LEARNING MATERIALS

SEMESTER-5TH SEM.

BRANCH-MINING ENGG.

SUBJECT-MINE MACHINERY-I(TH-4)

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MINE MACHINERY – I

1.0 Transportation :

1.1.1 State type of rope haulage and **1.1.2** Describe various types of rope haulage with simple sketches.

Rope Haulage : The rope system covers the following types of haulages :

1. Direct rope haulage.
   (a) Tail rope haulage.
2. Endless rope haulage.
   (a) Over rope,
   (b) Under-rope.
3. Main and tail rope haulage.
4. Gravity rope haulage.

Direct Rope haulage : This is the simplest system employing one pulling rope and one haulage drum for hauling mineral in tubs or mine cars up a gradient which is generally steeper than 1 in 10. the haulage engine is situated at the top of an inclined roadway. The train of tubs is attached to one end of the rope, the other end being fixed to the haulage drum. The empty tubs attached to the end of the haulage rope travel on the down gradient by their own weight and do not require power from the haulage engine. The rope speed is generally 8-12 km/h and the system can operate between any point of the haulage plane and the haulage engine.

Disadvantages of direct haulage :

1. High peak power demand as load starts its journey up the gradient.
2. Severe braking duty on the downward run.
3. High haulage speed demanding high standard of track maintenance.
4. Not suitable for mild inclination of roads.

5. A derailment is associated with heavy damage because of the high speed.

Endless rope haulage : In this system, there are two parallel tracks side by side, one for the loaded tubs and the other for the empties, and an endless rope passes from the driving drum/pulley located at the outbye end of the haulage road to the inbye end and back again via a tension bogey. The tubs, loaded as well as empties, are attached to the rope at regular intervals with the help of clips so that the entire rope length has tubs on it at intervals. Only one tub is attached to the rope at a time, but where lashing chain is used for attachment, the normal practice is to attach a set of tubs and the attachment or detachment is performed by stopping the rope. If, however, clips are used for single tubs they can be attached or detached when the rope is in motion. The gradient of haulage road is mild and rarely exceeds 1 in 6. the speed rages between 3km/hr and 7 km/hr and the haulage is slow moving. The rope moves in one direction only. A squirrel cage motor is commonly employed.

Advantages of endless haulage :

1. Because of the slow speed, less wear and tear.
2. Accidents from derailed tubs do not cause much damage due to slow speed.
3. Motor of less power required.
4. It does not place heavy peak demand on the power supply.

Disadvantages of endless haulage :

1. It requires wide roads for two tracks.
2. It is not suitable for steep gradients.

3. Load on the rope is large and a rope of larger cross-section is required.
4. Large number of tubs and clips are required as rolling stock.
5. If a breakdown of any tub occurs the whole system comes to a stand still.
6. It cannot serve a main road and a branch road simultaneously unless elaborate arrangements are made to course the rope to the branch line with the help of deflection pulleys. The tubs of main-road rope have to be detached and re-attached at the branch line.

Main and tail rope haulage : In this system the hauling engine is provided with two separate drums, one for the main hauls the empty train in. when one drum is in gear, the other revolves freely on the shaft but controlled, when necessary, by the brake to keep the ropes taut. The main rope is approximately equal to the length of the plane, and the tail rope twice this length. Only one track is required.

This system of haulage is suitable for undulating roadways where it is impossible or undesirable to maintain the double track required for endless rope haulage, it can readily negotiate curves, and it is convenient for working branches.

Gravity haulage : This is a haulage without any motor or external sources of power and consists of a cast iron pulley, 1.3 m – 2 m diameter, having a brake path on one side and a strap brake.

It is located at the top of an inclined roadway and is employed to lower by gravity loads attached to one end of the rope while simultaneously hoisting empties attached to another end of the rope which passes round the jig pulley. The jig pulley is vertical. Only single travk is required for its operation but at the mid-way of the road where the loads and empties meet, double track or a bye-pass is essential.

1.1.4 State & describe different type of safety devices on rope haulage roadways.

Safety devices on haulage roads :

Monkey or back catch : This consists of (i) a pivoted piece of steel rail placed between the track rails so as to catch the axle of a backward runaway, or (ii) a wooden block pivoted at one end and pressed over the rail by a strong spring. It is used for endless haulage track for tubs moving up gradient.

Stop-block : This consists of a wooden beam or block lying across the rails, pivoted at one end and held against pivoted side block at the other. It is a good plan to have two stop-blocks some distance apart, the one forming a reserve for the other.

Backstay : This is used behind an ascending set of tubs on a direct haulage road or on an endless haulage. It is attached to the tub axle and in the event of runaway of tubs; the pointed end of the backstay stops against sleeper of the track and the travel of the tub or train of tubs is arrested.

Drop Warwick : This is intended for arresting forward runaways, being placed below the brow of an incline and also near the bottom and below intermediate levels. It consists of a heavy-baulk or girder hinged at one end to a specially set roof girder and held up at the other by an eye-bolt and pin. The warwick is released when required in emergency by a haulage worker pulling the wire to withdraw the pin.

A combined stopblock and runaway switch : This is used at the brow of a direct haulage lane and is so constructed that at one time either the stop block or the runway switch is effective in the event of a run away of a set of tubs. It is manually operated by the haulage attendant when the set of tubs has to pass clear of the stopblock.

Hydraulic tub retarder : It consists of a hydraulic cylinder containing opposed pistons. The hydraulic pressure is supplied from a 1-2kW electric motor driven pump. The hydraulic tub retarders are used for locomotive haulage but for ordinary rope haulage where tubs of 1-1m^3 capacity are used wooden sprags, skillfully inserted between the spokes of a running tub wheel, suffice to slow down the tub.

