We've Got 4.8 stars!

STUDY MATERIAL FOR MINING ENGINEERING EXAMS (MANAGER CERTIFICATE, GATE, PSU)

- 100% exam oriented
- Latest questions included
- Frequent updates
- Guided by IITR faculty

MORE INFO

+91-9412903929

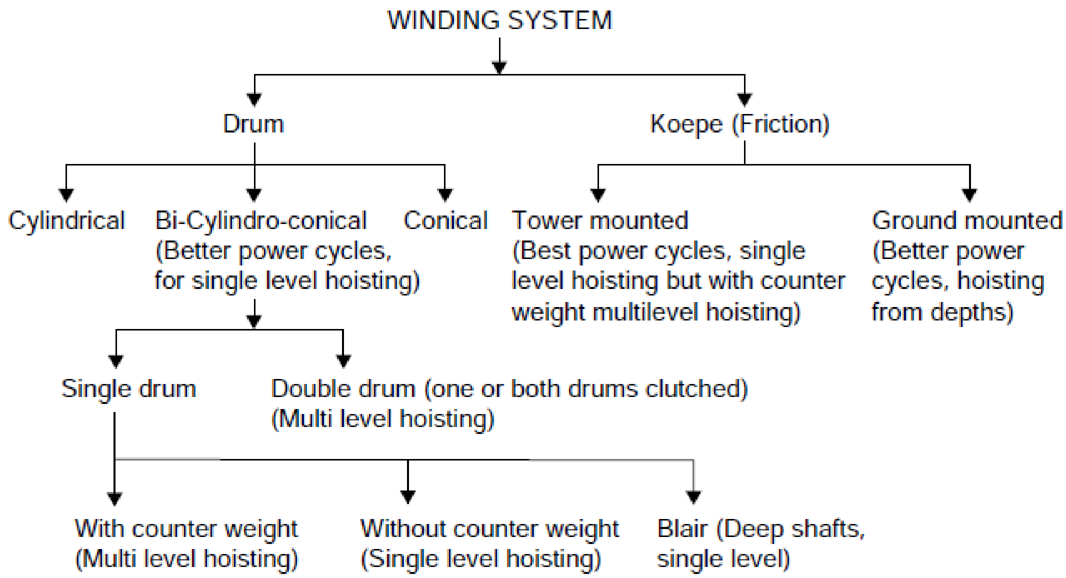
AMIESTUDYCIRCLE.COM

AMIESTUDYCIRCLE@GMAIL.COM

CIVIL LINES, NEAR IIT, ROORKEE

MINING MACHINERY

CLASSIFICATION OF HOISTING SYSTEM



COMPARISON OF HOISTING SYSTEMS

Drum and **friction hoists** are the two types of hoists that are in operation in the mines. Their main features have been compared in following table, and their sub-classification has been presented by way of a line diagram shown in following figure.

Features	Drum hoists	Friction sheaves hoist	Multi rope friction drum hoist
Relation w.r.t. rope	It stores rope	Rope not stored but extends in the shaft	Use multiple ropes extends in the shaft but extends in the shaft
Important features	Single rope; Multi level; Medium depth; Widely used	Multi rope; Single level; Limited depth; High output; Efficient	Used for great depths
Max. skip capacity	25 tons.	75 tons.	50 tons.
Max. output tons./hr.	800	2500	1600
Optimum depth	< 1800	< 900	>1800
Mounting	Head frame	Tower	Head frame

THE DRUM HOISTING SYSTEM

It is the only practical system for all mine shafts- inclined, compound, and vertical. It had served the mining industry since its inception with great success until it came to be challenged by the friction (Koepe) hoist in the 1950s. Great depths in metal mines especially in gold mines had resulted in the design and installation of conical and cylindroconical hoists before World War II but the high installation costs, high moment of inertia of the drums which had reached massive properties of 10.7 m in diameter, the doubtful overall saving in power costs, and the development of multi-layer coiling on drums have ruled out their use as mine hoists. Today, the conventional **parallel cylindrical drum hoist** is the only type which is still used both above and below ground.

