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Sustainable prevention of environmental pollution in iron-ore pelletizing plant: A case study

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Abstract

Today, iron and steel are the main product of most widely industrial metals; global production and consumption of iron and its alloys are increasing. The steps of mining in the steel-producing procedure include mineral, transportation, raw materials, operations, pelletizing, and steel restoration to get our rolled pollutants to the environment. The construction industry is confronted with difficulties minimizing energy usage, carbon emissions, and numerous adverse environmental effects while retaining an outstanding level of economic sustainability and constructability because of the growing consciousness of sustainable development and the ability to build. The bulb plant's environmental pollution has been investigated in this article according to the prediction made in different air, water, soil, and so on, and some of the proposed strategies for maintaining and improving Environmental health and pollution control management. Among these measures is the use of treated water for processing wastewater in Kerman, strategies to reduce energy, and an electric filter bag. The filters, to prevent pollution, create more green space than the standard required in one of the province's industrial sites in Kerman, which is investigated and continues to be fully explained.

Keywords: *Pelletizing, reverse osmosis, water treatment, environmental pollution*

1. Introduction

World steel production accounts for about 6% of the world's energy consumption annually. One hundred years ago, experts were working to reduce energy consumption from every ton of steel produced from natural iron. Experts have found that the higher the iron content is, the lower the energy consumption per tonne of steel made, the second will reduce slag production, and thirdly, the production efficiency increases (Zhong & Wu, 2015). Separating the extra material with iron ore after extraction is necessary to increase the iron content. Iron ore must be crushed to increase the optimum level of iron. The use of iron ore concentrates with a grain size of less than 10 mm cannot easily be carried out in a long furnace (Francová et al., 2017). Metallurgy specialists have been able to gradually begin to develop relative technology for the production of Zaynr (Sokhkah) since 1919. Despite all the efforts made by the experts, Zaynr's production continues to cause environmental pollution. In 1965, metallurgists began to devise another method to produce substantial pieces of iron ore to use in production. This preparation method depends on the iron ore type, with a refined granular concentration of about 60 microns. If the iron components used in the manufacture of zinc are used, they must be sizeable than one millimeter. That is, until the relative evolution of the pellet production process, there was no possibility of optimal grinding to increase near the theoretical boundary (71%) in concentrate in iron ore. Therefore, with the expansion of global steel production in the last 30 years, the production of pellets worldwide has gradually increased.

The pellets are raw iron ore and other additives pellets that are subsequently heated and hardened. They are used to reestablish the conventional iron-making technique in a furnace or to obtain direct recovery (Hussiny & Shalabi, 2011).

Since the concentrate, a product of the oregano, is a grainy iron ore that cannot be used in this physical form, these fissures reduce the permeability of gas in the furnace load unevenly and disrupt the operation of the furnace. Also, there are some drawbacks regarding the direct revitalization plant, so the iron fines are in the form of pellets. These are considered the middle product of the mines to the iron and steel furnaces. The purpose of the pelletizing units is to convert the iron concentrate into iron pellets with geometry and porosity. It is uniform. The relative improvement of the optimal preparation process for iron concentrate (pelletization) has increased the value added to iron ore minerals (Mousa et al., 2016).

The pelletizing process consists of three steps:

1. Preparation of raw materials (including crushing, separating, adding sticky materials, and mixing)
2. Formation of raw pellets
3. Hardening and cooking the pellets

This paper refers to the equipment and processes used to control environmental pollutants, including dust and exhaust gases from industrial units, industrial water supply, biological environment, and sanitation. The concepts of sustainable development discussed in this article include attempts to reduce resource consumption, Energy, repurpose resources, Utilize recyclable materials, Decrease toxic gas production, and release. The notion indicates that resource-conscious design is critical for sustainable construction, in which environmental and economic sustainability must be prioritized (Zhong & Wu, 2015).

2. Waste Water Management

Steel facilities utilize a significant quantity of water for several purposes, including cooling, dust suppression, cleaning, temperature regulation (heat treatment), and waste material transfer (ash, sludge, and scale, for example). Water is necessary for many procedures, including determining the moisture level of coking coal, pelletizing sinter mix, producing green pellets throughout iron ore pellets, producing steam and hence electricity, and granulating blast furnace slag. The utilization of a significant volume of water can result in a large amount of wastewater that may include suspended materials and various dissolved compounds and chemicals. Wastewater quality is determined by the method in which it is utilized and its intended usage. The steel plant's untreated waste fluids have the following significant environmental consequences if released into receiving water bodies: I toxicity to aquatic life, (ii) decreased dissolved oxygen, (iii) silting owing to suspended particulates, (iv) taste and odor issues, and (v) temperature increase influencing dissolved oxygen (Kumar et al., 2014).

