LAYOUT OF INTEGRATED STEEL PLANTS ENVIRONMENTAL ENGINEERING ASPECTS

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ABSTRACT

The Layout of an Integrated Steel Plant gives the best possible arrangement of units and equipment at the minimum capital and operating cost for both initial and expansion stages governed by the technological processes selected.

Environmental Engineering considerations monitor, control, reduce and dispose air, water and solid pollutants and wastes generated in the various units of the steel plant.

This paper critically looks at the implications of Environmental Engineering considerations as it affects Integrated Steel Plant design. It outlines the layout patterns and chooses the best pattern based on Environmental Engineering principles for good pollution control in steel plants in light of advances in pollution control techniques after other factors of cost, location, capacity, transportation, etc. have been duely considered.

1. INTRODUCTION

Environmental Engineering as is related to Integrated Steel Plants deals mainly with the requirements of water, air pollutants control and solid wastes management. Planning the general layout of an Integrated Steel Plant is basically as exercise in making rational arrangement of the main production units, the energy networks, and the auxillary shops within the limitations of the selected site. A good steel plant layout must fullfil at least four major criteria.

First, it must provide for the uninterrupted receipt and stocking of bulk materials, rapid movement of in process loads and the smooth disposal of products and by-products.

Secondly, it must provide opportunity for rational expansion to large future capacity to meet growing requirements and also to take advantage of the economics of scale. Such economics of scale include design provisions for enlarging utilities such as water, power and tracks with minimum interference with existing operations. (1)

Thirdly, the production and auxillary units together with the utilities must be arranged so as to assist in achieving minimum capital and operating expenditures for both initial and expansion stages.

The fourth and equally important criterion is that Technological Processes used must also pay adequate attention to the requirements, control, monitoring and management of water and waste water, air pollutants, and solid wastes generation in integrated steel plants.

The neglect of this Environmental Engineering aspect has led to the production and release of toxicants, mutagents or carcinogens into the atmosphere, water supplies, farmlands, etc. leading to all sorts of health hazards to the populace and other global effects like acid rain, increase in tropospheric carbon dioxide (Co_2), depletion of Ozone (0_3) layer in the statosphere, etc.

A typical diagram showing the principal process steps involved in converting raw materials into major steel products is shown in Figure (1).

Pollution control must be considered in terms of both total technological systems (equipment and processes) and ecological consequences such as the problems of treatment and disposal of collected pollutants. Control strategy for pollution focuses on five alternatives for the reduction and/or elimination of pollutant emissions: These are

(1) Elimination of the operation entirely or in part
(2) Modification of the operation
(3) Relocation of the operation
(4) Application of appropriate control technology
(5) Combination thereof

In conclusion, this paper will also review the advances in Pollution Control Technologies for Air, liquid and solid wastes in order to meet Environmental Protection Regulations. (7 & 8)

II. LITERATURE REVIEW ON ENVIRONMENTAL ENGINEERING CONSIDERATION FOR A STEEL PLANT

The mechanical and in-plant transport facilities for a steel plant are designed as an integrated system, account being taken of conditions of material delivery, production process requirements, full mechanization of handling operations, fire fighting and environmental engineering requirements and safety rules.

The designers will stipulate some basic design norms to cover every aspect relating to Environmental Engineering based on Environmental Protection Agency (EPA) standards or norms set up by other such regulatory bodies in the country.

Sites have to be selected with careful consideration of environmental attributes. At plant levels, factors that can minimize the impact of environmental-quality requirements are:

1) Maintaining an accurate source emission inventory
(2) Continually evaluating process operations to identify potential modifications that might reduce or eliminate environmental impacts.
(3) Ensuring that good housekeeping and strong preventive maintenance programmes exist and are followed.
(4) Investigating available and emerging pollution-control technologies and when possible applying them.
(5) Being well informed of Environmental Pollution regulations and the direction in which they are going.
(6) Working closely with and maintaining open communications with appropriate regulatory agencies on effects of new Environmental Protection regulations.

Required design norms will then cover areas like neumatic, vibration and pipeline transport and safety engineering and Environmental Engineering requirements to ensure normal working conditions for the operating, supervising and maintenance personnels of transport and processing equipment.

Some of these norms can be found in various design organizational booklets (6) and other publications. (4,1,5,8)

These norms must take into account the long and short term environmental engineering aspects of the water, air pollution and the solid wastes generated in an integrated steel plant. This calls for a review of advance in the water, air, and solid wastes pollution control technology.

AIR POLLUTION CONTROL DEVICES

Emission limits for sulphur dioxide (SO_2), total suspended particulate matter (TSP) and nitrogen oxide (NO_x) have led to the development of new combustion and post combustion control techniques to reduce atmospheric emissions. Particulate control devices comprise of Electro-static Precipitators (ESP), Fabric Filters, Venturi Scrubbers, and Cyclone Collectors.

ESP performance can be improved by use of electrode precharges, high intensity ionizer, electron-beam precipitation system. They are suitable for advanced pressurized fluid-bed and coal gasification systems.

Fabric filters or bag-house collectors are good for low sulphur coals with high flyash resistivity or for high sulphur coals. Some have reverse gas and shaker collectors while others have pulse jets collectors.

Venturi scrubbers can collect both particulates and gases. Often used when particulates are sticky, corrosive or combustible or when mixing of the particulate in a process liquor is desirable.

Granular bed filters can handle very high temperature with high superficial velocity and low pressure drops. Applicable to pressurized fluid bed boilers and coal gasification systems.

Cyclone collectors are used to recycle entrained materials. They can meet particulate emission standards on industrial boilers.

Flue-Gas Desulphurization (FGD) systems include Wet Scrubbing (wet lime), dry scrubbing (lime spray), Direct sorbent Injection (Limestone Injection with multistage burners).

Wet scrubbing uses organic acid buffers to improve the efficiency of FGD systems. High nickel or titanium alloys are used for its outlet ducts to reduce corrosion and failures.

Dry scrubbing using lime spray dryers are used for low sulphur coals e.g. limestone injection with multistage burners (LIMB). These reduce SO_2 by 50% and can use improved sorbents like hydrated lime.

Other FGD processes are the NOXSO process and the fluidized-bed copper oxide process. Both involve catalytic absorption and regeneration of sulphur in a fluidized bed with NO_x controlled by either thermal decomposition or by reduction with ammonia. The flue gases are irradiated in the presence of lime or ammonia.

Ionized sulphur and Nitrogen species then react to form solid products that are collected in a fabric filter. A dry waste is produced when lime is used and a fertilizer by-product produced when ammonia is used.

Nitrogen-Oxide Control Devices: Nitrogen oxides (NO_x) are compounds consisting primarily of Nitric oxide (NO) and Nitrogen dioxide (NO_2) formed at high temperature during combustion. NO_2 in NO_x = 5%. Once in atmosphere No oxidizes to NO_2 which has adverse effects on health and environments. NO_x emission and potential for controlling them depends on combustor design and fuel type. Thermal $_{NOx}$ emissions are reduced by lowering the peak temperatures by either flue gas recirculation, water injection, reduction of oxygen available in the hotter flame regions through low excess air firing or low NOx burners. Advance combustion to control NO_x emissions is reburning or in-furnace NO_x reduction.

Oil fired boilers, process heaters retrofitted to employ selective catalytic reduction by ammonia have reduced NOx by - 70 - 90%

POLLUTION CONTROL IN INDUSTRIAL WASTE WATERS

Industrial waste waters include domestic waste waters, process waste waters, and cooling waste waters. These are all generated in steel plants and are monitored, processed and disposed of in order to meet environmental Pollution Regulations by pretreatment, primary treatment, secondary treatment and the processing and disposal of the accruing sludge.

Domestic waste waters are produced by plant workers, shower facilities, and cafeteria. These

are generally handled by the normal sanitary-sewerage system to prevent the spread of pathogenic microorganisms which might cause disease.

Process waste waters result from spills, leaks, and product washing. These do not pose the potential for pathogenic microorganisms but they do pose potential damage to the environment through either direct or indirect chemical reactions. Some are readily biodegraded and create an immediate oxygen demand. Others are toxic and represent a direct health hazard to biological life in the environment.

Cooling waste waters are from various cooling processes and can be one-pass cooling system (i.e. employing large volumes of cooling water that are used once and are returned to the environment) or multiple-recycle cooling system (i.e. have various types of cooling towers to return excess heat to the environment and require periodic blowdown to prevent excess buildup of salts). These are least dangerous but they can contain process wastewaters as a result of leaks in the cooling systems. Recycled cooling wastewater tend to concentrate both organic and inorganic contaminants to a point at which damage can be created.

Basic wastewater characteristics are organic compounds (creating most of the pollution problems due to its effect on oxygen resources in the environment), inorganic compounds; pH values; and alkalinity; temperature; and dissolved oxygen levels.

The pretreatment of industrial wastewater prior to discharge to central industrial municipal sewerage systems are: Equalization, Neutralization, Grease and oil removal and Toxic substances removal.

