ENVIRONMENTAL MANAGEMENT FOR SUSTAINABLE GROWTH IN AN INTEGRATED IRON AND STEEL PLANT

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ABSTRACT

The manufacture of steel involves a large number of processing which lead to complex problems of environmental pollution. Coke making and sintering are two of the major areas in so far as pollution is concerned. Slag constitutes the major portion of solid wastes. Waste generation adversely affects productivity and contributes to the high cost of production. It has been shown that improving the efficiency of operation and fuel saving measures help in reducing pollution in steel plants. Utilization of slag, mill scale, sludge and dusts, safe disposal of hazardous wastes and minimization of emissions of CO, CO_2, SO_2, NO_x, cyanides, volatile organic compounds (VOC), NH_3, suspended particulate matters (SPM) etc. are essential steps towards environmental management.

INTRODUCTION

The iron and steel industry plays a vital role in the economic development of any country. However, the local and global environmental impacts associated with it is alarming (Fig.1&2). An integrated iron and steel plant comprises of preparation of raw materials, agglomeration of ore fines in sinter plants, manufacturing of coke in coke ovens, production of pig iron in blast furnaces, conversion of pig iron to steel, making and shaping of steel goods, granulation of slag for use in cement plant and recovery of chemicals from Benzol and tar products. About five tonnes of input materials namely iron ore, coal, fluxes, ferro-alloys, refractories etc. are required to produce a tonne of steel. Nearly 3.5 tonnes of solid wastes like slag, dust, sludge, fly ash etc. are also generated. This is primarily due to poor quality of raw materials in general and iron ore and coal in particular.

A comprehensive review of polluting areas in existing steel plants and measures to either safe disposal or utilization of wastes to the extent possible are the urgent need of the hour. This has been attempted in this paper.

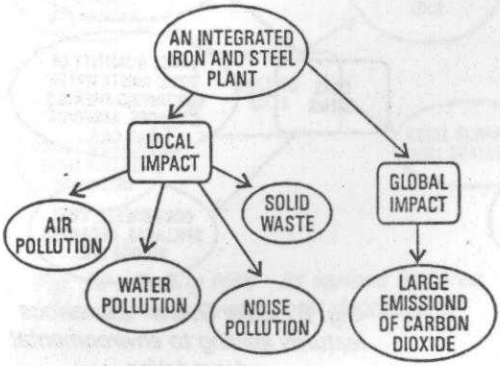

Fig. 1 : An integrated Iron & Steel Plant its local and global impacts

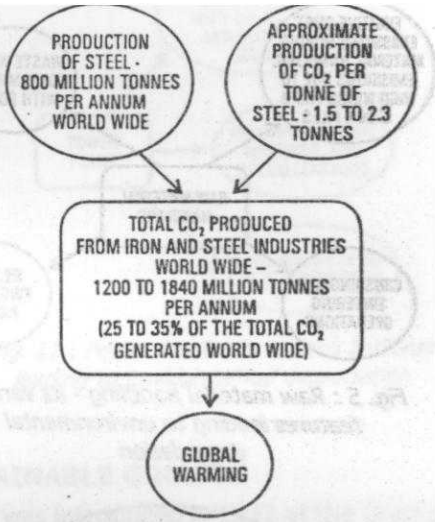

Fig. 2 : Iron & Steel Plant leading to significant global warmings

AN INTEGRATED PLANT - ITS VARIOUS UNITS AND THEIR ROLE IN ENVIRONMENTAL DEGRADATION

Fig. 3. shows the various units of an integrated steel plant . The material flow diagram is illustrated in Fig.4 and Fig.5 depicts the areas in raw material preparation leading to environmental degradation. The contribution from coke ovens, sinter plant, iron making, BOF steel making, rolling mills and power plant to environmental pollution are shown in Figs 6 to 11.

