# Department of Mechanical and Production Engineering
# Ahsanullah University of Science and Technology (AUST)

## IPE 3204: Material Handling and Maintenance Engineering Sessional
## Credit Hour: 1.5

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**Objective:**

To get familiar with different types of conveyor and product handling equipment. Designing concepts of common handling and transfer equipment. Concept of maintenance plan and maintenance management.

**General Instructions:**

1. Attend to the lab 5 minutes prior to the scheduled time and be prepared for the experiment.
2. Sessional grade will be calculated in the following way:

| Total Marks: 100 | | | |
|---|---|---|---|
| **Attendance** | **Lab Reports** | **Viva** | **Quiz** |
| 10 | 40 | 20 | 30 |

3. Students must bring the necessary instruments, data sheet (for particular experiment), calculator, graph papers (Cartesian, Semi-log, log-log).
4. Report should be submitted in the following week during the sessional time.
5. Write report on one side of an 80 gram A4 paper and follow the following format
    a) Top sheet
    b) Objective
    c) Apparatus (including technical specification)
    d) Figure/Experimental Setup
    e) Data Sheets/Result
    f) Sample calculation
    g) Graph
    h) Discussion
        i) Discuss the graphs and results
        ii) Discuss about the experimental setup if it could be improved
        iii) Discuss the different parameters that could affect the result
        iv) Discuss any assumption made
        v) Discuss any discrepancies in the experimental procedure and result
        vi) Discuss what you have learnt and the practical application of this knowledge
    i) Finally, add the data sheet with the report.

**Suggested Reading:**

1. Conveyors and Related Equipment – A. Spivakovsky and V. Dyachkov
2. Material Handling – Siddharta Ray

## Name of the Experiments:

1. Study of angle of repose (static and dynamic) for different materials
2. Determination of bulk weight of different material
3. Determination of the capacity of a belt conveyor
4. Study of a bucket conveyor and determination of optimum capacity
5. Determination of the capacity of an apron conveyor
6. Determination of the capacity of a Screw conveyor and power loss
7. Study of layout plan of AUST central Machine shop
8. Study of the replacement plans of tube lights in AUST campus
9. Determination of power loss of the roller conveyor
10. Study the impact of angle change of roller conveyors

## Equipment List

1. **Screw Conveyor with hopper feeder**
2. **Belt Conveyor with speed control**
3. **Bucket Conveyor with speed control**
4. **Apron Conveyor**
5. **Roller Conveyor with angle adjustment**
6. **Weighing Scale (0~10 kg)**
7. **Stopwatch**
8. **Cylindrical pipe**
9. **Container**
10. **Different Types of Granular Materials (Wheat, Rice, Gram, Paddy, PVC Granules, Lentils)**

## Experiment No: 1

## DETERMINATION OF ANGLE OF REPOSE (STATIC AND DYNAMIC) FOR DIFFERENT MATERIALS

### Objectives:

i. To determine the static and dynamic angle of repose for different bulk materials
ii. To study how long they vary at different working conditions, their implication on the selection and design of material handling equipment

### Theory:

### Angle of Repose:

When a loose material (bulk load) unobstructedly spills on a horizontal plane, it assumes a slope. The angle of the slope with the horizontal plane is called the angle of repose ($\varphi$).

The magnitude of the angle of repose depends on the mutual mobility of the particles. The larger their mobility the smaller their angle.

The angle of repose may be static ($\varphi$) or dynamic ($\varphi_{dyn}$). Dynamic angle of repose is approximately 0.7 times the static angle of repose.

The static angle of repose can be determined with various simple devices, a hollow cylinder, for example. The material is filled into the hollow cylinder and when the latter is carefully raised, the material pour out and from a cone on the horizontal surface. The cone forms an angle with the surface which is called static angle of repose. The angle is measured with angle gauge of different types. The dynamic angle of repose is obtained when the horizontal supporting surface vibrates vertically.

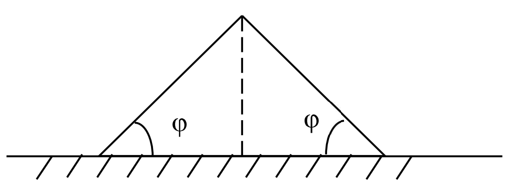



Figure 1.1: Natural slope assumed by a free – flowing material spilled on a horizontal surface

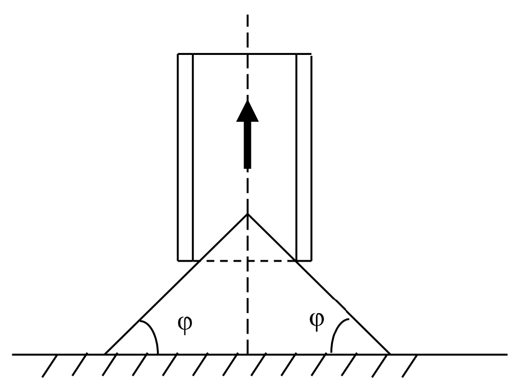



Figure 1.2: Determination of angle of repose with a hollow cylinder

## Determination of angle of repose:

## Procedure:

To determine static angle of repose, the bulk material should be filled into a hollow cylinder and then the cylinder should be raised carefully. The material would pour out and from a cone on the horizontal surface. The angle of the generatrix of the cone is the static angle of repose.

To determine the dynamic angle of repose, vertical vibration on the surface should be given while raising the hollow cylinder.

Determine the angle of repose by varying

i. Diameter and material of the cylinder
ii. Bulk material
iii. Type of the surface (such as floor table, cloth etc)

## Data Sheet: (for determination of angle of repose)

| Serial No. | Surface Condition | Material | Angle of Repose | | Radius of Expansion | | % of Static Angle |
|---|---|---|---|---|---|---|---|
| | | | Static | Dynamic | Static | Dynamic | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

## Questions:

1. What is the impact of angle of repose in conveying material?
2. Angle of repose changes with the mobility of the material, why?
3. How angle of repose can be changed for the same material?
4. Should we consider the coefficient of the bulk material on working surface in determining angle of repose? If yes, why?

## Experiment No: 2

## DETERMINATION OF BULK WEIGHT OF DIFFERENT MATERIAL

### Objectives:

i. To determine the bulk weight of different bulk materials
ii. To study the impact of bulk weight in conveying materials

### Theory:

Bulk or heaped weight γ is the weight of the material per unit of volume in bulk. It is usually measured in tons per cubic meter (or kg per liter), sometimes in kg per cubic meter. The bulk weight of granular and powdered materials is usually determined with a special device consisting of container of a definite given volume; rod attached to the container and revolving frame secured on rod. The larger the lump size of the material, the larger should be the volume of the container.