Primary wastewater treatment comprises of the followings:
The suspended solids are removed by either physical or chemical separation techniques and handled as concentrated solids by

(1) Screens (hydroscreens, fine screens and/or large bar screens)
(2) Grit chambers (settled grit removed with a continuous scree and buried in a landfill).
(3) Gravity sedimentation (can be rectangular or circular. Designed on the basis of retention time, surface overlow rate, and minimum depth).
(4) Chemical precipitation (to remove light-weight suspended solids and colloidal solids). It agglomerates the tiny particles into large particles that settle rapidly in normal sedimentation tanks.

Secondary Treatments are biological treatments designed to remove colloidal and soluble organics through microbial metabolism. The system converts the biodegradable organics in solution into suspended organics which flocculate and are removed by gravity sedimentation.

Bacteria as primary microorganisms are used to remove excess bacteria and to produce a clarified effluent.
Sludge Processing and Disposal: Sludges from primary and secondary treatment systems consist of concentrated unstabilized organics with inert organics and inert inorganics. Sludge processing consists of thickening, Flotation, Centrifugation, Anaerobic Digestion (conversion of biodegradable organics to methane, Co_2 and microbial cells). Chemical conditioning, thermal conditioning, vacuum or pressure filtration are also used to process sludges and they are disposed by Incineration, sanitary landfilling or land spreading.

Water shortage and conservation has now led to greater efforts in segregating toxic and hazardous wastes and re-using the treated waste water.

POLLUTION CONTROL FOR INDUSTRIAL SOLID WASTES

Various wastes grouped under industrial solid wastes are food wastes, rubbish, ashes and residues, demolition and construction wastes, treatment wastes and agricultural wastes.

Hazardous wastes are those that pose a substantial danger immediately or over a period of time to human, plant, or animal life. They have the following characteristics: ignitable, corrosive, reactive or toxic. They can be radioactive, chemical, biological, flammable or explosive wastes.

The specific solid wastes generated in steel plants are ferrous and nonferrous metal scraps, slag, flyash, sand, cores, patterns, lubricants, etc. A high percentage of these are recycled in the steel plant while the rest are disposed of by landfilling after due processing to reduce the pollution levels to acceptable norms. Processing equipment, vehicles for wastes collection, routes layout and dumping sites has to be determined and mapped out. Processing sites and transportation distance may be far and long necessitating adequate transfer and transportation.

Long term handling of solid wastes after processing and recovery of conversion products and/or energy is done by either landfilling, landfarming or deepwell injection.

Solid wastes in form of dryfly ash from ESP and boilers are water sluiced, ponded and landfilled. FGD dewatered sludge cake is mixed with flyash and lime additives to produce pozzolanic cementation (similar to portland cement hydration and hardening). The end product (cementation monolith of high structural strength and low permeability) is good for landfilling.

Limestone scrubbing with forced oxidation of wet FGD wastes produce coarse calcium sulphate solids (30-60 um) . The sulphate cake waste (80-90% dry solid content) is used for structural landfilling; manufacture of Gypsum boards, or for embarkments and construction material. Most hazardous and municipal solid wastes are disposed of by landfilling either in separate areas or by separate disposal operations.

Landfarming is suitable for wastes that contain organic constituents that are biodegradable and are not subject to significant leaching while the bioconversion process is occurring (e.g. petroleum oily wastes and oily sludges).

Deep-well injection is used for wastes that are difficult to treat and dispose of and for hazardous wastes (chemical, petrochemical and pharmaceutical wastes). They may be gaseous, liquid or solid.

All aspects of short term and long term action programs must be developed for the disposal of non-hazardous and hazardous solid wastes. See Table 1.

Table 1: Short-and Long-Term Actions for Effective Industrial Solid-waste Management (8)

Short Term	Long Term
Inventory Wastes	Remove all accumulated wastes (stored on the plant site)
Inventory Inactive sites	Separate wastes (at source or production)
Characterise wastes	Reduce Wastes (Develop alternative operations and processes to reduce waste generation)
Assign responsibilities (At plant for storage collection, treatment and disposal)	Improve facilities to meet statutory regulations
Track movement of wastes	Review all waste management agreements
Develop emergency procedures	Review and develop disposal site options
Obtain permits	Secure appropriate engineering and consulting services Monitor legislative programs.

III. LAYOUT PATTERNS

The best layout pattern of an Integrated Steel Plant is based on one that gives the least disadvantages based upon the selected sites (i.e. plant location), desired plant capacity (taking into consideration also future expansion), the techno-economics considerations of both capital and operating costs, terrain available and the technological process adopted which takes into account the best control of both gasous, liquid and solid wastes of the steel plant.

The terrain for a steel plant should be neither steep nor too flat. Steep slopes increase the volume of earthwork while flat terrains present problems of drainage. A ground slope of 1:200-1:250 would be desirable and a good foundation soil capable of bearing about 3-4 kg/cm^2 at a depth of 2-3m, and a deep ground water table.

Since there is a lot of economy in capital costs as well as operating expenses, it is better to start with a large capacity inbuilt in a steel plant. Based on steel plant capacities around the world, increasing a steel plant annual capacity from lmT/year to 9mT/yr corresponds to a 1:3 ratio increase in plant area, 1:6 ratio increase in volume of earthwork and a 1:5 increase in rail track length.

Many processes at the steel plant create fumes, smoke, fog and other gases while others contaminate water supplies. The siting of production units and their design must therefore pay attention to the control of air and water pollution.

These problems must be tackled from the earliest stages in order that the atmosphere above an industrial community and rivers and waters around it remain clean for all times (2)

Provisions have to be made for the respective layout of the various units of the steel plant; vis, raw material storage and beneficiation; cokeovem and by-product; iron making; steel melting shops; rolling mills and the auxillaries and utilities.

Layout can be classified into different types depending on the disposition of the units relative to each other. This is illustrated in Figure (2a-2g). (1) The rectangular sequential (2a) and rectangular parallel layouts (2b) are suitable for small plants or for specific elongated areas. The main drawback is the long haulage distances. The rect-

angular complex (2c) and the rectangular combination diagram (2d) have considerable compactness and are suitable for plants dependent on water transportation for outside freight. They are suitable for plants with one production cycle.

The oblique sequential (2e) and the oblique parallel layouts (2f) are suitable for larger plants with two production cycles and these layouts lend themselves to further expansion. They are also good for compactness. The oblique complex figure (2g) and oblique combination type layout, figure (2h) are suitable for difficult areas or for plants having three or more production cycles. The flow of goods, specialization of routes, and plant development are resolved. (3)

TRANSPORTATION

A characteristic feature of a steel plant is the great bulk of raw materials used and the magnitude of in process handling involved. On the average, for every ton of finished steel despatched, about 11-12 tons of materials have to be moved. Transport facilities are the most expensive single item in a steel plant and also constitute the most serious threat to its smooth operations, thus facilities and economy in movement are the primary objectives of an adequate layout.

Transportation is mainly by rail; conveyors (i.e. conveyor belts, chain links, rope ways and cable ways); and road.

The total freight turnover of a steel plant amounts to about 20 million tons/yr for a 1mT/yr steel plant. (4) i.e. considering both the internal and external transportation.

Rail transport has a lot of inherent inflexibility due to its permissible track gradients and minimum radii of curvature thus there is increasing trend towards road vehicles and conveyors.

A typical share of Mechanical Transport: Rail: Road in an internal freight turnover amounts to 41:55:4(4)

Even movement of personnel at peak periods to their various units can constitute a bottleneck in a steel plant if not well thought of in advance.

FACTORS IN POLLUTION CONTROL EQUIPMENT SELECTION FOR BEST TECHNOLOGICAL PROCESS ADOPTED

These can be grouped under three categories viz environmental, engineering and economic.

ENVIRONMENTAL FACTORS:

(1) Equipment location
(2) Available space
(3) Ambient conditions
(4) Availability of adequate utilities (i.e. power, water, etc. and ancilliary-system facilities i.e. waste treatment and disposal etc.
(5) Maximum allowable emission (pollution codes)
(6) Aesthetic considerations (i.e. visible steam and water vapour plume, etc.
(7) Contributions of air pollution control system to waste water and land pollution
(8) Contribution of the air pollution control system to plant noise levels.

ENGINEERING FACTORS

(1) Contaminant characteristics (i.e. physical and chemical properties, concentration, particulate shape and size distribution, chemical reactivity, corrosivity, abrasiveness, toxicity, etc.).

(2) Gas stream characteristics (i.e. volume flow rate, temperature, pressure, humidity, composition, viscosity, density, reactivity, combustibility, corrosivity, toxicity, etc.

(3) Design and performance characteristics of the particular control system (i.e. size and weight, fractional efficiency curves, mass transfer and/or contaminant destruction capability, pressure drop, reliability, power requirements, turndown capability, utility requirements, temperature limitations, maintenance requirements, and flexibility toward complying with more stringent air pollution codes).

ECONOMIC FACTORS

(1) Capital cost (equipment, installation, engineering, etc.)
(2) Operating cost (utilities, maintenance, etc.)
(3) Life-cycle cost over the expected equipment lifetime

Thus we have seen that the best layout pattern of an integrated steel plant depends on the followings: best location, plant capacity, and provision for expansion, techno-economics considerations of both capital and operating cost, terrain conditions, technological process adopted for best control of both gaseous, liquid and solid wastes reduction and disposal, production cycle of the plant and the best transportation share between mechanical, rail and road for internal freight turnover.

