ABSTRACT

Illinois produced about 34 million tons of coal in 2002 and almost all of that production required mechanical cleaning to be marketable. Between 250 and 350 employees working in the coal preparation area of Illinois mines accomplished that task. Thus, effective productivity training within this work area offers tremendous advantages because the tons per man are so much higher than in other areas of the mining sequence.

To provide this training, programs were developed for two mines in Illinois designed specifically to enhance the operation of the existing coal preparation plant. The programs were based on a survey of all plant operating personnel taken initially to develop an understanding of the specific training requirements at each mine site. Once the program was developed, it was reviewed by mine management and industrial contributors for accuracy and completeness before presenting to plant operating personnel.

Initial training seminars focused on the priority areas identified in the surveys at each site. Results indicate an annual reduction of $50,000 in direct controllable costs (i.e. chemicals, magnetite) or $0.03 per clean ton at one mine site.
EXECUTIVE SUMMARY

Nearly 100% of all the coal mined in Illinois is sold after it has been treated by some type of coal preparation process. Depending on plant size and operating efficiency, the amount of clean coal processed per employee annually is often in excess of 100,000 tons. This dictates that the employee be well trained to maximize the efficiency of the preparation plant.

In 2002, there were 19 operating coal preparation plants in Illinois. These coal preparation plants have plant feed capacities between 200 and 2200 TPH of raw coal. Of the nineteen plants, nine used water-based cleaning technologies, nine used media-based cleaning technologies, and one used a dry cleaning method.

The water-based plants had a plant capacity range of 200 to 1500 TPH and plant yields ranging from 58 to 75 percent. The media-based plants had a plant feed rate between 300 and 2200 TPH and plant yields ranging from 41 to 88 percent.

Most operations in Illinois no longer have the on-site support staff to provide the required training, let alone any additional training for productivity enhancement. The hypothesis behind this particular project is that the operating performance of many Illinois coal preparation plants can be improved through better training of the operating personnel.

To provide this training, programs were developed for two mines in Illinois designed specifically to enhance the operation of the existing coal preparation plant. The programs were based on a survey of all plant operating personnel taken initially to develop an understanding of the specific training requirements at each mine site. Once the program was developed, it was reviewed by mine management and industrial contributors for accuracy and completeness before presenting to plant operating personnel.

The objectives of the training seminars being provided are to improve plant process efficiency and productivity, and promote process improvement through employee awareness.

The training methods used in the course were such as to try to make the sessions as interactive as possible. The goal was to relate process parameters to actual situations an operator may have seen in the past in the preparation plant. An example of this would be to quantify the coal losses if an operator chose to continue to run the preparation plant with a plugged classifying cyclone underflow. Multiple training aids were used including videos, scale models of preparation plant equipment, and actual plant photographs. The goal of the project was to train the operators to react to what they have seen in the preparation plant on a day-to-day basis in the best possible way to optimize the recovery of coal from the raw coal feed to the plant.

Development of the optimum training schedule required input from all parties involved. Initially, one eight hour training class was envisioned by the principal investigator. However, discussions with the mine management at the training sites revealed that a
single session would not be feasible. To schedule the training around operating constraints, it was decided that two hours would be the maximum length of time for any individual training session. Training is complete at one of the sites and is ongoing at the other site.

At Mine #1, three training modules were given. Each module was given to all three operating shifts. Each training module was two hours in length and was given either at the start or at the end of the eight hour operating shift. A total of nine two-hour training sessions were given to cover the 15 technicians working 8-hour shifts, three shifts per day, and five days per week. A total of 90 man-hours were required to complete the training at Mine #1. Five technicians attended each training session along with the plant manager. The first training module covered thickener operation, chemicals and magnetite recovery. The second session covered plant flow sheet, controls, and interlocking. The third session covered the unit operations of the vessel, cyclones, and spirals.

At Mine #2, one training module was given. The module was two hours in length and was given on shift while the plant operated on a reduced staff level. A total of two two-hour training sessions were given covering 24 technicians working 12-hour shifts on an extended rotating schedule. Twelve technicians attended each seminar. A total of 48 man-hours were required to complete the training to date. Scheduling proved especially difficult at Mine #2 due to the 12-hour operating shifts. It was decided that the training had to be done on-shift to minimize impacting the technician’s time away from work. Because of production requirements, time could not be made available to complete the training at Mine #2.