1.1.5 State & describe different types of clips & coupling .

The different types of clips are :

1. Screw clip : This clip is tightened on the rope by a handle and screw and the handle is coupled to the drawbar of the tub by a long steel rod hinged to the clip.
2. Smallman Clip : This consists of a pair of steel-cheeks or side-plates, loosely held together by the adjustable central bolt which has a spring surrounding it to keep the plates apart, and kept in position by the pins supporting the lever and the coupling hook. The bent lever is pivoted and carries at its upper end a wedge which works between curved surfaces on the inside of the cheeks. When the lever is depressed, the wedge enters the narrower part of the space between the checks, so forcing them apart at the top, and at the same time causing the bottom jaws to grip the rope.
3. Cam clip : This consists of a plate and a cam-shaped lever which is pivoted and is connected by a small chain to the tub to be hauled. The pull of the tub turns the lever around the pivot so that the grip of the load. On undulating roadways, a clip must be provided at each end of the tub.

1.1.6 Describe rail sleeper, rail fastenings, fish plate, ballast, friction roller, vertical roller, bevel pulley, jim crow, transition curves & various types of crossing.

Sleeper and Ballast **:** The purpose of these is to distribute the intense bearing pressure of the wheels on the rails over a sufficient area of floor so that the safe bearing pressure of the floor is not exceeded. If the floor is wet, it is essential to make provision for draining the floor on which the track rests. In the mines sleepers are usually o sal wood. The ballast consist o crushed rock like sand stone, schist or any other hard rock, crushed to 50mm – 60mm size.

Curves and super-elevation (or cont) : The minimum radius of curve on which locomotives and mine cars can operate is dependent on a number of factors including length of rigid wheel-base, rail gauge, diameter of wheels, super-elevation and speed. Sharp curves cause increased tractive resistance, excessive rail and wheel wear, derailments and possible breaking of locomotive axles.

Curve radius : It is suggested that for speeds upto 13km/hr, the radius of any curve in a main haulage road should be not less than 20 times the longest rigid wheel-base of any vehicle in the train, and for speed overs 13km/hr the radius should be greater than this. The plate layer or line mistry lays down the curve by experience but for locomotive haulage the surveyor comes in the picture and he gives marks on the roof of underground roadway for the path of the curve. A jim crow is a handy device for bending the rail to suitable curvature in stages.

Super-elevation : On a curve, centrifugal action creats a tendency for the train to leave the track and proceed along a course tangential to the curve. This throws the wheel flanges hard against the inner edge of the outer rail, causing excessive wear on the wheels and rails. To counteract this the outer rail should be raised above the inner one, it should be super-elevated. This is not true for all rope haulages, with the main and tail rope system the forces in the two ropes puling in the opposite directions tend to pull the train into the inner rail.

Widening gauge on curves : It is advisable to widen the gauge on curves to prevent the wheel flanges binding on the rails and thereby increasing the track resistance. A widening of the gauge by 6mm is sufficient.

1.2 Transportation by conveyors :

1.2.1 <u>State different types of conveyors used in mines.</u>

The following types of conveyors used in the mines :

1. Belt conveyor.
2. Scraper chain conveyor.
3. Shaker conveyor.

1.2.2 <u>State & describe take up arrangements of belt conveyor.</u>

<u>Belt Conveyor</u> : The belt conveyor is basically an endless belt in a straight line stretched between two drums, one driving the system and the other acting as a return drum.

The system of transport by belt conveyors consists of the following :

1. A flat endless belt which continuously travels and carries on its top surface the material to be conveyed.
2. The idlers which support the belt.
3. The structure of angle iron or channel iron on which the idlers are mounted.
4. The tension arrangement for keeping the belt in proper tension, including the loop take-up arrangement.
5. The drums at the discharge end and opposite end (tail end) over which the belt passes.
6. The drive head comprising the electric motor, coupling, gearing and snub pulleys.

The belt conveyor works on a straight roadway which may be level, inclined or partly level and partly inclined in patches. The conveyor must be erected in correct alignment. The belt speed varies from 45 m/min to 150 m/min but a speed of 45 m/min to 60 m/min is generally preferred.

<u>The belt</u> : The belt is an endless thick flat strip of woven cotton, rayon or nylon fabric laid up in plies or layers and their surfaces and sides covered with rubber, plastic or P.V.C. The type of fabric, the number of plies and the reinforcement, if any, in the belt determines the strength of

the latter.

Belts having nylon fabric are strong as nylon offers very high resistance to longitudinal tearing and damage due to edge turn up. Nylon also improves the resistance to impact damage and the belts are more flexible, light in weight, have better fastener-holding properties and are also designed for use on deep toughing idlers.

1.2.3 Calculate the carrying capacity of belt conveyor.

The carrying capacities of the belt conveyors are as follows for a toughed belt with a speed of 30 m/min with uniform feed of coal.

Belt width	Te/hr.
650 mm ; common as fade or gate conveyor	50
750 mm ; common as fade or gate conveyor	70
1000 mm ; common as trunk conveyor	105

If the belt speed is 60 m/min the capacity is obviously double. The capacity can thus be calculate. If the feed is not uniform as very often happens, the capacity will be usually 30 to 60 % of the calculated value. Compared to a toughed belt, a flat belt has nearly 50% carrying capacity. The maximum lump size carried by a belt conveyor is limited to about half the belt width but large sizes like this cause spilling of the material.

The carrying capacity of a toughed belt conveyor is given by T = abv

Where T = the carrying capacity (in tones per sec)

a = the average cross-sectional area of mineral (in m^2)

b = the bulk density (te.m^3); this related to density of broken material including air spaces.

v = speed of conveyor belt (in m/s)

For a belt of width w the value of the area a varies approximately between $w^2/10$ and $w^2/10$ depending on the nature of the material.

1.2.4 Describe safety devices of belt conveyors.(care of the belt)

Following are the main safety devices pf belt conveyor:

1. Protect conveyor belt from direct sunlight during storage and keep it away from steam pipes or other places of heat.
2. Use drive drums and delivery as well as tail-end drums of adequate size so that sharp bending of the belt is avoided.
3. During handling do not subject the belt to many bending or warping.
4. Prevent the belt from rubbing against any prop, timber or other stationary object and avoid wandering of the belt.
5. For toughed belt an inclination of more than 30° for the side roller is not recommended.
6. When in use the cotton-fabric belt loses its strength gradually due to the action of moisture. Even small punctures can permit moisture to reach the fabric and this is spread through the carcass by wick action.
7. Use only impact absorbing rollers at the transfer point.

