AN INTRODUCTION TO MINE HOISTS

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ABSTRACT

With the emergence of Underground Nuclear Waste Repository Technology, the mine hoist will be called on, in many cases, to function as both a production hoist (during the excavation and the backfilling process) and a service hoist (during the lowering of the encapsulated radioactive waste). As noted herein, in many cases, there are often 2 or more types of hoists which will accomplish the desired results. A careful and thorough study should be done by an application engineer to define which hoists within a particular type are best suited for the application. At this point in time the customers may add their own values for the intangibles to define the optimum hoist for their particular situation.

INTRODUCTION

With the continuing investigation into deep underground Nuclear Waste repositories, the mine hoist and its related equipment are of fundamental importance. The mine hoist will be used throughout the project, from the removal of excavated rock from the shaft and repository, to the lowering of the radioactive waste into the repository and finally through the sealing of the shaft at the end of the operational life of the repository.

This paper is not intended to give the reader the means by which to select the proper types of hoist; it is however intended to give the reader an insight into the various types of hoists available, the operating constraints of each type of hoist and the factors affecting the application engineer's selection of a particular type of hoist.

TYPES OF HOISTS AVAILABLE

There are two basic types of hoists: the drum hoist, on which the hoist rope is stored during hoisting, and the friction (Koepe) hoist, which passes the rope(s) over a wheel during hoisting.

Various drum hoists are available to meet each particular need. The most simple drum hoist is the single drum (Fig. 1). As a service or production hoist with a cage or skip in balance with a counterweight, a single drum hoist can efficiently service one or more levels, since the location of the counterweight at any time is not important. As a production hoist with skips in balance, the single drum hoist is best suited for single-level hoisting. When this hoist is used as a multi-level production hoist with skips in balance, skip respotting is required and hoisting efficiencies are reduced. In fact, more production can be obtained from the lower level since respotting is required for each of the upper levels with this mining situation. Serious consideration should be given to dropping all material to the lower level. All rope adjustments for proper spotting must be done manually for the single drum hoist. The single drum hoist is most commonly applied in vertical shafts up to approximately 1500 ft in depth and on slope shafts (usually 15-30^{o}) to approximately 3600 ft.

A variation of the single drum hoist is the divided drum hoist (Fig. 2). Where operational considerations, such as depth, fleet angle, etc., dictate that multi-layer winding is necessary, the single drum hoist must have a divider to allow a separate compartment for each rope. If a counterweight is used with a divided drum hoist, the counterweight can be wound on a smaller diameter. Consequently the counterweight moves a shorter distance than the main conveyance and therefore rope adjustment problems are reduced. The divided single drum hoist is commonly found in shafts to approximately 1500 ft but have been applied to 3500 ft and beyond in some cases.

The third type of drum hoist is the double drum hoist with one drum clutched (Fig. 3). As a service hoist with a cage and counterweight, this hoist can service several levels efficiently. This hoist is also used, on a somewhat limited basis, as a production hoist with skips in balance for one level hoisting. The function of 2 drums and a clutch is to allow for quick rope adjustment to compensate for initial stretch. In both of the above cases the selection of this hoist over a single drum would be justified only if the added expense of the second drum and clutch would be offset by savings in rope adjustment time. This hoist does find the majority of its uses as a production hoist with skips in balance for multi-level operation, the clutch being used to adjust the hoist for efficient hoisting from any level.

The fourth type of drum hoist is the double drum with both drums clutched (Fig. 4). The main advantage of this hoist over the double drum with one clutch is that with this type of hoist, if something happens in one of the two compartments of the shaft, the hoist can operate in the other compartment to raise and lower men and supplies. This hoist arrangement is favored if there is only one shaft entrance to the mine or if each drum is operating in a different shaft. Both of the above double drum hoists are commonly found in shafts to approximately 1500-2500 ft deep and in shafts exceeding 5000 feet.

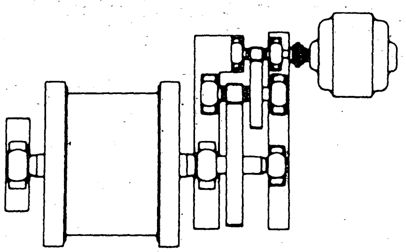

Fig. 1 Single drum hoist.

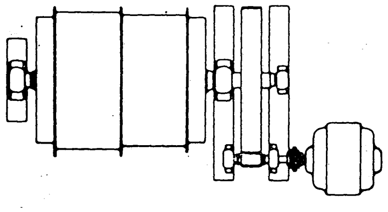

Fig 2. Divided single drum hoist.