Reduced operating costs have been documented at Mine #1 where the training was completed. Magnetite consumption has been reduced by approximately 20% since the training was initiated. In addition, chemical costs have been reduced by 10% since completion of the training. These two cost reductions represent annual savings of approximately $50,000 or $0.03 per clean ton. In addition, the training has given the operators a better understanding of the coal preparation process and has allowed management to begin to devote resources in other areas knowing that the operators are more likely to make better operating decisions without the direct oversight of management.
OBJECTIVES

The objectives of the training seminars being provided are to identify the training needs of individual organizations and to develop an effective training plan particularly suited to each operation. Time and money constraints limited the project so that only two mines were served. However, the groundwork was put in place so that training can be provided to additional mines in the future as requested or needed.

To reach the project objectives, the following tasks were developed and implemented.

Task 1. The principal investigator put together a preliminary outline and general training modules for the training course. These were reviewed by management at the participating mines and coal preparation equipment suppliers. After receiving positive feedback from mine management regarding the training, the remaining tasks were undertaken.

Task 2. The principal investigator then developed a questionnaire that was given to the technicians at the participating preparation plants. The questionnaire was general in nature and was designed to identify the areas of training needed at each site.

Task 3. After review of comments by the industrial and mine site reviewers and the compiling of the questionnaire results, the outline was refined to optimize the training at each site.

Task 4. Site specific training outlines were then developed into presentations for the technicians. After many scheduling issues, it was determined that one to two hour training sessions would be the best schedule to present the materials to the technicians. The sessions were designed around a specific topic and included a brief review of the previous topics as a refresher.

Task 5. The presentations were reviewed by the industrial and mine site reviewers as the presentations were being developed. The principal investigator incorporated the comments of the contributors and modified the presentation.

Task 6. Seminars were presented at two mine sites in sessions lasting one to two hours.

INTRODUCTION AND BACKGROUND

A critical success factor for the Illinois coal industry is the development and continued training of its existing workforce. Due to extreme market conditions faced by Illinois coal operators, many companies were forced to abandon self-directed training programs, develop multi-skilled and cross-trained employees, and reduce controllable costs at every possible level. The net result of this has been the potential loss of process skills and knowledge across the organizations.
If an organization has been fortunate enough to retain people with good process skills, often times they are unable to help with plant related problems due to other job responsibilities. Inherently, this has forced the need for the lowest levels of the organization to know process skills. However, often times, there has been no method to train process work groups in the unit operations of a modern coal preparation plant.

This project developed training courses designed for day-to-day operating personnel. The basic premise of each course is to provide the fundamental process knowledge and tool sets that allow the plant operating personnel to make the most informed process decisions throughout the work day.

Nearly 100% of all the coal mined in Illinois is sold after it has been treated by some type of coal preparation process. Depending on plant size and operating efficiency, the amount of clean coal processed per employee annually is often in excess of 100,000 tons. This dictates that the employee be well trained to maximize the efficiency of the preparation plant.

In 2002, there were 19 operating coal preparation plants in Illinois. These coal preparation plants have plant feed capacities between 200 and 2200 TPH of raw coal. Of the nineteen plants, nine used water-based cleaning technologies, nine used media-based cleaning technologies, and one used a dry cleaning method.

The water-based plants had a plant capacity range of 200 to 1500 TPH and plant yields ranging from 58 to 75 percent. The media-based plants had a plant feed rate between 300 and 2200 TPH and plant yields ranging from 41 to 88 percent.

There are an estimated 250 to 350 employees working in the nineteen coal preparation plants on a daily basis in the State of Illinois. This represents thousands of maintenance and process decisions being made on a daily basis. These decisions impact overall plant yield and ultimately, industry profitability. This project was designed to train the employees at two mine sites to be able to make better maintenance and process decisions to improve the operating results at the preparation plants.

**EXPERIMENTAL PROCEDURES**

To begin the project, general training modules were prepared in each of the following areas of coal preparation:

1. Flow sheets, controls, and interlocking;
2. Magnetite recovery;
3. Heavy media cyclone operation;
4. Heavy media vessel operation;
5. Thickener operation; and
6. Spiral operation.
Then, after positive feedback from mine management, an initial survey was conducted with the results utilized to prioritize the training needs for each individual plant from highest to lowest priority in the above areas. The general training modules were expanded and reviewed, then presented to the hourly work force at the mine sites.