1.2.5 Describe constructional features of shaker conveyor, scraper chain conveyor, armored flexible conveyor, cable belt conveyor & steel cord belt conveyor.

Scraper chain conveyor : A scraper chain conveyor consists essentially of stationary steel toughs, each usually 2m long, connected together end to end, and an endless e\chian with flights moving in the troughs, which are nearly 450 mm wide at top and 300 mm at bottom. The toughs are supported on angle iron frame work. Each tough is slightly dished at one end so that the next one fits in to form a flush joint. Adjacent troughs are secured together and to the under frame by bolts. This gives rigidly to the assembled conveyor and facilities dismantling and re-assembly. The chain consists of links and after every 3-4 links a flight is provided so that the flights are 2-2.5 m apart.

The capacity of a commonly used scraper chain conveyor is 30 to 40 tph on a level roadway, nearly, 50 m long and the drive motor is of 12-15 kW. It is a single chain conveyor, the chain moving with a speed of 35 m/min.

The advantages of scraper chain conveyor

1. Unlike the shaker conveyor, it can convey mineral uphill against relatively steep gradients (upto about 1 in 3, or even steeper) as well as on level or downhill gradient.
2. It is much stronger and can withstand more rough handling than the belt conveyor.
3. It can be readily dismantled, moved forward, extended or shortened.

The disadvantages of scraper chain conveyor

It is fairly high in first cost and in power consumption; it has too many moving parts; it is somewhat noisy in operation and tends to increase the percentages of small coal. The convenient length to handle is 100 m.

Armoured chain conveyor (also called snaking or python conveyors)

These are principally for use on a prop-free front of a long wall coal face. They can be advanced without dismantling, with the help of hydraulic, or pneumatic rams, or even hand operated jacks. They can work with lateral or vertical undulations and coal cutting machines and shearers may be mounted on them. These are used in India in only a few coal mines. The total power of motors used varies from 30 to 185 kW, the pan width at top varies from 750 to 850 mm and pan length from 1.3 to 1.8 m, the vertical flexibility of pans is 3-4° and the horizontal flexibility is 2-3°, limiting gradient without flights is 1 in 3 and with flights, 1 in 1.5, usual length with one drive is 90 m, with multi drives the length may be increased upto 360 m. Capacity is upto 100 te/hour. These are fitted with single chain or double chain.

Cable belt conveyors : In this type, the driving tension is taken by two separate steel wire ropes, one on each side of the belting and not by the belting inself. Belt only carries the material and is provided on either side with shoes, which rest on carrier ropes. Straight course is essential for operation. A1 m belt at 75 m/min. has a raed output of 300 te per hour. Rope dia is generally 25mm. sizes of belts are available between 0.75 and 1 m. Such conveyors are suitable for long lengths, particularly on inclinations. Cable belt conveyors are at present not used in Indian mines.

Steel band conveyor : This is in essence, the usual type of belt conveyor but the rubber belt is reinforced with steel bands and the nelt does not stretch appreciably in operation.

Disc conveyor : These are designed for steep gradients, especially for retarding conditions. Curved toughing is used.

Gate end stage loader (also called gate end loader) : These are generally short, low powered chain conveyors, which whilst being low in construction at the face end, and easily extensible, can elevate the coal and feed it uniformly on to the gate belt without causing spillage and damage. It is essentially a chain conveyor. Gate end loader can be profitability used for tub loading but is not suitable for large outputs.

2.0 Wire ropes

2.1 State the types of wire ropes used in Mines.

A wire rope is an important itam of engineering materials in mining and many other engineering industries. Wire ropes are classified in to two types.

(a) Stranded ropes.

- (i) Round stranded ropes.
- (ii) Triangular stranded ropes.

(iii) Oval stranded ropes.

(b) Non-stranded ropes.

2.1.1 <u>Describe constructional features of wire ropes & lay of wire ropes.</u>

On the basis of construction wire ropes are classified as

(a) Stranded ropes and (b) Non-stranded ropes.

<u>Stranded ropes</u> : A stranded rope is built up of strands and each strand consists of a number of concentrically twisted wires laid in the form of a helix round a central steel wire. A seven-wire strand consists of a single central steel wire, called king wire, covered by 6 concentrically laid wires and is common in the ropes used for haulages. If the wires of such strand are covered with a second layer of 12 wires the resultant strand is a 19-wire strand which is normally used for winding ropes.

Wire ropes are designated usually by stating the number of strands, followed by the number of wires in each strand. For instance, 6X7 wire rope means that it is made up of 6 strands, and each strand is made up of 7 wires. Such rope is the simplest construction and is used mainly for haulage purposes. For winding and hoisting 6 X 19 or 6 X 37 construction is preferred.

The flexibility of a strand depends upon,

(a) type of core :- a strand with a flexible core is more flexible than one with steel wire at the centre.

(b) Thickness of individual wires :- thinner the wires, more is the flexibility.

(c) Number of wires :- larger the number of wires, more is the flexibility.

<u>Non-stranded ropes</u> : An example of this category is the locked coil ropes. The cross-section of a locked coil rope shows that the central portion consists of strands of thick round wires. By laying up the outer wires in the direction opposite to that of the inner wires, locked coil ropes

are made non-spinning and this is a major advantage in sinking shafts where guide ropes are not installed. The ropes are of full-lock or half-lock construction. The locked coil ropes are heavier and stronger but less flexible than the stranded ropes of the same dia. For winding and hoisting purposes a locked coil rope is sometimes preferred because of its haigh capacity factor which permits a high factor of safety.

The disadvantages of locked coil ropes are :

1. Its construction is somewhat difficult.
2. Its interior cannot be lubricated from outside.
3. It cannot be spliced.
4. It is not so flexible.
5. It is somewhat difficult to cap as compared with the stranded ropes.

Lay of wire rope :

The term lay used in relation to a strand indicated the direction of laying of wires, in the strand. There are two types of lays, the right hand lay, and the left hand lay. In a right hand lay the wires spiral round the core in the same direction as the threads of a right hand screw. The opposite is known as the left hand lay. The length of lay is the distance measured along a straight line parallel to the strand in which the individual wire forms one complete spiral round the strand.

