Application of Various Equipment Used In Foundry for Prevention of Pollution - A Review

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Abstract:

Foundry process for production, treatment or handling of liquid metals can generate lot of dust particles, air pollutants and fumes. This is very harmful for human health and adverse effects on environment. In line with eco efficiency principle the first objective should be to prevent these emissions or to capture them before their release. It is impossible to vanish but it can be minimized by use of Modern pollution controlling equipment. A few points on the waste and cost reduction opportunities for foundry have also been presented in this paper. The main principle of Green foundry is described in this paper.

Keywords: Emission, Pollution control, VOCs reduction, Green Foundry

1 INTRODUCTION

Foundry produces casting that close to the final product shape, i.e., “near net shape” components. Castings are produced by pouring molten metal into moulds with cores used to create hollow internal section. After the metal has cooled sufficiently, the casting is separated from the mould and undergoes cleaning and finishing techniques as appropriate. Air pollution is a major environmental problem for foundries. The most significant releases to air are VOCs (including partial oxidized hydrocarbons) and odorous substance from mould production casting, cooling and knocking out, Dust and fumes from melting, material handling, finishing operation, hot metal transfer and casting, Dioxins and other organo halogens, which may produce during the melting of scrap contaminated with paint, plastics or lubricating oil, Lead, Zink, Cadmium, and other heavy metal.

Minimization of emission, efficient raw material and energy usage, optimum process, chemical utilization, recovering and recycling of waste and substitution of harmful substances are the important principles of the green foundry. 4Rs (reduce, reuse, recycle, remanufacturing) is accepted and adopted as a model of growth and sustainability all over the world. The emission and other pollutants are being reduced by installing some extra equipment in the industry. Some new techniques adopted in the foundry process are helping in optimizing the energy usages.

2 LITERATURE REVIEW

Mr. G.V. Thakre has conveyed various sources of emissions & pollutants for foundry operation. Moulding, melting & casting are the process required for the foundry operation. In this process liberation of heat, noise, Small particle dust, fumes and gases are generated. He describes different types of pollutants emitting from foundry process for controlling purpose in industry, the pollutants emitting from different areas and measures that has be taken by industry to control that pollution. He also discusses the controlling devices to reduce the emitting pollutants in the foundry operation. Every controlling device has to depend on foundry layout to execute dust and fume control.

Mr. Mats Holmgren and Peter Naystrom (2008) described the important principle of green foundry. In this a new greensand with low VOC –emission has introduced. The water based coating and inorganic solvants are used to reduce the VOCs and odour emission from the lost mould system. Many foundries make intensive use of sand as a primary material. For increasing the performance, sand should be reused and regenerate. For regeneration of sand various techniques are used. The selection of binders’ type and sand composition are one of the main consideration. Green sand - NAYVOC has taken in account for the better performance. It is a 60/40 mixture of coal dust and the new additive called green sand-NAYVOC. The emission is reduced by 35% and no negative effect have been observed for either casting quality or moulding sand properties.

Mr. R. Krishnaraj (2015) explained about the health hazard problem in the process of foundry. The foundry workers are exposed to the polycyclic aromatic hydrocarbon (PAH), which causes damage of the blood cells. The chemical used in foundry practice causes damage to many part of the bodies of the foundry workers. Some of those parts are damaged due to the foundry emission are lungs, liver & brain. Besides this the silica of the moulding sand affects the DNA of the foundry workers. The various pollutant emitted by the foundry are very harmful for worker's health & it will also affects the surrounding environment. To prevent these problems lots of devices are being used in the industry to collect the dust particle & also separate the small dust particle from the gas.

L. Venkatesh Muthuraman (2014) elaborated that in Today's world energy crisis increases exponentially. This should be lower down early on. In foundry operation more than 50% of energy is consumed to melt the raw material & this energy goes to waste when the molten metal solidifies in the sand mould. In his experiment the raw material embeds the sand moulds around the mould cavity & try to make it in such a way that the raw materials align themselves close to cavity and heat get used & preheats which the molten metal release it during solidification. Melting of raw material can be done with the help of these method; 1) induction furnace 2) electric arc furnace 3) cupola furnace. This experiment justifies that conservation of the energy is about 10-20% of the required melting energy.