The environmental engineering aspect carries over 50% of the needed decision in selecting the best layout for a steel plant.

IV ENVIRONMENT ENGINEERING ASPECTS

The three principal areas of Environmental Engineering are Water, Air, and Solid Waste and these will be covered briefly in relation to an integrated steel plant.

(A) WATER

Considerable quantity of water both potable water (especially if there is a township for the plant) and industrial water (both clean and makeup water) are needed in an integrated steel plant. Some of the processes employed in treating steel plant water are as follows: Physical processes involving self purification of water such as dilution, sedimentation, resuspension, filteration, gas transfer and heat transfer are used extensively as well as chemical processes such as oxidation reduction, dissolution - precipitation, and metabolic processes.

The various chemicals produced and or used in the steel plants sometimes find their way into the water supply. Some are known toxicants, mutagents or carcinogens.

The health effects of many of these are not known especially when small quantities are ingested over long periods of time.

Industrial waste water are treated and recycled and fresh or municipal water is added as a makeup Table 2 below gives some of the important waste water contaminants in an industrial plant like a steel plant.

Contaminants	Source	Environmental Significance
Suspended solid	Industrial Wastes	Causes sludge deposits and anaerobic conditions in aquatic environments
Biodegradable Organics	Domestic/Industrial Waste	Causes biological degradation which may use up oxygen in receiving water and result in undesirable conditions.
Nutrients	Domestic and Industrial waste	May cause eutrophication
Refractory	Industrial waste	May cause taste and odour problems, may be toxic or carcinogenic.
Heavy Metals	Industrial wastes, mining, etc.	Are toxic, may interfere with effluent reuse.
Dissolved inorganic	Increases above supply by domestic and/or industrial use.	May interfere with level in Water effluent reuse.

Table 2: IMPORTANT WASTE - WATER CONTAMINANTS

Waste water disposal and reuse,. Sludge removal and disposal are all useful for irrigation purposes, recreational purposes, industrial water supply, ground water recharge or can be reused in portable water systems.

(B) AIR

Air pollution can be defined as the presence in the outdoor atmosphere of one or more air contaminants (i.e. dust, fumes, gas, mist, odour smoke or vapour) in sufficient quantity, of such characteristics and of such duration as to be or to threaten to be injurious to human, plant or animal life or to property or which reasonably interfere with the comfortable enjoyment of life or property. (5)

The five major air pollutants are carbon monoxide (CO), Particulates, Sulphur oxides (SO_x). Hydrocarbons (HC), and oxides of Nitrogen (NO_x). Categorised as primary contaminants/pollutants are NO_x, SO_x and HC while O3 (Ozone) and PAN (peroxy-acetyl nitrate) which are formed in the atmosphere by photochemical reaction, hydrolysis or oxidation are categorised as secondary contaminments/pollutants.

Particulates are Dust (1-1000 μm), Flyash (1-1000 μm), Spray (10-1000 μm) Fumes (0.001-1 μm), Smoke (<1 μm), and mist (-0.1-10 μm).

The typical gasequs pollutants in steel plants, their sources and significance are given in Table 3.

Air Pollutants	Manufacturing Sources	Causes these damaging Effects
Sulphur Dioxide	Fuel combustion (coal and oil), smelting and casting.	Sensory and respiratory irritation, vegetation damage, corrosion, possible adverse effect on health
Carbon monoxide	Fuming of metallic oxides	Reduction in oxygen carrying capacity of blood
Ammonia	Coke oven + c.o. By Product plant	Produces chemical burn to skin. Corrosive to copper, brass and zinc.
Arsine	Pickling, etching or planting process involving metals	Breakdown of red cells in blood
Hydrogen cyanide	Metal plating, blast furnaces	Capable of affecting nerve cells.
Nitrogen oxides	High temperature combustion metal cleaning; carbon-arc Combustion, manufacture of H_2SO_4	Irritating gas affecting lungs; vegetation damage.
Phosgenes	Thermal decomposition of chlorinated hydrocarbons, Degreasing.	Damage capable of leading to pulmonary edema, often delayed.
Suspended particles (iron oxide, fly ash, soot, smoke)	Combustion and industrial process (Basic oxygen process)	Causing soiling and reducing visibility
Odours	Coke oven, coke oven bye product plant, blast furnace	Objectionable odours

Table 3: Typical gaseous pollutants in Steel Plants, their principal sources and significance. (8)

All the five categories of pollutants mentioned above are generated in the following units of an integrated steel plant. Coke oven and by-product unit; raw material yard and preparation yards; lime plant, pellet plants, Direct Reduction plant; Blast Furnace; Steel melting shop, (i.e. Electrical Arc Furnace, L-D plant, Oxygen Converter Shop, Open Hearth etc.). Reheating Furnace; Rolling Mill shops; Power plant etc.

Some of the effects of these pollutants are:

(i) Reduced visibility

(ii) Altered precipitation e.g. fog over cities, cloud formation due to SO_2 over industrialised areas and NO_x and SO_x linked with acid rain.

(iii) Urban Heat Island/Solar radiation reduction over urban areas leading to cities experiencing high average temperature and less snowfall, or rainfall.

(iv) Acid rain (or acid deposition) i.e. gaseous emissions of SO_x and NO_x interacting with water vapour to form H_2SO_4 and HNO_3 which are deposited on earth as aerosols and particulates (dry deposition) as rain drops, snowflakes, fog, or dew (wet deposition).

(v) Depletion of Ozone (0_3) layer in the stratosphere. Thus allowing more Ultraviolet radiation to reach the earth surface.

(iv) Increase in the Troposheric $C0_2$ at the rate of about 1.8mg/m^3 (at a distance of 0-10km above earth ground (level).

(vii) Harmful effect of these pollutants on human health, on animals and on plants.

Tables 4, 5 and 6 give effects of particulate matter on health, carbon monoxide in the heamoglobin (COHB); and health effects of Sulphur dioxide (SO_2) on humans.

CONCENTRATION μg/m3	ACCOMPANIED BY	TIME	EFFECT
750	715 $\mu g/m^3$ SO_2	24-h average	Considerable increase in illness
300	630 $\mu g/m^3$ SO_2	24-h average	Acute worsening of chronic bronchitis patients
200	250 $\mu g/m^3$ SO_2	24-h average	Increased absence of industrial workers
100 - 130	120 $\mu g/m^3$ SO_2	Annual mean	Children likely to experience increased incidence of respiratory disease.
100	Sulphate rate above 30mg/cm³/mo	Annual geo-metric mean	Increased deathrate or those over 50 likely.
80-100	Sulphate rate above 30mg/m²/mo	2-year geo-metric mean	Increased deathrate for those 50-69 yrs.

Table 4: Particulate matter - effects on health. (5)

COHb Level ppm	Demonstrated Effects
Less than 1.0	No apparent effect
1.0 - 2.0	Some evidence of effect on behavioural performance
2.0 - 5.0	Central nervous system effects; impairment of time interval discrimination, visual acuity, brightness discrimination, and certain other psychomotor functions.
Greater than 5.0	Cardiac and pulmonary functional changes
10.0 - 80.0	Headaches, fatigue, drousiness, coma, respiratory failure, death.

Table 5: Health effect of COHb at various levels in the blood. (5)

CONCENTRATION PPM	EXPOSURE TIME	EFFECTS
0.-0.6		No detectable response
0.15-0.25	1 - 4d	Cardiorespiratory response
1.0 - 2.0	3 - 10 min	Cardiorespiratory response in healthy subjects
1.0-5.0	-	Detectable response, tightness in chest
5.0	1 hr	Choking and increased lung resistance to air flow
10.0	1 hr	Severe distress, some nosebleeding
Greater than 20	-	Digestive tract affected, also eye irritation
400-500	-	Dangerous for short periods of time

Table 6: Health Effects of SO_2 on humans.95 (5)

There are certain emissions standards set by the Environmental Protection Agency (EPA) of the country concerned and whatever control methods that are used are towards meeting these set norms. EPA of Nigeria (FEPA) is yet to set standards in these areas.

Some of the control methods employed in a steel plant are prevention of reduction of the contaminant emission by

(i) Replacement of fuel
(ii) Proper use of existing equipment and advances in equipment technology.
(iii) Changing the process in use

Particulate contaminant control devices are, gravitational settler; centrifugal collectors, wet collectors (vis spray tower, cyclonic, impingement; venturi; electrostatic precipitators; Fabric Filtration). These control systems employ the principles of Adsorption; Absorption; condensation and or combustion, plus other atmospheric clearing methods like dispersion, flocculation, etc.

Table 7: Give Control Techniques Applicable to unit processes in various units of the steel plant.

