# IMPROVEMENT IN FOUNDRY ENVIRONMENT

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**ABSTRACT:-**

Present article mainly focuses upon environment related challenges to which the foundry industry is ever exposed to. Good deal of research articles have been consulted in order to develop the most relevant outline for the article in question. Information contained in the article would be of great help to the academia in general and the foundry industry in particular.

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## Introduction:-

The foundry industry faces specific challenges with respect to economic and environmental sustainability. Foundry processes require substantial energy, typically generated using fossil fuels; whether onsite or remotely at an electrical power plant. Melting the material consumes the majority of this energy; however, other energy intensive processes such as heat treatment are also included in many foundry operations. Also, a majority of foundries utilize sand as a molding material. The binders utilized can often include organic compounds, and, when burned out in the casting process, release volatile organic compounds and hazardous air pollutants which are regulated. The casting finishing process can also utilize organic materials which can result in environmental impact [1]. Figure 1 shows a diagram of a typical foundry system with potential waste streams.

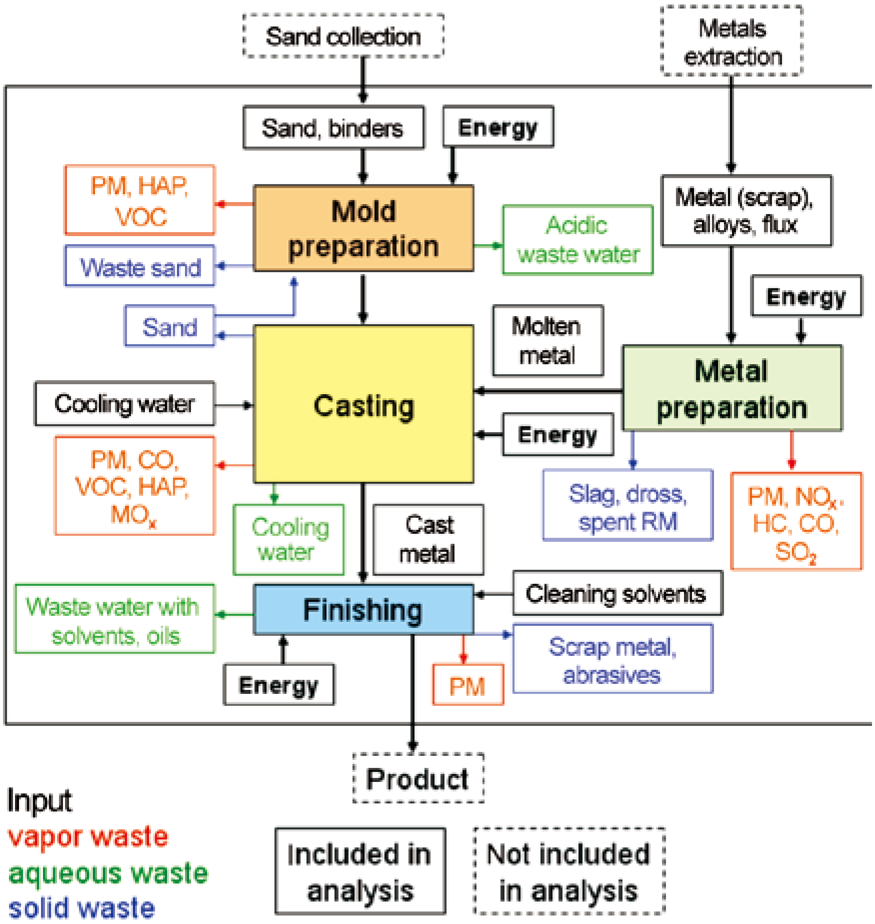


**Fig. 1: Example of foundry system waste streams [2]**

## Industry-Specific Impacts and Management:

There are different problems associated with foundries, which occur during the operational phase, along with recommendations for their management. Recommendations for the management of EHS(environment, health and safety) issues common to most large industrial facilities during the construction and decommissioning phases are provided in the General EHS Guidelines[3].

## Environment:-

Environmental issues associated with this sector primarily include the following:

- **Air emissions**

Gas emitted into the air from industrial and chemical processes, such as ozone, carbon monoxide, nitrogen oxide, nitrogen dioxide, sulfur dioxide and others.

- **Solid waste**

Solid waste makes up a large portion of the pollution from foundries. The waste comes from sand, slag, emissions control dust and spent refractories. Sand waste from foundries using sand molds has been identified as the most pressing waste problem in foundries. Molding and core sand make up 66-88% of the total waste from ferrous foundries.