Parallel Cylindrical Drum Hoists

The parallel cylindrical drum hoists may be classified depending on:

Number of drums used

- Single-drum hoists, and
- Double-drum hoists (i) with one drum clutched, and (ii) with two drums clutched.

Number of ropes used

- Single-rope drum hoists, and
- Blair multi-rope hoists.

Methods of drive

- Geared-drum hoists, and
- Direct-driven drum hoists.

Single-drum hoists

These are used in smaller shafts as service or production hoist for single or two-compartment hoisting with or without balance rope. In single-compartment hoisting, either a single unbalanced cage may be used or a cage/skip in counterbalance with a counterweight while in two-compartment hoisting, two cages/skips are used in counterbalance.

A single-drum unbalanced hoist is suitable for small installations often used for sinking shafts. The drive motor draws considerable energy from the supply when hoisting the loaded conveyance and returns some of it when lowering the empty conveyance. It may be used as a small service hoist when the cost of additional shaft section and guides required for a counterweight or second conveyance cannot be justified. A good proportion of the cost of the drive is in the control equipment. By means of a two-speed gearbox, the hoisting speed can be reduced to 1 m/s for man-riding.

As service or production hoist with cage/skip in counterbalance with a counterweight, a single-drum hoist can efficiently serve one or more levels, since the location of the counterweight at any time is not important. As a production hoist with cages/skips in counterbalance, the single-drum hoist is best used for single-level hoisting. By designing the counterweight as a service skeleton cage, service facilities can be provided at no extra cost. The peak power required is less than that required for an equivalent unbalanced hoist.

Double-drum hoists

These are normally designed with either *one or two clutched drums*.

The double-drum hoist with one drum clutched and a cage in counterbalance with a counterweight can be used as a service hoist for serving several levels efficiently as quick adjustment of rope can be facilitated. It can be used as a production hoist with two cages/skips in balance for one level or multi-level operation.

The main *advantages* claimed for double-drum hoists with both the drums clutched are that, if something happens in one of the two compartments, the hoist can operate in the other compartment to raise or lower men and supplies, and also that they facilitate rope changing. This hoist is particularly favoured in metal mines.

With continual two-compartment hoisting from more than one level, the use of balance rope is useless as operation from levels other than for which designed is only possible with an out-of-balance hoist. Also, the use of the balance rope would prevent clutching to the different levels as the dividers between the compartments would foul the loop of the balance rope. The other *disadvantages* of a balance rope are: increase in tension of main (head) rope due to vibrations of balance rope; oscillation of the loop during acceleration and deceleration; difficulty of changing the ropes; increase in the weight of the conveyance as well as conveyance suspension gear; and necessity of a guided tail sheave to compensate for variation in effective diameter in a multilayer-coiled drum for deep shafts. In the gold mines of South Africa, a few double-drum hoists with balance ropes had been installed in the past because of the restriction imposed by the power peak demands.

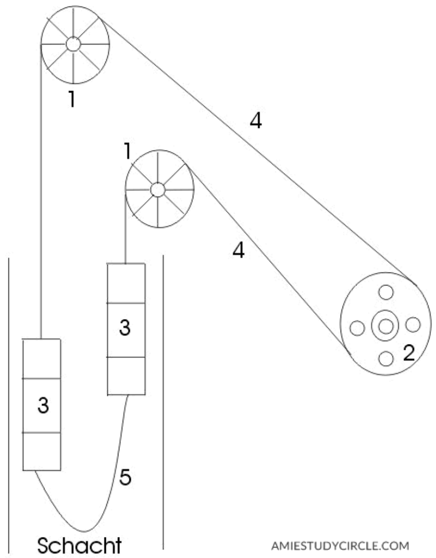
THE KOEPE (FRICTION) HOISTING SYSTEM

In earlier times the machines had huge cylinders on which the ropes were winded up. This was connected with the disadvantage that - with heavy loads in the pit cages and especially in the inner windings - a great strain was effecting the ropes, because they were winded up very tight. That caused a heavy wear and tear of the rope. That is the reason why a clever man named

Koepe had the idea that this effect could be avoided by not winding the rope up, but leading it around a driving wheel and then back to the winding tower and into the shaft.