Unit	Process Operation	Air Contaminants emitted	Control Techniques
Coal Preparation plants	Material handling, conveyors elevators, chutes	Particulates (dust)	Local exhaust systems and cyclones.
	Sizing, crushing, screening, classifying, dedusting	Particulates (dust)	Local exhaust systems, cyclones, precleaners, baghouse
	Storing coal in piles Refuse piles	Blowing particulates (dust) H_2S, Smoke	Wetting; plastic spray covering; Digging out fire; pumping water into fire areas; blanketing with incombutible materials.
	Coal drying, rotary, screen, suspension, fluidbed, cascade.	Dust, smoke, particulates, sulfur oxides, H_2S	Exhaust system with cyclones and venturi scrubbers
Coke Plants	By-product oven charging	Smoke, particulate (dust)	Pipeline charging portable hooding; scrubber & baghouses
	Pushing	Smoke, particulate (dust), SO_2	Minimise green coke pusing, scrubber and baghouses
	Quenching	Smoke, particulates (dust & mist). phenols & ammonia	Baffles and spray towers.
	By-product processing	CO, H_2S, methane, ammonia, H_2, phenols, hydrogen cyanide, N_2, benzene, xylene, etc.	Electrostatic precipitator scrubber, flaring
	Material storage (coal and coke)	Particulates (dust)	Wetting, plastic spray; fire prevention techniques.

Unit	Process Operation	Air Contaminants emitted	Control Techniques
Foundries Iron	Melting (cupola)	Smoke and particulates	Closed top with exhaust system; CO after-burner; gas cooling device; scrubbers; baghouse or electrostatic precipitator wetting to extinguish fire.
	Charging		
	Melting	Smoke, particulates fume oil, mist, CO	
	Pouring Bottom drop	smoke and particulates	
Lime Plant	Lime kiln	Particulates (dust);H_2S	Venturi scrubbers
Steel Mills	Blast Furnances; charging & pouring	CO, fumes, smoke, particulate (duest)	Good maintenance, seal leaks, use higher ratio pelletized or listered ores, CO burners in waste heat boilers stove, or coke ovens, cyclones, scrubbers, ESP, venturi scrubbers.
	Electric steel furnances, charging pouring, oxygen blow	Fumes, smoke particulates (dust) CO.	Segregating dirty scrap, proper hooding, baghouses, venturi scrubbers, or electrostatic, precipitators.
	Open hearth furnances	Fumes, smoke, SO,	proper hooding, settling chambers,
waste	oxygen blow, pouring.	particulates (dust) CO, NOx	heat boilers, baghouse, electrostatic precipitator or venturi scrubber.
	Basic oxygen furnances, oxygen blowing	Fumes, smoke, CO particulates (dust)	Proper hooding (capturing of emmissions and dilute CO) scrubbers or ESP.
Material preparation yard	Raw material storage	Patriculates (dust)	Wetting or applying plastic spray
	Pelletizing	Particulates (dust)	Proper hooding, cyclone, baghouse.
	sintering	Smoke, particulates (dust) SO2, NOx	Proper hooding, cyclones, venturi scrubber, baghouse or ESP.

Table 7: Control Techniques Applicable to unit processes in various units of the Steel Plants. [8]

(c) SOLID WASTE

Solid wastes generated in an integrated steel plant are both hazardous and indsustrial. They include rubbish, ash, slag, demolition and construction waste, ferrous and non-ferrous scraps, etc. Figures (3) and (4) gave the generation and flow of materials in the society and in the steel plant.

About 5-10% of the metal discards are recycled. Major factors considered under solid waste generation/management in an Integrated Steel Plant are:- Sources of solid waste generation, types of collection systems, determination of vehicle/labour requirements, collection routes and transportation, processing techniques and disposal by landfilling, deepwell injection, etc.

Landfilling is one of the major uses of solid waste. The main features of which are layout of the site and development of a workable operating schedule. Main factors considered under landfilling are access roads, equipment shelters, scales (if used), storage site for hazardous wastes, top soil stockpile sites, landfill areas and planting.

The special method of filling will depend on amount available cover material, topography, local hydrology and geology of the site. Figures (5) and (6) gave a typical landfill operation plan and a possible plan for filling landfill. Sometimes provisions have to be made for gas recovery and collections and pumping to a sewer of leachate. Landfilling in an integrated steel plant is generally done with unusable slag and other such debris.

Other forms of solid waste disposals are landfarming and deep well injection (for both untreatable liquid waste and hazardous waste) such as chemicals, by-product, wastes, etc.

V DISCUSSION AND CONCLUSION

The paper has looked into the advances in air pollution control devices, pretreatment, primary treatment and secondary treatment of industrial wastewater of steel plants, long and short term handling of solid wastes of steel plants for landfilling, landfarming and deep well injection. These have been adequately considered in order to meet stipulated environmental protection norms and regulations.

Water, Air and Solid pollutants in Steel Plants, their sources, their damaging effects, their processing and disposals have also been looked at in detail.

It can thus be concluded that in addition to the general and usual factors of site selection, plant capacity, techno-economics considerations of capital and operating costs, transportation considerations, etc, this paper has highlighted the importance of Environmental Engineering considerations for the seclection of adequate pollution control equipment for the best technological process to be used for various units of the steel plant in order to arrive at the best layout for an Integrated Steel Plant.

Set environmental regulations and norms are met thus guaranteeing the safety of humans, animals, vegetation (environment) and material properties

VI. TABLE AND FIGURES

Table 1 Short and Long- Term Actions for Effective Industiral Solid Waste Management

Table 2: Important Waste Water contaminants.

Table 3: Typical Gaseous Pollutants in Steel Plants, their principal sources and significance.

Table 4: Pariculate Matter - effects on health

Table 5: Health Effects of COHB at various levels in the blood

Table 6: Health Effects of SO_2 on Humans

Table 7: Control Techniques Applicable to unit processes in various units of the steel plant

Fig. (1a): Flow diagram showing the principal process steps involved in converting raw materials into major steel products.

Fig. (2a): Rectangular Sequential Diagram
Fig. (2b): Rectangular Parallel Diagram
Fig. (2c): Rectangular Complex Diagram
Fig. (2d): Rectangular Combination Diagram
Fig. (2e): Oblique Sequential Diagram
Fig. (2f): Oblique Parrallel Diagram
Fig. (2g): Oblique Complex Diagram
Fig. (2h): Oblique Combination digram
Fig. (3): Generalised flow of materials and the generation of solid wastes in society

Fig. (4) Flow of Materials in a Technological society

Fig. (5): A typical landfill Operations plan.

Fig. (6a & 6b): A possible plan for filling land fill.

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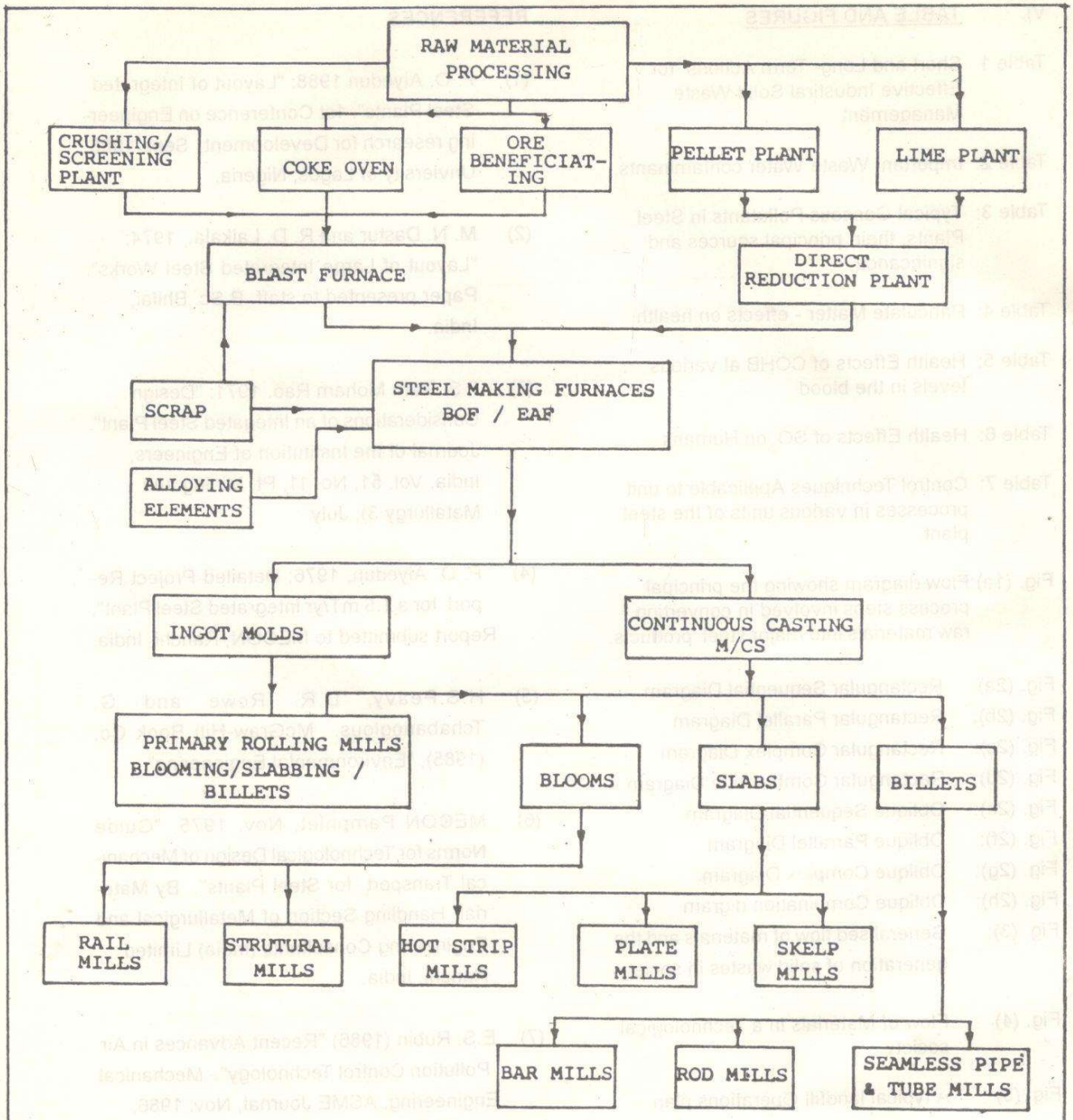


Fig. (1) Flow diagram showing the principal process steps involved in converting raw materials into major steel products.