H. Merve Basar (2012), has mentioned the re-usability of waste foundry sand (WFS) in ready mixed concrete (RMC). The mixture of different composition (0%, 10%, 20%, 30%, 40%) of regular sand by weight has been tested. The mechanical, leaching and micro-structural properties are the three aspects for qualification of WFS based RMC. The mechanical test shows that the addition of WFS reduces the strength and density but increases the water absorption ratio. Leach-ability characteristics at different pH represent variant natural cases. Furthermore, microstructure investigation of both control mixture and concrete mixture were performed by XRD, XRF, SEM and EDS techniques. This research suggests that if replacement is not exceeded by 20% then WFS can be effectively utilized in making good quality RMC.

Renato M. Lazzarin (2015), gives the information regarding the energy used in various processes in the foundry. Energy audits in Italian cast iron foundries has been performed in which main equipment was surveyed and evaluated the influence on overall energy consumption, producing a detailed analysis of energy use per department and energy perform indices. Heat recovery was identified in combustion air preheating, for building heating or to power direct cycle to produce electricity. The efficiency and process quality can be improved further more by using better and new insulating material.

3 METHODS USED FOR REDUCING POLLUTANTS IN FOUNDRY:

Stationary sources of air pollution emissions in foundry processes, release contaminants into the atmosphere as particulates, aerosols, vapors, or gases. These emissions are typically controlled to high efficiencies using a wide range of air pollution control devices. The selection of the appropriate control technology is determined by the pollutant collected, the stationary source conditions and the control efficiency required. In some cases, pollutant emissions can be reduced significantly through process modifications and combustion controls. However, in most instances, some form of add-on pollution control equipment is installed in the ductwork (or flues) leading to the smoke stack to meet current allowable emission limits.

The most commonly used devices for controlling particulate emissions include;

- Electrostatic precipitators (wet and dry types),
- Fabric filters (also called bag houses),
- Wet scrubbers, and
- Cyclones (or multiclones)

In many cases, more than one of these devices are used in series to obtain desired removal efficiencies for the contaminants of concern. For example, a cyclone may be used to remove large particles before a pollutant stream enters a wet scrubber.

Common control devices for gaseous and vapor pollutants include:

- thermal oxidizers,
- catalytic reactors,
- carbon absorbers,
- absorption towers, and
- bio filters.

The following table presents a list of common control devices, the typical contaminates they Control.

Table 1: Equipment used for various pollutants

Common Control Devices	Pollutants
Packed towers, spray chambers, venture scrubbers	Gases, vapors, Sulphur oxides, corrosive acidic or basic gas streams, solid particles, liquid droplets

Carbon absorbers	Vapor-phase volatile organic compounds (VOCs), hazardous air pollutants (HAPs)
Fabric filters or bag houses	Particulate matter (PM)
Catalytic reactors, catalysts	VOCs, gases
Cyclones	Large PM
Electrostatic precipitators (ESPs)	PM
Incinerators, thermal oxidizers, after burners	VOCs, gases, fumes, hazardous organics, odors, PM
Bio filters	VOCs, odors, hydrogen sulfide (H_2S), mercaptans (organic sulfides)

The following describes applications of these various pollution control devices in more detail.

3.1 Electrostatic Precipitators

ESPs are relatively large, low velocity dust collection devices that remove particles in much the same way that static electricity in clothing picks up small pieces of lint. Transformers are used to develop extremely high voltage drops between charging electrodes and collecting plates. The electrical field produced in the gas stream as it passes through the high voltage discharge introduces a charge on the particles, which is then attracted to the collecting plates. Periodically the collected dust is removed from the collecting plates by a hammer device striking the top of the plates (rapping) dislodging the particulate, which falls to a bottom hopper for removal.

Electrostatic precipitators are often configured as a series of collecting plates to improve overall collection efficiency. Efficiencies exceeding 99% can be achieved, and ESPs are used in many of the same applications as bag houses, including power plants, steel and paper mills, smelters, cement plants, and petroleum refineries. In some applications water is used to remove the collected particulates. ESPs using this cleaning mechanism are referred to as "wet ESPs" and are often used to remove fumes such as sulfuric acid mist.