- **Noise**

A sound, especially one that is loud or unpleasant or that causes disturbance.

## Air Pollution:-

Air pollution is a major environmental problem for foundries. The most significant releases to air are:

- VOCs (including partially oxidised hydrocarbons) and odorous substances from mould production, casting, cooling and knocking out
- Dust and fumes from melting, hot metal transfer and casting
- Dust and fumes from materials handling and finishing operations
- Dioxins and other persistent organo-halogens, which may be produced during the melting of scrap contaminated with paint, plastics or lubricating oil
- Lead, zinc, cadmium and other heavy metals released and concentrated in bag filter dusts or wet scrubber liquors and sludges[3].

## Dust & Particulate Matter:-

Dust and particulate matter are generated in each of the process steps with varying levels of mineral oxides, metals (mainly manganese and lead), and metal oxides. Dust emissions arise from thermal (e.g. melting furnaces) and chemical / physical processes (e.g. molding and core production), and mechanical actions (e.g. handling of raw materials, mainly sand, and shaking out and finishing processes).

## Solid Waste:

Solid waste makes up a large portion of the pollution from foundries. On-quarter to one ton of solid waste per one ton of castings is expected (Shah, 1995). The waste comes from sand, slag, emissions control dust and spent refractories. Sand waste from foundries using sand molds has been identified as the most pressing waste problem in foundries (Twarog, 1992). Molding and core sand make up 66-88% of the total waste from ferrous foundries (USEPA, 1992) [5].

Fig 2) Solid waste as scrap [5]

Solid waste of the following forms is included as solid wastes:

- Investement Casting Waste
- Cleaning Room waste
- Air Emission Control
- Sand Waste
- Slag Waste

### Investment Casting Waste:

Although investment castings are not as widely used as sand castings, they also produce solid waste, as they are usually destroyed when removed from a work piece. Spent molds are non-hazardous unless heavy metal alloy constituents are present. Spent wax, used as patterns for the molds, also contribute to solid waste. The patterns are removed by melting the wax and can usually be reused [5].

## Sand Waste:

Green foundry sand is routinely reused. After the sand is removed from the metal piece, it can easily be remolded. However, sand fines develop with reuse. These particles are too small to be effective in molds and have to be removed and often landfilled.

Sand that is chemically bound to make cores or shell molds is more difficult to reuse effectively and may be landfilled after a single use. Sand recovery methods, as discussed later, have been investigated with mixed results.

Sand wastes from brass and bronze foundries pose further waste problems as they are often hazardous. Lead, copper, nickel, and zinc may be found in the sand in sufficient levels to require further treatment before disposal. If metal levels are sufficient, recovery methods may be employed [6].

### Slag Wastes:

Slag waste is often very complex chemically and contains a variety of contaminants from the scrap metals. Common components include metal oxides, melted refractories, sand, and coke ash (if coke is used). Fluxes may also be added to help remove the slag from the furnace. Slag may be hazardous if it contains lead, cadmium, or chromium from steel or nonferrous metals melting. Iron foundry slag may be highly reactive if calcium carbide is used to desulfurize the iron. Special handling is required for highly reactive waste [6].

Fig 3) Slag waste of Blast furnace [6]

## Cleaning Room Waste:

Finished metal pieces are often cleaned in abrasion cleaning systems. The abrasive cleaners and the sand they remove from the metal pieces contribute to solid waste. Grinding wheels and floor sweepings also add solid waste. These wastes are collected and usually landfilled [5]

Recommended prevention and control to reduce fugitive emissions of dust include the following:

- Use of pneumatic conveying systems, particularly for transferring and feeding additives into the process area;
- Use of enclosed conveyers with dust-controlled transfer
- points, especially when transferring sand into the molding shop;
- Clean return belts in the conveyor belt systems to remove loose dust;
- Use indoor or covered stockpiles or, when open-air stockpiles are unavoidable, use water spray system, dust suppressants, windbreaks, and other stockpile management techniques;
- Use of enclosed silos to store bulk powder materials;
- Implement routine plant maintenance and good housekeeping to keep small leaks and spills to a minimum.
- Use of induction furnaces, where possible;
- Use of open hearth furnaces is no longer considered good practice for steel smelting and should be avoided;
- Avoid use of traditional cupola furnace technology. If cupola furnaces are used, enhanced technologies should be adopted to increase furnace energy efficiency and reduce the coke charge, including:
- Use of oxygen injection or enrichment of blast air
- Superheating of blast air in hot blast cupolas
- Use of cokeless cupola where the metal charge is heated by the combustion of natural gas.
- Use dry dust collection technologies (e.g. bag filters and cyclones) instead of wet scrubbers, especially in green sand preparation plants. The dry techniques allow dust to be easily collected, transported, and recirculated into the sand mixing process, thus avoiding the creation of effluent from wet scrubbers;

- Use of filters on exhausts, especially in casting and finishing shops;
- Use of vacuum cleaning in moulding and casting shop;
- Install closed dedusting units in working areas[4].