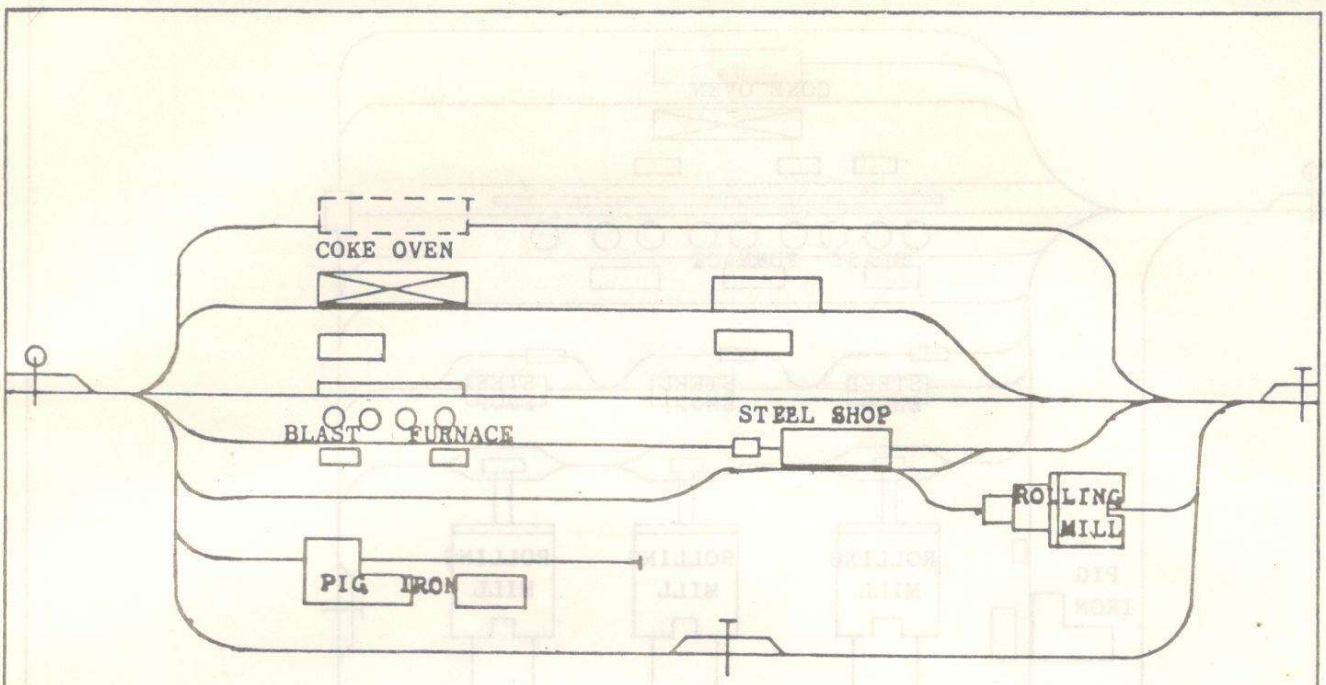


Fig (2) Rectangular Sequential Diagram

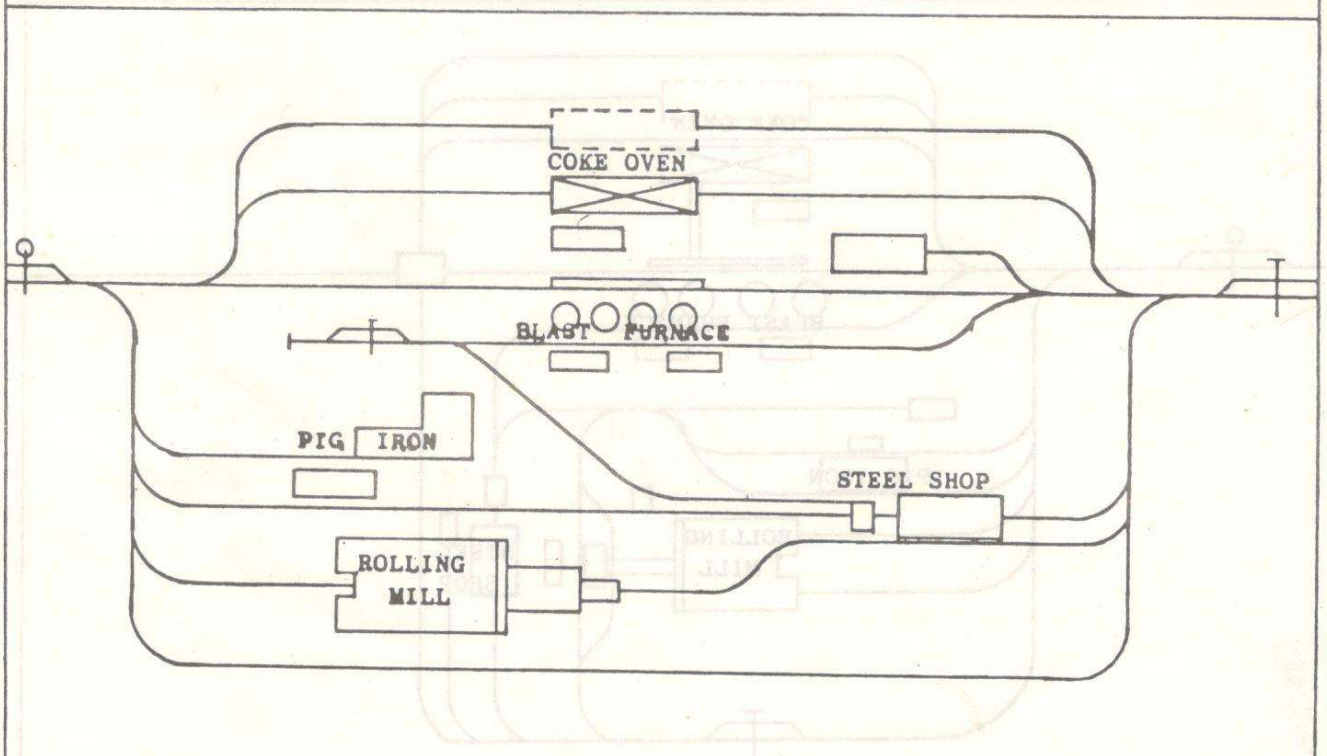


Fig. (3) Rectangular Parallel Diagram

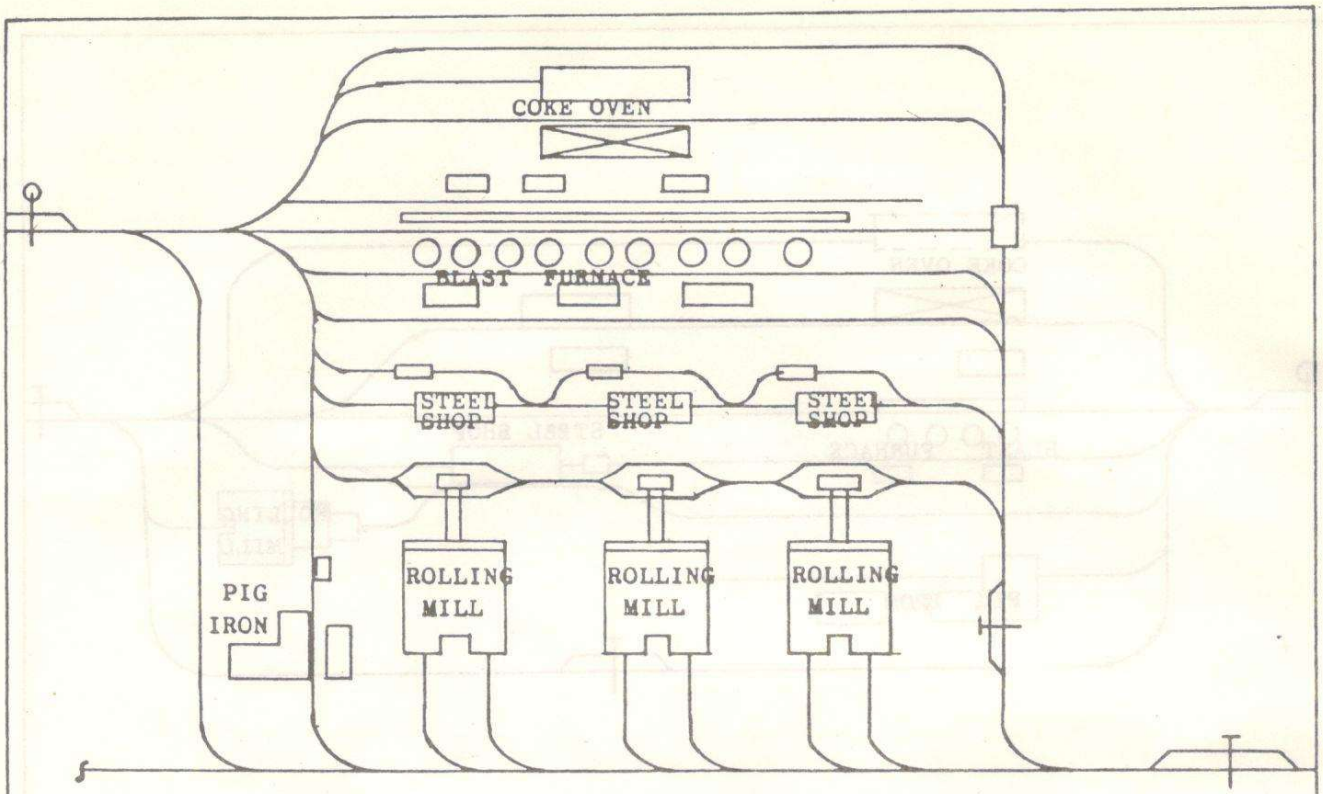


Fig. (4) Rectangular Complex Diagram

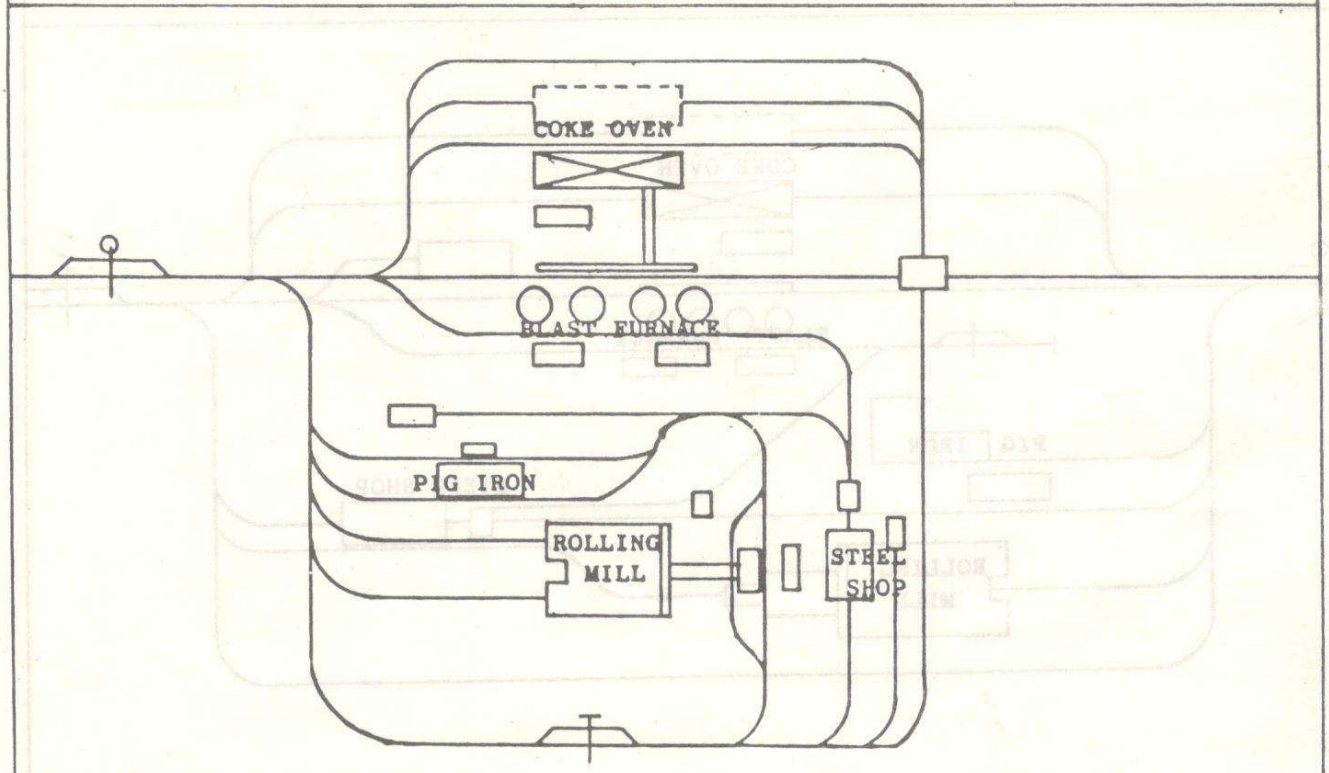


