Friction Hoisting in North America – A Historical Perspective

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ABSTRACT: Friction hoisting as an ore haulage method is a somewhat new development in North America when compared to some of the other major mining centers. Although invented in 1877 with widespread acceptance in most parts of Europe, it was only 1955 that the first friction hoisting systems were placed into operation in North America.

This paper will provide an interesting and entertaining historic perspective of the development and growth of friction hoisting as a viable hoisting solution in North America. The paper will include discussions on the reasons for North America's first friction hoist and it will examine in detail some of the originally published technical articles as well as provide a brief look at some of the notable friction winding installations in North America from all manufacturers.

EARLY FRICTION HOISTING

It is well known that the idea of the friction hoist was introduced by Frederich Koepe in the late 19th century in the German Coal mining industry. Early friction hoists, like drum hoists, were normally ground mounted and used tower mounted headsheaves to center the conveyance ropes within the shaft compartments. As mine operators and hoist manufacturers gained experience with the friction hoist concept, new developments and methods came on stream. These included improvements to friction lining materials, the use of two and sometimes three hoist ropes and in some cases installing the entire friction hoist within the headframe tower. These early friction hoist configurations gained widespread usage in Scandanavia, Germany, Belgium, Holland and France. By the early 1940s, friction hoisting systems dominated in the mining industry in the above mentioned countries to the point that drum hoists were rare and were, in some cases, converted to friction hoists. A 1954 report by representatives of the Ontario Department of Mines inspection branch [1] stated "in west Germany, where 3,000,000 men were employed in mining, 509 of 559 surface installations were friction hoists. Nearly all of the 1700 internal shafts in the Ruhr were also equipped with friction hoists. In France, Belgium, Holland and other European countries the percentage of friction hoists may be even higher. Few, if any drum hoists have been installed in these countries for some years".

With the friction hoist configuration higher payloads at depth were possible through the use of multiple head ropes, with all the ropes equally sharing (ideally) the payload mass. Numerous technical papers, magazine articles and mining conferences dealt with the subject of friction hoists, their operation, their design and construction and invariably comparisons with the well known drum hoisting configurations (at the time, single drum, double drum and various versions of conical drums). Generally speaking, friction hoists were touted as having the ability to handle heavy payloads with comparatively smaller mechanical equipment configurations resulting in comparatively smaller electrical drives. At the time, appropriate consideration was given to the area of rope selection, rope tension equalization, rope slip, brake systems, "pushbutton operation" and other areas of relevance to friction winding configurations (all of which remain true today).

While there were friction hoist installations operating with two and even three head ropes it is generally considered that the first large capacity, multi-rope friction hoisting system was developed in Germany in the mid 1940s at the Hannover – Hannibal mine. This was the first friction hoisting installation where four head ropes were used carrying a payload of 19200 kg from 950m at a speed of at 18m/s.

While the friction hoisting concept was well accepted in most parts of Europe, they were still regarded with some suspicion in North America, South Africa and even Great Britain. It was only after the development of large capacity Multi-Rope Friction hoisting systems that serious consideration was given to their use in North America.

CLEVELAND-CLIFFS IRON COMPANY – SHAFT C

Cleveland-Cliffs Iron Company had been operating an underground iron ore mine since 1883 in Ishpeming, Michigan [2]. They operated 12 foot single and double drum hoists manufactured by Nordberg Manufacturing Company in their shafts A and B. In 1952 they were planning a new mine shaft "C" for initial 400m depth with a possible future depth of 1220m. The major problem they encountered was that they simply did not have enough room on their site to accommodate a properly designed drum hoisting facility with separate tower and ground mounted hoist house. Various drum hoist layouts were drawn up for the existing site but each had to be discarded due to problems with interference with existing site facilities. Eventually, they concluded that a tower mounted hoisting system would best solve the site layout problems.