In the right hand lay the rope resembles a multi-start right hand screw thread. The right hand lay is a standard construction unless ordered otherwise by the user. The left hand lay construction is not common for haulage ropes or winding ropes used on drum winders but is sometimes adopted for ropes on multi-rope.

A rope is of ordinary lay construction if the wires in the strand and the strands in the rope are laid in opposite directions. Ordinary lay is also known as regular lay.

A rope is of Lang's lay construction if the wires in the strand are laid in the same direction as the strands are laid in the rope.

For the past few years, wire ropes of equal lay construction are being manufactured. In equal lay (or parallel lay) construction ropes, all layers of wires have the same pitch or length of lay. In most fields of application therefore equal lay ropes have given longer life than conventional ropes. The following examples of equal lay ropes: (1) Warrington pattern, (2) Scale pattern, (3) Filter pattern, (4) Warrington Scale pattern.

2.2 Define factor of safety to wire ropes nominal & actual factor of safety of wire rope. (Selection of wire ropes)

A wire rope is to be selected on the following considerations :

1. Watery places and corrosive atmosphere : A galvanized rope should be used in such places to prevent rusting and effect of corrosive fumes.

2. High temperature : Rope with fibre core should be voided in such places e.g. in foundries, steel melting shops.

3. Stationary or running coiling rope : Stationary ropes can be of large diameter rods or strands e.g. guide ropes in a shaft. Running or coiling ropes require flexibility and smaller the drum/pulley, more is the flexibility required, e.g. rope of a coal cutting machine which has to coil on a small drum should consist of a large number of thin wires and the lay of rope should be "regular" as it gives more flexibility.

4. Spinning or rotating quality : In a crane rope, one end is free to rotate and a non-spinning rope or one with ordinary lay should be used. In a sinking shaft, the sinking bucket is not traveling on guides; therefore, a non-spinning rope of locked coil construction or a rope with ordinary lay should be used.

5. Shock loads : Where a rope has to withstand shock loads, the core should be of steel strands e.g. coal cutting machine rope.

6. Resistance to wear : Ropes for haulage and winders have to be flexible and resistanct to abrasive wear. Such ropes should be of Lang's lay construction as they offer more wearing surface.

7. Tensile strength and factor of safety : Ropes used for winding of men should have high tensile strength and high factor of safety than those used for winding of materials only. Rope of the Lang's lay construction stretches under load more than the rope of regular lay construction.

8. Bending fatigue : Repeated bending of a wire rope over sheaves or drums causes fatigue failure of the wires. The rope should be flexible which is possible in a rope having large number of smaller diameter wires.

9. Groove size : The rope should not be loose or too tight in the groove of the pulley or drum.

10. Crushing and distortion : A flattened strand rope and locked coil rope is better able to withstand crushing than a round strand rope. The core should be of steel wire.

2.2.1 State factors influencing the F. O. S.

1. Depth of wind.
2. Accelerating force.
3. Type of construction of rope.
4. Conditions under which rope is used and the period of use.
5. Bending of ropes.
6. Man winding or material winding.
7. A winding rope is subjected to shock loads.

2.3 State efficiency of rope construction, space factor & cross sectional area rope.

Efficiency of rope construction :

$$\text{Efficiency of rope construction} = \frac{\text{Breaking strength of the rope.}}{\text{Breaking strength of the wire before making rope.}}$$

Space factor :

$$\text{Space factor / fill factor} = \frac{\text{Actual cross sectional area of the rope.}}{\text{Measured cross sectional area of the rope.}}$$

2.5 Describe care & maintenance of ropes.

The following points should be kept in mind during the storage and use of wire rope:-

1. Avoid use of rope with fiber core, when the rope is subject to heat, fumes and extreme pressure.
2. Buy right construction of rope suitable for the job.
3. Corrosion can be delayed by using galvanized rope,
4. Don’t load the rope beyond its safe working load.
5. Ensure that the rope is strongly seized before it is cut.
6. Flexibility of rope should be suitable to the size of drums and pulleys, and diameter of rope to grooves.
7. Grease the rope and cover properly before storing in a dry ventilated shed.
8. Handle the rope carefully while transporting and uncoiling to avoid kinks.
9. Inspect the rope periodically and lubricate with acid-free lubricant.
10. judge the safe life of the rope for the conditions under which it has to work and replace it in proper time.

2.7 Give the procedure of splicing of wire rope.

Splicing :Splicing is a method of joining two wire ropes permanently without using special fitting or attachments. Splicing of winding ropes, by which men are raised or lowered is not permitted under mining regulations, but haulage, power transmission, and aerial ropes can be used after splicing and the splice can be made nearly as strong as the original rope.

Precedure :

1. Decide the length of splice.
2. Bring the two ends of the rope to be spliced side by side the length of splice. On each rope, from the end, beyond length of the splice, tie twine on the rope.
3. Open out strands of the two ropes upto the twine binding and cut the fibre core.
4. Cut out alternate strands of each rope about 30cm from the twine binding.
5. Bring the two ropes face to face so that the cut-out cores meet. Temporarily lash the separated strands of left hand rope to the strands of right hand rope.
6. Gradually unwind or unlay strands of left hand rope which will be a short strand, and in its bed insert the meshing strand from right hand rope which will be a long strand.
7. Cut off strand to keep an equal length i.e 0.3 m and tie the strands temporarily in place.
8. In a similar manner lay strand of right hand rope into the groove formed by unlaying strand of left hand rope, but stopping the pair about 1/5 of the length of splice short of the preceding pair.

9. Repeat the process for the pair, strand of left hand rope and corresponding meshing strand of right hand rope.
10. Bend the splice back and forth until all strands rest firmly in their places. This also puts them under nearly equal tension.
11. Straighten each tail by removing any spiral formation.
12. With a vice and clamps untwist and open the rope at the end crossing, cut the fibre core at the centre, pull ir out and tuck in its place the tail of the strand. Cut off the fibre core at the end of the strand tail.
13. Tuck in the other strand tail of the same crossing in a similar manner.
14. Shift the vice and clamps to the next crossing and hammer the strands with a wooden mallet to fix them securely in their place.
15. Repeat the operations at the other five crossings and the splicing job is complete.

