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An Alternative Underground Hoisting System for Kahatagaha Underground Graphite Mine, Sri Lanka- A Case Study

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Abstract

Hoisting systems used in underground mines are essential for the transportation of equipment, personnel, mined ore and thus for the productivity of an underground mine. It consists of various components in which there are shear wheels, winches, wire ropes, lift cages, carriage boxes and electric motors. The safety and reliability of the hoist depends on its design, therefore proper and accurate design of a hoist is essential. A properly designed hoisting system also supports to increase underground productivity as well.

Kahatagaha underground graphite mine is the deepest underground graphite mine in Sri Lanka, where the deepest level is 2080 feet below from the surface. The main lift operates up-to 1130 feet level from the surface and there are 5 inclined winzes equipped with pneumatic winches and hanging wooden boxes with the support of wire ropes for hoisting or lowering men and material as hoisting method from 1130 feet level to 2080 feet step by step between main underground levels. This hoisting method is very primitive and it has many bottlenecks when going to increase underground production, productivity and safety. This paper aims to provide a solution for current hoisting system & it`s issues mentioned above and presents the benefits of proposed hoisting system for Kahatagaha underground graphite mine. In fact, a cost-effective and safe hoisting system is a great support for any underground mine so that the proposed design would be a good alternative against the primitive system still in operation.

Keywords: Cost-effective; Design; Productivity; Wire ropes; Winzes

1. Introduction

The hoisting system of underground mines operated for transporting of men, material and equipment has been developed from primitive hand operation to the mechanized and automated operation through the rapid progress and innovations of technology in production equipment and method of extraction, leading to higher productivity, safety and production. Hence, the hoisting system is the heart of the business for underground mines; if the hoist system malfunctions, production comes to a halt; therefore, simplicity of maintenance is as crucial as operational reliability.

When a mine is designed, the hoisting system is designed with a capacity exceeding the mine's expected throughput. The lifespan of the mine is however often decades with plenty of parameters changing over the years from ore quality to the depth of the mine; even on a daily basis there are variations in throughput. The daily average very rarely is linear. This means that the designed capacity of the hoisting system might meet the average throughput, but not the peaks.

In underground mines like Kahatagaha underground graphite mine, the transportation system is an essential part of the operation and the selection of appropriate transportation system and equipment is of great importance. Certain hauling equipment still used in the mine consume

more energy, less efficient and not up-to safety norms so that such machines need to be replaced with low energy consuming, more efficient ones. The selected equipment shall provide high productivity as well as low consumption of energy [1]. Selection of the rock transportation system depends on factors such as the mining method, rock properties, production requirements, production capacity and safety, and requires both operational and economic evaluation [2]. In a typical, deep underground mine, both vertical and horizontal transportation systems are used, creating a complex underground rock mass transportation system. If these individual transportation units are not appropriately integrated, it may result in production loss, reduced productivity and increased overall costs. The design and development of a locally manufactured and cheap hoisting system will help the miners in increasing their productivity and safety [3]. Occupational health and safety is the key in design for such a system.

2. Materials and Methods

Kahatagaha Graphite mine is a well-established underground graphite mine and a prominent player in the graphite industry since its establishment 1872, located in Maduragoda, Dodangaslanda in Kurunegala district of Sri Lanka`s North Western province. The mine is renowned for its high-quality crystalline vein graphite, which is priced for its purity and unique properties. It is the deepest underground mine and the current depth has reached to 2080 ft from the surface. The mining methods of crystalline vein graphite at Kahatagaha are open stope as well as cut and fill method, where practicing as per the vein behavior and some other geological characteristics. This mine is not equipped with one shaft enabling to access to underground working levels. The main vertical shaft exists only up to 1130ft only. Below 1130ft level, the mine is still having very primitive way of hoisting system which is a real bottleneck in all mine production, development, maintenance related activities.

2.1 Existing system of hoisting

The access into the mine has been arranged in two different hoisting modes at Kahatagaha mine. One vertical shaft equipped with an electrically driven winder with lift cage can be seen at Kahatagaha, which operates up to the 1130 ft from the surface. From 1130 ft level up to the 2000 ft level, there are five inclined access winzes available as shown in Fig. 1, where men and material hoisting taking place. A cableway of two wire ropes is attached to the hanging wall of winze, on which rolls a carriage moved by a pneumatically driven winch. Timber box is attached to this carriage, in which only two miners per turn travels where this mechanism is very same to the mechanism of cable cars. The same bucket is also used for hauling material from one level to another level. This material transportation system using timber buckets is highly labour intensive and much time-consuming task as handling of material from underground to surface needs step by step changes from one bucket to another bucket at each level.