They "had heard about the expanding continental practice of mounting Koepe hoists in the headframe directly over the shaft, but had previously not given them any serious consideration because of skepticism regarding the application of the Koepe hoist principle to hoisting under wet and occasionally muddy shaft conditions" [2]. At the time, their main concern seemed to be the possibility of rope slip in wet shaft conditions as well as tail rope damage from spillage during skip loading.

They realized, however, that due to somewhat unique shaft conditions at their location they would operate a relatively dry shaft and they could resolve any spillage issues by modifying the skip loading arrangements. With these issues in mind, they took a trip to Northern Sweden in the summer of 1952 to study various Swedish friction hoisting installations, including the Kiruna Iron Ore Mine in Northern Sweden where numerous multi rope friction hoisting systems were already in operation in similar conditions that would occur in shaft "C". At the end of their trip they subsequently reported to "management that such a hoisting system would apply to the new C shaft conditions" [2]. At the end of 1952 an order for North America's first friction hoisting system was placed on the Swedish company ASEA (now ABB).

FRICTION HOISTS AT SHAFT C.

Three friction hoists were delivered to Cleveland-Cliffs shaft C project and put into regular operation in December 1955. These hoists consisted of:

Service Hoist - Cage and Counterweight

- 2.26m diameter friction drum
- 6800kg payload hoisted from 400m
- 4 x 25.4mm head and tail ropes. Head Rope operating at 9.6 rope safety factor
- 5.59m/s full speed (initial), designed for 10m/s full speed (future)
- 1120kW Gearbox coupled DC motors supplied by MG Sets

2 x Skip Hoists – Skip and Counterweight

- 3.0m diameter friction drum
- 13600kg payload hoisted from 400m
- 4 x 25.4mm head ropes, 2 x 35mm tail ropes, Head Rope operating at 6.8 rope safety factor
- 7.62m/s full speed (initial), designed for 10m/s full speed (future)
- 1120kW Gearbox coupled DC motors supplied by MG sets

The hoist mechanical equipment including the friction drum, drum shaft, brake systems and gearbox and the hoist control equipment were designed and manufactured in Sweden by ASEA. The DC hoist motors as well as the MG set were designed and manufactured in North America by Westinghouse. Bethlehem Steel Company provided the hoist ropes and Lake Shore Engineering Company provided the bottom dump skips.

This first friction hoist in North America was a "pushbutton operated" mine hoist and was considered quite advanced in its time. The skip tender controlled the loading of the skips from the loading pocket. Once the skip was loaded, the skip tender "pushed the button". This would initiate the hoisting cycle by sending the skip to the dump where the ore was dumped into the receiving bin and the skip then returned to the loading pocket for a new hoisting cycle. Figure 1 shows early photos of the Cleveland-Cliffs friction hoists.

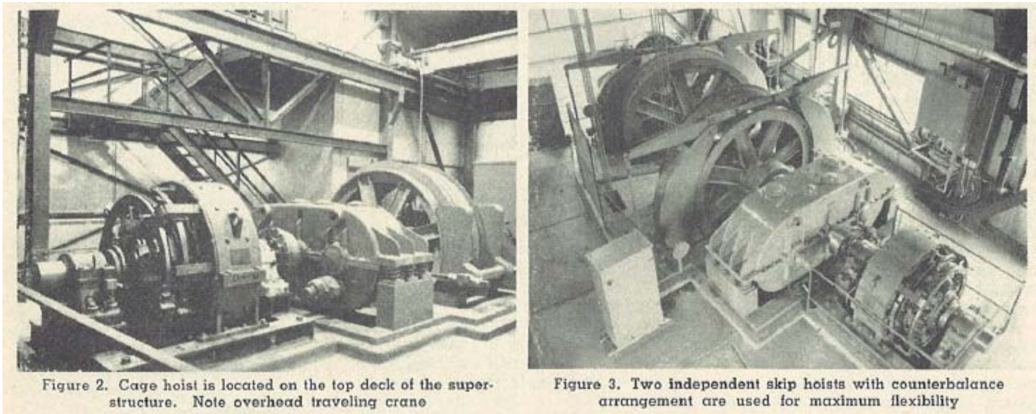

Figure 1. Photos of Cleveland-Cliffs friction hoists installed in Shaft C headframe

