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Unit 1 – Topic 6,7,8,9

The basic features that affect the design of the plant layout are as follows

1. Type of industry
2. Volume of production

It indicates the capacity or rate of production. While designing a plant layout the volume to be produced should be kept in mind & designed accordingly.

3. Influence of the process
4. Flexibility of layout:
    - Keep enough obstructed floor areas
    - Separate electric motors for individual machines.
    - Mobile machineries are to be used wherever possible
    - Equipments are to be placed on rubber footings instead of being fixed permanently
    - Portable conveyor units may be employed
    - Make use of portable jigs & fixtures.
5. Machine requirements
6. Nature of the product: The aspects of a product are
    - Product design
    - Product specification
    - Quantity & variety of the product
7. Work station design:

Work station or work space is the floor space occupied by the worker & the machine or group of machines.

8. Storage space required
9. Materials

10. Movement :

Material flow should be Straight line without back tracking or cross flow without unnecessary handling.

11. Employee's facilities:

This includes medical facilities, canteen, locker room, lavatories, wash basin, etc.

12. Building:

It protects man, material, machines & supporting activities.

13. Expansion
14. Adaptability
15. Type of machineries:
    - Manually operated machine
    - Semi-automatic machine
    - Fully automated machine
    - Universal machine
    - Multi-operation machines
    - Single purpose machine.
16. Effect of locational site on layout

PLANT LAYOUT

A plant can be divided into four sections namely processing section, axillary unit, administration section, waste handling & personal convenience. Plant layout has to be prepared based on these sections.

PROCESSING SECTION:

Consists of storage facility, processing unit, control room, packaging section & laboratory

1. Storage facility/Godown:
    - Well connected to the main gate. Inlet of raw materials & outlet of product will be made easy.
    - Vicinity of the security
    - Enough space for vehicles to turn around in the loading & unloading section.
    - Loading & unloading facility
2. Processing unit:
    - Good ventilation & lighting
    - Floor with appropriate slope for easy drain.
    - Floor material should be non-slippery in nature & easy maintainable. Cement floors are commonly used.
3. Control room
    - It should be inside the processing section at an elevated position.
    - Complete flow diagram of the process with electronic controls is necessary.
4. Laboratories
    - Near access to the processing area.
    - Chemicals & other items in lab should not be placed out in processing section.
    - Glass wares & all lab wares should be handled within the laboratory.

- The materials used in these laboratories should be stored separately. They should not be stored in raw material storage facility.

ANCILLARY UNITS:

1. Water supply:
    - Means of water supply & quality of water
    - Stored in water tank of required capacity
    - Consideration in length of the pipe line & plumbing to be made easy.
    - Section that requires more water supplies should be considered.
2. Boiler room:
    - Boiler installed if there is requirement of steam in processing section.
    - Steam line is costlier than water line due to insulation.
3. Power Supply:

Industries are located with minimum distance of power distribution. Electricity control room is the placed b/w the entry point of power supply and the power distribution to the different sections. Equipments require high or medium or low power supply.

4. Fuel room
    - To store fuels that facilitates boiler & generators.
    - Well connected to the main gate.
    - Fuels are not kept inside the store & boiler room.
    - Solvent like petroleum ether, hexane, etc & diesel are normally stored under ground. The under ground storage tank is 1-2 m below ground level and covered with two layers (sand as the top layer).
    - No activities are done above the tank
    - Pumping is done to take out the fuel.
    - Diesel is used for generators & furnace oil for boilers generally.

5. Maintenance Section
    - This section can be outside the plant
    - Small essential & portable machines can be used. They are efficient to repair machines in place.
6. Refrigeration section
7. Generator room: To support the operations during power failure.

It should be near the power grid.

ADMINISTRATION:

Office building outside the processing section for higher officials & staffs can be built. Here accounts can be maintained. Supervision section inside the plant is essential.