3.2 Fabric Filters or Bag House

Fabric filters, also commonly referred to as bag houses, are used in many industrial applications. They operate in a manner similar to a household vacuum cleaner. Dust-laden gases pass through fabric bags where the dry particulates are captured on the fabric surface. After enough dust has built up on the filters, as indicated by a buildup in pressure across the fabric, dust is periodically removed by blowing air back through the fabric, pulsing the fabric with a blast of air, or shaking the fabric. Dust from the fabric then falls to a collection hopper where it is removed. As dust builds up on the fabric, the dust layer itself can act as a filter aid improving the removal efficiency of the device. Fabrics used in bag houses can be made of a number of different materials, selected for the particular application. Common materials for these filters include paper, cotton, Nomex, polyester, fiberglass, Teflon, and even spun stainless steels. Bag houses maximize the filtration area by configuring the fabric filter media into a series of long small-diameter fabric tubes referred to as "bags". The bags are tightly packed into one or more filter compartments with one compartment normally off-line for cleaning. Most bag houses contain as many as ten or more compartments with several hundred bags per compartment. Bag houses are used to control air pollutants from coal-fired power plants, steel mills, foundries, and other industrial processes. Fabric filters can collect over 99.9% of the entering particulates, even fine PM. Bag houses also are sometimes used as part of a multistage gas cleaning system where they are used as a reactor as well as a particulate removal device, such as in semi-dry flue gas desulphurization systems.

3.3 Wet Scrubbing Equipment

Scrubbing is a physical process whereby particulates, vapors, and gases are controlled by either passing a gas stream through a liquid solution or spraying a liquid into a gas stream. Water is the most commonly used absorbent liquid. As the gas stream contacts the liquid, the liquid absorbs the pollutants, in much the same way that rain droplets wash away strong odours on hot summer days. Common types of gas absorption equipment include spray towers, packed towers, tray towers, and spray chambers. Packed towers are by far the most commonly used control equipment for the absorption of gaseous pollutants. However, when used with heavy, particulate-laden gas, they can be plugged by particulate matter (PM). Wet collection devices used for PM control include venturi scrubbers, bubbling scrubbers, spray towers, and in some instances, wet electrostatic precipitators (ESPs). Scrubbers use a liquid stream to remove solid particles from a gas stream by impacting these particles with water droplets either through water spraying into the gas or through violent mixing of water with the gas stream. For example, in a venturi scrubber, gas that is laden with PM passes through a constricted section of the scrubber (venture throat) where water and gas reach high velocities, resulting in high turbulence in the water and gas streams, which causes water droplet-particle contact.

Water is directed into the gas stream either immediately before or at the venture throat. The difference in velocity and pressure resulting from the constriction causes many small and larger water droplets to form. These droplets then collide with the particulates and essentially stick to them. The reduced velocity at the expanded end of the venture throat allows droplets of water containing the particles to coalesce into larger droplets, which then drop out of the gas stream. Often a large cyclonic section is placed after the venture to improve fallout of PM-laden water. Wet scrubbers can be highly effective in removing particles, with removal efficiencies of up to 99%; however, their efficiency for very small particles can be much lower. Wet scrubbers produce a wastewater stream that will likely require treatment before reuse or discharge. When possible, collected PM is separated from the water, and the water is reused, but this is often difficult; disposal of a wet sludge by-product is often required.

Cyclones (or Multiclones)

Dust-laden gas is whirled rapidly inside a collector shaped like a cylinder (or cyclone). The swirling motion creates centrifugal forces that cause the particles to be thrown against the walls of the cylinder and drop into a hopper below. The gas left in the middle of the cylinder after the dust particles have been removed moves upward and exits the cylinder. Cyclones operate to collect relatively large size PM from a gaseous stream, and can operate at elevated temperatures. Cyclones are typically used for the removal of particles 50 microns (µm) or larger. Efficiencies greater than 90% for particle sizes of 10 µm or greater are possible, and efficiency increases exponentially with particle diameter and with increased pressure drop through the cyclone. Cyclones are widely used; they control pollutants from cotton gins, rock crushers, and many other industrial processes that contain relatively large particulate in the gas stream. They can be used to remove either solid particles or liquid droplets. Cyclones can experience a number of problems including particles recirculating from the hopper, and erosion and corrosion of the cyclone internals due to the nature of the material being collected (corrosive and/or abrasive). Heavy dust at the inlet of the cyclone can also lead to plugging of the cyclone hopper.