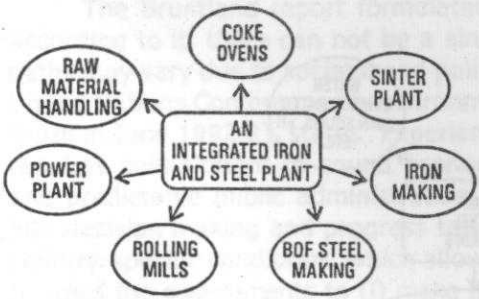

Fig. 3 : An integrated Iron & Steel Plant its various units

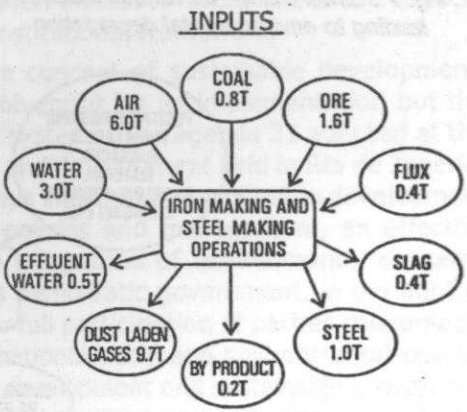

Fig. 4 : Material Flow Diagram for Steel Making

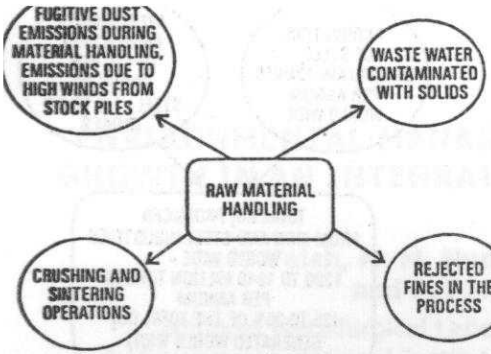

Fig. 5 : Raw material handling - its various features leading to environmental degradation

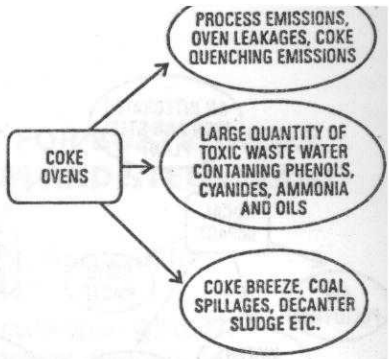

Fig. 6 : Coke Ovens - its various features leading to environmental degradation

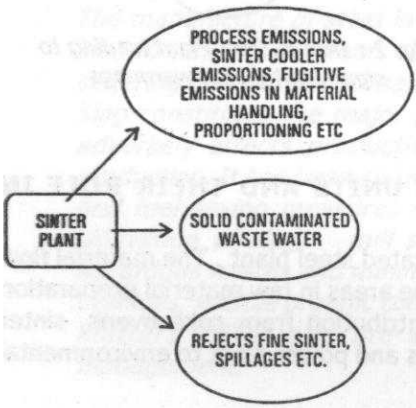

Fig. 7 : Sinter Plant - its various features leading to environmental degradation

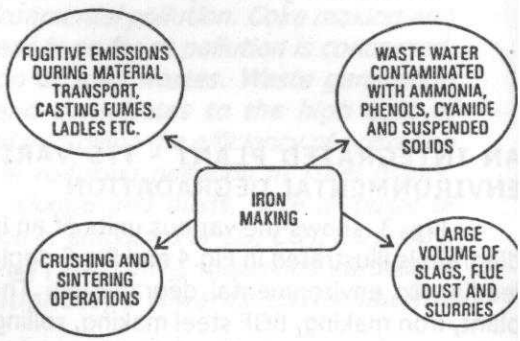

Fig. 8 : Iron Making - its various features leading to environmental degradation

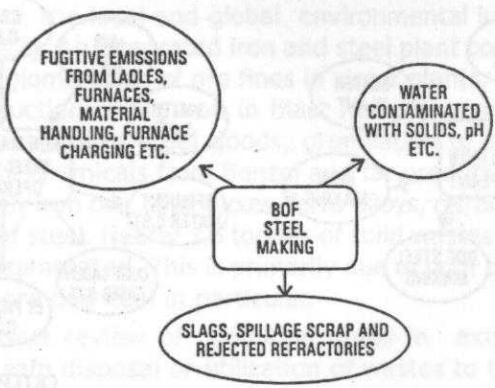

Fig. 9 : BOF Steel Making - its various features leading to environmental degradation