The principle works in the following way: The rope coming out of the shaft is lead around the wheels at the winding tower's top and by this to the winding machine in the corresponding building. Then the rope is driven by the driving wheel and after this it is sent back vertically into the shaft after passing another wheel at the winding tower. So there are two pit cages fixed at each rope - one moving upwards and the other moving downwards the shaft at the same time.

After that one of the pit cages arrived at the onset of a certain level and the other one arrived at the pit bank, there is a strong difference concerning the sharing of the loads: At the first side of the driving wheel just a few metres of rope and the pit cage are pulling and at the other side there are up to 1.500 metres of rope and the pit cage, so that another rope is used for levelling out these differences: It is fixed under the pit cages and connects their floors. In this way the load of both sides is levelled out, so that the machine just has to bring up the power to move what has been put into the pit cages, for example the miners, the mine cars or the coal. The rope connecting the bottom ends of the two pit cages is in most cases a flat one. If you imagine the rope at the top, the both pit cages and the rope connecting them at the bottom, you can nearly see a circle. That is why this kind of hoisting is called "endless rope hoisting".

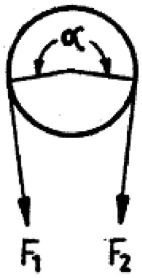


In given figure

- The wheels on top of the winding tower.
- The machine's driving wheel.
- The pit cages in the shaft, the ones in the picture have three levels.
- The ropes carrying the load.
- The rope fixed under the pit cages for levelling out the different loads.

Explanation: "**Schacht**" is the German word for **shaft**.

In Koepe hoisting system, a friction hoist is used that uses the principle of friction to drive the hoisting rope. The driving force of the motor is transmitted to the rope by static friction between the rope and the tread of the Koepe sheave. As long as the frictional force available is greater than the driving force of the motor and greater than the difference in rope tensions between the heavier and lighter loaded ropes at the drive sheave (see figure), the rope will not slip under any condition of operation.



The limiting condition occurs when

$$\frac{F_1}{F_2} = e^{\mu\alpha}$$

where

F_1 = the rope pull or tension in the heavier loaded rope;

F_2 = the rope pull or tension in the lighter loaded rope;

α = the angle of contact (180° - 205°); and

H = the coefficient of friction between rope and rope tread, which for design purposes, is taken as equal to either 0.20 for locked-coil or 0.25 for stranded ropes.

A balance or tail rope must be used with Koepe friction hoists to maintain an adequate value of F_2 in order that the rope does not slip.

The Koepe hoists may be classified depending on:

Method of mounting

- Ground-mounted hoists, and
- Tower-mounted hoists.

Number of ropes used

- Single-rope friction hoists, and
- Multi-rope friction hoists.

Method of drive

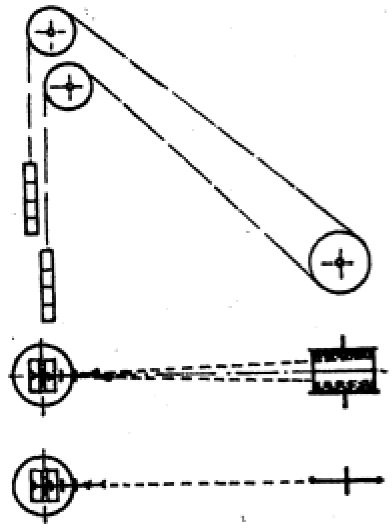
- Direct-driven D.C. hoists, and
- Geared A.C. hoists.

Single-rope and multi-rope hoists may be used as production hoists for single-level hoisting with two conveyances in balance, or with a conveyance and a counterweight for single or multi-level hoisting. They can also be efficient as service hoists with conveyance and counterweight for single- or multi-level hoisting.