Fig. (5) Rectangular combination Diagram

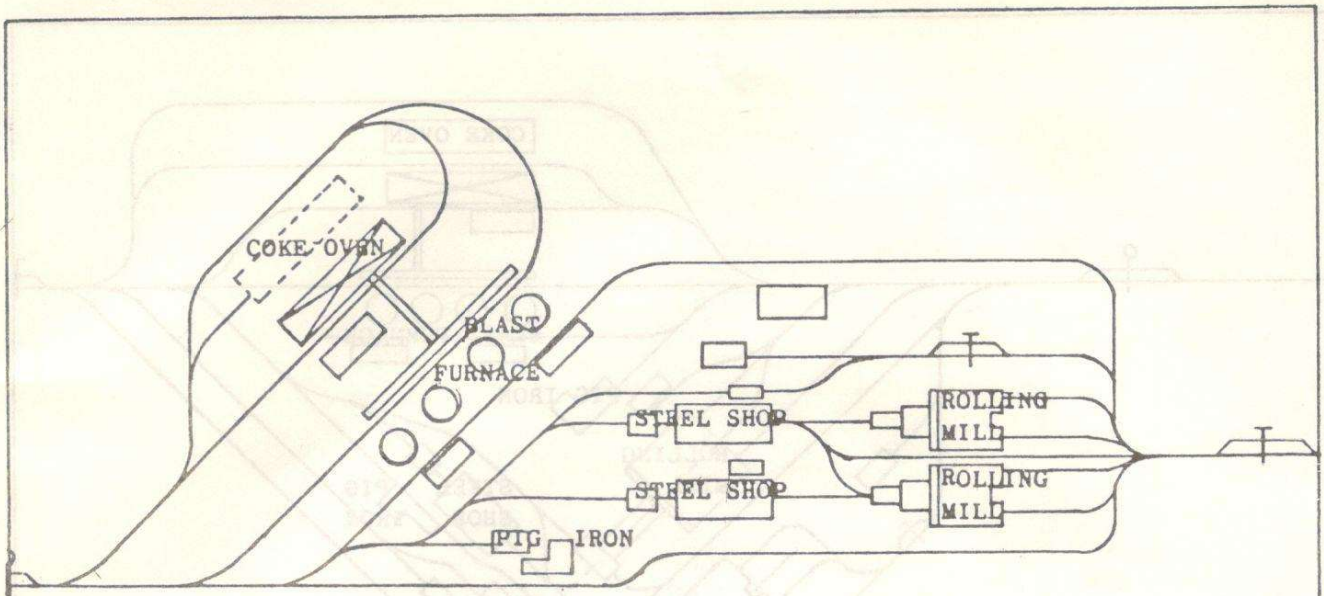


Fig. (6) Oblique Sequential Diagram

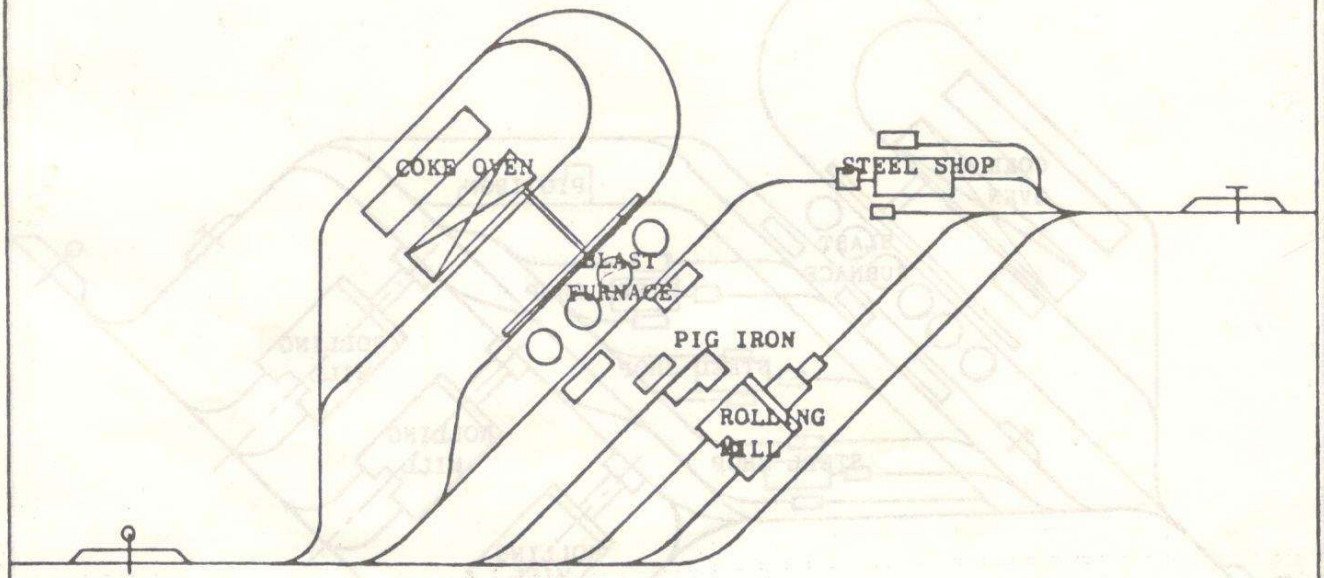


Fig. (7) Oblique Parallel Diagram

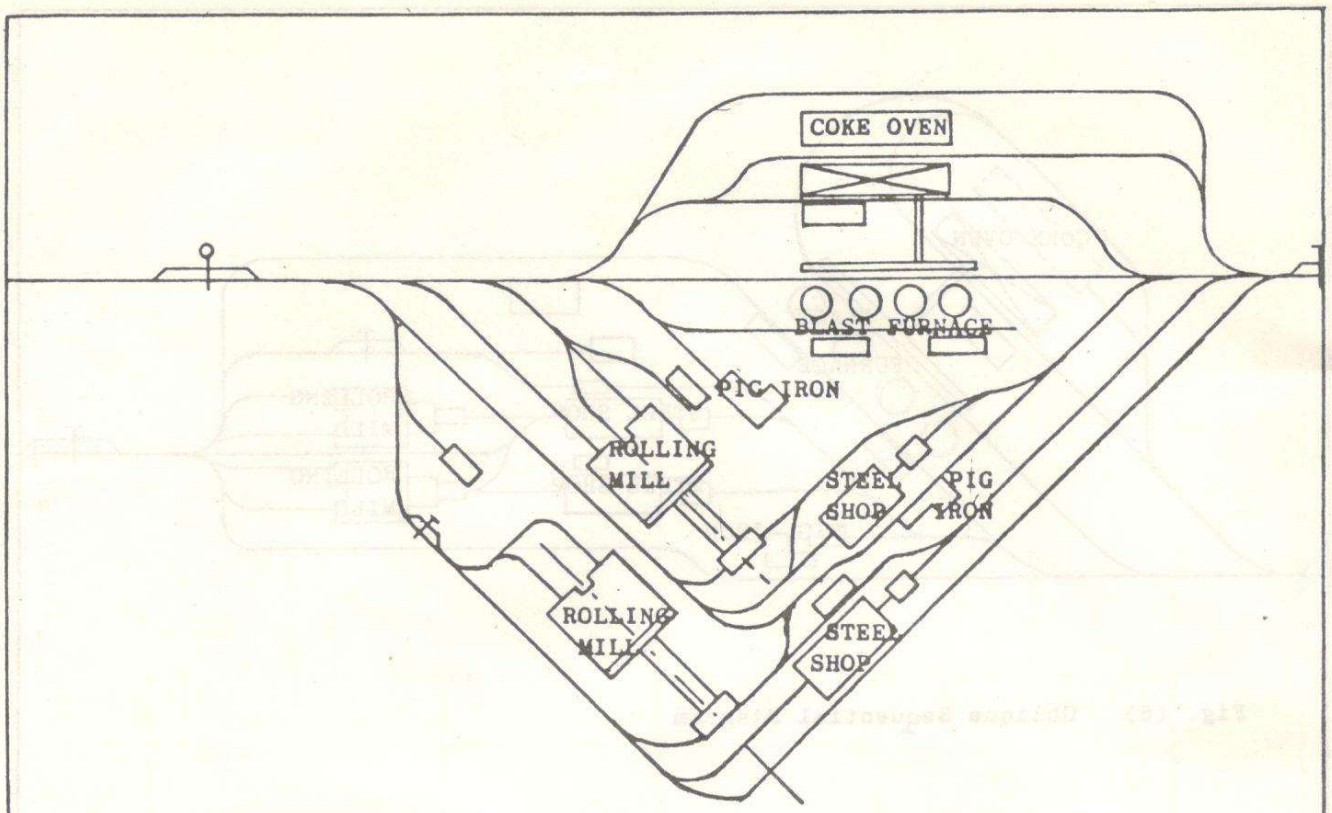


Fig (8) Oblique Complex Diagram