It can be assumed that this first friction hoist in North America attracted a lot of attention within the North American mining community. Cleveland-Cliffs anticipated this interest by writing “We think that operators are interested in learning how the Koepe hoists have performed for us during the past ten months of operation”[2]. To which they responded. “Excellent coordination of the electric control equipment with mechanical equipment, ingenious design and good workmanship on these hoists are factors which are particular pleasing. Tempering our satisfaction with the knowledge that these hoists are new to us and that we have operated them a relatively short time, we have no hesitation in stating that we are well pleased with them in every respect”[2].

SUBSEQUENT FRICTION HOISTS AND MANUFACTURERS IN NORTH AMERICA

After the Cleveland-Cliffs Iron Ore Company “tested the waters,” friction hoisting systems began to be viewed as a viable alternative for mine hoist systems in North America. During the 1950s and 1960s, numerous technical publications from manufacturers, technical committees and regulatory bodies appeared describing the friction hoisting system. North American manufacturers, who until then were mainly experienced with drum hoists, rapidly developed their own friction hoist designs.

About one year after Cleveland-Cliffs placed contracts for friction winders, Falconbridge Nickel Mines Ltd (Ontario, Canada), Algoma Ore Properties (Ontario, Canada), and National Potash Company (New Mexico, USA) all ordered friction hoists from ASEA. These hoists ranged from 2.26m to 3m in diameter.

ASEA was not alone, North American mine hoist manufacturers, quickly saw the benefits of having a design for friction hoisting systems.

Canadian Ingersoll-Rand

Canadian Ingersoll-Rand was a well known Canadian manufacturer of drum hoisting systems who, while delivering mainly to North America, had sold a number of mine hoists worldwide. In 1953 they sent their chief design engineer to Europe to look at the construction and applications of Friction hoisting systems [3] and shortly thereafter produced their own friction hoist design. Canadian Ingersoll-Rand made their first friction hoist deliveries to GECO Mines in Manitouwadge, Ontario. The GECO project included a 2.43m counterbalanced service hoist operating at 7.62m/s and a 3.3m counterbalanced production hoist operating at 8.1m/s. The friction hoists were installed in a 67m concrete headframe designed by Cook Engineering. Electrical systems for both hoists were provided by Canadian General Electric.

Canadian Ingersoll-Rand went on to manufacture around 30 friction hoists until about 1970 when their full designs and assets were transferred to John T. Hepburn, Limited.

Westinghouse

Westinghouse had, up until then, provided mainly electrical equipment in the form of hoist motors, MG sets, hoist control systems and switchgear to the mine hoist mechanical manufacturers or directly to the mine owners. In the late 1950s, Westinghouse developed their own complete friction hoist system, including the world’s first disc brake system using Westinghouse air operated disc brake calipers.

Westinghouse's first complete mine hoist system (called Select A Level in reference to push button operation) was delivered in late 1958 to the Opemiska copper mine in Quebec. The 4 rope friction hoist was 2.54m diameter and was driven by a direct coupled, 750kW DC motor. Hoist full speed was 8.76m/s and the hoist was designed and manufactured in their Hamilton, Ontario, Plant #1. This hoist was unique in that it was the world's first hoist to utilize disc brakes instead of caliper shoe brakes, typical of the time. The pneumatic disc brake was developed by Westinghouse Air Brake division and the calipers were air applied and spring released. Back-up weights were provided in the event of an air supply failure.