In the melting process, particulate matter (PM) emissions in the form of dust, metallic materials, and metal oxide fumes, vary according to furnace type, fuel, metal to be melted and melting characteristics. Cupola furnaces produce the most significant amount of particulate matter (e.g. coke, fly ash, silica, rust and limestone). Electric arc furnaces (EAFs) are another significant source of PM during charging, at the beginning of melting, during oxygen injection, and during the decarburizing phases. Lower emission rates are associated with other melting furnaces types, particularly induction furnaces. Load-based emissions for metal melting range from insignificant values for certain nonferrous metals up to above 10 kilograms per ton (kg/ton) for melting of cast iron using a cupola furnace [3].

Recommended pollution prevention techniques include the following:

Use of dust control technologies, typically including installation of bag filters and cyclones to control emissions from melting processes. Wet scrubbers may be used to capture water-soluble compounds (such as sulfur dioxide (SO2) and chlorides). The adoption of cyclones as pretreatments and use of bag filters typically enables emission levels of 10 $mg/Nm^3$ or less [4]. Implement technologies in melting furnaces which allow reduction of energy consumption (e.g. installation of oxyfuel burners, slag foaming practice in the EAFs, or oxygen injection whichever is applicable) [4].

**Installation of Off-Gas Collection Hoods For Cupolas**,

Canopy hood enclosures for electric arc furnaces (EAFs), and cover extraction for induction furnaces to reduce fugitive emissions. Installation of an appropriate furnace hooding system may facilitate the capture of up to 98 percent of the furnace dust[4].

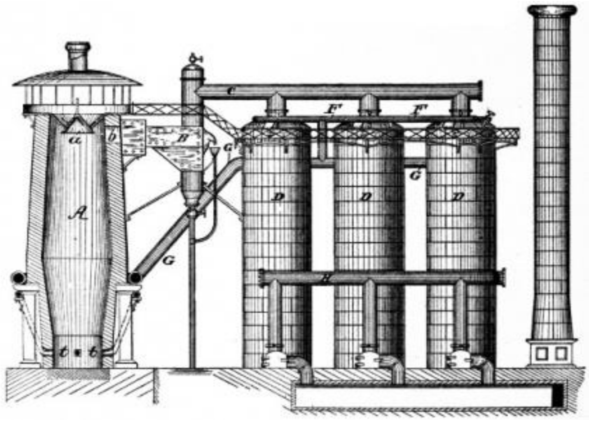

Fig 1) Secondary products collection in Blast furnace [4]

**Use of Dust Control Technologies**, typically including installation of bag filters and cyclones to control emissions from melting processes. Wet scrubbers may be used to capture water-soluble compounds (such as sulfur dioxide (SO2) and chlorides). The adoption of cyclones as pretreatments and use of bag filters typically enables emission levels of 10 $mg/Nm^3$ or less.

The large amount of sand used in lost mold casting generates dust emissions during the various molding stages, and produces non-metallic particulates, metallic oxide particulates, and metallic iron. Non-metallic particulates are emitted from casting, shakeout and finishing processes.

## Volatile Organic Compounds (VOCs) and other hazardous air pollutants:-

Emissions of VOCs, mainly consisting of solvents (e.g. BTEX – benzene, toluene, ethyl benzene, and xylenes) and other organics (e.g. phenols and formaldehyde) are primarily generated by the use of resins, organic solvents, or organicbased coatings in molding and core making. Organic hazardous air pollutant (HAP) emissions may also be released during the pouring, cooling, and shakeout of either green sand or no bake molds, resulting from the thermal decomposition of the organic compounds (carbonaceous additives contained in green sand molds and different core binders) during metal pouring.

Cold-box systems using organic solvents may generate emissions of VOCs during core production and storage. Amines are the most significant emissions, and may pose a potential hazard due to their low odor detection thresholds and relatively low exposure value limit. Potential hazardous air pollutants are emitted when chemical binding systems are used during hardening, coating and drying, including formaldehyde, methylene diphenyl diisocyanate, isopropyl alcohol, phenol, amines (e.g. triethylamine), methanol, benzene, toluene, cresol / cresylic acid, naphthalene and other polycyclic organics, and cyanide compounds.