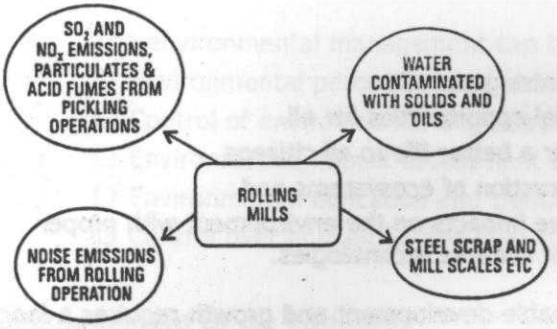

Fig. 10 : Rolling Mills - its various features leading to environmental degradation

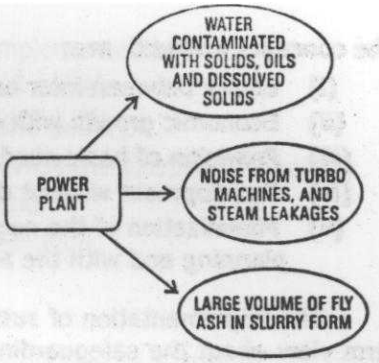

Fig. 11 : Power Plant - its various features leading to environmental degradation

SUSTAINABLE DEVELOPMENT AND SUSTAINABLE GROWTH

The concept of sustainable development was introduced in 1972 at the United Nations Conference on Human Environment(1) . It states that any development should meet the "needs of the present without compromising the ability of future generations to meet their own needs". In other words it is a process of change in which the exploitation of the resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. Sustainable development leads to sustainable growth.

Sustainable development and growth strive to establish inter-generational equity. Future generations should not be deprived of resources and wealth because of unsustainable levels of consumption by the present generation. The available resources must be conserved and exploited to yield maximum economic benefit with appropriate management and socio-cultural performance. Therefore sustainable development and sustainable growth are often discussed under the broad aspects of social, natural resource, economic and institutional framework.

The Bruntland report formulated the concept of sustainable development. According to it, there can not be a single blueprint for its implementation but the paths may vary due to societal and political systems. The agenda 21 adopted at the United Nations Conference on environment and development held in Rio de Janerio, Brazil in June 1992(2), states "Experience has shown that sustainable development requires commitment to sound economic policies and management, an effective and predictable public administration, the integration of environmental concerns into decision making and progress towards democratic government, in the light of country-specific conditions, which allows for full participation of parties concerned". It urges the governments to (i) make international trade and environmental policies mutually supportive in favour of sustainable development and sustainable growth and (ii) encourage international productivity and competitiveness and play a constructor role on the part of the industry in dealing with environmental and developmental issues.

The concepts involved are:

(i) Equity between inter and intra generation.
(ii) Economic growth with equal opportunities for all.
(iii) Provision of basic needs for a better life to all citizens
(iv) Development without destruction of ecosystems and
(v) Minimization of the negative impacts on the environment with proper planning and with the aid of suitable technologies.

The implementation of sustainable development and growth requires a long term view about the safeguarding of the interests of future generations. Decision making has to be based on the interaction between economic growth, social justice and environmental protection. The environment should include not only physical, chemical and biological surroundings but also our economic, social and cultural spheres(3).

India has implemented a number of plans and programmes(4) towards sustainable development and growth. The ministries of Environment and Forests, Agriculture, Water Resources, Finance, Industries, Rural Development, Non Conventional Energy Sources and External Affairs are involved in decision making. Some of the major legislations relating to environments are:

- ☐ The environment [protection] Act, 1986.
- ☐ The water [Prevention and control of Pollution] Act, 1974.
- ☐ The air [prevention and control of pollution] Act, 1981.
- ☐ The National Environment Tribunal Act, 1995.
- ☐ Hazardous wastes [Management and Handling] Rules,1989.
- ☐ The prevention and control of pollution [uniform consent procedure] rules, 1999.
- ☐ Ozone Depleting Substances [Regulation] Rules, 2000.
- ☐ New Biodiversity Bill 2000.

ENVIRONMENTAL MANAGEMENT

Environmental management is a technique to protect man and improve his environment. As a matter of fact all waste materials are economic assets and should be exploited to the maximum extent .

Environmental management(5) means

- ☐ Maintenance of environmental quality
- ☐ Balancing the eco-system
- ☐ Restricting and regulating the exploitation of natural resources
- ☐ Protecting the environment from degradation
- ☐ Renewing natural resources and reducing natural disasters
- ☐ Adopting engineered technology without creating adverse effect on the environment and
- ☐ Formulating laws and regulations to control pollution.