Advantages of Koepe Hoisting

Compared with the drum hoisting system, the Koepe hoisting system has the following advantages:

- The Koepe system is most suitable for heavy-duty hoisting from great depths. With drumhoisting, large drums are required for hoisting large payloads from great depths and multi-layer coiling results in reduced rope life on account of crushing and heavy wear.
- When it is required to hoist from a greater depth with an existing hoisting plant, the drum hoist cannot take the greater length of rope. In such a case, it is possible to replace the drum by a friction sheave and use the existing plant to raise the load form the deeper loading level. If the existing hoisting plant is a friction hoist, it can easily be adapted to hoisting from greater depth by fitting a longer rope and altering the depth indicators and the signalling and controlling devices.
- The Koepe hoist is simpler, more compact, and lighter than the drum hoist. Less costly engine house foundations are required. The carrying capacity and the span of crane required will also be less. The capital cost with Koepe hoisting will, therefore, be lower than with drumhoisting for similar duty, the saving in cost increasing with depth.
- With Koepe hoisting, the inertia of rotating parts is less than with drumhoisting, This is, however, partly offset by the greater inertia of the ropes and conveyances. The smaller inertia and the balance rope lower the peak h.p. demands. For the same duty, the r.m.s. motor power can be as low as two-thirds of that required by an equivalent drum hoist. There is an appreciable saving in the overall consumption of electrical energy.
- With ground-mounted hoists, the headsheaves can be arranged so that the underlay and overlay ropes do not deviate at the headsheaves as well as at the friction sheave rope tread (Fig. 3.6). In this way, the fleet angle becomes zero. With drumhoisting, on the other hand, the ropes deviate at the headgear sheaves and also fleet across the drum.



Fleet Angles with Vertical Arrangement of Heads heaves with Drum and Friction Hoists.

- The wear of rope tread does not affect the decking of cages. With drumhoisting, owing to non-uniform wear of the wooden grooving where used on the drums, difficulty is experienced with cage decking.
- The Koepe system is ideally suited for multi-rope hoisting. The use of multiple ropes means that, for a given payload, smaller diameter ropes can be used with consequent reduction in the size of the friction drum and tower and saving in capital cost. As a tower-mounted hoist, it is directly mounted over the shaft which is not possible with a drum hoist. The tower-type mounted hoist is most suitable for sub-vertical and internal shafts as the amount of excavation required for its installation will be much less than for a drum hoist for the same hoisting capacity.
- In the case of ground-mounted hoists, there is flexibility in the choice of location of the hoist with respect to the shaft. The distance of the hoist from the shaft can be considerably reduced to render stresses in the headframe as nearly vertical as possible and to save on space requirement.
- A smaller length of main rope is required compared to drum hoisting using a balance rope.
- Koepe ropes are much less severely treated than multi-layer drum hoist ropes.
- Operating costs are less due to the smaller rated output of the electric motor, the smaller electrical and mechanical losses, and less mechanical maintenance required because of fewer moving parts.
- Koepe hoists are commonly designated for push-bottom operation.
- A high measure of standardization in Koepe hoist design is practicable since the unloaded hoisting system is in static balance for all shaft depths.

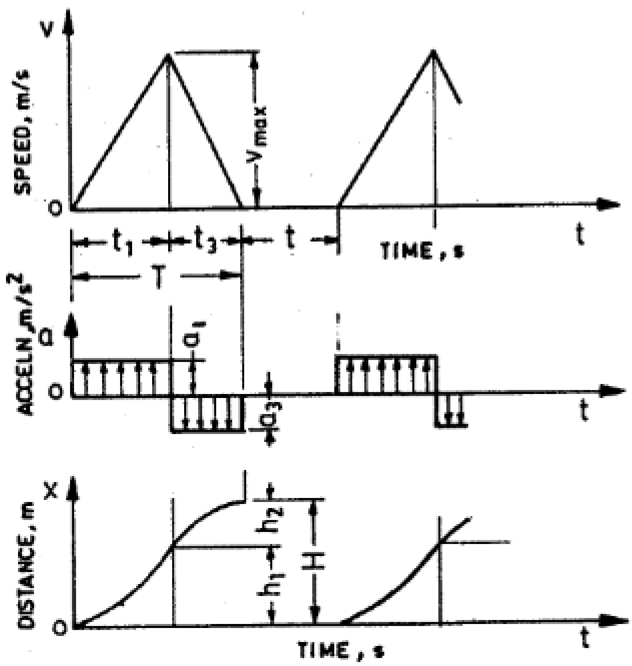
FACTOR OF SAFETY

The factor of safety of a hoist rope is the ratio between the minimum breaking load of the rope and the maximum static safe working load (or static permissible working load). It is in effect a load factor. It may be based on the actual breaking load, rated breaking load, aggregate breaking load, or load bearing capacity of the rope.