2.2 Proposed system of hoisting

The proposed system can be replaced for all five existing systems and can be used the same space along the winze as well. The major difference of the newly proposed system is that the deck having horizontal floor with small rail wheels go on two small rail rails fitted on the inclined winze. The deck movement i.e. lowering or hoisting can be performed by using electrically driven winch connected to the deck. The existing pneumatic winches can be replaced with electrically driven winches as pneumatic winches are driven by compressed air which is inevitably very expensive with current electricity tariff. When transporting men with this proposed system, at least 8 men can be transported in the deck as shown in Fig. 4 and one trolley can be accommodated easily with in the deck as shown in Fig. 3.

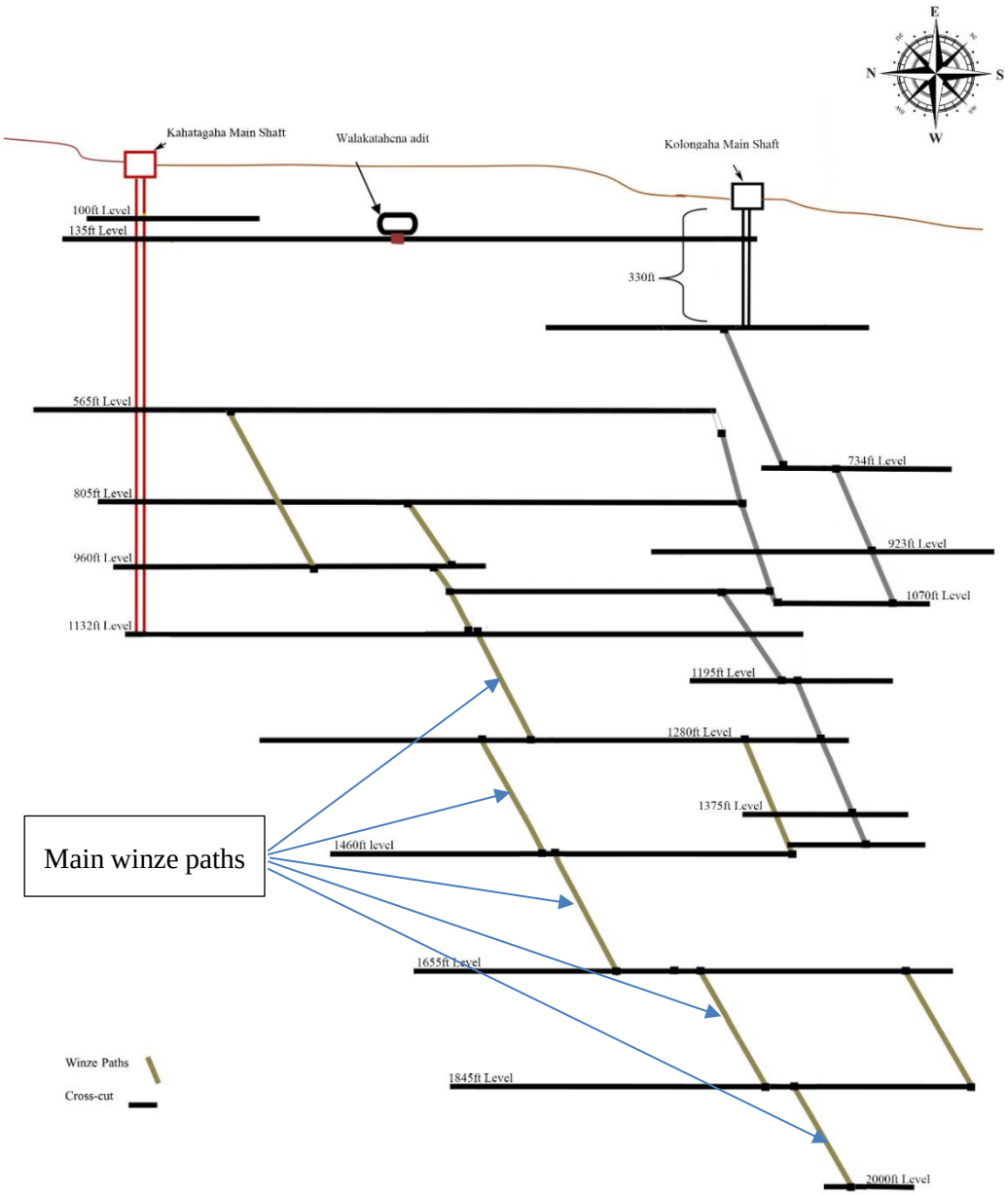

Figure 1 Main winze paths of Kahatagaha underground graphite mine

Figure 2 shows the existing mode of bucket type hoisting system in Kahatagaha Graphite mine where hoisting is performed below 1130 ft. as mentioned earlier. There are six such separate hoisting units operating through main winze paths between underground sub levels in Kahatagaha mine. They are not aligned in the same vein and there are horizontal transfers between them on every sub level, which slows down hoisting and obviously ties up much labour involvement specially in material hoisting.

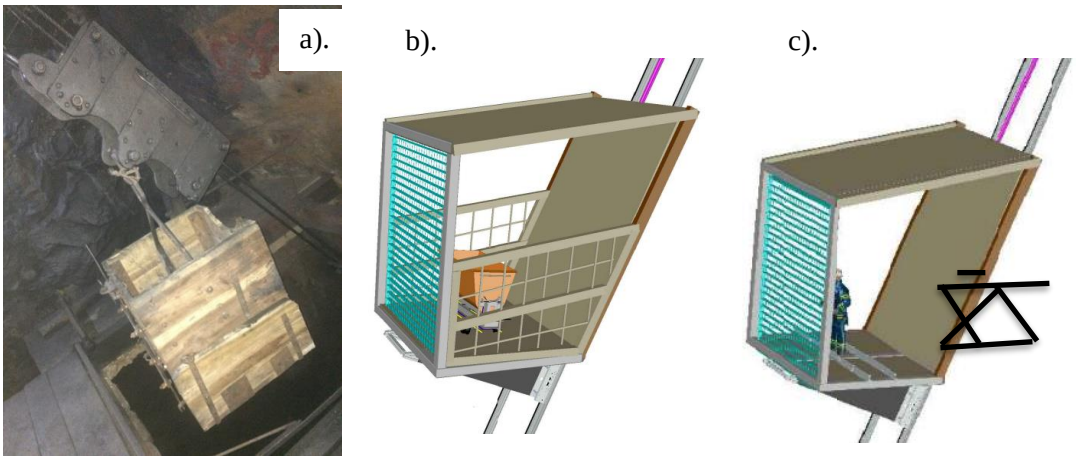

Figure 2 a). Hoisting bucket now in use, b) Material hoisting with proposed system c) Man riding with proposed system

2.3 Comparison of systems

As far as two systems are concerned, the existing system inherits number of disadvantages.

1. Poor safety of miners when travelling in the timber box as no breaking system available
2. Only two miners can travel up or down per turn so more time taken to lower miners to underground levels and sending to their working places.