The massive quantities of process water that directly interact with raw materials, products, and off-gases should be handled for reuse or recycling or the purification of pollutants to the standards established by regulatory entities before their discharge. Wastewater treatment also results in the recovery of certain solid waste products that may be recycled back into the process either as is or after additional processing, thereby helping preserve natural resources (Gu et al., 2015).

2.1 Treatment of wastewater:

Legal authorities typically control the most critical criteria are suspended solids, oil and grease, phenol, cyanide, ammonia, and heavy metals, including lead, zinc, chromium, and nickel. Predicted solutions for water pollution control are summarized in Table 1. The following sections explain the typical wastewater treatment techniques used to effectively treat the steel plant's waste fluids (Fig. 1) (Jørgensen, 1979).

2.2 Wastewater treatment methods

a) Physical techniques
b) Chemical techniques
b) Biological techniques
d) Method trickling filters
e) Biological substrates
f) The process of reverse osmosis (RO)

Since water is the most desirable water for any industrial water without ions, the cost of water purification is very high until it reaches the ion-fee water level. For each industrial plant, the most desirable water is that the cost of water treatment is less than the cost of treatment of the consequences of harmful impurities. For most industries, relying on the use of an (RO) reverse osmosis system is possible due to the drought in Kerman province. Three RO stages are considered for optimal use of urban sewage water; the water transformed to the site after the initial physical treatment (filtration) is transferred to RO1, which is the treated water used in the process. Moreover, the discharged water is removed from the system on other industrial sites. However, this site also contains water with exhaust water Z cooling towers and clarifiers entering the RO2. After re-treatment of quality water in the process of using and discharging water, this stage is introduced into RO3 and refined again. The treated water enters the process, and the discharged water is of low quality. Due to the fact that all impurities in the three stages of treatment are very low, they are logged to remove from the process (Fig. 2).

Sewage treatment and separation of harmful substances from the environment have always been one the concerns of human societies. On the other hand, Iran, and especially desert provinces like Kerman, are facing dehydration and reuse of wastewater for purposes. Industrialization also helps to reduce the water shortage, helping to keep our environment clean. It should be noted that the treated water is used to irrigate the planted green space, which in addition to beautifying its environment, is one of the best air purifiers.

3. Forecast of management deployment on solid waste:

Soil is known as a valuable resource, and the protection of the ecosystem is an integral part of environmental protection goals. Dust and sludge are extra solid waste, and spent consumables are stored in the pelletizing facility. Recycling is critical in steel production for both environmental and financial reasons. All process units generate secondary materials, recycled, sold, or disposed of in landfills.

The following are some standard guidelines for waste management:

- Avoiding or, if feasible, reducing waste output in all activities.
- Whenever possible, ensure reclamation or recycling.
- Ensure that any waste that cannot be recycled is neutralized
- Waste must be recovered or neutralized where it is generated.
- The policy for waste management must be designed, coordinated, and monitored at several stages (corporate, local, and area).
- All waste movements must be documented and reported responsibly.

3.1 Decrease the amount of solid waste that is generated:

It necessitates meticulous planning, a shift in attitude, capital investment, and, most importantly, a genuine commitment. Investing in waste reduction and recovery usually pays off tangibly within a short period. The most economical approach is eliminating waste at the source (Usapein & Chavalparit.,2014). Table 2 summarizes the predicted options for reducing soil contamination.

It is noteworthy that utilizing iron and steel furnaces for the treatment of Municipal Solid Waste Incineration-Fly Ash (MSWI-FA) has received considerable research attention. According to Liao and He (2018), in the steel industry, sintering iron ores has been known as the earliest high-temperature process, and the yearly sinter production in China has surpassed one thousand million tons. The subsequent benefits mostly recognized in the process of sintering iron ores for the treatment of MSWI-FA may be served as calcium-based fluxes in the sintering of iron ores, and decomposing dioxins is the result of a high-temperature process (Wong et al., 2020). In general, iron plants and steel plants can be found in municipal regions and are also used in the treatment of fly ashes generated by waste incineration plants situated at a particular site. Decreasing the possible hazards of transporting MSWI-FA and its related expenses is the result of reducing the transportation process. According to the findings of Wong and colleagues (2020), adding a proper quantity of MSWI-FA to the sintering process does not significantly affect the sintering index. Qui and colleagues (2019) have found that directly adding a powder form of an unwashed MSWI-FA to the sintering process may lead to rising dioxin concentration in the flue gas. Currently, the main purpose of applying MSWI-FA to the sintering process is to obtain raw fly ashes using no pretreatment.