In October 1958, Westinghouse held a "special test with the worlds fastest friction hoist" [4] in their Plant #1, where they invited more than 100 influential members of the Canadian mining industry. According to an internal Westinghouse document, "the package deal was made possible because the 1000HP, 66 RPM DC motor does not require a gear to slow it down (the Company doesn't make gears). The motor will operate directly on the 100 inch diameter four-rope drum."[4]

Westinghouse went on to deliver around 30 complete friction hoists throughout North America a number of which were delivered to the Saskatchewan Potash Industry. By 1977, however, Westinghouse exited the mine hoist manufacturing business.

General Electric / Canadian General Electric

General Electric was also a large supplier of electrical equipment and systems to both mine hoist manufacturers as well as mine owners. In their 1947 catalog "Electric Equipment for Mine Hoists," they show numerous examples of hoist motors, MG sets, and hoist control apparatus for all types and sizes of drum hoists (friction hoists were not yet known in North America). General Electric, like Westinghouse, decided to develop their own friction hoist when these systems became accepted in North America.

The Canadian General Electric, Peterborough Large Motor factory designed the GE friction hoist which was called "the Axi-Disc Friction Hoist". The Axi-Disc friction hoist incorporated a somewhat unique pneumatic brake system where each side cheek of the hoist pulley acted as a brake path. A large C frame assembly containing spring applied, air release brake calipers on each leg of the C frame was then mounted near the hoist drum so that each leg of the C frame was adjacent to the brake path. During braking operations, the brake calipers on each side of the C frame acted against both brake paths (squeezing the drum).

An interesting GE development was a unique friction hoist design whereby each hoist rope was assigned an independent, free to rotate friction wheel with one of the rope wheels fixed to a motor shaft.

This design was intended to assist in resolving the problem of rope tension distribution that can sometimes be a problem in multi-rope friction hoists if rope tread lengths are not maintained. 1978 GE designed and patented this unique friction hoist [5]. The design consists of a number of friction pulley wheels (one per head rope), each mounted on a common shaft with each wheel (except the driving wheel) able to rotate freely on that shaft, thereby equalizing the tension distribution among the head ropes. It is not known if General Electric delivered any of these friction hoists.

The largest friction hoist project delivered by Canadian General Electric was for the Cathedral Bluffs shale oil project in Colorado. The friction hoist equipment was delivered and installed in the early 1980s. The equipment was then commissioned and ready for production, but before production began, the oil shale project was cancelled completely.

For this project, GE designed and manufactured two 4.32m diameter, 6 rope friction hoists for production duty as well as a smaller service hoist (service hoist data unavailable). The production hoist was designed for a skip payload of 47600kg to be hoisted from 585m at a full speed of 14.83m/s. The overhung DC hoist motors were rated at 7100kW. This friction hoist is considered to be the largest friction hoist system manufactured by Canadian General Electric and for many years the largest friction hoist ever designed.

Canadian General Electric stopped the design and manufacturing of friction hoist mechanical equipment in the mid 1980s.

John T Hepburn / Hepburn Engineering Inc.

John T Hepburn Limited was a Canadian manufacturer of mine hoisting systems and other industrial equipment that began business in 1905. Like Canadian Ingersoll-Rand, they delivered both drum hoists and friction hoists, mainly in North America but globally as well. The largest friction hoist manufactured by John T Hepburn was for the Dennison potash mine in New Brunswick Canada. This hoist, delivered around 1988, was a 6 rope, 4.88m friction hoist with a direct coupled AC synchronous motor with cycloconverter drive system. The motor and drive system were manufactured in Germany by Siemens. This hoist was unique in that it was one of the first mine hoists in North America supplied with a cycloconverter drive system and AC motor.

John T Hepburn Limited is no longer in business but the mine hoist technology of the company was acquired by Hepburn Engineering Inc in 1994. Hepburn Engineering continues to supply friction and drum hoisting systems today in North America, South America with deliveries also to Indonesia.