WASTE DISPOSAL:

Waste disposal is necessary to maintain sanitary conditions inside the plant. Also waste has to be disposed properly without environmental pollution or sent to treatment plant nearby. Drainage system inside the plant is constructed in such a way that effluent & liquid wastes are conveyed to the treatment plant by gravity. Solid disposals can be collected in small jute bags and conveyed out of the plant on a wheel barrow.

DRAINAGE SYSTEM

Drainage system is provided to collect & convey the effluents & sewage out of the processing plant to treatment area. After the treatment the water can be used for cleaning or irrigation. The system can be open or closed type.

Factors affecting this system are type of effluent, slope, topography & future expansion. Strainers are used to prevent large sized effluents/rodents from entering in. The system has laterals, sub-mains & main pipe lines to collect the effluent from different parts & convey to the treatment area. The pipes are made up of cast iron, earthen tubes (earlier days), PVC (upto 200mm diameter) & M.S. Once the pipelines are out of the plant they can be provided with appropriate closure.

Traps prevent backward flowing of effluents. Example is the bottle/ U trap in AC. Sometimes they are filled with some liquids to prevent bad odor.

PERSONAL CONVENIENCE

1. Parking :

   They can be made convenient by allotting separate parking facilities for officials, employees, traders & for wagons that unloads & loads materials. It has to be in vicinity of security.

2. Canteen
3. Hand wash: In the processing section with sanitizers to clean hands. Normally foot or elbow operated taps can be used.
4. Rest room: They are maintained at two levels

1st level-

- Locker facility to keep personal belongings.
- They can be provided with technical magazines, organization's newsletter, newspapers & sometimes tv.
- Furniture to rest b/w shifts
- Sometimes bathing facility.

2nd level:

- Provision for changing cloths/uniform.
- Toilet/lavatories- Sanitation should be maintained. Urinal basin with push & flush type. Water closet in Indian/EU type of flushing.
- Shower, soaps & detergents to be provided in hand wash.
- FDA recommends use of disposal tissue paper of 24 inches long rolled into rolls of 25cm width to be used. Otherwise 1 time use towels that can be washed, sanitized, dried & reused.
- Spring operated door or curtains with rubber or plastic material.
- Near the processing section. Even if it is a part of the building, entrance should be different.
- Emergency bath can be made in the processing section.

WATER SUPPLY

SOURCE OF SUPPLY:

1. Well:

The opening of the well is properly closed to avoid large particles from entering in. Area around the well should be properly fenced. Pumping system is provided to take out the water.

2. Bore well:

It utilizes water in the under-ground water table. Sump is provided to suck water from below. The water is then stored in over-head tanks.

3. Municipal source:

The water got from municipal source is normally stored in tanks whose capacity depends on the frequency of supply, quantity of water to be stored, number of days of storage.

4. Outsource water supply: The water comes in a tanker & stored in tanks. The water to be procured depends on the daily requirement.

TANKS:

The water is stored in overhead & under-ground tanks. In olden days cast iron tanks are used. Nowadays brick or concrete tanks are used. Manhole of size .75x.75 sq.m (minimum) can be provided for maintenance of the tank. The openings are covered with slabs made of cement. The size of the tank depends on number of fillings/day i.e., at what interval it has to be filled & daily requirements.

Pumps are provided to suck & deliver the water from tank & its capacity depends on the rate of water supply & capacity of tank. Efficiency of the pump has to be taken into account. Air vent is provided at the delivery point of overhead to release the trapped air inside. The height of the air vent is not more than 3m.

PIPES:

Pipes are used to convey fluids. Pipes are made up of metal or non-metal material. Metal can be ferrous which includes mild steel (M.S), stainless steel (S.S) & galvanized iron (G.I) or non-ferrous which includes copper, aluminium & brass. Non metal includes different grades of PVC. PVC & G.I. are normally used for water supply. Lengths of pipes are normally upto 6m. Metallic pipes are coupled by threading in it

& PVC pipes are joined by threading up to >4mm length or using solvent paste at the time of usage. For conveying hot water, mild steel & galvanized steel (mild steel with zinc coating to avoid rusting & corrosion) can be used.