Training sessions were given in two-hour time periods. This was done to allow the training to be done either on shift or just prior to or immediately after the end of an operating shift. This schedule was decided on after discussing the training with both mine sites. Training sessions of 2, 4, and 8 hour duration were considered and it was decided the shorter sessions would provide the best learning opportunity.

RESULTS AND DISCUSSION

General training modules were prepared to provide day-to-day operating personnel with fundamental process knowledge and tools to better operate a coal preparation plant. After the general modules were prepared, they were reviewed by management at the mine sites. Both operations concluded the training would be beneficial to their operations and gave the approval to perform a survey of the technicians to prioritize and develop a training program for their site.

The initial training survey asked plant operating personnel to force rank seven categories (“other” was included as a category) in order of training needs (i.e. the area where training is needed most equals 1 and the area where training is needed least equals 7). The survey was very general in nature and did not try to test the participant’s process understanding. Rather, the survey only tried to understand the training needs of the process work group that the respondent was a part of. Surveys were returned from 73% of the technicians at Mine #1 and 41% of the technicians at Mine #2. The lower response rate from Mine #2 was in part due to several surveys that were incorrectly completed and not included in the summary. Inclusion of the incorrect surveys would have raised the response rate to over 50% at Mine #2.

The results of the survey from Mine #1 are shown in Table 1. The survey results are listed in order of descending importance: 1) Plant flow sheet, controls, and interlocking; 2) Magnetite recovery; 3) Heavy media cyclone operation; 4) Heavy media vessel operation; 5) Spiral operation; 6) Thickener operation; and 7) Other.
Table 1
Mine #1
Initial Training Survey Results

<table>
<thead>
<tr>
<th>Area of Training</th>
<th>Individual Responses</th>
<th>Total Points</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant flow sheet, controls and</td>
<td>1 5 1 2 1 1 1 5 1 1 1</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>interlocking</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite recovery</td>
<td>5 4 2 3 2 3 4 2 2 2 2</td>
<td>31</td>
<td>11</td>
</tr>
<tr>
<td>Heavy media cyclone operation</td>
<td>2 1 4 5 4 2 1 6 4 4 5</td>
<td>38</td>
<td>12</td>
</tr>
<tr>
<td>Heavy media vessel operation</td>
<td>3 2 3 6 5 5 2 7 5 5 4</td>
<td>47</td>
<td>15</td>
</tr>
<tr>
<td>Spiral operation</td>
<td>4 3 5 4 3 6 3 6 6 6 6</td>
<td>49</td>
<td>16</td>
</tr>
<tr>
<td>Thickener operation</td>
<td>6 6 7 6 4 6 5 3 3 3 3</td>
<td>55</td>
<td>18</td>
</tr>
<tr>
<td>Other</td>
<td>7 7 1 7 7 4 7 7 7 7 7</td>
<td>68</td>
<td>22</td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td>308</td>
<td>100</td>
</tr>
</tbody>
</table>

Mine #2 survey results are shown in Table 2. The survey results were as follows in order of descending importance: 1) Plant flow sheet, controls, and interlocking; 2) Magnetite recovery; 3) Heavy media vessel, Heavy media cyclone, and Thickener operation; 4) Spiral operation; and 5) Other.