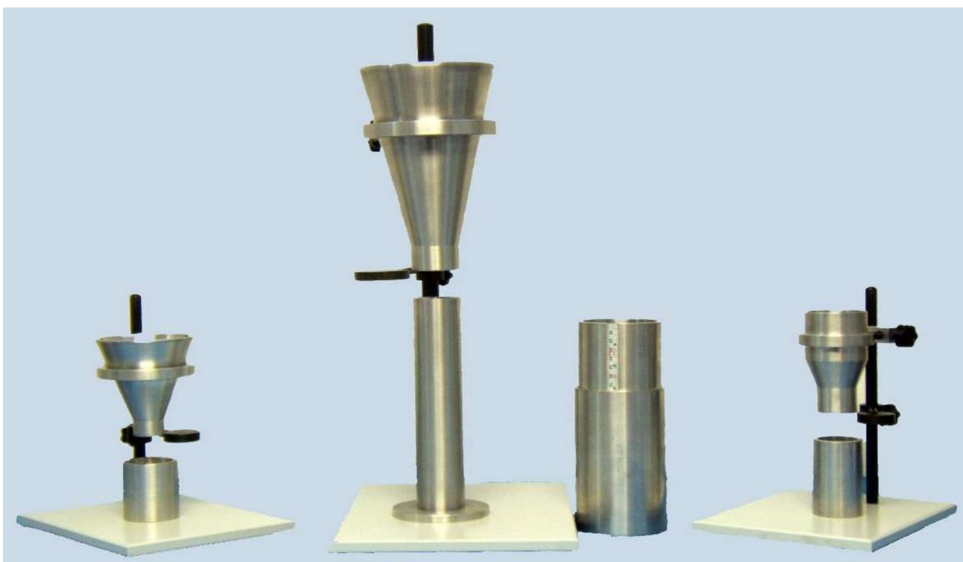


Figure 2.1: Bulk weight of material

## Procedure:

i. Measure the weight of the empty container.
ii. Bulk material is poured into the container through the frame until the container is full.
iii. A turn of the frame removes excess material and leaves the container full to the rim.
iv. Then contained is weighted with bulk material.
v. The difference between the final weight and the initial container weight is the net weight of the material.
vi. Divide the net weight of the material by the container volume is the bulk weight of that material.

## Data Sheet:

Radius of the container: _________________ m

Height of the container: _________________ m

Volume of the container: ________________ $m^3$

| Initial weight of the container (kg) | Final weight of the container including bulk material (kg) | Net weight of the material (kg) | Bulk weight, $\gamma$ (kg/ $m^3$) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

## Questions:

1) What is the impact of moisture in bulk weight measurement?
2) Significance of bulk weight.
3) While designing a material handling system what type of bulk weight should be calculated? ($\gamma$ or $\gamma_{packed}$)

## Experiment No: 3

## DETERMINATION OF THE CAPACITY OF A BELT CONVEYOR

### Objectives:

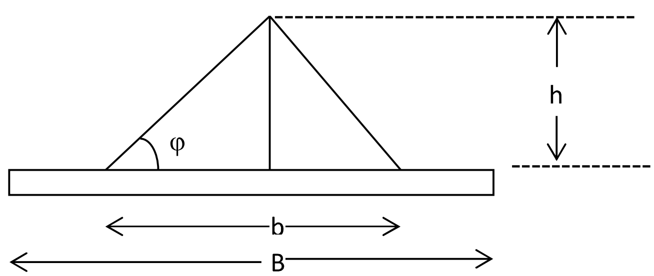
i. Study Different Parts of the Belt Conveyor
ii. To find the capacity of a belt conveyor (theoretical and actual)
iii. To find tensions at different points of the belt
iv. To calculate the required horsepower of the drive motor

### Determination of theoretical capacity:

Cross sectional area of bulk load over the belt,

$F_1 = ½ bhC_1 = ½ (0.8B) (0.5 b \tan\varphi_1) C_1$

$= 0.16 B^2 C_1 \tan (0.35 \varphi)$




Capacity of the belt conveyor, $Q_{theoretical} = 3600 F_1 v\gamma$ tons/hour

Where, v =belt speed, m/sec

$\gamma$ = bulk weight of material, tons/m$^3$

$\varphi$ = static angle of repose

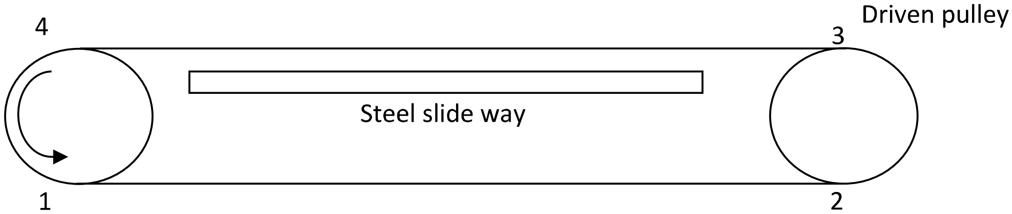
$C_1$ = correction factor for possible spillage of the load on an inclined belt. (For horizontal belt its value is taken as 1.)

## Determination of actual capacity:

Determination the actual capacity of the conveyor, $Q_{actual}$ by taking weight of the material at the discharge end for a certain period of time (measured by stop watch)

| Observation | Weight of material discharged (kg) | Time (sec) | Capacity, $Q_{actual}$, (tons/hr) | Average value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

## Determination of required Horse power of Motor:




Let the conveyor outline be divided into separate sections of the different resistance, neglecting the resistance on the deflecting rollers; and number them from 1 to 4.

The tension $S_1$ in point 1, where the belt leaves the driving pulley is assumed to be equal to $S_{s1}$.

- The tension in point 2,

  $S_2 = S_1 + W_{1,2} = S_1 + 0 = S_1$

  [Where, $W_{1,2}$ is the resistance on the section between point 1 & 2]

- The tension in point 3,

  $S_3 = S_2 + W_{curve} = S_2 + kS_2 = (1+k)\, S_2 = KS_2$

  [Where, the resistance $W_{curve}$ consists of the resistance set up by the stiffness of the pulling member when it bends entering the curve and straightens out leaving it and of the frictional resistance on the hub of the pulley or that of the shaft carrying the pulley. These resistances are generally proportional to $S_2$. The value of K lies between 1.05 and 1.07]

- The tension in point 4,

$$S_4 = S_3 + W_{3,4} = S_3 + (q+q_b)L\mu_1 = KS_2 + (q+q_b)L\mu_1 = KS_1 + (q+q_b)L\mu_1$$

[Where, $q$ = weight of the load per meter of belt length, kg/m

$q_b$ = weight of the belt per meter of its length, kg/m

$= 1.1B\ (\delta_i+\delta_1+\delta_2)$

{Assume, $\delta$ (thickness of one ply) = 1.25mm

$\delta_1$ (cover thickness on the loaded side) = 1.5 mm

$\delta_2$ (cover thickness on the return side) = 1.0 mm

i (number of plies) = 4}

L = length of the section between points 3 &4,

$\mu_1$ = belt friction factor on steel runway = 0.35 to 0.67]

- Now it is known from friction drive theory that there will be no belt slip on the pulley when

$$S_t = S_4 \leq S_{sl} \times e^{\mu\alpha} \leq S_1 \times e^{\mu\alpha}$$

[$\alpha$ is the wrap angle of the belt on the driving pulley in radian, $\mu$ is the friction factor between belt and pulley (= 0.3 for cast iron or steel pulley and dry atmosphere and dusty)]

Or, $KS_1 + (q+q_b)\,L\mu_1 = S_1 \times e^{\mu\alpha}$

Or, $S_1 = (q+q_b)\,L\mu_1 / (e^{\mu\alpha} - K)$

- Thus, $S_2$, $S_3$, $S_4$ can be found
- Now, the resistance on the driving pulley, $W_{dr} = 0.05\ (S_t + S_{sl})$
- The effective tension $W_0 = S_{st} - S_{sl} + W_{dr}$
- The required motor power for the conveyor, $N = (W_0 \times v)/102\eta$ Kilowatt [Assume v = 4m/sec]

## Questions:

1. Why the tension differs from slack to tight side of the belt conveyor?
2. Can the resistance factor be changed of the “roller & belt” & “belt & pulley”? If yes, then how?
3. Is it possible to have a value of $\mu$=0.9 for the belt and slideway friction?
4. With net sketches classify belt conveyor according to the path of motion.
5. Briefly describe different types of drive arrangements used for belt conveyor.
6. What are the factors those influence the magnitude of the pull transmitted by the driving pulley?
7. How can the magnitude of the pull be enhanced?