PIPES FITTINGS & VALVES:

Fittings are used to connect pipes, to adapt to different sizes and to regulate fluid flow. Fittings are of the followings kinds.

1. Nipple: It is a short stub of pipe, externally threaded at both sides.
2. End cap/cup: It is used to cover the end of a pipe. End cap has internal threading where as end cup has internal threading.
3. Coupling: It connects two pipes with each other by internal threads.
4. Reducer: If the two pipes differ in size, reducer coupling is used
5. Tee: It is used to combine or split the flow. In the form of T shape with internal threading.
6. Elbow: This allows a change of direction of the flow to 90° or 45°.
7. Bend: Y bend fitting has a side inlet pipe entering at 45-60° to the straight pipe.
8. Union: Allows for a quick & convenient disconnection of pipes during maintenance or fixture replacement. It is similar to coupling.
9. Flang: It is an internal or external rim of different standards. It allows easy functionality & inter-changeability. They are held together by screws & nuts.

VALVES:

A valve is a device that regulates the flow of a fluid by opening, closing, or partially obstructing various passages. Valves that regulate water falls into two categories wheel & ball valves. Wheel valves are gate & globe valves.

Gate is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid. The distinct feature of a gate valve is the sealing surfaces between the gate and seats are planar. Used in moderate / medium pressure application. **Globe valve** consists of a movable disk-type element and a stationary ring seat in a generally spherical body. Used for high pressure applications. A **ball valve** is a valve that opens by turning a handle attached to a ball inside the valve. The ball has a port (hole), through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked. No leakage occurs & can be used for sudden or instantaneous applications.

TAPS:

Taps of 20-25mm diameter are used. Copper or Al coated on steel is used. Threaded or push type taps are used. Nowadays foot or elbow operated taps are common in industries.

BOILER

Boiler is used to produce steam that can be used in several heating process. Steam has the following advantage

- Flow evenly & has good contact with all heat transfer surfaces
- Heat transfer co-efficient is high
- Easy to elevate the temperature & in turn the pressure
  (As PV=mRT)

- Heat exchangers are used to transfer heat. Different types of heat exchangers are Shell & tube, tubular, plate, scrapped, falling/climbing film heat exchanger.

FACTORS:

Heat exchange depends on

- Mass flow rate of fluid & steam
- Specific heat of the fluid & steam.
- Inlet & outlet temperatures of the same.
- Surface area of heat transfer.
- Logarithmic mean temperature (Δt_m) of counter flow is higher than parallel flow for given U & A (Ref equation: $Q=UA\Delta t_m$). So counter flow is preferred in industrial level.

BOILER COMPONENTS:

- Exclusive water supply preferred with automated supply.
- Softener: Salts of calcium & magnesium carbonate in water cause hardness. They have to be removed in this softener to avoid scaling in boiler.
- Feed pump
- Boiler
- Level indicator
- Steam outlet
- Safety valve

BOILER:

- Fuel: Firewood is used depending on the availability. But diesel is mostly used. Crude oil, electricity (costly), LPG, biogas (for small capacity) are other options

- Size of the boiler depends on the quantity & pressure of the steam.
- Upto 200ksc steam pressure production, the boiler comes under non-IPR (Intellectual Property Rights). Above 200ksc boiler is an IPR.
- Normally for the steam pressure of 10ksc, the steam temperature will be in the range of 150-170°C. Similarly for 1ksc pressure, the temperature will be approx. 121.3°C.
- If the boiler is heated without water in it, melting of boiler takes place. To avoid this water level indicators are normally used.