The environmental management can be implemented by

- ☐ Environmental perception and people awareness
- ☐ Control of environmental degradation and pollution
- ☐ Environmental impact assessment to review the existing technology
- ☐ Environmental education and training and
- ☐ Control over population and over consumption.

Management of Air Pollution

During the process of steel making large amounts of emission [stack and fugitive] comprising of dust, gaseous pollutants like SO_2, NO_X etc are generated. Control of gaseous emissions is accomplished by employing various measures/ equipments at sorce in different locations as given in the following table.

LOCATIONS	POLLUTION CONTROL EQUIPMENTS
Raw Material Plant	Bag Houses
Blast Furnaces	Ventury Scrubbers, Electrostatic Precipitators [ESP]
Boilers	ESP
Sinter Plant	ESP
Stock House & Cast House	ESP
L D Shop	ESP

Management of Water Pollution

Steel plants consume 150-200 tonnes of water per tonne of steel produced. Wastewater treatment is carried out by cooling the stream and separating and disposing of oil and suspended solids. The soluble organics are to be biologically oxidized, the waste water is to be neutralized with acids and inorganic soluble salts are to be crystallized and removed. The cooling water is kept in continuous circulation through cooling and recirculating pond. Generally collective treatment of water is carried out by settling or coagulation except in a certain sections of plant where wastewater is segregated and treated separately. Needless to mention that a good day to day survey and inventory of various locations in steel plants to identify the source of specific polluting area is essential for effective control.

Management of Noise Pollution

Noise is generated in various sections of plant due to high speed rotating equipments like fans, blowers, exhausters and also due to the leakage of compressed air and steam, rolling mills, forge shops, foundry etc. Acoustic absorbing system, use of bellow type tuyeres etc. are to be employed to contain noise pollution in the plant. The options to contain noise pollution in plant are shown in Fig. 12

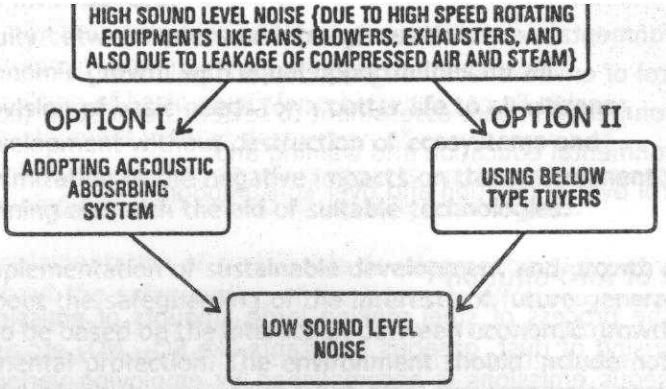

Fig. 12 : Options to contain Noise Pollution

Management of Solid Wastes

A variety of solid wastes such as fly ash, acid sludge , tar sludge, coke breeze, granulated B.F. slag, calcined lime and dolomite dusts, steel scrap etc. are generated in steel plants. Suitable measures will have to be used to recycle, utilise or safe disposal as discussed in the text.

Management of Sustainable Growth

Multiple operations in various units of an integrated iron and steel plant have both local and global impacts. Local impact leads to environmental degradation and global impact leads to global warming due to emissions of carbon dioxide. Sustainable growth in an iron and steel plant can be managed by adopting the following.

CONCEPT OF WASTE MINIMIZATION

The concept of waste minimization is a preferred method of waste management. The iron and steel industry has to concentrate its efforts towards waste minimization i.e. attack the problems of waste generation at source, which not only maximize production and product quality but also minimize the overall environmental impact.

The techniques used for waste minimization are as follows:

- ☐ Technology upgradation.
- ☐ Raw material quality improvement.
- ☐ Waste minimization audit.
- ☐ Adopting innovative management strategies.
- ☐ Waste exchanges.
- ☐ House keeping and employee awareness Programme.

Various techniques of waste minimization are shown in Fig. 13.