3.4 Bio filters

Bio filters operate to destroy VOCs and odors by microbial oxidation of these problem compounds. They are most effective on water-soluble materials. The polluted air is passed through a wetted bed, which supports a biomass of bacteria that absorb and metabolize pollutants. Efficiencies over 98% are possible with this application.

4 ENERGY SAVING SECTION IN FOUNDRY

4.1 Melting

The industry's major energy is used in the melting section. The use of baghouse heat recovery system may prevent the wastage of heat that is produced in Cupola and also used in Induction furnace and use it for later uses.

4.2 Sand Reclamation

The most important section in foundry industry in which 15% of the industries energy used. The use of thermal sand reclamer and pneumatic /mechanical sand reclamer saves the energy used in this section.

4.3 Machining

Machining is the most important job in the foundry which deals with customer satisfaction. The motors at present used in bench grinding and other machining tools consume more electrical energy.

4.4 Lab

The lab in foundries does not consume more energy but to make a foundry green each and every step is clearly to be noted and done.

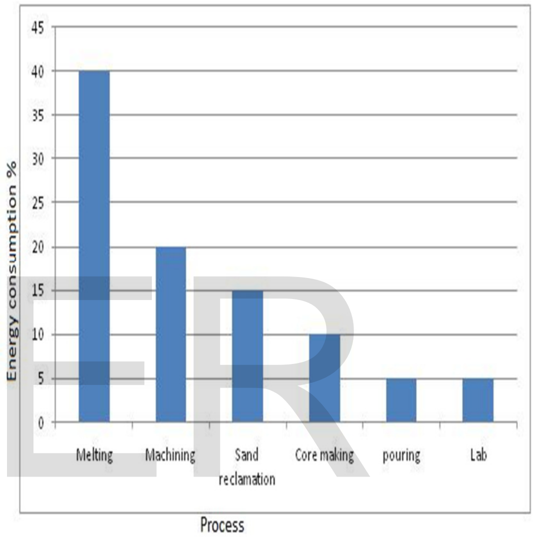

Fig. 1: Energy distribution chart

5 WASTE AND COST REDUCTION OPPORTUNITIES FOR FOUNDRIES

5.1 Reducing foundry sand

Reducing foundry sand waste continues to be a major cost saving opportunity area for many foundries. New formulations of binder materials increase the useable life of foundry sand. Sand recovery and reuse processes incorporate effective capture and segregation of unwanted materials from the waste sand stream. Effective capture systems make recovery less cumbersome and more profitable.

5.2 Reducing foundry scrap

Techniques to reduce scrap, an important goal for foundries, have been evaluated and refined over time. Companies that remains vigilant at continual improvement strategies to address their scrap increase efficiency and profitability. Good procurement strategies, testing/sampling of incoming materials, proper storage/handling and blending/melting techniques should be re-examined at regular intervals.

5.3 Water and Energy Conservation

Water and energy conservation are areas where companies can continually make improvements and save money. For saving heat energy replace Cupola furnace to induction with modern batch melters, this improves energy efficiency for this process. Apply existing air/natural gas mixing methods to reduce ladle heating energy.

6 DISCUSSIONS AND CONCLUSIONS

In foundry process waste generation directly affects the economy as well as environment. If we reduce the waste by applying new accessories and new technique, the cost is compensated by this. Many opportunities exist for making significant waste and cost reductions in foundry operations. These opportunities have been implemented by foundries successfully and have shown significant cost savings. Other things are to control the pollution generated by the process. This is reduced by installing the equipment. This equipment helps to control the pollution and increases the efficient flow of the process.

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