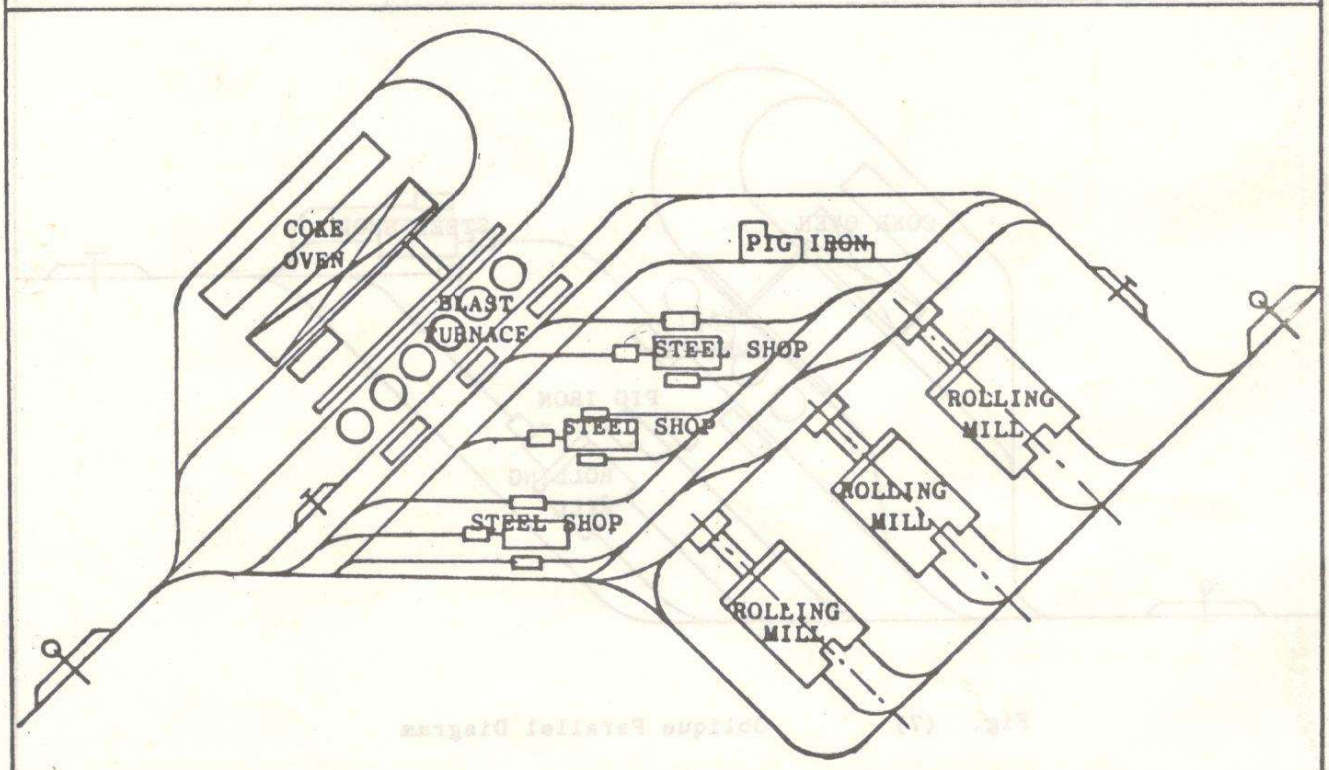


Fig. (9) Oblique Combination Diagram

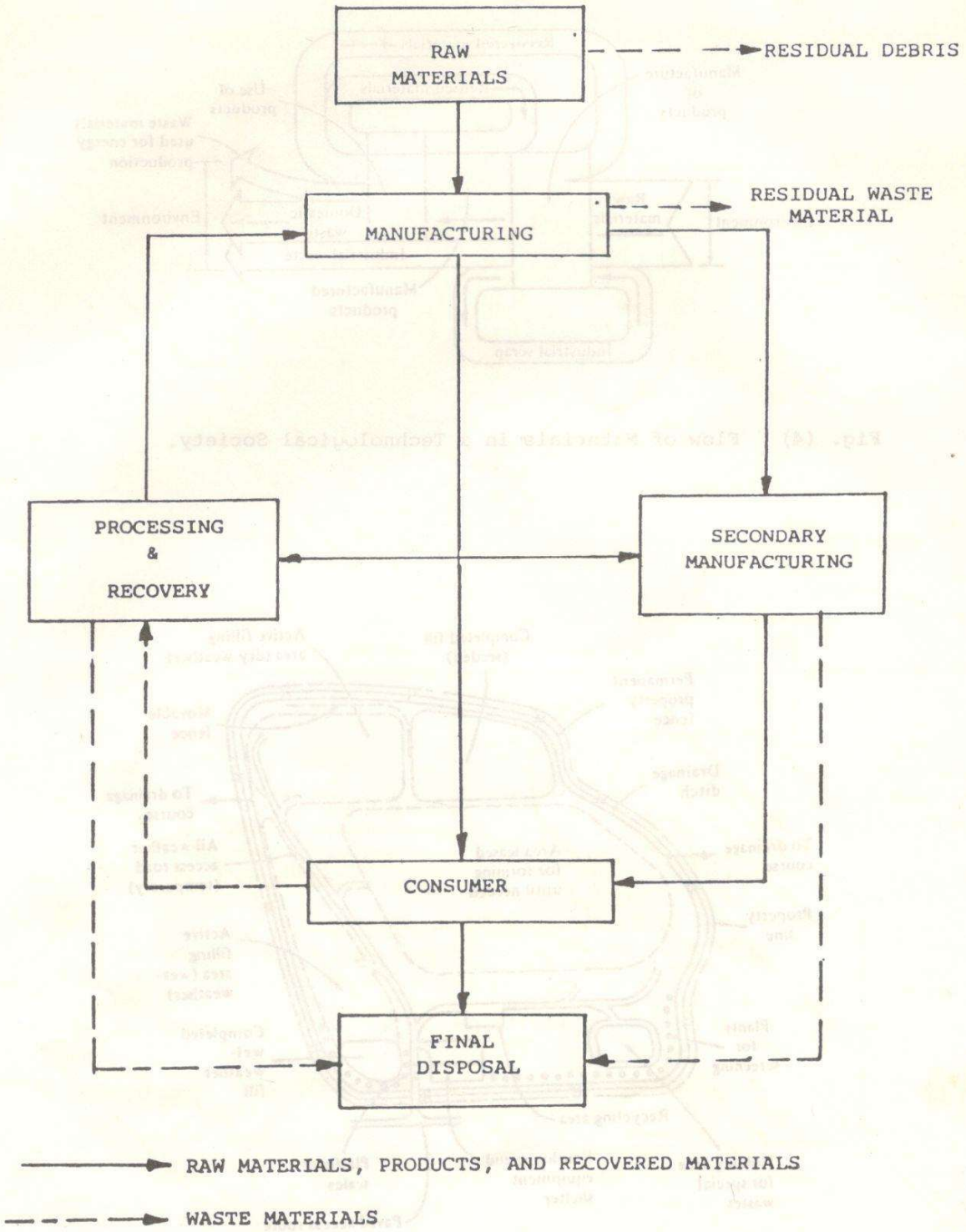


Fig. (3) Generalised flow of Materials and the generation of solid-wastes in Society.

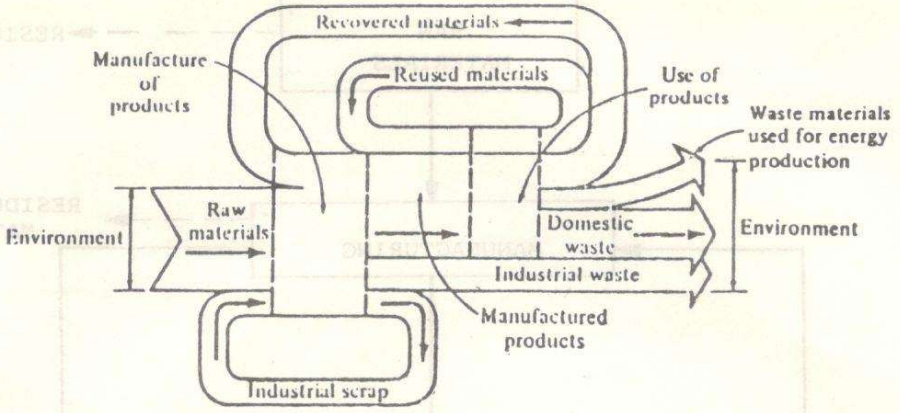