PIPES FOR STEAM:

- The pipeline carrying steam can be made up of M.S or G.I & has threaded joints.
- From boiler room, steam goes through main line & then through sub-main & then through laterals.
- Pipes can be classified as class A, B, C for least, medium & thickest thickness of pipes.
- Rigid connection can be through steel & for flexible connection; hard rubber tube can be used.
- Suitable valves can be used based on the steam pressure & its application. Diaphragm type valves are common.

Pressure Control:

Pressure release mechanism is same as that of in pressure cooker.

Safety valve: Safety valve works when pressure release mechanism does not work. This valve is made up of lead surrounded by Aluminum. Lead has low melting point than Al so if temperature increases beyond certain level; it melts & releases the pressure.

Pressure reduction station: This station consists of a U tube with a valve connected to the steam line. To reduce the pressure, the valve in U tube is opened & steam is passed n number of times by which pressure is reduced.

INSULATORS:

The pipe line carrying steam is normally insulated to avoid heat loss. The insulators normally used are

- Asbestos rope
- Plaster of paris – good binder & insulator.
- Glass wool covered with iron cladding – disadvantages are difficult to dismantle & difficult to locate in case of any leakage & cannot be handled with bare hand.

Iron cladding can be less thick Al or G.I or tin sheet. Workability is more in case of less thickness. At bends, number of grooved sheet connected together can be used.

BOILER INSTALLATION:

- Outside the processing section. Because of handling of fuel/ smoke/firewood.
- Boiler should not be placed in the floor. It should be kept at certain height from the floor. This will increase the aeration & spills dries up easily thus maintaining the floor.
- Diesel furnace has no waste after combustion.
- Chimney should be long & provided with cap to prevent entry of dust particles.
- Fuel tank having diesel should be kept away from the boiler. There should not be any leakage from fuel pump.

- Pipelines passing through opening in the wall can be large for convenience. But it should be seen that no heat loss takes place.
- Boiler failure results in bursting. To prevent this periodical maintenance should be carried out. It can be scheduled daily, weekly, fortnights, monthly & annually.
- Boiler operator (completed certificate/diploma course in boiler operation) must be appointed. Inspections are made by Boiler Inspectors from Department of Industries.

REFRIGERATION PLANT

Refrigeration unit is installed in a plant to achieve low temperature storage conditions. The unit achieves different temperatures by thermostat & the temperatures are maintained by a sensory device. The temperature can be controlled by NO (normally open circuit) & NC (normally closed circuit).Once the temperature is achieved the unit will switch over from NC to NO which stops further cooling.

Refrigeration unit can be of following type

- Individual
- Centralized

COMPARISON:

INDIVIDUAL REFRIGERATION UNIT	CENTRALIZED REFRIGERATION UNIT
As many as system are required	Refrigeration components are less
Investment will be more	Cost of installation & insulation will be more.
Capacity depends on the requirements of the storage system	Refrigeration component of high capacity is needed.
Individual maintenance is required	Maintenance is easy
If one system stops working (Sometimes a power failure), another can work.	Total unit gets affected due to failure of refrigeration unit

Refrigeration Unit:

- In modular structure instead of walls, blocks of PUF (Poly urethane foam) covered with plastic or rubber is used. Each block is of 2mx1m size. They can be dismantled easily.
- Various grades of Ref PUF are available which can be selected based on type of insulation & temperature required.
- In case of less space availability (for a cold store), multi-storey building is an option. The space is economically utilized though large number of pipelines is required. This increases the cost of installation. More over maintenance cost & heat loss due to open space for staircase is more.

LAYOUT FOR PREPARATORY MACHINERY

Preparatory operations are early operations where field carrying impurities, soil borne micro-organisms are removed. In processing of grains, pre-cleaning before & after parboiling are preparatory operations. For these purpose graders, destoner, aspirator, gravity & magnetic separator are used. In fruits & vegetable processing ripening, washing, slicing, pulping, filtration is the preparatory operations.