2.8 <u>Calculate the size of wire ropes for winding & haulages.</u>

The size of a wire rope is usually quoted in mm, but the centimeter (cm) leads to more convenient constants. If it is considered necessary to work with the rope diameter in mm all the time, the two formulate can be written as.

Mass=k $(d/10)^2$ in kg/m, d being in mm

And breaking strength = s$(d/10)^2$ in kN, d being in mm.

2.9 <u>Describe rope capel for haulage winding & recapping.</u>

The end of a rope where the load is to be attached should be a good portion of the rope, free from worn, rusted, bent or broken wires and free from effects of bending and corrosion. The simplest and easiest way to make the rope end suitable for attachment of load is to use a grooved thimble and bend back the rope end on it and part of the rope before finally tightening

4-6 rope lips at intervals on. The method needs little skill. Such attachment is permissible for haulage ropes and skips ropes hoisting on inclined planes but not permitted for winding ropes. Rope length under clips is nearly 30 times rope dia.

Different way of attaching capels :

1. Split capel with rivets : This is normally used on haulage ropes in mines but not permitted on winding ropes. Conical portion of capel fits the rope. Near the end of the rope mark two points, one point one cone length away and another point, two cone lengths away from the end. On the rope between points, wrap a number of turns of binding wire tightly to form a layer. Near give several wrappings of the wire to make it thick and slightly conical. Open out wires between rope end and point and clean them with petrol, kerosene oil or diesel oil to remove grease, oil or rust. After fanning out the wires cut $1/3^{rd}$ of them to $1/3^{rd}$ length and another $1/3^{rd}$ to $2/3^{rd}$ length. Turn back all the wires on the rope portion to give a cone and tie them on that rope portion with binding wire. Cut the exposed fibre core. Hammer a thin wooden wedge into the cone at the end. Push a split capel with its mouth slightly widened on to the cone and hammer the widened arms in position to grip the coned portion of the rope. Rivets are then hammered into the capel and through the rope at 3-4 points nearly 200mm apart.
2. Coned-socket type capel : The coned socket type capel is probably the most compact type of rope capping. This can be fitted on the rope used for practically every purpose, including winding. Near the rope end where the coned socket is to be used on the rope, wrap a few turns of binding wire tightly at a point equal to 1.1/4 times the length of conical portion of the capel. Thread the rope end through the capel. Open out the end

wires beyond the binding wire lashing, clean then with a suitable solvent like kerosene or diesel oil and cut the exposed fibre core. Reassemble the wires so that the rope end resembles a brush with the ends of the wires even. Pull the rope through the capel so that the brush remains inside its conical portion. Clamp the capel, complete with the rope in place, in a vertical position with the large end of capel pointing up, in readiness to receive molten white metal.

3. Interlocking wedge type capel (reliance capel) : In this capel there are 2 tapered iron wedges which grip the rope. The end of the rope is embedded in a block of white metal and the wedges are placed in a U-shaped steel strap on which 4-5 wrought iron hoops or clamps are fitted by hammering. The wedges have a machined groove curved to fit the rope surface and a taper of approximately 1 in 20 upon which the u-shaped strap is held. The jaws of the capel are about 24 times rope diameter in length.

3.0 Headgear :

The headgear is a steel or concrete frame work on the shaft mouth. Its purpose is (i) to support the headgear pulleys, the weight of the hoisting ropes, cages and the rope guides, and (ii) to guide the cage to the banking level. It should withstand dead and live loads ans wind pressure.

3.1 State function of head gear .

To support the headgear pulleys, the weight of the hoisting ropes, cages and the rope guides, and to guide the cage to the banking level. It should withstand dead and live loads ans wind pressure. The dead loads on the headgear are reasonably constant and calculate but the live load due to winding is a variable one depending on the length of ropes in the shaft, the contents of the cages and the rate of acceleration or deceleration. Headgears used for tower mounted Koepe winders are designed to carry in addition the load of motors, winding pulley and other equipment for winding.

3.2 Calculate height of headgear.

The height of the headgear is decided by considerations of number of decks on a cage, banking level or skip discharging point, pit-top layout, and depth of the shaft.

The level of joists carrying the detaching plate or bell above the decking level is equal to the overall height of cage/skip, plus length of cage chains and suspension gear plus a margin of 3-7 m. this margin of 3-7 m allows a cage to be lifted for materials to be slung beneath it.

The headgear pulleys should be at such a height above the detaching plate that the rope capel is released before it comes into contact with headgear pulley. The distance is about 3m.

A derrick is fitted on some headgears to facilitate lifting of the headgear pulleys at the time od replacement or repairs.

Headgears of wood are prohibited by Law.

3.3 Describe constructional features of headgear pulley.

The headgear pulley should have as large a diameter as possible to minimize bending stresses in the winding rope. Its diameter should be at least 100 times the rope diameter. Pulleys of over 2.5 m diameter are generally constructed in two halves and bolted together. Normally the diameter of the groove of the headgear pulley should be 110% of the rope diameter for stranded ropes and 105% for locked coil ropes. This ensured that 1/3rd of the circumference of the rope is in contact with the groove. A lesser angle of contact causes excessive strain on the rope and wear on the pulley. The headgear pulley is keyed to a mild steel forged shaft which rests in plain bushed journal bearings.

The angle of fleet which is the angle between the vertical plane of the pulley and the rope when the cage is a the pit-top or pit bottom, should not exceed 1.5°. More fleet angle results in wear of the rope and wear of the pulley also.

The shaft of the two headgear pulleys which are placed side by side are in a horizontal line and their planes of rotation are vertical and parallel. In the case of Koepe winders, ground mounted, the planes of rotation of the two headgear pulleys are one below another (though not vertically one below another). There is therefore no fleet angle in the case od Koepe winder pulley. If a drum winder is used for a deep shaft, it may be necessary to consider double layer coiling of rope in order to accommodate all the rope on the drum and keep the fleet angle limited to 1.5°.

3.4 Define angle of fleet.

The angle of fleet which is the angle between the vertical plane of the pulley and the rope when the cage is a the pit-top or pit bottom, should not exceed 1.5°. More fleet angle results in wear of the rope and wear of the pulley also.