Fig. (4) Flow of Materials in a Technological Society.

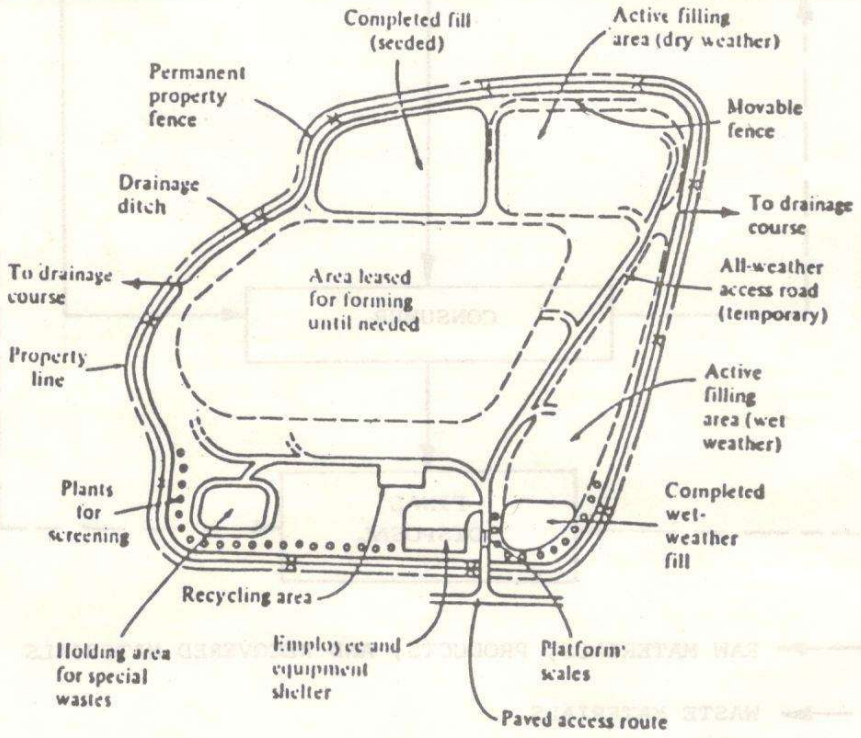
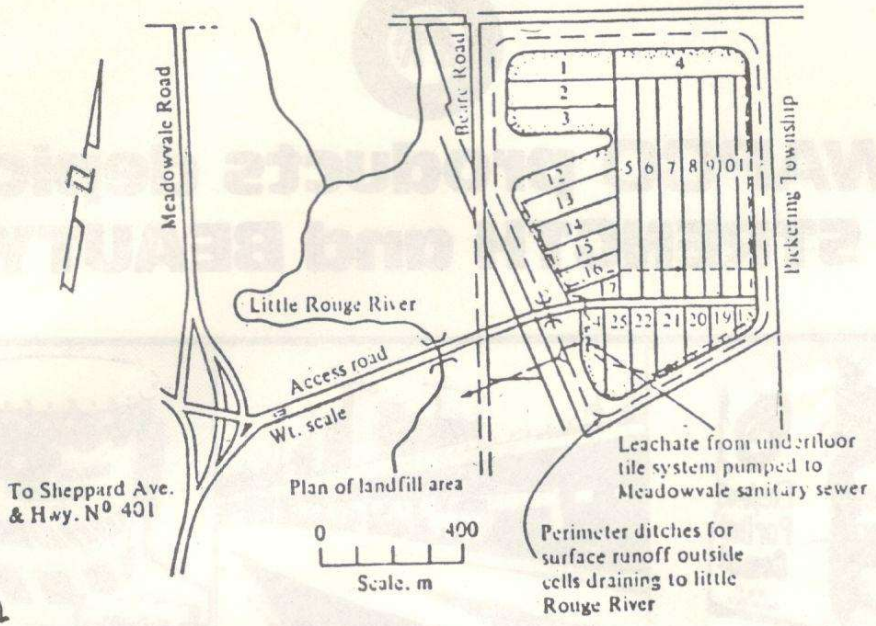
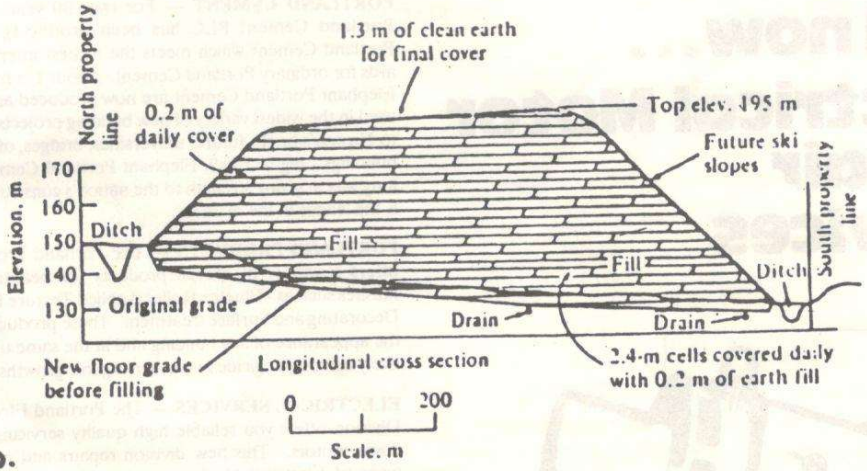


Fig. (5) A Typical landfill Operation plan [5]



6a



6b.

Fig (6a & b): A possible plan for filling landfill [5]