Preparatory machineries:

a. Ripening shed
b. Grader
c. Washer
d. Dryer
e. Pulper.
f. Cold storage

Ripening shed:

Ripening makes fruit more palatable & juicy. The acid to sugar ratio lowers on ripening & the fruit softens. Thus before processing the fruit is allowed to ripen in ripening shed on procurement of fruits. The shed has to be well ventilated & aerated for natural ripening to occur. To avoid bruising & aberration cushioning materials like straw, saw dust is used.

The ripening sheds are numbered & sectioned. Individually procured commodities are ripened separately. The ripened fruits are then stored in temporary storage facility before being processed.

Working table:

Used for pulping & peeling. It is provided with waste disposal vent with trough at the bottom. Sometimes platform is provided for standing purpose. The table is made of stainless steel & has a border of 10-15cm ht. It is raised from floor by brick, plastic or non-metal to avoid corrosion while cleaning the floor.

For washer, pulper & working table adequate water supply, proper waste disposal, drainage is made. Also ventilation & lighting should be proper.

Washer:

It is provided with beater arm & strainer. In case of using working table, mild slope is provided in its surface towards wash basin in it. Adequate water supply has to be provided. In case of cleaning the equipment, beater arm & strainer has to be removed & cleaned. More space is provided around the equipment for cleaning purpose & for the workers to move around.

Slicer:

Slicing can be done with knife or in equipment provided with blades. Manual cutting board made of wood or nylon is used. By fixing cutting blade the process can be done soon. They are washed with a jet of running water & brush. Sometimes air-drying is done to remove surface moisture in sliced product e.g. potato chips.

Cold Storage:

Cold storage reduces the heat load of the product. To economically utilize the space, the material has to be cleaned to reduce bulkiness.

LAYOUT FOR SIZE REDUCTION EQUIPMENT

Size reduction:

In the grinding process, materials are reduced in size by fracturing them. The force applied may be compression, impact, or shear, and both the magnitude of the force and the time of application affect the extent of grinding achieved. The ruction ratio is given by

Factors:

The factors that has to be considered for the layout for size reduction equipments are

1) Vibration free installation:
   Vibrations are due to imbalance of rotating components in the equipment. The equipments are mounted on vibration free platforms or foundation.

2) Inlet/Outlet:
   The outlet of the equipment is provided with cloth bag in case of small scale unit & cyclone separator in case of large scale units. The porous structure of cloth bag traps dust. Hooks, stones, iron pieces, dust are prevented from entry into the equipment. They are removed in the following pre-processing operations

   a. Sieve mechanism
   b. Magnetic separator- to remove iron pieces.
   c. Gravity separator-to remove stones, mud particles of same size.
   d. Aspirator- to remove light weight impurities.

3) Overload protection:
   Electrical supply to hammer, jaw & pin mills are provided with overload protection relay in the form of release mechanism. These equipments while reducing size of certain material draws more current. If the equipment draws more current than set, by dripping mechanism the motor is switched off.

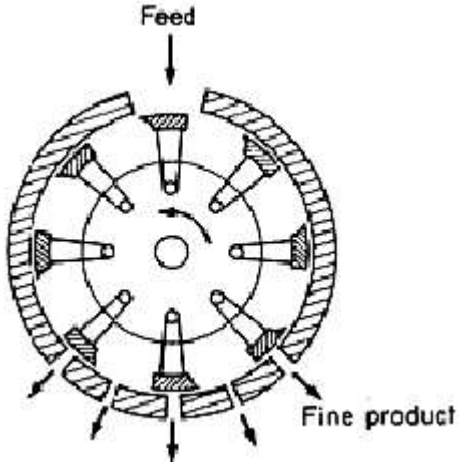
Ball Mill:

Ball mills rotate around a horizontal axis, partially filled with the material to be ground plus the grinding medium namely balls. The grinding works on principle of critical speed. The critical speed at which the ball falls by gravity gives impact on the material. Heat is produced during this operation making this operation unfit for heat sensitive materials. Mostly used in pharmaceutical & cement industries.