Nevertheless, there are large amounts of chlorine salts and alkali heavy metals in MSWI-FA. One of the possible concerns associated with the direct addition of MSWI-FA using no treatment involves specific corrosion and blockage of the equipment, which is the result of a high-temperature chlorine salt volatilization process (Mao et al., 2020a; Wang et al., 2021). Consequently, washing MSWI-FA before joining the further collaborative treatment process is a necessity. Lin and colleagues (2018) state that the maximum amount of chlorine can be eluted while washing MSWI-FA using water. One of the prevalent kinds of dangerous solid waste is M-FA, which poses a considerable possible risk to human health. Based on the study conducted by Zhiyun and colleagues (2022), adding WM-FA in the form of pellets with a diameter of 5–8 mm can lead to the finest air permeability of the spray mixture, leading to improved growth in productivity as well as increased speed in the cooking process without having any detrimental effects on further sintering parameters. The utilization of such technology in the available plants has been taken into account because reducing the amount of municipal waste can exert a considerable effect on sustainable management.

4. Air pollutants and control methods:

The growing industry trend and consumerism are two important factors in recent years. Industrial, cause the pollution of the metropolitan areas and areas affected by it if natural factors such as volcanoes, forest fires, and pastures, cross-sectoral crises such as wars, as well as regional conditions such as weather stability and others. We can also add to the aggravating or moderating effects of the abovementioned factors. One of the main indicators of air pollution is the presence of particular matter (CO2, CO, SOx, NOx), volatile organic compounds (octane, CFCs, heavy metals, and other), voc, pops. Some of the above compounds alone cause direct harm to humans, and others indirectly affect human societies' health due to interactions between particles and compounds, including the formation of photochemical fumes caused by the verb. The effects of solvents, chemicals, and suspended particles with sunlight in the upper atmosphere. These pollutants are mainly due to the combustion of fossil fuels in industries and cars, and some due to the leakage or lack of effective control of chemical substances and compounds used in industries and Consumer goods (Xu & Lin., 2017).

Air pollutants cause a change in the natural air purifier or as new harmful substances. These factors, in general, are:

- Gases include hydrocarbons, NOx, O3, SOx, CO2, CO, HF, NH3, H2S, and the like
- Particles such as dust, fume, flame, smoke, and so on

The iron and steel industries emit significant pollutants into the atmosphere. Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2), Carbon Monoxide (CO), and Particulate Matter (PM) are the main pollutants affecting ambient air quality (Chen et al., 2015). The environment and human health are affected by iron and steel industry emissions. Climate change, the incidence of global warming, ocean ice melting, and an increase in chronic illness exposure were all linked to industrial emission levels. The adverse impacts of many gaseous air pollutants, including nitrogen oxides, sulfur dioxide, and tropospheric ozone (O3), pose a serious threat to human health and the environment (Dey et al., 2014). Iron ore pellets are brought into the complex by truck and transported to the Wagon Returning Unit via a single internal railway station. Following discharge, iron pellets are conveyed by a conveyor belt to the accumulation and withdrawal region. Pellets are collected using a reclaimer machine in the withdrawals unit (Day Bin). The environmental effects of the two mentioned units' activities are illustrated in figure 3.

Pellets transported from daily storage reservoirs into the Direct Reduction Unit lost their oxygen after entering the direct reduction furnace using the Midrex process in the presence of decreasing gases (Co, H2) at a temperature of 760° C. The sponge iron generated at the bottom of the furnace is delivered to storage silos through a conveyor belt. The phase produces sponge iron, which contains all of the contaminants found in iron ore. Figure 4 depicts the unit's environmental impacts.Fig.4.

It should be noted that the Iranian steel complex, to reduce air pollution and plant more than 100 hectares of green inside the complex, began to plant more than 1000 hectares of afforestation with plants in arid and semi-arid regions. Predicted solutions for air pollution control are summarized in Table 3.

5. Transportation of raw materials:

At this stage, the raw material particles are winded and released in the medium depending on the diameter and particle size. Distribution of raw materials, in addition to economic losses, will cause environmental and social problems.

It is possible to use a suitable plan to prevent the release of materials while transporting, using conveyance vehicles, or creating protective layers on raw material shipments using various chemicals.

5.1 Raw material accumulation and harvesting:

Discharging and particles of the particle distribution will always accompany the harvesting of raw materials. Dust emissions depend on several factors, including sex and particle diameter, humidity, and wind speed. Measures that can control and reduce the release of dust particles at this stage include:

1) Use dust collecting systems at the material discharge site, including equipment such as Multi cyclone and Bag Filters.

2) Installing the cover on the conveyor belts carrying the raw material.

3) Use of Dust Collecting Equipment in Transfer towers.

4) Wetting the surface of the material onto the conveyor belt.

5) Properly repair and maintain the conveyor belts with minimum vibration.

6) Moisturizing the level of raw material deposits through fixed and mobile systems.

7) Spraying chemical substances on raw material deposits to form a resistant layer.

8) Establishing appropriate barriers against wind flow at the site of storage and storage of materials.

