issues, being both non-hazardous (similar to food-grade lubricants) and with a high flashpoint; they are also easy to apply and deliver high de-moulding efficiency and lubrication performance.

Finally, powder-based coatings help reduce waste and lower transportation costs and emissions. INSTA coatings, for example, are about half the volume of slurry-based alternatives and do not require the use (and subsequent disposal) of plastic buckets or drums for transport.



FOUNDRY 4.0

Today's production can be networked in such a way as to be highly flexible and precisely tailored to customer requirements.

A final piece in the sustainability puzzle is the use of the latest digital technologies to improve foundry processes – an innovation dubbed Foundry 4.0. Digital solutions offer the ability to network, monitor and precisely control processes as never before. This results in foundries that are more efficient and productive, bringing both financial and environmental sustainability benefits.

The Intelligent Coating Unit (ICU), for example, automates the process of measuring and controlling the dilution of refractory linings to ensure the correct consistency is maintained and the optimum properties for application are maintained. At a foundry in the UK, this resulted in uniform coating layer thickness,

reducing coating waste and increasing core shop productivity by 25%. Casting scrap and rework requirements were also reduced.

The new FERROLAB V measuring system, meanwhile, provides advanced easy-to-use thermal analysis of liquid iron, resulting in consistent quality, less variation in casts, and ultimately a reduction in scrap rates. It does this by precisely monitoring the melt and compensating for changes in the feed material with precise addition of inoculants and magnesium carriers. This ensures the correct physical properties of the base iron are maintained and controls nucleation, microstructure formation and shrinkage.

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THE --- CONCLUSION

With its complete range of foundry products and expertise, Foseco offers solutions that ready the foundry industry to overcome the sustainability challenge in all of its forms. Through our parent company, Vesuvius, we are also committed to sustainability in our own operations via the Vesuvius Sustainability Strategy, which includes commitments to the following:

- Fight climate change by reducing our own CO2 emissions and helping our customers reduce their own CO2 footprint with the use of our products and services. Our objective is to reach a net zero carbon footprint at the latest by 2050.
- Engage in the circular economy by reducing the amount of waste we generate, recovering more of our products after they have been used, and increasing the usage of recycled materials.
- Extend our sustainability commitment to our suppliers and encourage them to progress.
- Improve safety and wellbeing at work both for our employees in our facilities and for our customers

Economics and the environment are often played off against each other. But as we have seen throughout this white paper, this is a false dichotomy. Indeed, the two often accompany each other in technologies and solutions that reduce the consumption of energy, that optimise yields, that improve the longevity of foundry equipment and ensure the quality of castings, and that reduce the production of harmful pollutants.

Achieving sustainability is not however the outcome of one company's efforts. It is a collective approach to the way we act and operate as an industry. Only together, we can forge the future of the foundry industry, today.

THE FOSECO SUSTAINABILITY TOOLBOX

... HOW OUR PRODUCTS CAN CONTRIBUTE

Sustainability has always been at the heart of our business. Our technology has helped our customers improve their processes and their environmental footprint. Advancements in material science, pioneered by Vesuvius, have helped to ensure that the amount of refractory material required to cast one tonne of steel has reduced by 80% in the past 60 years.

Concentrated inoculants contain an increased quantity of the active ingredient and reduced silicon, providing similar performance to traditional recipes, but in smaller doses.

FEEDEX VAK self-centring feeder sleeves offer minimum footprint and contact area, optimum mould sand compaction, and constant feeder volume for improved yield, easy knock-off, and minimum fettling work.

FEEDEX FEF spot feeders deliver similar performance and benefits as traditional FEEDEX feeders, without the fluoride emissions.

The Intelligent Casting Unit (ICU) automates the coating process to deliver a consistent layer thickness and ensure optimised coating performance.

HOLLOTEX shroud protects pouring metal from reoxidation, while reducing heat loss during mould filling.

INSTA powder-based coatings reduce packaging waste and transportation costs and emissions compared to ready-for-use coatings.

KALMINEX FF fluoride-free slurry for the production of free vacuum-formed exothermic sleeves eliminates the use fluoride, while delivering similar performance to traditional slurry form recipes.

KALPUR direct pouring for automatic green sand moulding lines improves yield and cast quality by reducing fettling and non-metallic inclusions, lowering turbulence-related defects, and improving directional solidification.

KALTEK insulating ladle linings for iron and steel alloys improve thermal and energy efficiency, while ensuring metal quality in metal transfer vessels.

KELLUNDITE lining systems for coreless induction furnaces help reduce waste and energy consumption with increased refractory life and reduced sintering time.

The ROTOCLENE melt treatment process purges the melt with ultra-fine bubbles to effectively remove oxygen bi-fold and other inclusions, while also homogenising melt temperature.

PARTISAL ECO release agents include non-toxic oils with high flash points to replace harmful, more easily flammable petroleum-based oils.

STELEX filters enhance casting quality by removing non-metallic inclusions and providing better control of mould fill.

SEMCO water-based coatings eliminate the health, safety, and environmental issues that arise with solvent-based coatings, such as the release of VOCs and solvent-related respiratory conditions. The range includes:

SEMCO CC colour change coatings visually indicate when the coating is dry, reducing the potential for over-drying.

SEMCO FD fast-drying coatings reduce energy consumed in the drying process, while maintaining product performance

SEMCO FF formaldehyde-free coatings are designed to reduce formaldehyde emissions in compliance with the latest EU regulations.

SOLOSIL inorganic binders are a range of low-viscosity, high-performance sodium silicate binders with advanced breakdown agents.

TRIAD Z castable linings for cupola melting increase campaign life, with high resistance to slag erosion, in an easy-to-mix solution that requires no post-application curing.

VAPEX multi-life nozzles overturn the standard practice of replacing nozzles after one shot and can be used as often as the VISO stopper for a safer working environment, higher productivity, and less waste.

Warm start lade package comprises KALTEK lining, warm-start VISO stopper, and VAPEX nozzle, and reduces preheating to a minimum.

A BETTER TOMORROW

Vesuvius & Foseco

VESUVIUS

From our very beginnings, our core business has been to improve our customers' operational performance. This delivers a number of environmental benefits, including reduced consumption of materials, less scrap and waste and improved metal yield and energy consumption, which result in lower CO₂ emissions.

2020 marked a new beginning in this journey.

We set an overarching objective to reach a net zero carbon footprint at the latest by 2050.

We became signatories to the UN Global Compact, making a formal public commitment to support its principles on human rights, labour, environment and anti-corruption, and to engage in activities which advance the development of the UN's Sustainable Development Goals.

Our goal: to create a better tomorrow for our planet, our customers, our people and our communities.



Our planet



Our customers



Our people



Our communities

FIND OUT MORE AT: [VESUVIUS.COM/SUSTAINABILITY](https://www.vesuvius.com/sustainability)

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