Ball Mill Mechanism

Hammer Mill:

In a hammer mill, swinging hammerheads are attached to a rotor that rotates at high speed inside a hardened casing.



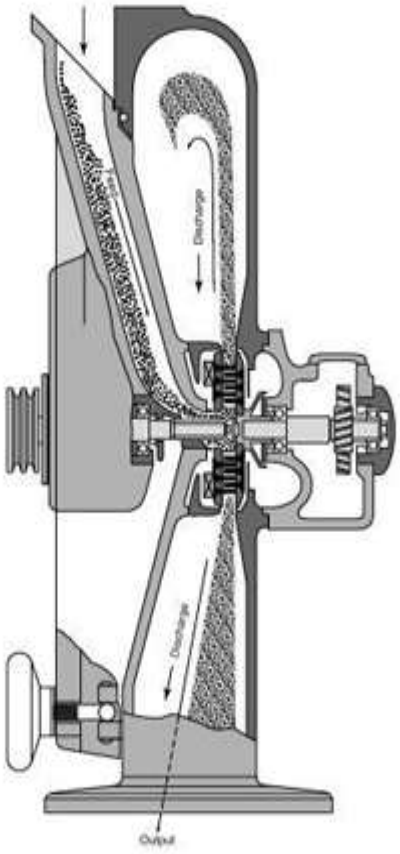
The material is crushed and pulverized between the hammers and the casing and remains in the mill until it is fine enough to pass through a screen which forms the bottom of the casing. Both brittle and fibrous materials can be handled in hammer mills, though with fibrous material, projecting sections on the casing may be used to give a cutting action.

Burr/Attrition/Plate Mill:

It is a machine in which materials are pulverized between two toothed metal disks rotating in opposite directions. The clearance b/w the rollers can be adjusted according to the size of the material.

Pin Mill:

It consists of two vertical steel plates with horizontal projections on their near faces. One disc may be stationary whilst the other disc is rotated at high speed; sometimes, the two discs may be rotated in opposite directions.



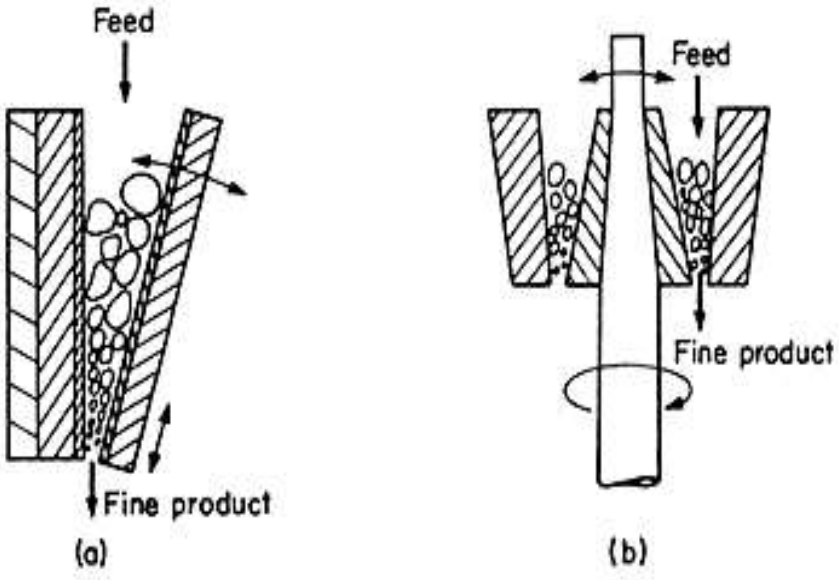
The material is gravity fed in through a hopper or air conveyed to the centre of the discs, and is thrown outwards by centrifugal action and broken against of the projections before it is discharged to the outer body of the mill and falls under gravity from the bottom of the casing.