**Experiment No: 4**

# STUDY OF A BUCKET CONVEYOR AND DETERMINATION OF OPTIMUM CAPACITY

## Objectives:

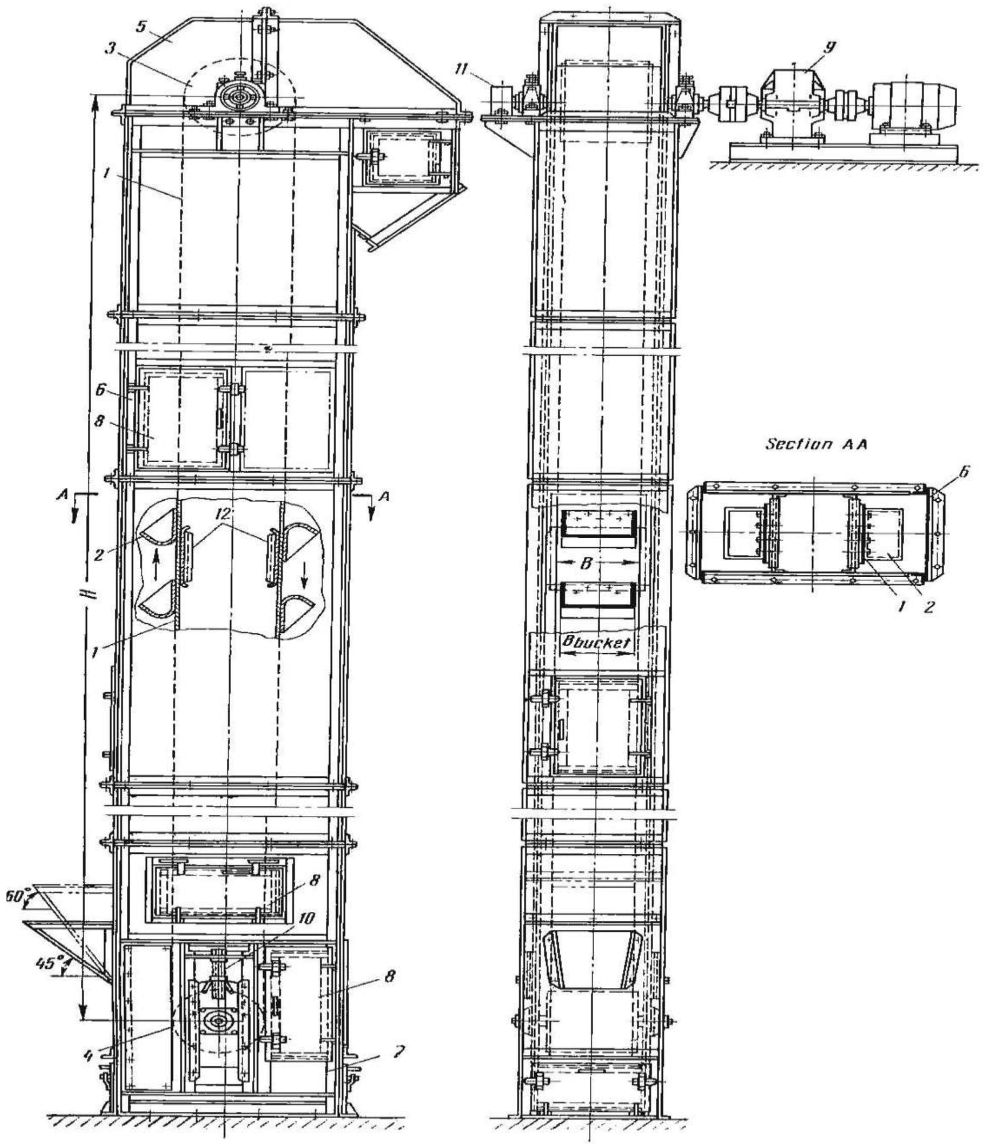
i. To study different components and the operation of the bucket conveyor
ii. To determine both the theoretical and actual capacity
iii. To determine the optimum capacity

## Theory:

## Definition, descriptive specifications and use:

These are powered equipment for conveying bulk materials in a vertical or steep inclined path, consisting of an endless belt, or chain/s to which metallic buckets are fixed. With the flexible belt/chain, the buckets move unidirectionally within a casing and collects bulk materials at bottom end of the equipment and delivers it at the top end.

A typical bucket elevator with different constructional parts is shown in Figure. The different major parts constituting a bucket elevator are as follows:
(*i*) An endless pulling member- flat belt or chain.
(*ii*) Driving and take up pulleys or sprockets at top and bottom respectively, mounted on bearings and blocks.
(*iii*) Metal casing covering the entire elevator. It consists of **head** at the top, **boot** at the bottom and intermediate sections, all joined at flanges by fasteners.
(*iv*) Buckets, generally made out of sheet metal, which are attached at definite pitch to the pulling member by fasteners (screw and nuts, riveted etc.)
(*v*) Drive at the top consisting of an electric motor, gearbox, and couplings.
(*vi*) Hold back brake attached to the top pulley/sprocket shaft, to prevent reverse motion of the elevator when drive is stopped.
*vii*) Feed hopper attached to the boot for feeding materials to the elevator.
(*viii*) Delivery/ discharge spout fixed with the top part of the casing, through which the material is discharged.
(*ix*) Manholes are provided at the casing to check operations of the elevator.
(*x*) Guides and guide sprockets are provided for belt and chain respectively to keep them in a straight path.




1-belt; 2-bucket; 3-driving pulley; 4-take-up pulley; 5-upper casing section; 6-intermediate casing sections; 7-lower casing section (boot); 8-manholes; 9-drive unit; 10-take-up; 11- holdback brake; 12-guides.

Figure 4.1: A vertical belt-and-bucket elevator

## Types of bucket elevators:

Bucket elevators are classified based on bucket spacing and mode of discharge of materials.

## Centrifugal discharge elevators:

In a centrifugal discharge elevator, the buckets are spaced at a regular pitch to avoid interference in loading and discharging. The charging of buckets is by scooping action and the discharge is by centrifugal action. These elevators are generally used in vertical configuration and used for practically all types of free flowing, small lump materials like grain, coal, sand, clay, sugar, dry chemicals etc. Both belt and chain may be used and the speed of these elevators range between 1.1 to 2 mpm.