4.0 Cage and shaft fitting .

4.1 Describe cage, cage suspension gear, detaching hooks & its fanction, safety

catch at headgear & keps.

Cage: The cage is lift suspended from the winding rope, open at both ends where gates can be positioned during man riding and it has rails fitted to the floor for mine cars or tubs. To prevent the mine cars/tubs from falling outside the cages, catches are provided on the floor which act against the axles of the mine car/tub, in addition, a long bar, turned at both ends and hinged at one side of the cage, prevents movement of the tubs during travel up or down the shaft. Cages used for man riding have a hand bar near the roof for the men to hold and at both ends collapsible gates are provided which can be closed or opened manually or by compressed air. The roof has a hinged or removable door for accommodating long timber or rails whenever necessary. A cage which can accommodate only a single tub is called a **single cage;** a cage which can accommodate two tubs is called a **tandem cage**.

Detaching Hook : Detaching hook which is always placed just below the rope capel, is a safety device which acts when an overwind takes place. Its purpose is to suspend the cage/skip in the headgear if an overwind occurs, and at the same time to release the rope (along with the capel) to go over the headgear pulley. Detaching hooks are used only for vertical shafts served by drum winders but they are not used on koepe winders.

The two types of detaching hooks are in common use :

1. Ormerod detaching safety hook : The ormerod detaching hook consists of three mild steel plates i.e one centre plate and two outer plates. The plates are assembled on a common centre pivot and a copper rivet, 16 mm dia. Passes through a small hole of all the plates when assembled.
2. King detaching safety hook : It consists of 4 wrought iron plates i.e two being movable inner plates and two fixed outer ways so that the hook of one plate and that of the other jointly form a secure hole for the reception of the rope capel bolt.

Safety catches : As a safeguard against the failure of the detaching plate to hold the cage, safety catches may be fitted in the headgear. These safety catches consist basically of short levers mounted in the headgear at intervals that very from 0.3 to 1m. These are located above the normal running position of the cage. The catches are free to turn on a pivot. In the event of an overwind the catches are lifted allowing the cage to pass up into the headgear. They then fall back to the normal position and so prevent the cage falling back down the shaft. A mechanical linkage is provided so that all the catches may be withdrawn simultaneously in order to lower the cage after an overwind, or when the apparatus is to be checked/tested. This operation is performed by a single hand lever for each set of catches. The safety catches should be inspected regularly to prevent accumulation of dirt or coal dust and to ensure their free movements.

The detaching safety hook provides safety for the ascending cage and arrests its ascent, the safety catches also provide for safety of the ascending cage but no safety device is employed for the descending cage which in the event of overwind strikes the pit bottom joists with full speed and the consequent damage to the installations and injuries to the persons traveling in the cage.

Keps : Keps are retractable supports for cages and have to be used at the pit top under our mining regulations. Their use is not necessary at the pit bottom as the cages rest on the rigid platform of steel girders and wooden planks. Keps are not required at the mid set landing and in a shaft served by koepe winding system. Keps ensure not only support to the cage but their use results in proper alignment of the cage-floor and decking level so that the stretch of the winding rope creates no difficulties arise and are overcome by the use of tilted or hinged platforms. Keps are manually operated by the banksman at the pit top. The ascending cage pushes the keps back and as it is raised slightly higher than the decking level, the keps fall back in position by gravity as the banksman releases the operating lever. The cage after it has come to a halt, is lowered by the winding engineman to rest on the keps. When the top cage is to start on its downward journey, the winding engineman raises the cage only slightly to make it clear of the keps, the banksman withdraws the latter by manual operation of a lever which is held by him till the cage is lowered past the keps.

4.2 State & describe the types of guide.

The guides in mine shafts are :

(i) Rigid guides.

(ii) Flexible guides or rope guides.

Rigid guides : Rigid guides are of hard wood or steel (rail section). They are of rectangular cross-section, usually 10cm X 20xm, and are fixed by countersunk bolts to the buntons placed across the shaft at intervals of 1.8m – 3m. They suffer from the risk of fire.

Steel rigid guides are installed in some deep shafts in this country. They are made of flat-bottomed or T-section rails weighing from 20-55 kgf/m length, in lengths of upto 13 m. Owing to their shape and the manner in which the shoes embrance them, they need only be placed at one side of each cage. Only one line of buntons, in the middle of the shaft, is required for fixation of guides if the guide shoes are on inner sides of the cages but on either side of the bunton.

Flexble guides : Flexible guides consist of wire ropes which may be of locked coil construction of of 1 X6 construction with thick wires. They are suspended in a vertical shaft from a secure attachment placed on the top cross member of the headgear while at the shaft bottom they are given the requisite amount of tensioning by placing cheese weights on them. These weights ensure correct verticality and also eliminate to a great extent oscillations of the guide ropes during a wind. In shafts which are not deep, 2 or 3 guides per cage suffice but for deep shafts 4 guides per cage is the standard practice and the guides are arranged near the corners of the cages. If the clearance between the cages and shaft sides is limited “buffer” ropes are arranged between the cages and outside of the cages-sides. These buffer ropes are not attached to the cages through shoes but are hung freely with proper tension. The minimum space between the 2 cages is generally 40 cms to prevent collision of the cages as the guide ropes oscillate during the wind, the maximum oscillation being at the mid-run of the cages. The tensioning weights are about 10kN per 100 m depth in shallow shafts and about 5 kN per 100 m depth in deep shafts.

5.0 <u>Winding Drum</u>

Drum winding employing a cylindrical drum is the earliest and simplest system of winding adopted in mines. One end of the winding rope is secured to the hoisting drum and from the other end the conveyance (cage, skip or bucket) is suspended. Practically all the mine winders are balanced winders in that the drum accommodates two ropes, one for the hoisting cage and the other for the down-going cage, and the travel of the two cages is simultaneous – loaded cage, and coming up and the empty cage going down.

