UNDERGROUND MINING TRANSPORTATION SYSTEMS

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Contents

Summary

Underground mines have changed their operation systems in accordance with the evolution of equipment, the system and method of mining. Transport is also of critical importance in underground mines as is the mining operation itself. The underground transport system of ores, materials, equipment and persons has been developed from

primitive hand operation to the mechanized and automated operation through the rapid progress of technology in production equipment and methods of extraction, leading to higher productivity and production.

The transport system must be designed, considering the many other elements of the mining operation, and we must take into account the number of possible steps from the extraction site (stope/face) to the shaft or ramp portal. The total system has been established - as a combination of various types of equipment - such that it is most applicable to the ore deposits being mined, the mining methods employed and the mine layout.

1. Introduction

Transport developments followed two distinct routes in each of the major functions, namely the movement of ore/coal, persons, materials and equipment. Ore/coal transport has either been by locomotive-hauled mine cars, belt conveyors or rubber-tired trucks. The transport of persons, materials and equipment has either been by rail-mounted track systems or trackless systems/movable vehicles. Each system described above is still widely popular for those various specific reasons.

The considerations of transport systems for ore/coal, persons, materials and equipment are major factors in the decision to use drifts and/or shafts for a mine.

2. From Surface to Underground/Vice Versa

Considering transport systems from the surface to underground, mines may be classified into two basic categories; shallow mines with roadways of level or shallow gradients, and deep mines with vertical shafts or long inclined drifts. Deep mines require some form of specific transport system between the surface and the underground level. On the other hand, shallow mines generally require a direct and simple transport system.

There has been considerable and continuing debate on the use of shafts or inclined drifts in deep mines.

The advantages of drift transport systems over shaft systems are as follows:

1. The lowering and raising of all materials and equipment without dismantling and reassembly.
2. The compatible use of drift for persons and materials transport and ore/coal haulage by conveyor without any operational interference of one with the other.

2.1. Shafts

There are many mines using a shaft for persons, materials and equipment transport. The main advantage of a shaft for personnel transport compared to a drift is in the traveling time.

The maximum load that can be carried in each shaft varies depending on the installation. Transported materials are generally palletized, railed into the cage and lowered inside the cage. Pipes and long materials may be slung either in or below the cage. Large machines must be partially dismantled, loaded, lowered and then reassembled underground. Personnel vehicles such as rubber-tired vehicles are self-trammed into the cage and then lowered with people on board.

The winders used for shaft transport are drum type and multi-rope friction type. The winding operations are done automatically or manually.

Figure 1 shows a vertical shaft at Ikeshima Colliery, Japan. The winder is a multi-rope friction type and automatically operated.

Figure 1: Vertical shaft at Ikeshima Colliery

2.1.1. Cage

The prime function of a cage is the transport of persons and materials to and from underground. In high production mines, the handling of large pieces of equipment is important. A cage used for lowering and raising persons must be covered and equipped with gates for safety.

The size and number of decks on the cage depends on the size of the operation and the equipment being handled. Cages vary from a single deck up to a triple deck. Figure 2 shows the triple deck cage system used in Ikeshima Colliery, capable of carrying a maximum of 30 people per deck.

Figure 2: Triple deck cage

The cage is normally equipped with safety devices for protection in the event of rope failure. These safety devices are designed to operate on the timber guides.

2.1.2. Skips

Skips are shaft conveyors for hoisting ore/coal or waste from the underground. The most significant feature is the method by which ore/coal is discharged from the skip. Skips now in use are almost always the bottom-dump design.

Skip loading is often automated in conjunction with automated slumping and automated ore/coal hoisting systems. Loading systems that involve measurement by load or by volume can be used.

Volumetric systems are used primarily for use of relatively uniform density and where an occasional waste rock is of lesser density than the ore. Any condition where ore density variation can cause overload on the hoist, necessitates the use of measurement by the load system. Volume measurement is by cartridge or pocket with switching or gate control.

Measurement by load utilizes a load cell device supporting the pocket plus the ore. This allows constant loads irrespective of density with limit devices for overfill.

2.2. Inclined Shafts or Inclined Drifts

Many underground mines use an inclined shaft for the transport of persons, materials and equipment to and from the underground. Figure 3 shows an inclined drift at Ikeshima Colliery.

Figure 3: Inclined shaft at Ikeshima Colliery

The inclined shafts are often used also for belt conveyor transport, and therefore are generally inclined at 16-18 degrees from the horizontal.

There are many inclined shafts that are equipped with rail tracks and a winder. Winders are electric powered drum types. Old winders were controlled manually, however, currently all installed winders are automatic and controlled by radio from the dolly car at the end of the winch rope.

With an inclined shaft using materials and equipment track-mounted transport system, mines are readily able to lower all materials and equipment to the bottom on track-mounted trolleys. Large items such as mining equipment (shearers, continuous miners, shield supports, etc.) can be raised or lowered on special trolleys at reduced speeds without dismantling.