3. Wire ropes used for guiding and acting as hanging supports for the timber box need to be replaced frequently.
4. The quantity of material hoisting is very limited in the box.
5. Loading / unloading in each level from box to the trolley and again trolley to the box at each level so labor-intensive system but with proposed system, no dismantling or reassembly is required as same trolley can be used from the bottom level to the surface or vice versa.
6. More time taken to lower miners to underground levels and sending them to underground working places.

3. Results and Discussion

Considering the existing mine conditions in Kahatagaha Graphite mine, different concepts were individually analyzed for selection of an optimum alterative mode of haulage system below 1130 ft level. The selection was made through critical consideration and practical possibility of each important factor and its relevance compared to other considered factors and existing system of haulage.

The implementation of proposed alternative hosting system has a direct impact on below areas and considered as major benefits for the mine.

1. The profitability of the mine
2. Increased safety of the miners
3. Increased production hence increased productivity
4. Less maintenance of electrical winders compared to pneumatic winders
5. Less electricity consumption for hoisting

This study can be further extended to calculate and analyze the cost benefits of above benefits with statistical values as well.

4. Conclusion

The proposed hoisting system for Kahatagaha Graphite mine can be a major break through for the mine if implemented as it solves many practical issues currently experiencing by the mine. Not only in hoisting aspects, many other underground mining related activities can go for better changes as the mine hoisting effects all other underground mining activities. So the net benefit may be huge and pay back time may be minimal with this proposed system if cost-benefit analysis done for the same.

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