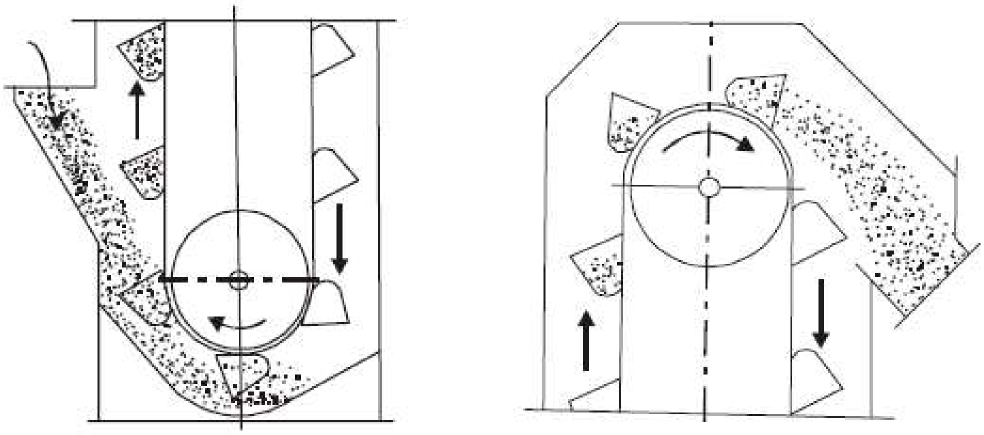


Figure 4.2: Charging and discharging of buckets of centrifugal discharge elevator

## Positive discharge elevators:

These are similar to centrifugal discharge type excepting that the buckets are side-mounted on two strands of chains (i.e. buckets lie between two strands of chains), and are provided with a pair of two snub sprockets under the head sprockets to invert the buckets for complete discharge. The speed of the elevator may be slow in the range of 0.6 to 0.67 mpm. These elevators are used for light, fluffy, sluggish and slightly sticky materials. The feeding is through scooping or digging by the buckets. Fig.4.3 shows the discharging of these elevators. An inclined elevator is particularly suitable for perfect gravity discharge.

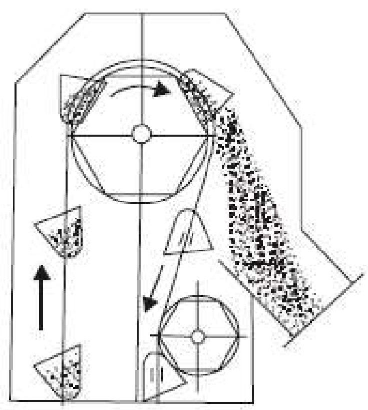


Figure 4.3: Discharging of positive discharge elevator

## Continuous discharge elevators:

In these elevators, V-type buckets are used without any gap between them. These elevators are employed for handling larger lumps and materials that may be difficult to handle by centrifugal discharge. The charging of the buckets are by direct filling. The discharge is by directed gravity i.e. when the buckets pass over head wheel, the flanged end of the preceding bucket act as a chute to deliver materials gently to the discharging spout. This type of charging and discharging is particularly effective for handling fragile materials.

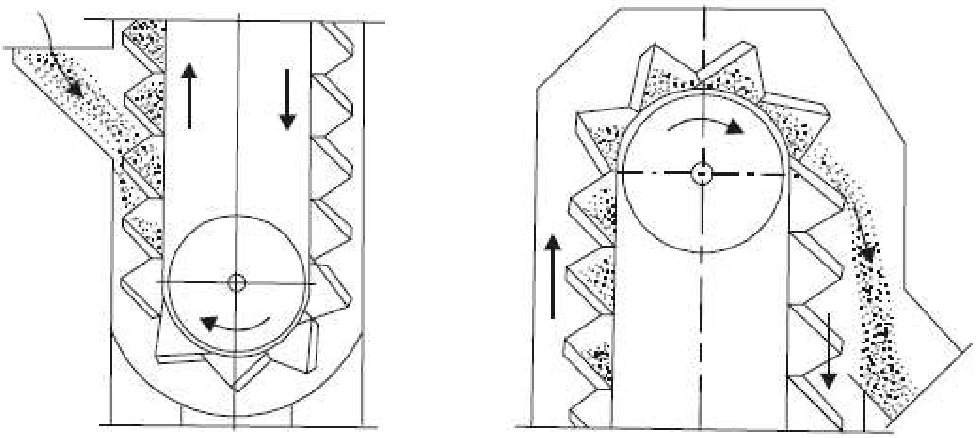


Figure 4.4: Charging and discharging of a continuous bucket elevator

## Determination of theoretical capacity:

Capacity of the bucket conveyor, $Q = 3.6\ \psi\ \gamma\ V\ (i_o/a)$ ton/hr

Where,

$i_o$ = capacity of the bucket, liter

a = distance between bucket, m

v = belt or chain speed, m/sec

$\gamma$ = bulk weight, ton/m$^3$

$\psi$ = loading efficiency

## Determination of actual capacity:

Determination the actual capacity of the conveyor, $Q_{actual}$ by taking weight of the material at the discharge end for a certain period of time (measured by stop watch)

rpm: ____________

| Observation | Weight of material discharged (kg) | Time (sec) | Capacity, $Q_{actual}$, (tons/hr) | Average value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

rpm: _____________

| Observation | Weight of material discharged (kg) | Time (sec) | Capacity, $Q_{actual}$, (tons/hr) | Average value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

rpm: _____________

| Observation | Weight of material discharged (kg) | Time (sec) | Capacity, $Q_{actual}$, (tons/hr) | Average value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

## Questions:

1) How the power consumption varies with inclination angle of bucket conveyor?
2) Which kind of discharge is required? Gravity or centrifugal? Explain.
3) Differentiate between scoop type and direct feeding charging.

**Experiment No: 5**

# DETERMINATION OF THE CAPACITY OF AN APRON CONVEYOR

## Objectives:

i. To study different components and the operation of the apron conveyor
ii. To determine both the theoretical and actual capacity
iii. To determine the optimum capacity

## Theory:

## Definition:

The term chain conveyor means a group of different types of conveyors used in diverse applications, characterized by one or multiple strands of endless chains that travel entire conveyor path, driven by one or a set of sprockets at one end and supported by one or a set of sprockets on the other end.

## General Characteristics

Different types of chain conveyors are used in wide varieties of applications. Chain, compared to belts of a belt conveyor, have certain advantages as well as disadvantages. The major advantages are that the chain easily wraparound sprockets of small diameter, and the drive is positive i.e. no slippage takes place between chain and sprocket. The chain stretch is also little. The disadvantages of chain are its high weight, high initial cost, higher maintenance cost and most importantly, limited running speed because of dynamic loading that come into play in chain-sprocket drive causing intensive wear at high speeds.
Maximum length and maximum lift of chain conveyors are limited by the maximum allowable working tension of the chain used.

Figure 5.1: Apron Conveyor

## Power Calculation:

Sprocket diameter, d = 8 in

N = 70 rev/min

Velocity, V = $\frac{\pi d N}{1000}$ m/min

Apron width, B =?