Fig. 13 : Various techniques leading to waste minimization

USE OF CONTROL EQUIPMENTS

The following major pollution control equipments are recommended in various units of plant to abate all types of pollution

FERTILIZER PLANT ALKALI SCRUBBERS, AMMONIA SCRUBBERS, NEUTRALIZATION PLANT CYCLONE AND BAG FILTERS,	**CAPTIVE POWER PLANT** ESPs, NEUTRALIZATION PITS, OIL RECLAMATION UNIT, DUST EXTRACTION SYSTEMS
COKE OVENS ON-MAIN CHARGING, BOD PLANT	**COLD ROLLING MILLS** NEUTRALIZATION PLANT, SETTLING TANKS, FUME EXTRACTION SYSTEMS
COAL CHEMICAL DEPARTMENT DUST CATCHER, SCRUBBER, ESPs, VACUUM DISK FILTER, BAG FILTERS	**MODERNIZATION UNITS** CALCINING PLANT BAG FILTERS
STEEL MELTING SHOP ESPs, WATER TREATMENT PLANT, SCRUBBERS, BAG FILTERS	**SINTERING PLANT** ESPs, BAG FILTERS, CYCLONES
CAPTIVE POWER PLANT ESPs, NEUTRALIZATION PITS, BAG FILTERS	**ORE BEDDING & BLENDING PLANT** WATER SPRAY SYSTEM, BAG FILTERS.

Different Options to Control Emissions

The emissions from various locations in the integrated plant comprise of dust, CO, CO_2, SO_2, NO_X etc. In this regard different options can be adopted to control these emissions as shown in Fig. 14.

Various Options for the Treatment of Waste Water

The polluted water from various units of plant comprises of suspended solids, cyanides, phenols, oils, greases, BOD, COD etc. It can be treated by adopting various options as shown in Fig. 15.

Utilization and Recycling of Solid Wastes

The quantities of solid wastes produced can be as high as 1000 kg / tonne of crude steel production. Some of the wastes like sludge and dusts from pollution control equipment can be hazardous wastes. Earlier these wastes were dumped in open low lying areas affecting ground water quality and altering top soil characteristics. Solid wastes generated from various operations largely depend on the quality of raw material and technology adopted for production. These wastes can be classified mainly into two categories:

i) Solid wastes generated from process units and

ii) Solid wastes generated from pollution control equipments.

Source wise generation of solid wastes (6) in an integrated iron and steel plant is as follows:

UNIT	SOLID WASTES FROM PROCESS UNITS	SOLID WASTES FROM POLLUTION CONTROL EQUIPMENTS
Coke Oven & By-Product Plant	Coke Breeze, Tar sludge, Acid Sludge	Coke Fines / Sludge, BOD Plant Sludge
Sinter Plant	Under size Sinter	Dust/Sludge
Blast Furnace	BF Sag, Broken Refractories	BF Flue Dust, BF Sludge
SMS	SMS Slag, Broken Refractories	Dust/Sludge
Rolling Mills	End Cutting, Broken Refractories	Mill Scale, Oily Sludge
RMHP & RMP	Fines	Dust/Sludge

Some wastes of uniform size and composition with low moisture content and high contents of Fe, Ca, C etc. can either be directly recycled within the plant premises or can be sold outside after proper treatment as feed material for other industries. The dust and sludge generated from BF and S.M.S. gas cleaning plants and other pollution control equipments mainly comprising of useful resources such as Fe, C, CaO, MgO etc. are suitable for recycling. Dusts generated from dry type pollution

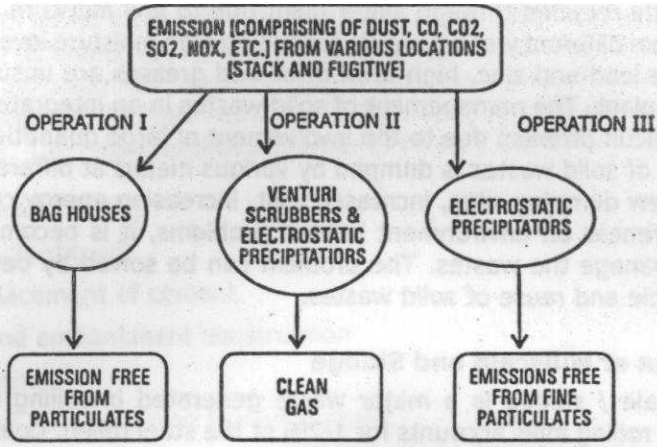

Fig. 14 : Various options to control emissions in an integrated Iron & Steel plant