## Air Emissions Control:

Baghouse air emission control systems are one of the most frequently used technology for controling air emissions in foundries. Air is pumped into the baghouse where particulates accumulate on a fabric filter. The system is efficient for removing particles above or below 0.1 - 0.3 micrometers (Shah, 1995). Other types of air emissions control systems may also be used including wet scrubbers, absorption and adsorption systems, combustion and electrostatic precipitation. All systems produce a solid waste from the air emissions and release the cleaned air.

The emissions control dust is collected at almost all stages of foundry production. If it does not contain hazardous wastes, it is usually landfilled. However, steel foundries frequently produce emissions control dust that contains zinc, lead, nickel, cadmium, and chromium, depending on the metal content. Nonferrous emissions control dust may also be classified as hazardous due to copper, aluminum, lead, tin and zinc. Depending on the metals content in the emissions control dust it may be permitted for land fill, or it may require further treatment before disposal. Nonferrous foundry dust often contains sufficient levels of metals to make metal recovery economically favourable [5].

# Noise:

Noise induced hearing loss is a common injury occurring in foundry work. Hazardous noise may affect how the inner ear works, which can cause temporary or permanent hearing loss, tinnitus and difficulties in communication. Hazardous noise can destroy the ability to hear clearly and can also make hearing sounds necessary for working safely more difficult, for example instructions and warning signals.

Hazardous noise for hearing loss means noise that exceeds the exposure standard for noise in the workplace. The exposure standard for continuous noise is 85 decibels dB(A)averaged over an 8 hour equivalent, and is 140 dB(C) peak for impulse noise. Regard less of the exposure standard, exposure to noise should be minimised so far as is reasonably practicable.

Noise levels for foundry equipment and processes often used in foundries are shown in Table 1. Pattern and core making, moulding, knockout and cleaning operations, fettling and some furnace operations are among processes which are likely to produce noise levels above the exposure standard [7].

**Table 1** The dB(A) levels of common foundry equipment and processes

| Foundry equipment and processes | dB(A) |
|---|---|
| Mould vibrators | 85-114 |
| Inverter | 83-116 |
| Arc/air gauging | 82-107 |
| 9-inch angle grinder | 97-110 |
| Shot blasting | 86-101 |
| Shake out | 84-95 |

Source: *Your health and safety guide to Foundries*, WorkSafe Victoria, 2007 [8].

Recommended pollution prevention and control techniques for VOC and other hazardous air pollutant emissions include:

- Minimize binder and resin use through optimization of process control and material handling in mixer operations and through temperature control;
- Optimize temperature control during core making;

Replace alcohol-based coating (e.g. isopropyl alcohol) with water-based coating;

- Use non-aromatic solvents (e.g. vegetable oil methyl esters or silicate esters) in core box production;
- Minimize curing gas used for ‘cold box binders’.
- Enclose molding or coring machines as well as temporary core storage areas;
- Use cold box systems (e.g. activated carbon adsorption, incineration, chemical scrubbing or biofiltration) to treat spent amines;
- Use of collection systems (e.g. canopy hoods) to capture VOC resulting from chemically-bonded sand preparation, in addition to pouring, cooling and

shakeout. Use of adsorption to activated carbon, catalytic oxidation, or biofiltration treatment, as necessary[9].

Control measures include:

- Eliminating exposure to hazardous noise e.g. by replacing existing plant or processes with quieter plant or processes
- Modifying or replacing plant and processes to reduce the noise using engineering control measures
- Isolating workers from the source of the noise by using soundproofing enclosures or using distance, barriers and sound absorbing surfaces
- Providing quiet rest areas
- Providing task-specific hearing protection for workers and continually reviewing noise levels while consulting with workers about the means to reduce noise
- Checking the effectiveness of risk control measures so the noise exposure standard is not exceeded.

The purpose of audiometric testing is to determine whether workers have suffered noise induced hearing loss. If so, the control measures should be reviewed and workers consulted about the most effective way to reduce noise.

Some chemicals can contribute to hearing loss and are known as ototoxins. In a foundry, workers may be exposed to ototoxins like mercury or lead [7].

## General Guidelines for Foundries

### 1. Pollution Prevention and Control Measures

The following pollution prevention measures should be considered, (World Bank Group, 1998) [10].