Many mines also use trackless systems in drifts with gradients not steeper than 12 degrees. Large equipment, such as a continuous miner, is generally self-tramming in such circumstances.

3. Underground Transport for Materials and Equipment

A variety of different systems are used for the transport of materials and equipment in underground mines. The systems now in use have evolved with time, and this evolution is largely dependent upon such factors as increasing transport distances, the gradients and undulations of transport routes, increasing volume and weight of equipment and materials used, safety and inspection requirements, economic factors and technological changes in mining, and finally transport equipment. Once materials and equipment are lowered underground through shafts or drifts, they are transported by a variety of diesel and electric (including battery) powered track mounted and trackless systems.

There are two basic options for the underground transport of materials and equipment: track/rail systems and trackless systems. Most underground mines use the latter only. In some German coal mines, monorail systems are employed for materials and equipment transport.

When materials and equipment are transported over long distances, the transport equipment and railroad or roadway must be capable of allowing sufficient average speeds around the mine. To achieve this, the equipment must be capable of moving at a high speed and the system must minimize the number of stops and delays in the transport cycle. Naturally, loading and unloading must be efficient.

Roadway gradients flatter than 3 degrees allow for the choice between the adhesion rail mounted or rubber tired systems. For gradients steeper than 3 degrees, adhesion rail locomotion becomes less desirable, with the long distance gradient limit generally being about 3.5 degrees in dry conditions (steeper for short distances). At steeper gradients, the choice is between rubber tired/trackless equipment and rail-mounted systems employing rack-rail locomotion or rope haulage assistance, with the trackless system being far more popular.

Transport roadway undulations also have to take significant consideration. Some gradients and undulations may be smoothed out in the process of driving or preparation of a transport roadway.

Other important factors affecting the selection of the materials and equipment transport system are the ore/coal haulage and personnel transport systems, since the decisions are very difficult and not always possible in isolation from the other two.

Important factors that affect the selection of the materials and equipment transport system are as follows:

1. Quantity (volume and weight) and size of materials and equipment.
2. Access method to the destination.
3. Transport roadway size (height and width).
4. Transport distance and transloading points.
5. Roadway conditions (gradient, undulation, soft floor, etc.).
6. Relation to the personnel transport system.

3.1. Track System/Rail-mounted Systems

Track or rail-mounted systems can provide fast transport of all materials and equipment over relatively long distances. The speed and efficiency of the rail transport depends upon the standards of roadway grading, preparation and the installation of the track. Poor grading and water drainage, insufficient sleepers, inadequate surveying and leveling and the lack of good ballast will lead to an unreliable track, derailments and slow operation. Mechanical rail laying with purpose-built machinery to reduce manual handling was successfully introduced. The cost of setting up the roadways and trackwork is high but the ability to handle high volumes and heavy loads with speed is an advantage in large mines with long distances and particularly where the floor is incompetent. The system lacks the flexibility of trackless arrangements and is comparatively slow to extend but can handle much larger loads per trip than a trackless system.

Distances over which materials and equipment must be transported vary with mining operations. For most mines, supply distances are not so long. However, at some mines, supplies must be transported over 10 km. Mines with very long supply distances most often use a rail transport system. Figure 4 shows the transport of steel arches by using the rail-mounted system.

Figure 4: Material transport by a rail-mounted system

Rail-mounted materials and equipment transport systems are used either alone or in combination with trackless systems. The power source of the locomotives is either electricity (including battery) or diesel.

The movable drive permits operation in branched rail networks, so that several operating points can be supplied with materials by moving a train. Drive trolley operation means continuous transport and transloading of materials is substantially reduced compared to conventional rope operation.

Monorail systems are the most widely used means of transport in the German coal mines for essentially two reasons: firstly, their operation is independent of the quality of the roadway floor, and secondly, the transloading of materials is facilitated by beam hoists. Whereas monorails were previously always rope-operated movable monorail drives, currently drive trolleys found in the system are predominantly equipped with diesel engines.

The monorail system is a highly developed means of transport, although it contains clear limits to the useful load and rate of transport. The reasons lie partly in the system and partly in the customary suspension of the rail from the roadway supports.

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Biographical Sketch

K. Matsui received B. Eng., M. Eng., and Dr. Eng. In respectively 1975, 1977, and 1983 all from Kyushu University where he joined the Department of Mining Engineering as an Associate Professor in 1985 and is a Professor since 1994.
He serves on the Professional Committee on Kyushu Coal Mine Safety Technology, since 1983 and was member of Kyushu Mine Safety Committee, 1989-2001.
Professor Matsui has been engaged in study of ground control problems in underground coal mines and machine tunnel drivage. Nowadays, his research interest expands to the fields of mechanization and automation of mining in limestone quarries and pipe-jacking in civil engineering. He has authored/co-authored one book and over 300 papers in journals and conference proceedings.