Transforming Engineering Education and Experience into Higher Productivity in Mining

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Abstract — The Dragline Productivity Center at Southern Illinois University teaches basic engineering concepts to mining equipment operators. Large surface coalmines from around the world have sent dragline crew members, supervisors, maintenance personnel and mine engineers to SIU for Dragline Productivity Training. Draglines are large radial machines, they have the ability to pick up over 100 cubic yards of overburden and place it 600 feet away. Draglines operate around the clock and they have a three-man crew: an operator, an oiler and a groundman/dozer hand. Draglines are the most expensive piece of excavating equipment at the mine site and it is important that they are operated safely, efficiently and productively. Most dragline operators have very little formal education and have received "On the job" training from an experienced older dragline operator at the mine site. These operators have learned good operating techniques as well as the bad ones. The training program teaches the operators to look at the way they are operating and to apply basic dragline engineering concepts to their day to day operation. By putting these basic concepts into practice the dragline operators can reduce average cycle time, reduce electrical energy consumption, and operate the machine in the less stressful manner thereby reducing maintenance down time and costs. Ultimately, improving the productivity of the dragline and keeping the mining operation profitable.

The Dragline Productivity Center (DPC) at Southern Illinois University Carbondale (SIUC) provides a unique service to the mining industry. The DPC teaches basic engineering concepts to mining personnel who are associated with dragline mining operations. McDonnell Douglas Corporation started the training program in early 1980 with the development of a dragline simulator. It was modeled after flight simulators in which airlines used in training flight crews. The simulator was originally set up for training Illinois Basin coalfield dragline operators. The training program also was designed to train new in experienced operators. The training facilities are located on a branch campus to SIUC; at the Illinois Coal Development Park located in Carterville, Illinois.

Draglines are versatile, and provide a low cost mining method. They are relatively simple to use with only four controls for operating the entire machine, Hoist, Drag, Swing and Propel. They can range in size from 10 cubic yards to 160 cubic yards in capacity, with boom lengths ranging from 120 to 420 feet. Smaller machines (<25 cubic yards) are crawler mounted and larger machines are tub mounted and have walking shoes mounted on eccentric cams on each side of the dragline house. Draglines also require the same amount of power that a small city would need.

Training tools used at the DPC include the dragline simulator, the mine model table and the course work manuals. The dragline simulator has two sets of operator controls, conventional contactor-type with swing pedals and new joystick controls. The new style joystick controls are standard on all other excavating equipment and most new operators achieve quicker cycle times in the simulator with the joystick controls. At present an experiment is being conducted with our clients to monitor a production increase associated quicker cycle times with the joy stick operators chairs. The simulator consists of a model digging sand in a model pit with a broadcast quality camera and projector system to provide a life-size image at which the operator may look at. A printout of each student's sessions is provided for comparison from the first day to the last day of the training. Cycle times, swing angles and bucket drag distance are important production factors. Boom stress, bucket shock, tightlining are errors, which should be avoided.

Prior to each class session the mine site engineers will send mine maps, pit cross-sections, geologic data and a dragline manufacturers specification sheet. This information is used to set up to scale the mine model table. Course work manuals are also used for providing information about safe, efficient, and productive dragline operations. Videotape presentation on a new dragline mining method called Spoil Side Dragline Operations and a Sound Slide Presentation on Dragline Bucket Maintenance are used in conjunction with the mine model table and simulator experience. The majority of the classroom time is spent in discussions on problem area identification and potential solutions to the problems confronting the dragline.

The weeklong training sessions start off with a Round Table Discussion on training goals. Followed by a pre-assessment evaluation that includes questions covering basic dragline operations. This helps in determining different terminology and helps identify areas where additional time needs to be spent. There is also an in-depth

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discussion on machine parameters, pit parameters and historical production data. A productivity analysis is done for each machine and compared to industry benchmarks. Another calculation is done to determine a dollar amount of coal uncovered with the reduction of average cycle time of just one-second. An average cycle is approximately 60 seconds and consist of loading the bucket, swinging to the dump, dumping the bucket and returning to the dig area. The calculation of the productivity index and the affects of a quick cycle time are always a real eye opener with the trainees. With most large dragline mining operations at a coalmine, a one-second reduction in average cycle time will uncover an additional $500,000 worth of coal in a year.

After areas of potential improvement have been identified, another series of round table discussions is held to determine what can be done to increase productive operating hours and reduce average cycle time. This helps to make the training session more mine site oriented and less of a generic training program.

The next step is to have trainees explain their particular dragline progression to the class. Where is the first position and what tasks are performed from this position? Where does the dragline move to next and what are the required tasks from this position? This helps to assess verbal communication skills. Next, the three basic dragline mining systems are presented in detail as to machine positioning and where to dig the overburden and how to stack it in the spoil area. Rehandle material is targeted as an area of productivity enhancement. If the dragline has to handle the material more than once it is considered rehandle and this erodes the productivity of the dragline operation. Comparisons are made as to which dragline mining methods are being utilized and potential areas of improvements to the current dragline mining method.

Basic engineering concepts are presented to the operators. Most of the trainees are not engineers but vectors and force diagrams assist in explaining the efficient digging and hoisting zones on the dragline. When hoisting the loaded bucket it needs to be out towards the boom point where more of the force will go to lifting the bucket, the vertical component of the force. When digging with the bucket it needs to be out towards the boom point as well, the horizontal component of this force directly affects how efficiently the bucket is loaded. The amount of electrical energy consumption during the digging cycle is also analyzed. Electrical energy consumption is becoming more important to the mining operations do to the current energy crisis in the Western United States.

The dragline bucket plays a paramount part of the operation since it is in contact with the ground during the digging cycle. The bucket should balanced, well maintained, have sharp teeth, and have the proper rigged. The bucket should fill to 70 to 90 % fill factor after being dragged two to three bucket lengths. Productivity improvement can be made at the mine site just by shortening the dump rope on the bucket that controls when and where the bucket can be picked up and placed in the carry position. A shorter dump rope will decrease average cycle time, reduce electrical energy consumption and place the least amount of stress on the machine.

The SIUC Dragline Productivity Center training program is geared toward the retraining of experienced operators at existing mining operations. These operators already know how to run the machine. However, a higher level of understanding of the correct dragline operator techniques can lead to better safety, more efficiency and productivity. The importance of communication and consistency among the individual operators is discussed as well as how to get the ideas implemented at the mine site. These basic concepts of safe, efficient and productive dragline operations are then put into practice on the mine model table, and on the dragline simulator.

The final session of the class week is another round table discussion “What did I learn this week? And “How can I apply this at the mine site? This provides the trainees with some ownership of their newfound knowledge and how it can be put into practice.

Some of the benefits of dragline training are:

- Decreased cycle time,
- Decreased electrical energy consumption,
- Less stress on the dragline = less maintenance
- Better highwall stability,
- Better spoil stability, and
- INCREASED PRODUCTIVITY

Training is not an expense but a continuing investment in the mining operation.