Slat material weight, $q_o$ = (60B+A) kg/m

Table: Approximate values of factor A for flanged aprons

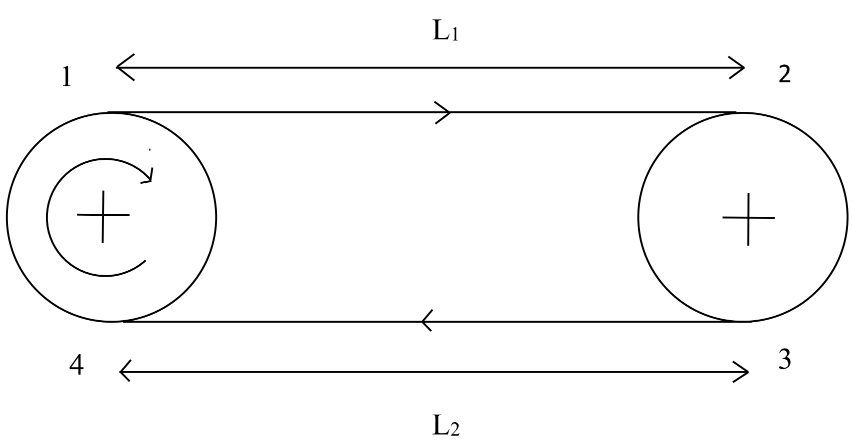
| Type of Apron | Factor A for an apron having a width of | | |
|---|---|---|---|
| | B<0.5m | B<0.8m | B>0.8m |
| Light | 40 | 50 | 70 |
| Medium | 60 | 70 | 100 |
| Heavy | 80 | 110 | 150 |

For unflanged aprons the corresponding value of factor A is decreased by 10 to 15 percent.

Considering the maximum weight, G = 4 kg per load

Distance between two load, a=?

Weight of the material per meter, q = $\frac{G}{a}$ kg/m




From the above figure,

Least tension will be at point 3 or point 1

Let, $S_1$ = 100 kg [the minimum pull of apron conveyor is between 100-300 kg]

For rolling bearing,

Resistance factor, $\omega' = 0.045$ [Adverse operation condition]

$S_2 = S_1 + (q_o+q) L_1. \omega'$ kg

[$L_1$ = length of the section between points 1 & 2]

$S_3 = k.S_2$ kg

$S_4 = S_3 + q_o. L_2. \omega'$ kg

[$L_2$ = length of the section between points 3 & 4]

The resistance on the driving pulley $W_{dr} = k (S_{4+} S_1)$

Peripheral pull, $W_o = S_4 - S_1 + W_{dr}$ kg

Considering the efficiency of bevel gear, $\eta_g = 75\%$

Power required, $N = (W_o * v)/ 102 \eta_g$

Efficiency of motor, $\eta = ?$

## Capacity:

Capacity, Q = 3.6 qv ton/hr

Where, q = Weight of the material in kg per meter

v = velocity, m/s

## Questions:

1) What is the basic difference between belt and slat conveyors?
2) When it is appropriate to use slat conveyors?
3) What are the ways to increase the efficiency of slat conveyor?

## Experiment No: 6

# DETERMINATION OF THE CAPACITY OF A SCREW CONVEYOR AND POWER LOSS

## Objectives:

i. To study different components and the operation of the screw conveyor
ii. To determine both the theoretical and actual capacity
iii. To investigate the possible causes of deviations of the result and ways to improve the overall efficiency of the conveyor

## Theory:

### Screw conveyor:

Screw conveyor consists of a spiral member, which advances around a circular shaft. Material is advanced by the action of the helical screw as it is turned by the shaft in a trough. As the shaft rotates the material fed to it is moved forward by the thrust of the screw or flights.

The screw conveyor is of simple design, easy to maintain, of small width, permit intermediate discharge of the material at several points, is readily made dust tight by jacketing the trough. They are relatively inexpensive means of conveying pulverized or granular materials.

Thrust reaction force on screw is opposite to the direction in which the material flows. When the setup is such that the trust is taken at discharge end, the conveyor is in tension and if thrust is taken at receiving end- the conveyor is under compression.

Standard pitch conveyors are used for handling materials horizontally or inclined up to $20^0$. Longer pitches are for high capacity, free flowing material. Shorter pitches are for materials which are fed slowly, as for cooling, drying etc.

The spiral may be mounted to run in either open or covered troughs, usually made of steel.

The total resistance to motion in a screw conveyor is made up of –

i. Friction of the material against the trough
ii. Friction of the material against the surface of the screw
iii. Friction in the intermediate and terminal bearings
iv. Friction in the axial thrust bearings
v. Packing in the axial thrust bearings
vi. Mixing of the materials
vii. Friction on the edges of the screw against the particles in the clearance

Applications of screw conveyors are limited. Materials that can be satisfactorily handled by it are few. It is effective only when there is uniform feeding. It cannot be used for easily crushed, large lumped, abrasive, and sticking materials. Overloads cause bottlenecks near the intermediate bearings obstruct the shaft revolving and stop the screw. Friction of the material against screw and trough is responsible for high power consumption, wear of the conveyor part and crushing of the material. Therefore, screw conveyors are used for low medium capacity (up to 100 $m^3$/hr).

## Parts of screw conveyor:

1. Screw and shaft
2. Trough (generally made of sheet steel)
3. Intermediate hanger bearing (generally located at discharge end other conveyor. It is a thrust bearing taking up the force of frictional resistance directed along the longitudinal axis of the conveyor).
4. Loading spout
5. Discharge spout
6. Intermediate discharge spout
7. Drive unit

The inner diameter of the cylinder trough section is slightly larger than that of screw, so that a certain clearance is left between them. The clearance should be such that there is less breaking up of the material and less power consumption. Recommended clearance is 6 to 9.5 mm. the clearance increases with screw diameter.

## Theoretical capacity of the screw conveyor:

$Q = V\,\gamma$

$Q = 60.\pi\,(D^2/4)\,S.\,n.\,\psi.\,\gamma$   tons/hr

Where, Q = capacity of the conveyor, tons/hr

V = volumetric capacity, $m^3$/hr

$\gamma$ = bulk weight of the material, tons/$m^3$

C = factor that takes into account the inclination of the conveyor

D = screw diameter, m

S = screw pitch, m

n = speed of the shaft of screw conveyor

$\psi$ = loading efficiency of the vertical cross sectional are of the screw

In typical design the screw pitch equals D. for slow flowing and abrasive material it is 0.8D.

Loading efficiency, ψ = 0.125 for slow flowing abrasive material

= 0.25 for slow flowing mildly abrasive material

= 0.32 for free flowing mildly abrasive material

= 0.4 for free flowing non-abrasive material

Ψ is taken relatively low to obviate risk of bottlenecks near the intermediate bearings. It is large for free flowing, non-highly abrasive material and vice-versa.

