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Development of a six drillhead roof bolting machine

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ABSTRACT

In underground mining, machine design is predominantly dictated by mine conditions and individual customer desires. In partnership with Foresight Energy, J. H. Fletcher & Company was tasked to design and manufacture a new roof bolting machine with six independent drilling apparatus on board capable of drilling and bolting the roof and ribs with material handling. The objective was to produce a machine capable of drilling and installing six bolts simultaneously with a limited number of operators. The goal of the mine is to decrease the time to bolt a cut to improve the safety level of the current roof bolting method, improve efficiency and to improve the bottom line cost of entry development. The customer wanted four drills at the front of the machine dedicated to installing roof bolts and then another two drills behind them dedicated to rib bolts. This dictated the requirement of latched controls, which would allow the operator to start drilling one hole and then latch the controls to be able to move on to the next. The result of the design is a machine with a single platform and six independent masts with drillheads: four masts strictly for drilling and installing roof bolts on the front of the platform and two masts on the back of the platform for rib bolts. The controls at each operator's station include a latch control for drilling. The six-head roof bolter allows fewer operators to drill and install roof and rib bolts, which in turn lowers the miners' roof exposure per cut. This design reduces the operator's exposure from the inherent pinch points and rotary hazards once he has engaged the latch drilling. Therefore, the machine will help to decrease the time to bolt a cut, improving productivity while enhancing the ability to operate the machine safely.

1. Introduction

When mining underground, it is necessary to support the roof quickly to prevent it from collapsing after an area has been mined. Since the 1950s, the primary method for supporting the roof has been the installation of roof bolts. Roof bolting is one of the most basic functions yet one of the most dangerous jobs in the underground mining operation [1]. The Mine Safety and Health Administration's (MSHA) Health and Safety Accident Classification injury database showed an average of 660 roof bolter operator accidents per year over a 5-year period (1999–2003) [2]. The numbers show that roof bolting is the most hazardous machine-related job in underground mining. It represents 39% of all machine-related accidents in underground coal mines. In 1993, the U.S. Bureau of Mines conducted a study that has shown the activity of drilling as the most hazardous job task performed by a roof bolter operator, accounting for 31% of all roof bolting injuries [3]. Almost half (46%) of these drilling injuries were due to falling rocks or coal from the roof. All of these injuries occurred under supported roof. The majority of these injuries (about 99%) are not caused by a major roof collapse but from falls of smaller rock from the immediate roof. This type of roof failure has also been termed "skin fall."

In Spring of 2014, Foresight Energy and J. H. Fletcher & Company started conceptualizing a new six-drillhead roof bolting machine. The objective was to produce a machine to provide the capability of drilling and installing six bolts simultaneously while using a limited number of operators. The machine would have the capability of drilling the mine roof and side walls (rib), as well as having a material handling system and approved dry dust system. J. H. Fletcher & Company agreed to design, develop, and manufacture the six-drillhead roof and rib bolter with the expected delivery to the mine site of summer 2015.

The six-drillhead roof and rib bolting machines (Fig. 1) were specifically designed for Foresight Energy to be used in their mine located in the Illinois Coal Basin. The initial two machines were shipped and are currently being used in production at the Williamson Energy-Mach Mining coal mine. The mining method used at this particular mine is room and pillar with coal being

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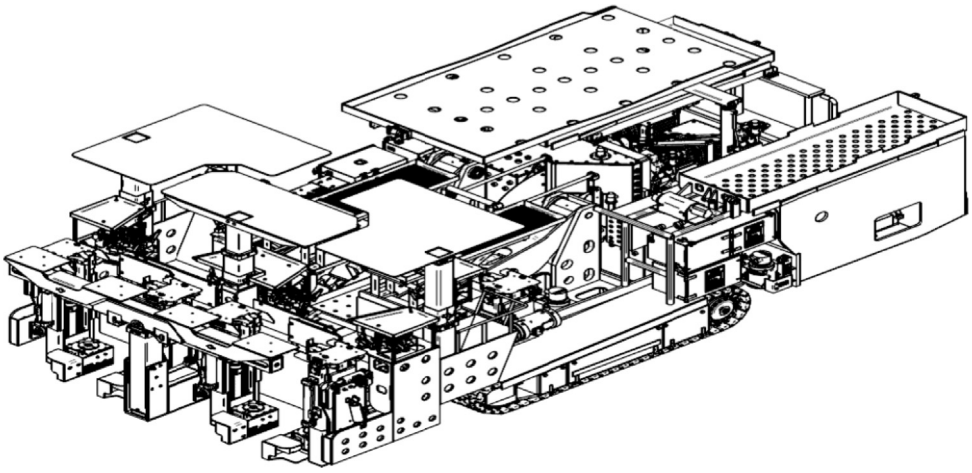