9) Outlet air, the furnace contains a large amount of dust, CO2 gas, SO2 gas, and vapor, which passes through a droplet set (multi cyclone) and eventually leaves a chimney at the height of 120 meters at a temperature of 1800ºC.

To control gases, setting the furnace and torch temperature is very important. Of course, for the control of SO2 gas, the type of ore is also important in mining. The amount of SO2 gas will be reduced when proper mineralization is done while mining mineral ores with less sulfur.

5.2 Impacts on soil quality

Several variables determine the soil quality of areas next to steel factories. Some fundamental factors influencing soil quality include water and solid wastes; one may highlight the expelled gases containing heavy metals that complicate the surrounding soils (Dragovic et al., 2014). Moreover, the output of plant effluent that is utilized for irrigation of green areas or released in sub-streams might impact soil quality. Metal examination of soil samples collected near slag and dust depots revealed that such wastes might raise metal concentrations in soils by many orders of magnitude in certain circumstances. Along with heavy metals, the soils' pH was significantly increased due to limestone, dolomite, and magnesia in the slag.

6. Biological environment

6.1 Impacts on plants

Plants may be harmed by direct consequences of the steel project, such as soil removal or the building of the latest access road, in addition to water, soil, and air contamination. The yearly growth rings of trees next to steel facilities with a high activity level have been shown to contain absorbed heavy metals (Macdonald et al. 2011).

6.2 Impacts on the health of staff

Steel mills are potentially harmful work environments that provide health and safety concerns to employees. High temperatures, strong noise, emissions, vapors and particle pollutants, infrared radiation, dangerous compounds, such as acids, and the risk linked to high electrical voltage are the most critical variables that decrease safety and human health.

6.3 Social-economic environment

This plant will generate a large number of direct and indirect employment. Because of migration and growing population, various modifications will be made to the social and economic settings, such as greater income levels, rising health care, welfare, education, traffic, groundwater extraction, wastewater production, land-use modification, and rising real estate values.

6.4 Cultural environment

Cultural environments could change because of the influx of immigrants from other civilizations. Furthermore, with specialists from many fields, a new generation of specialists may emerge among the locals. Increased wages can influence the culture of the population in the area. Table 4 shows environmental pollution pellets and management strategies for environmental control.

6.4.1 Electric filters

Electric filters can dump large volumes of gas from a wide range of temperatures, pressures, humidity, dust particles and dry dust. In many industries, the effluent of these filters is higher than 99.99%. Electric filters work by storing dust particles in the gas stream. The electrical current connected to the discharge electrodes creates a strong electric charge between these electrodes and collector plates. The suspended dust particles in the gas stream passing through the discharge electrodes after entering the filter from the electric field around the discharge electrodes. The gas molecules are ionized due to their presence in this strong field. Because of interacting with these ions, the mist's suspended particles are pregnant and diverge under the influence of the electric field toward the nonhomogeneous pole, which is the collecting electrode. The particles lose their load after collision with the collector plates and fall into the hopper after the planned duration of the impact of the impactor system.

6.4.2 Cyclones

The main work of cyclones is separating gas from the gas stream. The dust is removed through the funnel underneath the device, and the air is removed through the outlet of the machine. Cyclones (or centrifugal collectors) act to create centrifugal force to separate dust from contaminated gas. This state of affairs is exactly the same as the outflow of water from underwater wastewater.

Gas and dust, with angles, enter the cylinder collector and move at high speed and in an eddy path downward. This will create a centrifugal force. During this move, the heavier dust particles, due to the collision with the walls, dissipate from the gas stream and slide towards the hopper.

6.4.3 Bag Filter and Bag House

The fabric duster, known mainly as Bag Filter and Bag House, is one of the most efficient and economical types of filters. Dusty gas enters one of the filter housing, dust particles with larger diameters, after entering, move their weight to the hopper, and the rest are collected on the filter bags. When the thickness of the dust collected on the bags reaches a level where the flow passes through a hard (pressure drop), the process of cleaning the bag begins.

7. Conclusion

There is no excuse to create employment and increase production capacity; it does not allow us to cause environmental degradation, and this is the legal responsibility of any organization paying enough attention to this. Of course, observing environmental issues does not contradict the development of industry and steel. Finally, to invest in the environment, investments must be made. Certainly, this importance must be considered in the initial investment to clean up contaminants such as water, soil, etc. On this industrial site, the value of equipment installed to protect the environment is several billion dollars, which is solely for measuring and controlling pollutants.

This paper presents energy-saving methods, including the use of refined water for sewage treatment for the steel industry and methods for preventing environmental pollution in one of the pelletizing sites of Kerman province. The iron and steel sector can accurately portray the business's real hazards associated with WC and water. In this manner, environmental contamination could be reduced, and the iron and steel sector can achieve cleaner manufacturing.

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