5.2 <u>Describe different types of winding brake.</u>

The different types of winding brakes are described below :

1. <u>Mechanical brakes</u> : It acting on the winding drum must be provides of all winding engines. For a winder with two cages the brakes must hold the maximum torque of the engine. The brakes shoes are connected by rods and levers to the operating pedal of the winding engineman. The brake lever is connected by a system of rods to the brake engine control. The control valve must be designed to move to the brakes on position.
2. <u>Electrical braking of winders</u> : The method of braking to be adopted in a particular case will depend upon the energy to be absorbed in the retardation period. This is the only method possible on steam winders. The types of electrical braking for winders are :

(a) Counter current braking, (b) Dynamic braking, (c) Regenerative braking, (d) Eddy current braking.

Of these the first three are commonly adopted.

(a) Counter current braking : This is effected by reversing the electric supply to the starter. The amount of braking depends upon the position of the lever. This nethod of braking is simply and commonly adopted in mines.

Advantages :

1. A large amount of electrical energy converted into heat.
2. It involves a high line current and cables to carry such high line current have to be provided.
3. The reversing switch is subject to severe wear and tear.
4. The method has been proved to be bad for the winding ropes.

(b) Dynamic braking : The principle of dynamic braking for AC winders is perhaps the must important development of economical braking which has yet been employed. This system is particularly useful for heavy lowering winds and for slow speed shaft inspection. A survey of dynamic braking system used for A.C winder motor indicated that they broadly fall into four categories. (1) Coordinated control, (2) Compensated control, (3) Torque control, (4) Coordinated and compensated control.

(c) Regenerative braking : The net effect is that the winder motor receives less effective power and this amounts to in braking action on the winding drum. This is known as regenerative braking. It can take place at any speed in the case of Ward Leonard system. In case of A.C winders, however, regenerative braking can occur only beyond the synchronous speed of A.C motor.

5.3 Describe various types of safety devices on winding system.

The safety devices used for winding system are the following :

1. Mechanical brake or friction brake : When considering safety devices this is the first device that comes to mind and its required by mining regulations.
2. Additional mechanical brake : This acting or the brake rim of the flexible coupling between the motor and the gear box.
3. Automatic contrivance : It prevents over speeding, over winding and ensures slow banking at a speed not exceeding 1.5 m/s. Usually the speed during slow banking is 0.5 m/s.
4. Reverse direction prevention switch : It trips power if the winding engineman through mistake operates the motor is wrong direction.
5. Time limit switches at the pit top : It mounted on the headgear which trips electric supply to the motor if ascending cage over shots decking level.
6. rope deviation limit switch : It used as multi-koepe winder.
7. Limit switch for tail rope loop on koepe windes. It length of pit rope is reduced for any reason or if the loop is abstracted for any reason, a limit switch actuates the power trip switch.
8. Tachometer generator on the gear box : If the gear box is faulty and the winding drum shaft does not run at its normal speed the tachometer generator will not generate sufficient direct current.
9. Wedge arresters for down going cage.
10. Safety catches mounted on the wedge gear for the ascending cage.
11. Safety detaching hook for ascending cage.

6.0 Friction winding / Koepe Winding :

The friction winder, which is also called Koepe winder after its inventor, Fredrick Koepe, consists of a steam or electrically driven sheave fitted with renewable friction lining which is grooved to suit the main winding rope whose are of contact varies between 185° and 230° according to the design of the winder.

6.1 State & describe principle & constructional features of ground mounted koepe & tower mounted moepe.

The ground Koepe : In the ground Koepe the winding engine is installed at the ground level and the head gear pulleys are situated one above the other on the head gear as shown on figure below. The rope operates in the plane of the Koepe driving wheel without any angle of fleet.

The tower Koepe : In the tower Koepe the winding engine is erected on a tower over the shaft. This type of Koepe winder possesses many advantages over the ground Koepe, these being:

1. A large angle of rope contact on the ground driving pulley can be obtained, normally 200 degrees to 230 degrees.
2. The winding rope is protected against adverse weather conditions.
3. The head gear structure need to no stronger for a given duty than some of the head gears that are in existence today for normal drum winding.
4. It eliminates any obstruction by a winding engine house in the neighborhood of the pithead.
5. The rope is subjected to less number of bends on a tower mounted Koepe.

6.2 State advantages & disadvantages of Koepe winding.

Advantages of Koepe winding :

1. Koepe system is most suitable for winding heavy payloads from larger depths.
2. Koepe winder is simple for manufacture, compact and lighter than the drum winder. Initial cost is therefore, less for similar duties.
3. Less costly engine foundations are required for koepe winder due to lighter weight and compactness.
4. In koepe system the inertia of rotating parts that have to be set in motion is less compared to a drum winder. This is however partly offset by greater inertia of ropes.
5. there is no fleet angle in koepe system and wear on the winding pulley is reduced.
6. Koepe system lends itself to adoption of multi-rope winding which has important advantages listed.
7. It is very suitable for horizon mining system where both cages wind from one level.
8. The cage does not rest on the keps and therefore, to startit, no shock loads are transmitted to the rope.
9. A smaller length of main rope is required compared with drum hoisting using a balance rope, as there are no extra coils.
10. Operating costs are less to the smaller rated output of motor.

Disadvantages of Koepe sinding :

1. Winding is possible from one level only if the two cages are nearly balanced.
2. Koepe system can be used for only vertical shafts and not for inclined shafts as guiding and tensioning of balance rope poses problems,
3. Koepe system cannot be used during shaft sinking.
4. Koepe system is not suitable for shallow shaft as the cylindrical drum size, if drum winding is adopted, would be nearly the same as the Koepe sheave size.
5. A deeper shaft sump is required to accommodate the tail rope loop.

6. The rope changing equipment costs more and the balance rope requires heavier suspension gear and stronger shaft conveyance.
7. Separate run with one cage is impossible.
8. If the rope breaks, both cages fall in the shaft.