Fig. 1. Six drillhead roof and rib bolting machine.

extracted in 10.67 m cuts by way of a continuous miner, followed by a dual-boom CHDDR-style bolter that installs mesh and rib bolts. The entry width of their operation is 5.49–6.1 m with a mining height of 2.44–4.27 m; the average working height is 3.05 m. The current bolting process uses a 1.22 m × 1.22 m bolt pattern, which involves installing roof mesh panels and corner rib bolts with 90°, 610 mm × 610 mm channel. The mine has good top and bottom conditions. Fig. 2 shows one of the mine's proposed bolting patterns that the six-drillhead roof bolter would achieve.

The exploitation of such deposits requires the continuous upgrading of mining technology in order to minimize the risk of injury, costs of excavation, processing and storage of barren rock. The main focus is on minimizing the operator's risk of injury by means of reducing or eliminating their exposure to dust, noise, machine and geological hazards as well as upgrading the operator's ergonomics.

2. The design

J. H. Fletcher and Company has always operated with the philosophy of designing custom machines detailed to customers' requirements. Furthermore, the company maintains its focus on safety, reliability, ergonomics and efficiency while building on previous designs. Given the customer's desire for a semi-automatic drilling system, we decided to start with our existing four-head roof bolter design and see how it could be expanded to a six-head roof and rib bolter to meet the customer's needs. The main design concerns were how to fit two more drilling apparatus along with material handling onto this machine and how to get this new machine and the concept of a latched feed and rotation drilling system approved by the Mine Safety and Health Administration (MSHA).

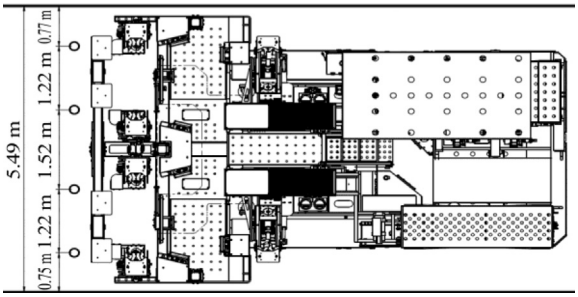

Fig. 2. One of the mine's intended bolting patterns for bolter.

With two more drilling apparatus for rib drilling, the four-head designed machine had to be augmented to handle the additional hydraulic requirements and mass of the additional drilling components. The first major obstacle for this new machine was that a new, higher-capacity crawler drive system had to be designed to handle a machine of this size. A completed six-head machine loaded with drilling components is approximately 10 tons heavier than a twin-boom crawler machine. Therefore, a 508 mm wide crawler pad drum miner type crawler assembly was developed with a bolt-on style gear case. The large crawler pad lowered the machine's ground pressure and the higher-capacity crawler drive system had the increased torque needed for a machine of this size. To accommodate the increased hydraulic demand, the chassis had to be enlarged to be able to handle the much larger hydraulic tank (1306 L) and the addition of another electric motor. The machine now consisted of two 74.6 kW, electric motors used on the four-head design and an additional 56 kW electric motor to power the two new rib drills attached to the machine. In addition to the motor and pump, other necessary elements that accompany two more drilling devices, such as filters, control valves, and dust systems, were added. The two additional blowers for the dust system were added to the 74.6 kW electrical motors, consequently having three blowers for each 74.6 kW electric motor. The 74.6 kW electric motors have a shaft at both ends so that two blowers are belt driven on the front end and one blower is belt driven on the back end, thus giving six blowers, one for each drill mast.

Due to the magnitude, and quick turnover in supplies of the six head bolter, it was essential to have the ability to stock various bolting supplies on the machine. To bolt a 10.67 m cut in an entry width of 5.49 m and a mining height of 3.05 m, it would require installing approximately 36 panels of mesh and 45 roof bolts, roof plates and resin. This situation dictated the need for a storage system, called a material handling system, which provides the operator immediate access to large varieties of roof bolts, roof bolt plates, steel straps and steel screen or mesh that can be installed on the roof to prevent small rock or debris from falling. On the rear of the machine, the material handling system had to be added containing two material pods: a large pod over the two 74.6 kW electric motors and a smaller pod located over the cable reel and 56 kW electric motor. The mine staff would have to lift these pods onto the machine; however, machine mounted hydraulic winches would pull the pods into position once they were on the machine. The operator could then lock them into place. A mesh tray that