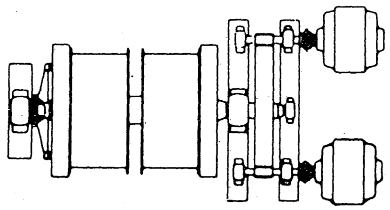

Fig. 3 Double drum hoist with one drum clutched

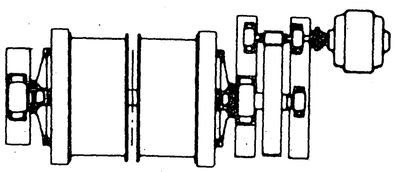

Fig. 4 Double drum hoist with both drums clutched

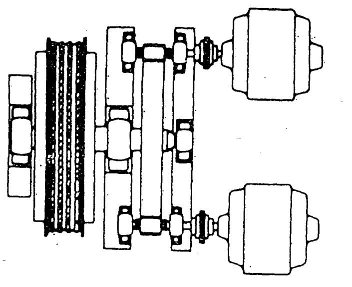

Fig. 5 Friction or Keope hoist

The final type of drum hoist found in modern hoisting applications is a South African mining innovation called a multiple drum hoist. Basically, it uses 2 ropes per conveyance, which at great depths permits the use of smaller ropes and consequently smaller drums. There are none of these multiple rope drum hoists now in use in the U.S., but consideration should be given to them in very deep mines.

The other basic type of hoist in use today is the friction or Koepe hoist (Fig. 5). This hoist was first introduced by Fredrick Koepe in 1877. The hoist rope(s) pass over a friction-type wheel which has a tension differential between the point where the rope enters the wheel and the point where it leaves the wheel. In order to keep this tension differential constant over a complete hoisting trip, the friction hoists are designed to use a tail or balance rope. A perfectly designed friction hoist using skips in balance will present the same out-of-balance torque to the motor on either side of the hoist. Multi-rope Koepe hoists can be efficient as service hoists with a cage and counterweight for single or multi-level hoisting. The friction hoist though is most commonly found as a production hoist with skips in balance for single-level hoisting. Two important considerations with friction hoists are as follows: Because multiple ropes are commonly used, the rope diameter for a particular set of conditions is smaller, consequently allowing for the use of a smaller drum; and because the rope is not stored on the drum, energy consumed is applied only to productive load, thus lowering the horsepower requirements of the friction hoist. Both of the above factors can lead to a lower cost of the mechanical and electrical portions of a friction hoist when compared to a drum hoist. The majority of friction hoists find their application in shafts of between 1000 and 5000 ft in depth.

Fig. 6 (shown below) shows the various depths to which a particular type (Koepe or drum) of production hoist is commonly used. The service hoist, because of its greatly varying conditions of loads within each application (man load, normal equipment load, heavy equipment load, etc.) is not as easily generalized. However, when selecting a particular type of hoist (Koepe or drum) for an application, both types should be considered.

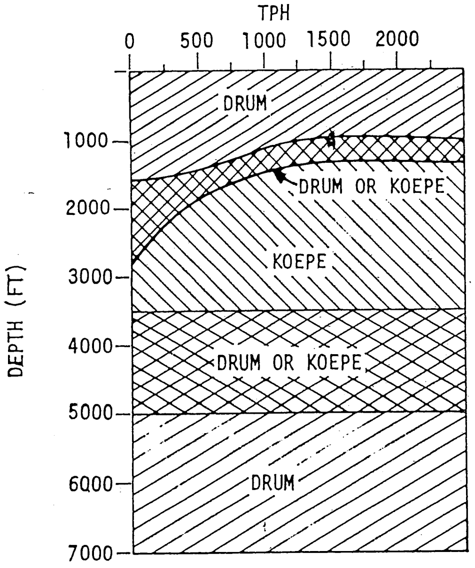

Fig. 6 TONS PER HOUR

THE APPLICATION ENGINEERS SELECTION OF A HOIST

The application engineer after defining the operating conditions of a particular application will conduct an intensive computer search for the hoist best suited for that application within each of the various types of drum and friction hoist described above. Before deciding which hoist types to use, five general factors should be considered by the application engineer. Hoist mechanicals, hoist electricals, ropes, shaft layout and headframe and hoist house arrangement.

Mechanicals - As pointed out earlier the cost of the friction hoist mechanicals is often less than that of a drum hoist for a particular situation.

Electricals - As noted earlier the horsepower requirements and therefore the cost of friction hoist electrics are also less than those of a drum hoist. However, since the automatic control of a friction hoist is more costly than that of a drum hoist, in situations where the horsepower requirements for a friction and drum hoist are very close, the electrics may be more costly for the friction wheel.

Ropes - Although debated at great lengths, it is generally agreed that a larger rope safety factor should be applied to the friction hoist since rope ends cannot be reshackled periodically for inspection. With multiple hoist ropes, the use of tail ropes and added rope attachments, it can be seen that the ropes for the friction hoist will cost more. Although the initial cost difference may be a small percentage of the total hoist system, the shaft and local restrictions will determine what effect this cost difference has on operating costs.