6.3 Describe multirope system of koepe winding:

Multirope system of winding :

The multirope koepe winder is an improvement over the single rope koepe winder and is essentially a friction winder with a drum replacing the pulley. The friction drum has as many parallel grooves as the number of ropes. These roves are 30 cm apart, centre to centre, and are as deep as the radius of the rope. The tread material, in which the grooves are made, is wood or a kind of plastic and it is attached to the drum plate by countersunk bolts. The number of ropes for the cage is even, usually 2 or 4. The reason for these even number of ropes is that adjacent ropes on the drum are of opposite lays i.e one rope of right hand lay and the other of left hand lay, as such arrangement avoids the rope tendency to untwist. In Russia *-rope hoists are in use for 50-te net payload. On the European continent 4-rope friction winders are popular though there are isolated installations of even ten-rope friction winders. In India, Jaduguda mine is equipped with a multi rope friction winder (2 ropes) with a payload of 5 te in the skip. The tension in all the ropes should be equal, as far as practicable.

Advantages of multi rope winders :

1. Each rope has to be of small diameter compared to one large diameter rope which is difficult to manufacture and handle.
2. It results in better safety.
3. There is saving in space at the pit top.
4. The capital cost of the installation is less.

5. No defection sheaves will be required.

6. The ropes are protected from the atmosphere.

7.0 Skip winding :

The term skip is sometimes used for a cage of larger size which accommodates mine cars but very often the term is restricted to a lift which does not accommodate mine cars but can be filled with mineral through its top opening. Skips traveling in a vertical plane have a discharge opening at the bottom for unloading the mineral content but skips traveling on rails along an inclined haulage plane are so tilted, during travel, near the unloading end that their contents are discharged from the top end. Skips moving in a vertical plane are sometimes partitioned for accommodating men at the upper half and material/mineral at the lower half.

7.2 Compare skip winding cage winding.

Skip winding v/s Cage winding :

Skip winding is best suited for deep shafts where high output is desirable in view of the large investment on deep sinking and the need for early return on such large outlay. The ratio (pay load : gross load of loaded skip) is high, nearly 0.6, in the case of skip winding but with cage winding of mine cars used underground is less as they are not to be raised to the surface, moreover such mine cars are independent of the size of the shaft or skip. Skip lends itself to automatic loading, unloading and decking operations, thereby providing a quicker cycle of operations of winding of mineral. This also means less manpower required for skip installation. Trackless mining is possible from the working face right upto the surface.

Skip winding has, however, the disadvantage that separate arrangements have to be made for winding of men and material, tough some recent installations have modified the skips for manwinding. With skip winding it is difficult to import dirt, washery refuse or mill tailing for underground packing of goaf or stope. Degradation of mineral, particularly soft mineral like coal, takes place during loading and unloading of skip and to prevent coal dust from entering the mine it is essential to install the skip in U.C. shaft. Winding of coal or mineral from different levels is not as convenient as in cage winding and where coals of different seams are raised from the same level, the qualities get mixed up, necessitating a washery at the surface. Skip winding requires large excavations at the pit bottom to accommodate measuring pockets, tippler and small bunker to store the mineral. A higher headgear is essential and the shaft has also to be sunk deeper than the level of the mineral bed, as compared to cage winding.

8.0 Pit top & Pit bottom circuit layout :

State factor affecting pit top and pit bottom layout :

Factor affecting the design of pit bottoms. The choice of the type and design of pit bottom depends on certain factor which are describe below.

1. Yearly output or capacity of mine.
2. Shaft capacity.
3. Method of development.
4. Surface configuration.
5. Number of shafts in the area of pit bottom.
6. Method of shaft hoisting and distribution of conveyances in shaft section.
7. Underground main haulage system.
8. Size and types of car used.
9. Method of handling cars in the pit-bottom.
10. Number of decking levels.
11. Provision for bending and preliminary in under ground.
12. Amount of diet & supply handled.
13. Intial capital cost and operating cost.

Factor affecting design of pit-top car circuit :

The various factor affecting the design of a pit top car circuit are :

1. location and number of shaft.
2. Surface of shaft ventilation
3. location of banking level.
4. method of hoisting in shaft.
5. Number of cages in shaft.
6. Types of cages.
7. Shaft capacity.
8. Amount of dirt & supply handles.
9. Size of cars.

Minimum car circulation time :

The following point should be borne be mine, when pit-top car circuit to reduce the car circulation time.

1. The car should not be allowed to run speedily under gravity for long distance.
2. The circuit should be as such as practicable by using car control appliences.
3. The teeper should preferable located in the shut or in securely plant on order that the duration of car circulation.
4. The teeper capacity should be selected on the event of any breakdown or interruption the entire output can be handle by a single teeper only.
5. The operation of the teeper and entry of cars into them should be automatic.
6. To large a number of control appliance or control point should be avoided.

The design of pit top and pit bottom layout is done with the following objects in view :

1. Use of the shaft to its fully capacity.
2. Use of minimum number of tubs in the circuit.

3. Use of minimum number of operatives.
4. Maintaining steady flow of tubs.
5. Minimum decking time.
6. Lowering of materials.
7. Handling of ores or coals of different grades.
8. Avoiding large excavations near pit-bottom.

Pit bottom circuit :

The most important types of pit bottom circuit are :

1. Circular type circuit :

(i) The circular type pit bottom circuit in which cars move only in one direction.

(ii) It is commonly used in large capacity modern mines.

(iii) It is running of strain in opposite direction on different tracks in the same roadways can be avoided.

A great disadvantage of this type of circuit a large amount of excavation work will be necessary.

The circular type layout are soon further classify depending on the location of the shaft relative to the man haulage road and the direction in which the mine cars are pushed into the cages.

2. Non-circular type circuits : These are suitable for smaller output, the layout are not flexible. They are divided into

(i) Roadway pit-bottoms.

(ii) Blind or dead pit bottoms.

(iii) A serious dis-advantages of the former type of pit-bottom, it causes traffic consecution in the pit bottom.

3. Back shunt circuit : The back shunt is cheep and simple but a speed feed is essential to allow sufficient time for each car to clear the back shunt before the next one enters. The space feed may be provided by a creeper or a stop start ram placed before the back shunt car clearance by may accurate by making the back shunt on steep or installing in a ram stop on.

4. Turn table circuit : A turn table circuit ensures continues feed of cars which need not be delivered to the turn table at regular intervals unlike the back shunt. Two reversal of car is accomplished within a restricted space. The turn table for outputs exceeding 500te/day are usuable power operated. The length of pit top required for turn table circuit is smaller than that for back shunt circuit. Only three man are required on pit top.