HOISTING SPEED TIME DIAGRAM

The motion of cage/skip during a hoisting cycle is governed by the hoisting speed-time diagram chosen. The selection of the most suitable speed-time diagram for economic hoisting depends on the hoisting distance, the type of cage or skip used, and the type of drive selected. Generally speaking, for a payload to be hoisted which should be as large as possible, the maximum hoisting speed and the acceleration should be taken low to keep the r.m.s. power and peak power of the hoist motor down.

2-peroiod speed-time triangular diagram with linear change of speed during the accelerating and decelerating periods but without maximum speed (or full speed) period is shown below.



Two-Period Speed-Time, Acceleration-Time and Distance-Time Diagrams

Let

v_{max} - maximum hoisting speed, m/s;

t_1 = accelerating period, s;

t_3 = decelerating period, s;

T = running time, s;

t - rest time (or idle time), s;

H = hoisting distance, m;

a_1 - acceleration, m/s^2;

a_3 = deceleration, m/s^2.

Accelerating period

$$t_1 = \frac{v_{max}}{a_1}$$

Distance travelled by conveyance

During accelerating period

$$h_1 = \frac{v_{max}}{2}.t_1$$

Decelerating period

$$t_3 = \frac{v_{max}}{a_3}$$

Distance travelled by conveyance

During decelerating period

$$h_3 = \frac{v_{max}}{2}.t_3$$

Running time

$$T = t_1 + t_3 = v_{max}\left(\frac{1}{a_1} + \frac{1}{a_3}\right)$$

Hosting distance (= area of triangular)

$$H = \frac{v_{max}}{2}t_1 + \frac{v_{max}}{2}.t_3 = \frac{v_{max}T}{2}$$

$$v_{max} = 2\frac{H}{T} = 2.v_{avg}$$

where v_{avg} = average speed = H/T

When acceleration is equal to deceleration, the triangle becomes an isosceles triangle, and

$$v_{max} = \sqrt{aH}$$

where a = a_1 = a_3

$$T = \frac{2H}{v_{\max}} = 2\sqrt{\frac{H}{a}}$$

Now $$v_{\max} = TC = 2v_{avg}$$

It is obvious that greater the value of the maximum speed, less will be the running time of the shaft conveyance and larger the hoist motor power required. Furthermore, as the motor does not work under constant load, such hoists are **used only for very small hoisting distances of 15 to 20 m.**

MULTI-ROPE FRICTION HOISTS

As mine shafts grow deeper in coal- and ore-mining industries and the hoisting distance increases, the mass of the suspended hoisting rope will increase. Since the prescribed factor of safety for the rope is to be maintained, an increase in the mass of the hoisting rope can only take place at the expense of payload. Consequently, the rope diameter will increase affecting the size of hoisting equipment. For a reasonable size of rope diameter and hoisting equipment, the operating or working load must be uniformly divided between two or more smaller but equal diameter ropes. For the same total static rope pull or tension on the heavier side, the diameter of rope of a multi-rope friction hoist, d_n will be $1/\sqrt{n}$ of the diameter, d, of an equivalent single-rope hoist.

$$d_n = \frac{d}{\sqrt{d_n}}$$

The diameter of rope of a 4-rope hoist will, therefore, be half of the diameter of rope of an equivalent single-rope hoist.

The diameters of ropes employed in multi-rope hoists vary between 16 and 65 mm. Payloads up to 60 t can be hoisted from depths of 600 to 1500 m with reasonable rope diameters using multi-rope hoists. Hoisting speeds vary between 4 and 18 m/s.

Multi-rope hoists are now being widely used in all new installations in both coal and metal mines using 2 to a maximum of 10 ropes and the older installations are being converted to multi-rope hoists.

DRUM HOISTS

Drums

The drum must have adequate strength to withstand crushing and distortion due to rope pull and to transmit the torque produced by the drive motor. It must also possess great rigidity to prevent movement between the separate component parts resulting from the periodic reversals