Nordberg Manufacturing / Siemag

Nordberg Manufacturing Limited of Milwaukee, Wisconsin was North America's largest drum hoist manufacturer and the fabricator of the famous "Quincy" steam operated, 9.2m cylindro-conical hoist delivered to the Quincy Copper mine in Michigan in the early 1900s. Their first US friction hoist deliveries were in 1958 to the M.A. Hanna project in Michigan, USA where they delivered two 3.73m production hoists operating at 830m using 1000kW motors as well as a 2.84m service hoist operating at 1000m using 375kW motors.

Nordberg's Canadian manufacturing partner was Bertram & Sons. Bertram & Son's first friction hoist was put into production in 1958 at the McIntyre mine in Northern Ontario. This hoist was unique in that it was the first application of a friction hoist underground in North America. The 4 rope skip / skip friction hoist had the capacity to hoist 2500kg from a depth of 1100m.

Nordberg and its licensee partners manufactured approximately 80 friction hoists for mainly North American but as well global markets prior to Nordberg being sold to the German firm Siemag Transplan (now Siemag M-tec). Siemag M-tec North America, continues to supply both friction and drum hoisting systems in the North American market today including a new 6 rope, 50 Tonne friction hoist soon to be delivered to the Canadian Potash Industry.

ASEA / ABB

After the first friction hoist delivery in North America, ASEA continued to deliver a large number of friction hoists both in North America as well as globally, including some of South Africa's deepest mines at 2000m. One of the more notable North American projects delivered prior to ASEA's merger with Brown Boveri (forming ABB), was the Brunswick Mining & Smelting project. This project was delivered in 1976 and included 5 mine hoists with three large friction hoists. Production hoists consisted of two 5.33m counterweighted friction hoists using four ropes, operating at 1380m at 13m/s with a payload of 27 Tonnes. The service hoist was a 4.27m counterweighted friction hoist operating from 1380m at 10.2m/s with a payload of 22.7 Tonnes

In 2006, ABB delivered the largest friction hoisting system currently in operation in North America. This production hoist was delivered to Mosaic K2 Potash Mine in Esterhazy, Saskatchewan Canada. The Mosaic production hoist is a 5.95m x 4 rope friction hoist using 56mm Notorplast ropes, operating from 1000m at 18.3m/s with a payload of 45000kg. The new production hoist was installed in a new hoisthouse that was constructed over top of the existing concrete production headframe. This allowed the new mine hoist to be installed and pre-commissioned during normal production with the existing mine hoist (Westinghouse 1965 delivery).

Since then, ABB has been contracted by another Potash mining company to supply and deliver three 5.95m x 4 rope production hoists (of similar design to Mosaic K2) as well as one 5m x 4 rope production hoists and two 5m x 4 rope service hoists. The first of these hoists to be placed into production during the summer of 2010.

CONCLUSION

Friction hoisting systems have indeed been around since the late 1880s, however, it was not until the introduction of the first large capacity, multirope friction hoist in the mid 1940s that North American mine hoist operators considered them as a viable alternative to drum hoists. Within 10 years of the first multirope friction hoist being put into operation in Germany, at least three were operating within North America with a large number put into operation shortly thereafter. Once North American mine hoist operators were satisfied that the Multirope friction hoist was suitable for their application, they were quick to adopt it as a viable alternative to drum hoists.

REFERENCES

Little, E.S., Barrett, C.M. 1954. *Observations on Friction Hoists.* Canadian Mining Journal, January 1954. **1**
Cory, E.D. 1957. *Koepe Hoist Installations at Cliffs Shaft Mine.* Mining Congress Journal, January 1957. 2
Whatley, J.M., 1955. *Mine Hoists in Canada.* Mining Society of Nova Scotia, Bulletin for August 1955. 3
Westinghouse News. *Inventions Aid Sales in Mine Hoist Orders.* Westinghouse News, February 1958. 4.
Eastcott et al., *Plural Rope Friction Hoists With Braking Apparatus* United States Patent 4,108,280.5