- Prefer induction furnaces to cupola furnaces.
- Replace the cold-box method for core manufacture, where feasible.
- Improve feed quality: use selected and clean scrap to reduce the release of pollutants to the environment. Preheat scrap, with afterburning of exhaust gases.
- Store scrap under cover to avoid contamination of storm water.
- Provide hoods for cupolas or doghouse enclosures for EAFs and induction furnaces.

- Use dry dust collection methods such as fabric filters instead of scrubbers.
- Use continuous casting for semi finished and finished products wherever feasible.
- Store chemicals and other materials in such a way that spills, if any, can be collected.
- Control water consumption by recirculating cooling water after treatment.
- Use closed-loop systems in scrubbers where the latter are necessary.
- Reduce nitrogen oxide (NOx) emissions by use of natural gas as fuel, use low-NOx burners.
- Reclaim sand after removing binders.

**2. Pollution Reduction Targets**

The recommended pollution prevention measures can achieve the target levels given below.

***Air Emissions*** Recover metals from collected dust. The target value for PM from furnaces and die casting machinery is not to exceed 0.5 kg/t of molten metal (after controls). The oil aerosol should not exceed 5 mg/Nm$^3$.

***Wastewaters***

Recycle wastewaters, if any. Avoid allowing contamination of storm water with oil; oil in storm water is not to exceed 5 mg/l.

***Solid Wastes***

Reclaim sand used in molding.

**3. Treatment Technologies**

***Air Emissions***

Dust emission control technologies include cyclones, scrubbers (with recirculating water), baghouses, and electrostatic precipitators (ESPs). Scrubbers are also used to control mists, acidic gases, and amines. Gas flame is used for incineration of gas from core manufacture. Target values for emissions passing through a fabric filter are normally around 10 mg/Nm$^3$ (dry). Emissions of PM from furnaces (including casting machines used for die casting) should not exceed 0.1–0.3 kg/t of molten metal, depending on the nature of the PM and the melting capacity of the plant. At small iron foundries, a somewhat higher emission factor may be acceptable, while in large heavy-metal foundries, efforts should be made to achieve a target value lower than 0.1 kg PM per metric ton. Odors may be eliminated by using bio scrubbers.

***Wastewater Treatment***

Recirculate tumbling water by sedimentation or centrifuging followed by filtering (using sand filters or ultrafilters); separate oil from surface water. In the very rare cases in which scrubbers are used, recirculate water and adjust its pH to pre-cipitate metals. Precipitate metals in wastewater by using lime or sodium hydroxide. Cooling waters should be recirculated, and polluted storm water should be treated before discharge.

## 4. Emissions Guidelines

The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems. The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is un-acceptable. All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours, (World Bank Group, 1998)[10].

***Air Emissions***

Air emissions of PM should be below 20 $mg/Nm^3$ where toxic metals are present and 50 $mg/Nm^3$ in other cases. This would correspond to total dust emissions of less than 0.5 kg/t of molten metal.

***Liquid Effluents***

For foundries, the effluent levels presented in Table 1 should be achieved. In Table 2 the emission limits applied in some EU member states are shown, (Haskoning, 1997)[11].

### Solid Waste

Sludges from wastewater treatment operations should be disposed of in a secure landfill after stabilization.

***Ambient Noise***

Noise abatement measures should achieve either the levels given below in Table 3, or a maximum increase in background levels of 3 dB (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

### 5. Monitoring and Reporting

Air emissions should be monitored continuously for PM using an opacity meter (for an opacity level of less than 10%). Wastewater discharges should be monitored daily except for metals, which may be monitored monthly or when there are process hanges. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

## Conclusion:-

Foundry industry faces many challenges with respect to environmental sustainability. These environmental issues are associated with air emissions, solid waste, water waste and noise. Air emissions are polluting the atmosphere, as foundry air emissions contain VOCs, heavy elements etc. In the same way waste water also contaminate the soil and the under water resources. Solid waste of foundries is also major problem which compromises of used sand, slag and spent refractories. In this review article, environmental issues related to foundries are discussed and to minimize these issues some general guide lines are given, which would be help for academia and specifically for foundry industry.

## Acknowledgements:-

In the name of "Allah", the most beneficent and merciful who gave us strength and knowledge to complete this Case study report "Improvement in Foundry Environment". This review has been prepared under the supervision of Prof. Dr. Khalid Mahmood Ghauri by Zeeshan Khalid & Mubbusher Zia khan.

## Abbreviations

EHS(Environment, health and safety

PM (Particulate Matter)

EAFs (Electric arc furnaces)

VOCs (Volatile organic compounds)

Db ( Decibel)

ESPs (Electrostatic precipitators)

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