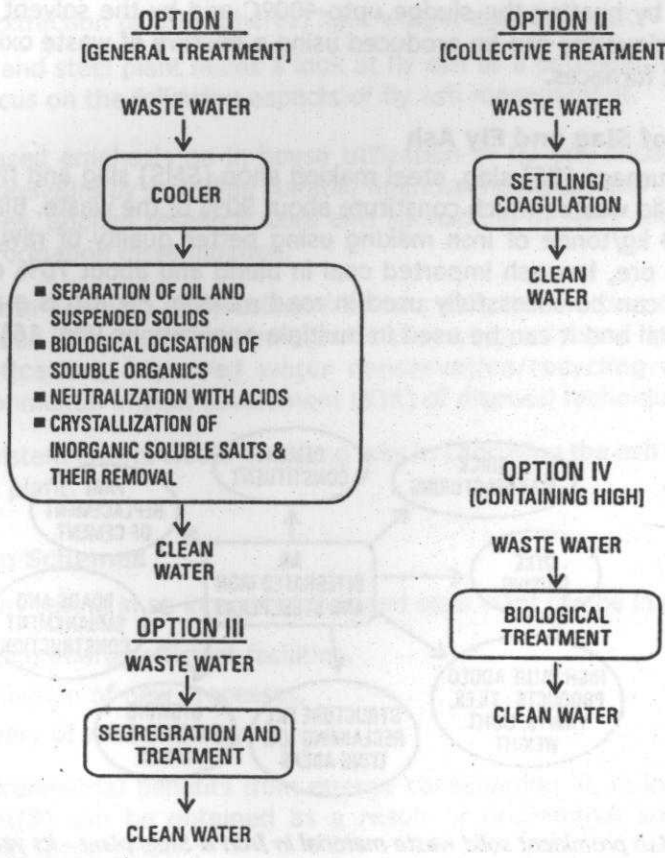

Fig. 15 : Various options for the treatment of Waste Water

control equipments like bag filters, electrostatic precipitators, multi-cyclones etc. can be directly recycled through sinter plant due to low moisture content. Sludge generated from different wet type units containing high moisture levels and unwanted materials like lead and zinc, high level of oil and greases are unsuitable for direct use in sinter plant. The management of solid wastes in an integrated iron and steel plant is a difficult problem due to the involvement of large quantities and nature of wastes. Bulk of solid wastes is dumped by various means at different sites. Due to scarcity of new dumping sites, increased cost, increasing energy consumption and greater awareness on environment related problems, it is becoming increasingly difficult to manage the wastes. The problem can be solved by devising means to reduce, recycle and reuse of solid wastes.

Reutilisation of Millscale and Sludge

Mill scale / sludge is a major waste generated in rolling mills. Mill scale generated in rolling mills accounts for 1-2% of the steel rolled. Coarse mill scale [+ 6mm] can be used in blast furnaces while fine mill scale [-6mm] mixed with a small portion of sludge can be used in sinter making. Mill sludge containing about 65% total iron can be used in blast furnace. Its oil content is more than 10%. This oil can be removed by heating the sludge upto 400°C and by the solvent extraction also Mill sludge briquettes can be produced using a mixture of waste oxides and can be used in blast furnaces.

Utilisation of Slag and Fly Ash

Blast furnace [BF] slag, steel making shop [SMS] slag and fly ash are three important solid wastes which constitute about 90% of the waste. Blast furnace slag is about 400 kg/tonne of iron making using better quality of raw materials [low alumina iron ore, low ash imported coal in blend and about 70% of sinter]. Blast furnace slag can be sucessfully used in road making. Fly ash is a prominent solid waste material and it can be used in multiple applications [Fig. 16]

