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Using Mechanical-Assist Devices to Reduce Musculoskeletal Injuries

Thomas G. Bobick and Richard L. Unger

About 25 percent of lost-time injuries in underground coal mines involve trauma to the worker's back. These account for 30 percent to 40 percent of worker compensation payments in the industry. Typically, one-quarter of the underground workforce is involved exclusively in handling parts, supplies, and equipment components, and all underground miners are occasionally required to manually lift and transport some type of material. Those who work in low-seams (48 in. or less) often handle heavy materials in stooped and kneeling postures. Studies of miners working in the 36- to 42-inch seams of eastern Kentucky showed that they kneeled on two knees 53 percent of the time and were stooped over 23 percent of the time. In contrast, in mines located in central Pennsylvania (seam thickness 41 to 46 in.), the additional 4 or 5 inches of clearance resulted in kneeling on two knees only 18 percent of the time, but the time stooped over increased to 46 percent.

Research has shown that the stooped posture increases the pressure in the disks of the lumbar spine and can increase the possibility of damaging a disk. Handling materials while kneeling can injure a worker because the twisting motion that is used to complete the task results in torsional loading to the lumbar spine.

Mine Safety and Health Administration accident report data indicate that equipment maintenance and handling mining supplies results in a third of all lost-time, low-back injuries. This shows a need for specific mechanical-assist devices to help handle heavy items and to reduce lost-time injuries. Three devices that were designed by the Bureau of Mines and have had some field evaluation include: a machine-mounted swivel crane, a heavy component lift–transport (mine jack), and a beam-raising vehicle.

Machine-Mounted Swivel Crane

For this crane, an inexpensive, easily fabricated mount is first permanently welded at a variety of locations on any underground machine. Attaching the mount at multiple locations on the machine permits the crane to be moved around to provide access to all machine components. The height of the crane can be varied by simply replacing the crane leg with a longer or shorter one, depending on the seam thickness. Design features include 1) load capacity of 500 lb; 2) boom height from 24 to 68 in., depending on the leg length; 3) arm radius from 24 to 48 in.; 4) lightweight, making it transportable by one person; 5) no tools required for assembly; and 6) the device can be fabricated in a typical mine shop.

Mine Jack

The prototype mine jack utilizes a standard automotive-type hydraulic floor jack to provide the lift mechanism. It has been modified to allow the attachment of specialized jack heads, one for easy alignment of bolt holes when installing shuttle car tires and another for installing electric motors or pumps on equipment. These components can range in weight from 150 lb (tires) to 500 lb (50 hp motor). Very large motors (100 hp) can weigh over 1000 lb.

The jack travels along the device frame by means of a sump drive mechanism. This permits forward and backward movement of the heavy components during removal and installation, and it enables the component to be balanced over the device wheels during movement over short distances (50 to 100 ft). Oversized tires increase the stability of the device and permit the safe movement of the heavy components over the rocky, uneven, often wet mine floor.

Beam-raising Vehicle

One of the most hazardous materials-handling tasks in underground mining is installing I-beams (400 to 600 lb), sections of rail (400 to 525 lb), or heavy wooden beams (200 to 300 lb) in haulageways needing extensive roof support. During mine visits to eastern Kentucky and southeastern Ohio, these three items were observed being manually lifted and supported on the workers' backs until the support posts were installed at each end

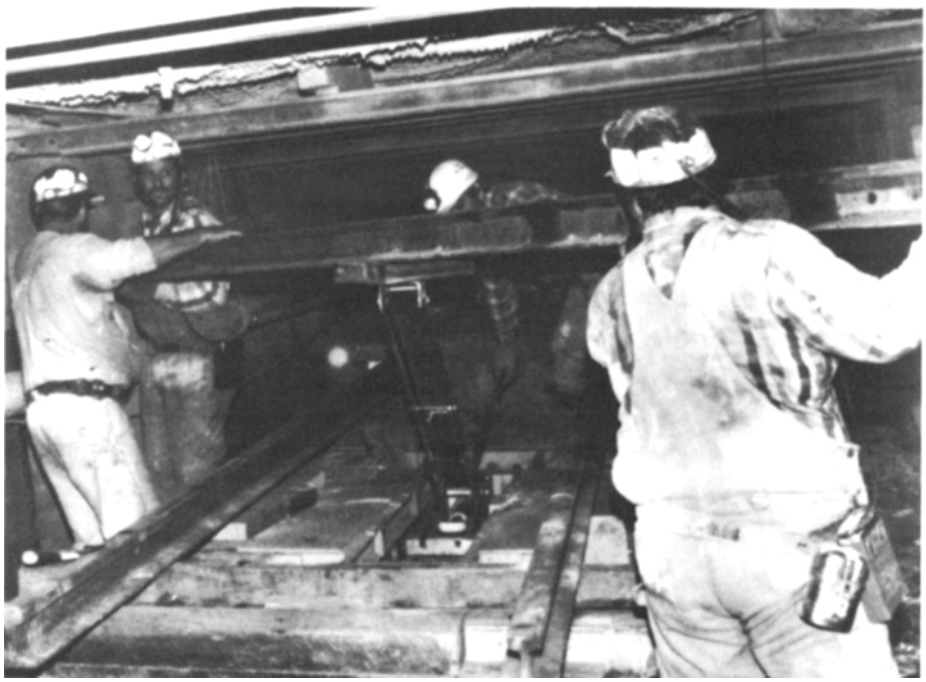

FIGURE 1. The beam-raising vehicle eliminates manual lifting of these 500 lb sections of rail. Before, each of these workers had incurred a lost-time injury on this task.

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of the beam. To eliminate this manual lifting task, the Bureau designed a special vehicle, which can be either rail-mounted or rubber tired, that uses a movable hydraulic jack to safely lift the crossbeams, I-beams, or sections of rail to the mine roof and position them for permanent installation (Figure 1).

The hydraulic jack is recessed into the vehicle, so that the vehicle can serve as a regular flat car for hauling supplies when it is not being used for beam installation. The jack can also be rolled back and forth along the length of the car while the jack arm is raised. This permits placing the beam in its proper location without moving the entire car. The end of the arm that supports the beam can be rotated in a horizontal plane, making it easier to maneuver the heavy awkward beams. Essentially, this device will permit the beams to be safely installed by only two workers—one to balance the beam on the support head and the other to operate the jack to raise the beam to the roof. This vehicle has been successfully evaluated in an Ohio coal mine for over one year and is now part of the normal operation of the mine. The first model of the beam-raising vehicle had a load capacity of 500 lb and a lift height of only 6 ft; a second version increased the load capacity to 900 lb and raised the lift height to 9 ft. Detailed drawings are available from the U.S. Bureau of Mines for all of these devices for fabrication by a normally equipped mine maintenance shop.

Conclusion

The three devices were well received by the workers. The machine-mounted swivel crane was felt to be quite applicable for both surface and underground mines. The mine jack stimulated immediate interest from the maintenance personnel. Surface miners wanted to use it to assist in replacing the transmissions of large, off-road haulage trucks. The rotatable head was a very positive feature for this task. The beam-raising vehicle has had the longest, most consistent usage of any of the devices.

Materials-handling tasks related to maintenance represent a significant safety risk for underground miners due to the lack of properly designed, easily accessible materials-handling equipment. Lacking appropriate aids, underground coal miners manually handle heavy materials repetitively. A variety of simple-to-construct, easy to operate, task-specific devices is needed. They can be designed and will be welcomed by the underground workforce. ♦

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