Crushers:

Jaw and gyratory crushers are heavy equipment and are not used extensively in the food industry. In a crusher, the material is fed in between two heavy jaws, one fixed and the other reciprocating, so as to work the material down into a narrower and narrower space, crushing it as it goes. The gyrator crusher consists of a truncated conical casing, inside which a crushing head rotates eccentrically. The crushing head is shaped as

an inverted cone and the material being crushed is trapped between the outer fixed, and the inner gyrating, cones, and it is again forced into a narrower and narrower space during which time it is crushed.

Crushers: (a) jaw, (b) gyratory



Cryogenic grinding:

It involves cooling a material below its embrittlement temperature (sub zero temperatures) with a cryogenic fluid, typically liquid nitrogen or, in certain applications, carbon dioxide. After cooling, the material is fed into an impact mill where it is reduced in size primarily by brittle fracture. Cryogenic grinding is used for grinding spices, thermoplastics, colour concentrates, and similar materials.

Other pulverisers:

Micro pulveriser is similar to that of hammer mills & produces fine particles. Muller mills are nothing but grinder that is used at homes. Here the roller above the surface works breaking the material.

MULTI-STORIED BUILDING

DRAINAGE

Drainage for a multi-storied building can be collected

-Independently or

-Pooled

Independent Drainage System:

- Quantity of drainage will be less.
- Small pipes of less capacity can be installed
- Maintenance will be easy

Pooled Drainage System:

- Required pipelines will be less
- Increased cost of installation
- Hard to find blocks if there is any.
- But the major problems encountered in this pooled system are blockage & fittings.

To have good look of the building, number of pipelines has to be reduced. Thus pooled system is preferable.

To overcome Pooling problems, door elbow can be fixed at bent places in pipes through which any blockage can be cleaned. In olden days, doors with screw are fixed but nowadays threaded doors are installed.

Economisation:

One can economise the cost of pipes by gradually increasing the size of pipes from top to ground floor.

Quantity of Drainage:

If quantity (q) is equal in all stories,

Total quantity of drainage = qxn

If quantity (q) is not equal in all stories,

Total quantity of drainage = $q_1+q_2+\ldots\ldots+q_n$

Where n= no of stories.

Fittings in drainage system:

- If more numbers of fittings are used, there will be increased head loss & thus the flow is limited.
- Also chances for leakage are more if the fittings are more.
- It may increase the cost.
- Avoid using sharp edge & corner fittings so that frictional losses are reduced.

Other considerations:

At ground level, **chamber** is provided with air tight lid to avoid bad smell & blockage can be cleaned. The chambers at end of each drainage collection pipes are connected to one another & then to a tank. **Cowl**, an air vent like provision at top of the pipe line is provided to release gas. Traps are provided at the entry of drainage to avoid large particles from entering the system & blocking it. **Non return valves** are to be provided in all floors other than ground floor to avoid black flow of drainage during blockage.

WATER SUPPLY

The water is supplied from the tank to all floors through main, sub-main & laterals. The tank is placed at the top of the building to ensure flow is by gravity. Gate valve should be at proper height ensuring comfortable operation. Good reliable commercial brands of pipes should be used.

Fillers are used to avoid leakage of threaded joints.

One of the examples is the shellac got from lac tree. It is semi-solid, sticky & should be applied using brush. Twine is wounded on shellac applied threads. Teflon tape can also be used instead of threads.

For PVC pipes pastes are normally used.

MATERIAL HANDLING

-One fifth of the power consumed in material handling of roller flour mills are single floored.

-Thus they are multi-storied to have gravity flow of product

-Screw conveyor will not work above 20° & belt conveyor not above 15°.Thus belt conveyor is used

-From sifters, the product is collected using inclined channels.

-Vertical channel not used because of more impact on the product. Also sifting the outlet in same level is not possible in case of vertical channels.

-Collection is easy in inclined channels as the potential energy of product is low.

- Materials are conveyed in PVC, M.S & G.I. pipes. Flexible connection is preferred rather than rigid as the latter do not bare load & vibrations.