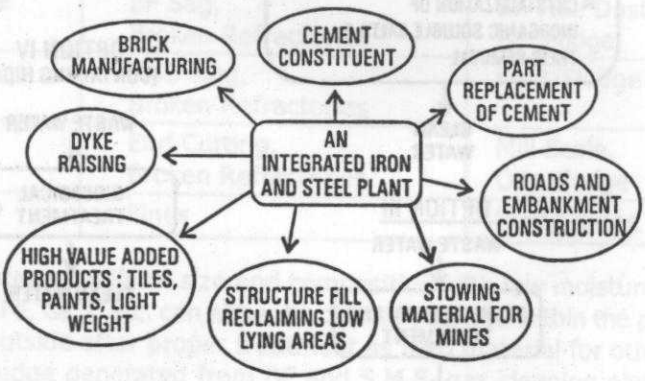

Fig. 16 : Fly Ash prominent solid waste material in Iron & Steel plant - its various applications

Fly ash is one of the most prominent solid waste generated in the Indian iron and steel plants. In recent times the country has witnessed growth in fly ash utilization and safe disposal technologies. Fly ash is one of the most abundant residues of coal combustion. Its indiscriminate disposal requires large volumes of land, water and energy. Fly ash utilization in India has increased to nearly 15-18% of total generation from 3% in 1994. The major application areas (7) for fly ash are as follows:

- Brick manufacturing.
- Cement constituent.
- Part replacement of cement.
- Roads and embankment construction
- Dyke raising.
- Structural fill, reclaiming low lying areas.
- Stowing material for mines.

The other areas where fly ash can be used are agriculture, forestry, tiles, wood, paints, extraction of cenospheres, light weight aggregate etc.

The iron and steel plant needs a look at fly ash as a potential resource. The plant should focus on the following aspects of fly ash management.

a) Increased emphasis on in-house utilization of fly ash encouraging local entrepreneurs by providing suitable financial incentives and infrastructure facilities, applied research work and sponsoring of work shop/ seminars for information dissemination.

b) Separate handling of fly ash and bottom ash, introduction of dry fly ash collection infrastructure, dense phase conveying, ash bond design, raising/ densification, improved water conservation/recycling aspects and environmental impact assessment (EIA) of disposal techniques.

The consistent efforts would go a long way in improving the ash management scenario in the plant.

Energy Saving Schemes

The energy saving in an integrated iron and steel plant can be implemented by

- Adopting energy efficient facilities.
- Introduction of new processes.
- Recovery of waste energy.

The environmental benefits from energy conservation in an integrated iron and steel plant(8) can be obtained as a result of operational and equipment improvements as given below :

SOURCES / MEASURES	BENEFITS
COKE OVENS	
Charging of briquettes	Reduced charging emissions
On-main charging	Elimination of charging emissions
Stream driven exhausters	Better availability of steam to ammonia stills
SINTER PLANT	
Improved material input	Less emissions in sinter making
Increased bed height	Reduced emission per tonne of sinter
Plug air leakages	Reduced volume of gases, higher efficiency of control equipment
Waste recovery from coolers	Reduced overall emissions
BLAST FURNACES	
Charge distribution	Reduced dust entrainment
High top pressure	Reduced dust entrainment
Injection of alternate fuels	Reduced coke rate (indirect environment benefits in coke making) & low slag volume.
Cast house granulation	Less generation of waste slag
BOF FURNACES	
Low sulphur, silicon	Low slag volume
Ladle management	Reduced fume emissions during waiting periods and reduced skul
Waste heat recovery	Reduced emissions
OTHERS	
Continuous casting	Higher yield and less waste generation
Coke dry quenching	Reduced quench emissions
Product mix optimization	Lesser waste generation
Ore bedding of raw materials	Consistent quality and less waste generation
Rotative speed control	Indirect benefits
Improved furnace condition	Less mill scale generation
Yield improvement	Indirect benefits due to less waste generation.

CONCLUSIONS

- Integrated iron and steel plant has impact on the environment. These impacts are both global and local in nature.
- The global warming will have to be monitored closely in iron and steel plants with a view to minimize CO_2 emissions through energy conservation programmes and by developing energy efficient processes.
- The integrated iron and steel plant influences all aspects of local environment viz. Air, water, noise as well as large quantities of solid wastes of varying characteristics.
- Environmental management Programme should be evolved to overcome all types of pollution and make the iron and steel plant more environment friendly.
- Application of clean technologies is most important consideration for sustainable growth.
- Sustainable growth can be achieved by adopting concept of waste minimization, use of control equipments to control emissions, treatment of waste water. Utilization and recycling of solid wastes, reutilization of millscale and sludge, utilization of slag and fly ash and energy saving schemes should become part of steel making process.

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