β = angle of inclination

For horizontal conveyor, C=1.0

| β | $0^0$ | $5^0$ | $10^0$ | $15^0$ | $20^0$ |
|---|---|---|---|---|---|
| C | 1 | 0.9 | 0.8 | 0.7 | 0.65 |

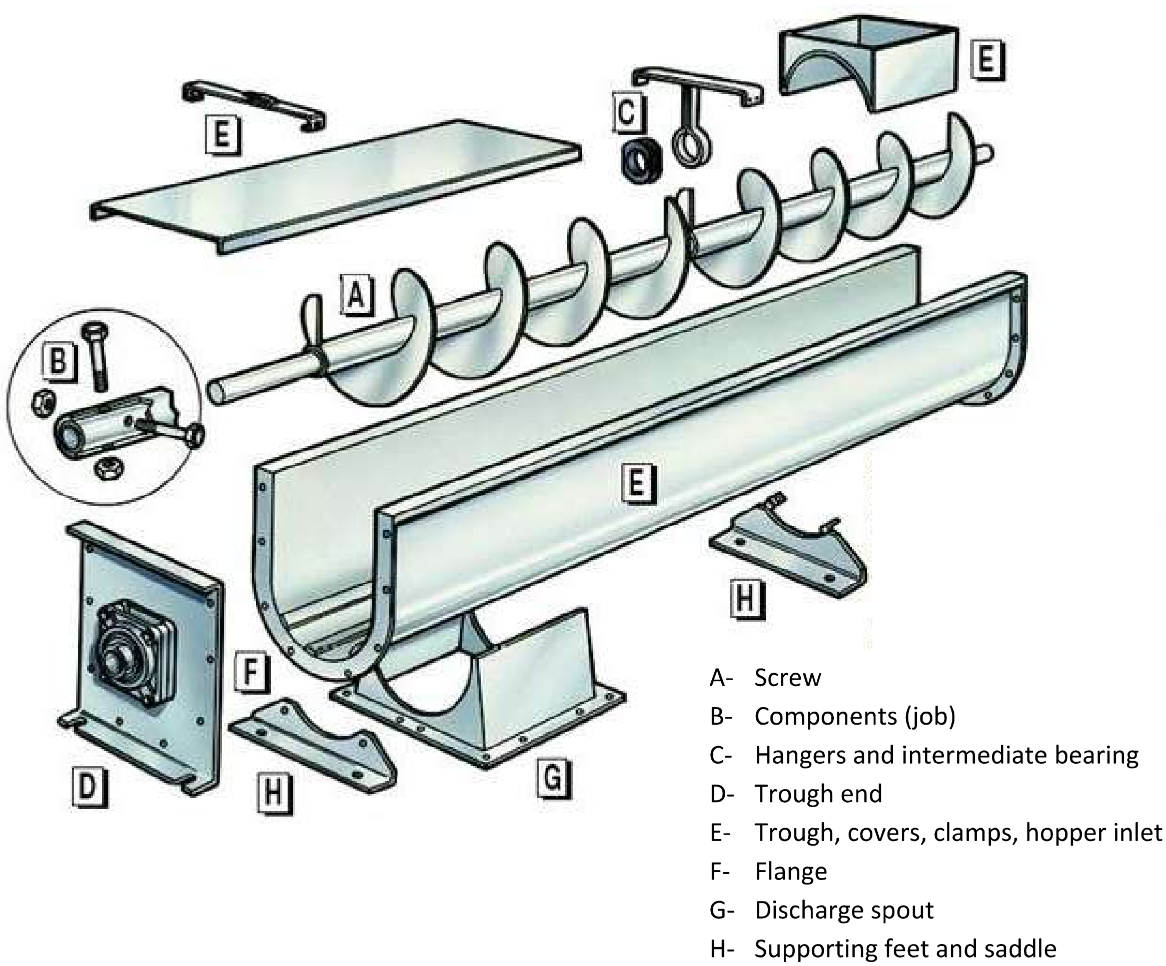



Figure 6.1: Schematic diagram of screw conveyor

## Determination of actual capacity:

Determination the actual capacity of the conveyor, $Q_{actual}$ by taking weight of the material at the discharge end for a certain period of time (measured by stop watch)

| Observation | Weight of material discharged (kg) | Time (sec) | Capacity, $Q_{actual}$, (tons/hr) | Average value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

## Procedure:

i. Start the motor and hereby start the operation of the screw conveyor.
ii. Start feeding bulk material into the loading spout of the conveyor.
iii. Wait some time until the flow-rate of bulk material becomes steady.
iv. Determine the weight of the accumulated bulk material in a certain time at the discharge spout. Measure time by stopwatch.
v. Calculate amount of accumulation of bulk material per unit time, this is the capacity of the conveyor.
vi. Calculate capacity of the conveyor using the conveyor using the formula given above. Measure value of D, S, n. Take the value of $\gamma$ from the chart, for wheat it is 0.65 to 0.83 tons/$m^3$
vii. Compare both the capacities.

## Questions:

1. Why the value $\psi$ changes for different bulk materials?
2. What is the relationship between $\beta$ and C both for
   i) increasing rate of $\beta$ ii) decreasing rate of $\beta$
3. Bulk weight of the material $\gamma$, why changes for different bulk materials? Explain, why it taken from a range?
4. What type of bearing will you select for designing screw conveyor? Explain.
5. Under which circumstances you will choose screw conveyors for material handling?

6. What are the basic types of screws normally used in screw conveyors? For conveying the following types of materials what type of screws will you choose:
    i. Lumpy and clinging materials
    ii. Dry granular or powdered materials
    iii. For blending, churning and homogenous mixing of two or more grades of materials

## <u>Experiment No: 7</u>

## STUDY OF THE LAYOUT PLAN OF AUST CENTRAL MACHINE SHOP

### Objectives:

i. To study different types of layout of production floor
ii. To study the influence of layout on the material handling system
iii. To study the selection of layout type depending on the manufacturing process involved in order to optimize the material handling system as well as the overall process

### Plant Layout:

Plant layout refers to arrangement of physical facilities in a production plan

A layout suited to flow-type mass production is not appropriate for job-shop production and vice-versa.

There are three types of plant layout:

i. Product flow layout
ii. Process flow layout
iii. Fixed position layout

In **Product Flow layout** (also called Flow – Shop layout), the plant specializes in the production of one product or one class of products in large volumes. The processing and the assembly facilities are placed along the line of flow of the product. This type of layout is suitable for flow-type mass production.

In **Process layout** (also called Job Shop layout), the production machines are arranged into groups according to general type of manufacturing process. The layout provides flexibility. This layout is typical in job shops and batch production.

In **Fixed Position layout**, the product remains in one location, and the equipment is brought to it.

In **Group Technology (GT) or Cellular layout**, dissimilar machines are grouped into work centers or cells to work on products that have similar shapes and processing requirements. A GT layout is similar to process layout in that cells are designed to perform specific set of processes, and it is similar to product layout in that the cells are dedicated to a limited range of products.

**Effect of plant layout on material handling:**

Plant layout is an important factor influencing the design of a material handling system. In case of a new plant, the design of the handling system should be considered as a part of the layout design.

The plant layout should provide the following information for use in the design of the handling system:

- Location where materials must be picked up (load stations)
- Location where materials must be delivered (unload station)
- Possible route between the locations
- Distances that must be traveled to move materials
- Flow patterns, opportunities to combine deliveries, possible places where congestion might occur
- Total area of the facility and area within specific departments in the layout
- Arrangement of equipment in the layout

## How different layout types influence the selection of the material handling system:

The product flow layout usually involves the production of a standard (or nearly identical types of) product in relatively high volumes. The handling system typically exhibits the following:

i. Fixed installation
ii. Fixed route and
iii. Mechanized for automated

It is often a delivery and storage system (to reduce the effects of downtime between production areas along the line of production flow). Conveyor systems are often used to transport the product in product-flow layouts. Delivery of component parts for stocking at the various workstations a long path in assembly plants is accomplished by trucks and similar unit load vehicles.