Shaft Layout - It can be seen that under certain conditions of depth and number of levels, two production friction hoists operating with a skip in balance with a counterweight may be required. The additional cost of guides and guide maintenance can be considerable in deep shafts.

Headframe and Hoist House Arrangement - Space requirements are less for a friction hoist than for a drum hoist in most cases. Further, in cases where space limitations are critical, the Koepe hoist can be mounted on top of the headrame.

Once the various types of hoists have been determined, the application engineer will assign costs for each one of the five areas listed above for each type of hoist; at this point, a hoist type can be selected which will yield the lowest apparent capital cost of the various types available. An example of the comparison done can be seen in Charts I, II and III for the conditions of 1500 TPH from 1000 ft (single level).

The per unit cost shown is based on the lowest capital cost hoist being unity. As can be seen, the optimum hoist in this case is a friction hoist. The optimum single drum hoist would cost an additional 46%, and the optimum double drum hoist would cost an additional 121%.

The final and perhaps the most overlooked factors affecting hoist selection can now be applied. These factors are the intangibles, which have a customer-perceived value. These intangibles include such things as:

1. Familiarity with a certain type of hoist
2. Experience of maintenance personnel
3. Flexibility of hoist
4. Duplication of hoist to reduce parts inventory
5. Unfavorable experiences with a certain type of hoist
6. Ease of rope maintenance

TABLE I

Computer Search of a Single Drum Hoist with a Required Capacity of 1000 TPH and a Hoisting Distance of 1100 Ft

HOIST NUMBER	SKIP LOAD (TONS)	VELOCITY (FPS)	SKIP WGT (TONS)	DRUM DIA. (INCH)	MOTOR H.P.	PER UNIT COST ($)
1	21.18	23.29	14.47	192	2000	1.46
2	19.80	26.82	13.52	192	2500	1.53
3	18.82	30.35	12.85	192	2500	1.53
4	18.12	33.87	12.37	180	2500	1.53
5	17.62	37.40	12.03	180	3000	1.49
6	17.26	40.93	11.79	180	3000	1.49
7	17.03	44.46	11.63	180	3500	1.55
8	16.87	47.99	11.53	180	3500	1.55
9	16.79	51.52	11.47	180	4000	1.61
10	16.77	55.05	11.45	180	4000	1.61

TABLE II

Computer Search of a Ground Mounted Friction Hoist with a Required Capacity of 1000 TPH and a Hoisting Distance of 1100 Ft

HOIST NUMBER	SKIP LOAD (TONS)	VELOCITY (FPS)	SKIP WGT (TONS)	DRUM DIA. (INCH)	MOTOR H.P.	PER UNIT COST ($)
1	41.4	8.83	62.56	180	1600	1.32
2	29.07	13.97	43.97	160	1600	1.11
3	23.66	19.10	35.79	140	1800	1.26
4	20.76	24.24	31.38	130	2000	1.00
5	19.05	29.37	28.80	130	2000	1.00
6	18.01	34.51	27.26	120	2500	1.03
7	17.39	39.64	26.29	120	2500	1.03
8	17.01	44.78	25.71	120	3000	1.08
9	16.82	49.91	25.44	120	3500	1.14
10	16.77	55.05	25.34	120	3500	1.14

TABLE III

Computer Search of a Double Drum Hoist with a
Required Capacity of 1000 TPH and a Hoisting Distance of 1100 Ft

HOIST NUMBER	SKIP LOAD (TONS)	VELOCITY (FPS)	SKIP WGT. (TONS)	DRUM DIA. (INCH)	MOTOR H.P.	PER UNIT COST (S)
1	21.18	23.29	14.47	192	2500	2.26
2	19.80	26.82	13.52	192	2500	2.26
3	18.82	30.35	12.85	192	2500	2.26
4	18.12	33.87	12.37	180	3000	2.21
5	17.62	37.40	12.03	180	3000	2.21
6	17.26	40.93	11.79	180	3500	2.21
7	17.03	44.46	11.63	180	3500	2.21
8	16.87	47.99	11.53	180	4000	2.32
9	16.79	51.52	11.47	180	4000	2.32
10	16.77	55.05	11.45	180	4500	2.39

The customers after reviewing the hoists best suited for the application within each type of hoist, along with their associated estimated costs, can now apply their own perceived values to each of the particular types of hoists before determining which hoist is to be used. These customer-perceived values in many cases have led to the purchase of a hoist which has an apparent increased capital cost.

CONCLUSION

With the emergence of Underground Nuclear Waste Repository Technology, the mine hoist will be called on, in many cases, to function as both a production hoist (during the excavation and the backfilling process) and a service hoist (during the lowering of the encapsulated ratioactive waste). As noted herein, in many cases, there are often two or more types of hoists which will accomplish the desired results. A careful and thorough study should be done by an application engineer to define which hoists within a particular type are best suited for the application. At this point in time the customers may add their own values for the intangibles to define the optimum hoist for their particular situation.

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