In process layout, there are a variety of products manufactured and the quantities made per product are medium or small. The handling system must be flexible and programmable to deal with the variations. Considerable in process inventory is usually one of the characteristics of this type of manufacturing and the handling (and storage) system must be capable of holding this inventory.

In case of the fixed position layout, the product is large and heavy and therefore remains in a single location during most of its fabrication. Heavy components and subassemblies must be moved to the product. Handling systems used for these moves in fixed-position layouts are larger and often mobile. Cranes, hoists and trucks are common in this situation.

## Data requirement to prepare a plant layout:

1. The area of each department expressed in square feet or as a number of unit squares
2. The rectilinear distances between candidate locations or between departments usually measured between their centers
3. Departmental relationship measures that can be expressed either quantitatively in a from-to chart or qualitatively in relationship chart
4. A scale for plotting the layout by the computer.

## Preparing plant layout of machine shop, AUST:

i. Go to Machine shop, AUST
ii. Measure the area of the machine shop
iii. Measure the areas required for different types of machine
iv. Study the flow of materials as well as people inside the machine shop
v. Draw a current layout of the machine shop
vi. Suggest any changes required for the machine shop with relevant information

## Questions:

1. What are the objectives of layout designing?
2. Differentiate Product layout from Process layout.
3. What are the benefits and limitations of GT or Cellular layout?
4. Which type of layout should be used in a machine shop or workshop where different types of automobile parts are manufactured?
5. When Fixed Position layout should be used and why? Explain with example.

## Experiment No: 8

## STUDY OF THE REPLACEMENT PLANS OF TUBE LIGHTS IN AUST CAMPUS

### Objectives:

i. To study and know about different replacement policies
ii. To develop a model of replacement for different equipment based on reliability, at house as well as in industrial level
iii. To solve the model to get the optimum replacement policy

### Sample problem:

Following is the data available on the failure of 10 identical special-purpose bulbs being used in a plant:

| Time in months | Failure Probability |
|---|---|
| 1 | Nil |
| 2 | Nil |
| 3 | Nil |
| 4 | 0.05 |
| 5 | 0.15 |
| 6 | 0.30 |
| 7 | 0.25 |
| 8 | 0.15 |
| 9 | 0.10 |

The cost of replacing the bulbs individually, when they fail, is Tk. 100 (per bulb). The cost of replacing all the 10 bulbs together is Tk. 500. Four different replacement policies are possible:

a) *Independent Breakdown Replacement,* i.e. replace bulb/bulbs as and when they fail to function.
b) *Group Breakdown Replacement,* i.e. as soon as one bulb fails, all the ten bulbs are replaced.
c) *Individual Preventive Replacement,* i.e. each bulb is replaced when it is n (some number) months of age, even though it does not fail.
d) *Group Preventive Replacement,* i.e. at fixed intervals, all bulbs is replaced; but within the interval, independent breakdown replacement is undertaken if bulb/bulbs fail.

The cost of independent preventive replacement of a bulb is Tk. 70. Which will be the best policy?

### Solution:

***Case (a): Independent Breakdown Replacement Policy***

Mean life of a bulb = (4×0.05)+(5×0.15)+(6×0.30)+(7×0.25)+(8×0.15)+(9×0.10) = 6.6 months.

$$\therefore cost\ per\ month, for\ the\ policy = \frac{Tk.100}{6.6}\times 10\ (bulbs) = 151.5\ per\ month.$$

***Case (b): Group Breakdown Replacement Policy***

Cost of replacing all 10 parts together = Tk. 500.

$$Per\ month\ cost = \frac{500}{Average\ life\ (for\ 1st\ failure)}$$

$$\text{Average life} = 4\begin{bmatrix} Probability\ that\ the \\ failure \\ occurs\ at\ month\ 4 \end{bmatrix} + 5\begin{bmatrix} Probability\ that\ the \\ failure \\ occurs\ at\ month\ 5 \end{bmatrix} + 6\begin{bmatrix} Probability\ that\ the \\ failure \\ occurs\ at\ month\ 6 \end{bmatrix}$$

$$+7\begin{bmatrix} Probability\ that\ the \\ failure \\ occurs\ at\ month\ 7 \end{bmatrix} + 8\begin{bmatrix} Probability\ that\ the \\ failure \\ occurs\ at\ month\ 8 \end{bmatrix} + 9\begin{bmatrix} Probability\ that\ the \\ failure \\ occurs\ at\ month\ 9 \end{bmatrix}$$

Now, the probability of surviving up to the $4^{th}$ month = 1- 0.05 =0.95

Therefore, probability of all 10 bulbs surviving up to the $4^{th}$ month = $(0.95)^{10}$ =0.599

So, probability that any one of the bulbs fails for the first time at month 4 = 1- $(0.95)^{10}$ = 0.401

We can find the other probabilities as follows:

Probability of all 10 bulbs surviving up to the $5^{th}$ month = $(0.80)^{10}$ = 0.107

Probability of any one bulb failing either in the $4^{th}$ or the $5^{th}$ month = 1- $(0.80)^{10}$ = 0.893.

Probability that the first failure occurs in the $5^{th}$ month = $[1-(0.80)^{10}] – [1- (0.95)^{10}]$ = 0.492.

Similarly,

Probability that the first failure occurs at,

$6^{th}$ month = $[1- (0.5)^{10}] – [1- (0.8)^{10}]$ = 0.999 – 0.893 = 0.106

$7^{th}$ month = $[1- (0.25)^{10}] – [1- (0.5)^{10}]$ = 1.000 – 0.999 = 0.001

$8^{th}$ month = $[1- (0.1)^{10}] – [1- (0.25)^{10}]$ = negligible.

$9^{th}$ month = $[1] – [1- (0.10)^{10}]$ = negligible.

Therefore, the average life = 4(0.401) + 5(0.492) + 6(0.106) + 7(0.001) + 8(0.000) + 9(0.000)

= 4.707 months.

Hence, per month cost = $\frac{500}{4.707}$ = Tk. 106.22

***Case (c): Individual Preventive Replacement Policy***

Let us consider,

*Preventive replacement period of 5 months:*

The total cost per unit replacement comprises two components: a) the possibility that the bulb may fail before the replacement age needing breakdown replacement; and b) the possibility that the bulb may not fail till its replacement age.

Component (a) = Tk. 100 × (0.05 + 0.15) = Tk. 20.00

Component (b) = Tk. 70 × (0.80) = Tk. 56.00

So, total cost of unit replacement = Tk. 76.00

Now, cost per month = $\frac{total\ cost\ of\ replacement}{expected\ life\ of\ a\ bulb} = \frac{76 \times 10}{expected\ life\ of\ a\ bulb} = \frac{760}{4.95} = Tk. 153.53$

Where, expected life of a bulb = (4×0.05) + (5×0.95) = 4.95 months.

*Preventive replacement period of 6 months:*

Then, Component (a) = Tk. 100 × (0.05 + 0.15 + 0.30) = Tk. 50.00

Component (b) = Tk. 70 × 0.50 = Tk. 35.00

Total cost of unit replacement = Tk. 85.00

Expected life of a bulb = (4×0.05) + (5×0.15) + (6×0.80) = 5.75 months.

Cost per month = $\frac{total\ cost\ of\ replacement}{expected\ life\ of\ a\ bulb} = \frac{85 \times 10}{expected\ life\ of\ a\ bulb} = \frac{850}{5.75} = Tk. 147.83$

*Preventive replacement period of 7 months:*

Component (a) =Tk. 100 × 0.75 = Tk. 75

Component (b) =Tk. 70 × 0.25 = Tk.17.5

Total cost of unit replacement = Tk. 92.5

Expected life of a bulb = (4 × 0.05) + (5 × 0.15) + (6 × 0.30) + (7 × 0.50) = 6.25 months.

Cost per month = $\frac{total\ cost\ of\ replacement}{expected\ life\ of\ a\ bulb} = \frac{92.5 \times 10}{expected\ life\ of\ a\ bulb} = \frac{925}{6.25} = Tk. 148.00$

*Preventive replacement period of 4 months:*

Component (a) =Tk. 100 × 0.05 = Tk. 5.0

Component (b) =Tk. 70 × 0.95 = Tk.66.5

Total cost of unit replacement = Tk. 71.5

Expected life of a bulb = 4 months.

Cost per month = $\frac{total\ cost\ of\ replacement}{expected\ life\ of\ a\ bulb} = \frac{71.5\times10}{expected\ life\ of\ a\ bulb} = \frac{715}{4} = Tk.178.75$

With this policy, the replacement period of 6 month is found to be optimal.

*Case (d): Group Preventive Replacement Policy*

Let us consider a replacement period of 8 months to start with.

The total cost under this policy comprises of two components:

a) Cost of group replacement = Tk. 500
b) Cost of individual breakdown replacement = Tk. 100 × number of failures within 8 months

Now, the number of failures within 8 months = for the $4^{th}$ month (10×0.05) + for the $5^{th}$ month (10×0.15) + for the $6^{th}$ month (10×0.3) + for the $7^{th}$ month [(10×0.05) × 0.05 + (10×0.25)] + for the $8^{th}$ month [(10×0.15)×0.05 + (10×0.05)×0.15+(10×0.15)] = 9.175

Cost per month = $\frac{500+100\times9.175}{8} = Tk.177.20$

For other months, the similar calculations are shown in the Table.1

**Table 1: Group Replacement Cost**

| Breakdown Replacement costs in Different Periods | | | | | | | Total Costs, Tk. | Average Cost, Tk. |
|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | | |
| Replacement Period | | | | | | | | |
| 3 | | | | | | | 500 | 166.66 |
| 4 | 100×0.5 | | | | | | 550 | 137.50 |
| 5 | 100×0.5 | 100×1.5 | | | | | 700 | 140.00 |
| 6 | 100×0.5 | 100×1.5 | 100×3.0 | | | | 1000 | 166.66 |
| 7 | 100×0.5 | 100×1.5 | 100×3.0 | 100× 2.525 | | | 1252.5 | 178.92 |
| 8 | 100×0.5 | 100×1.5 | 100×3.0 | 100× 2.525 | 100× 1.65 | | 1417.5 | 177.20 |
| 9 | 100×0.5 | 100×1.5 | 100×3.0 | 100× 2.525 | 100× 1.65 | 100× 1.525 | 1570 | 174.44 |

Summarizing the costs for different policies:

| | |
|---|---|
| *Independent Breakdown Replacement* | Tk. 151.50 per month |
| *Group Breakdown Replacement* | Tk. 106.22 per month |
| *Individual Preventive Replacement* | Tk. 147.83 per month |
| *Group Preventive Replacement* | Tk. 137.50 per month |

**Answer: We choose group breakdown replacement policy.**

## Procedure:

i. Specify the area (i.e. $5^{th}$ floor, $6^{th}$ floor, Arts/Science faculty, MPE) for which you want to develop the replacement model.
ii. Collect information of tube lights. (i.e. total number of lights, price of one piece, lot price, charge for set up).
iii. Determine the failure probability of each light.

Solve the model to get the optimum replacement policy among the above four policies.

## Experiment No: 9

## DETERMINATION OF POWER LOSS OF THE ROLLER CONVEYOR

### Objectives:

i. To study different components and the operation of the roller conveyor
ii. To determine both the theoretical and actual power required
iii. To investigate the possible causes of deviations of the result and ways to improve the overall efficiency of the conveyor

### Theory:

### Roller Conveyor:

Roller conveyors also known as roller runways or roller tracks serve to convey piece goods (ingots, plates, molding boxes, rolled stock, pipes, boxes etc.) horizontally and up or down slight inclines. The articles are conveyed on rollers evenly spaced on the conveyor frame. The articles to be moved must have a smooth bottom or straight longitudinal ribs. Wedged and cylindrical articles may also be conveyed on the conveyor.

### Classification:

According to the principle of action roller conveyors are classified as powered and unpowered roller conveyors. The rollers of live (powered) roller conveyors are driven by a motor and revolve around their axes. They transmit motion to the articles conveyed by friction. In unpowered roller conveyors the motive force is applied directly to the load and the rollers are rotated by friction of the article as it moves along the roller bed. Unpowered roller conveyors commonly have a slight incline, sufficient for the force of gravity to overcome the slight frictional resistance.

### Calculation of a Powered Roller Conveyor:

The rollers of a powered conveyor rotate continuously no matter whether a load passes over them or not. Unloaded rollers having diameter D rotate with a resistance factor equal to

$$w' = \frac{\mu d}{D}$$

Where $\mu$ = friction factor in the bearing reduced to the journal diameter d

A transport roller conveyor with a design capacity of Q tons per hour (with the irregularities of feed taken into account), a length of L m, a length of the horizontal projection $L_{hor}$ m, elevation of H m, a total of z rollers having a weight (of the rotating parts) of p kg and with the load moving at a rate of v m/sec will require a motor rated at

$$N = \left(\frac{QH}{367} + \frac{QL_{hor}\omega'}{367} + \frac{zp\omega_1'v}{102}\right)\frac{1}{\eta_g}\ kW$$

Where $\boldsymbol{\omega'}$ = resistance factor of the weight of the conveyed load G determined from equation

$$\boldsymbol{\omega'} = \frac{\mu d + 2k}{D};$$

Where, k = rolling friction factor of the load on the rollers, cm

D = roller diameter, cm

μ = friction factor in the journal reduced to the roller axel journal diameter d, cm

$\boldsymbol{\omega_1'}$ = resistance factor of the weight of the roller rotating parts $p_1$ determined from the equation no. 1

For a horizontal conveyor H = 0 and $L_{hor}$ = L, hence

$$N = \left(\frac{QL\omega'}{367} + \frac{zp\omega_1'v}{102}\right)\frac{1}{\eta_g} kW$$

## Procedure:

i. Start the motor and hereby start the operation of the roller conveyor.
ii. Start feeding material into the loading zone of the conveyor.
iii. Determine the weight of the material in a certain time at the discharge zone. Measure time by stopwatch.
iv. Calculate amount of conveyed material per unit time, this is the capacity of the conveyor.
v. Calculate capacity and the power required by the conveyor using the formula given above.
vi. Compare the actual and theoretical power.
vii. Discuss the causes of the variation between both the powers.

## Questions:

1. Distinguish between powered and unpowered roller conveyors.
2. Write some potential applications of powered and unpowered roller conveyor.
3. How to keep gravity sag of the article conveyed to minimum?
4. Discuss the reasons behind the variation between theoretical and actual power.
5. Discuss the role of friction in roller conveyor.