Table 2
Mine #2
Initial Training Survey Results

<table>
<thead>
<tr>
<th>Area of training</th>
<th>Individual Responses</th>
<th>Total Points</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant flow sheet, controls &amp;</td>
<td>5 1 1 2 1 1 1 1 5 2 1 1 1 1 1</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>interlocking</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite Recovery</td>
<td>1 3 2 5 2 2 3 4 4 4 1 5 5 5 4 2 2 6</td>
<td>62</td>
<td>12</td>
</tr>
<tr>
<td>Heavy Media Vessel operation</td>
<td>3 2 4 2 3 5 4 4 6 2 1 3 3 6 6 2 6 3 4</td>
<td>69</td>
<td>13</td>
</tr>
<tr>
<td>Heavy Media Cyclone operation</td>
<td>4 4 3 4 4 5 2 3 5 3 4 4 4 3 3 5 6 2</td>
<td>72</td>
<td>13</td>
</tr>
<tr>
<td>Thickener operation</td>
<td>2 6 6 3 5 3 3 6 2 3 2 6 2 3 4 6 3 4 3</td>
<td>72</td>
<td>13</td>
</tr>
<tr>
<td>Spiral operation</td>
<td>6 5 5 6 6 6 5 5 6 6 5 6 2 1 5 4 5 5 9</td>
<td>95</td>
<td>18</td>
</tr>
<tr>
<td>Other</td>
<td>7 7 7 1 7 7 7 7 7 7 7 7 7 7 7 7 7 7 134</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td>535</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3 compares the survey results between the two mine sites. Similar results of the initial training survey were obtained between the two sites. The responses are expressed as a percentage of the total and the lower percentage indicates areas where training is most needed.
Table 3
Summary of Initial Training Survey

<table>
<thead>
<tr>
<th>Area of Training</th>
<th>Mine #1</th>
<th>Mine #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant flow sheet, controls, and interlocking</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Magnetite recovery</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Heavy media cyclone operation</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Spiral operation</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Heavy media vessel operation</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Thickener operation</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The areas of plant flow sheet, controls, and interlocking and magnetite recovery were the two highest priority areas at both mine sites. The principal investigator believes the area of plant flow sheet, controls, and interlocking is the area of highest priority because of the fact that this requires the ability to put all parts of the coal preparation plant together to fully understand the process. Often times, individual vendors will provide training specific to a piece of equipment, but typically this does not identify what changes in the overall plant will occur when making changes to that individual piece of equipment. Vendor training is typically geared toward maintenance and repair of the equipment and often does not relate that to the effects it has on the coal preparation process. The area of plant flow sheet, controls, and interlocking involves pieces of plant equipment that are not as well supported in the field as the major coal preparation process equipment.

The survey showed that the next area of concern was with the heavy media cyclone and vessel circuit operation. In a typical media-based plant, approximately 80% of the plant feed tonnage will go through the media circuit(s). Due to the high percentage of material going through these circuits, minor improvements in operating parameters can have a substantial impact on plant yield or product quality. Density control in a media-based preparation plant is a critical success factor. The technicians were given examples which quantified the impacts of running the plant at densities different than the design.

The spiral circuit was next to last in priority. The principal investigator believes this is because of the relative simplicity of the circuit in comparison with other plant circuits. However, significant coal losses can occur if certain process and maintenance controls are not maintained. Often times a spiral circuit will suffer from poor performance due to the lack of good feed size control. This is either caused by process upsets ahead of the circuit or gradual wear on the sizing media ahead of the circuit.

One difference between the two mine sites was the priority given to the area of thickener operation. The difference can be explained by the timing of the training sessions given at Mine #1. Chemical treatment and cost had been given a high priority by the management.
at the mine due to some issues regarding plant downtime and direct chemical costs. A thickener training session was given at Mine #1 prior to the survey being completed. Therefore, when the survey was done, the understanding of thickener operations had already been covered with the technicians at that mine site.

The lowest area of training requirements was the “Other” category. This category allowed the respondent to write in a topic that he would like to have some training on. The following are some of the topics identified: 1) Computer training; 2) Methane checks; 3) Electrical; and 4) Coal management. Due to time constraints placed on the project, these additional topics could not be covered. These areas of training could easily be developed as a part of an organization’s continuing training plan.

At Mine #1, where training was completed, two cost reductions were identified. The first was a reduction in consumption of magnetite by 20%. Figure 1 shows the reduction in magnetite expressed as a relative usage when compared to actual usage in January 2003. Magnetite usage was expressed in this manner to prevent disclosing actual site specific costs. The actual training for magnetite reduction was given in December 2003. This reduction is attributed to the technicians at the plant identifying where the magnetite losses were and then modifying the plant flow sheet to recover the magnetite previously being lost. Some of the month-to-month variability of the magnetite consumption can be attributed to the fact that the magnetite consumption is calculated based on magnetite received during a given month versus what was actually used. The improvements achieved represent an annual savings of approximately $40,000 at Mine #1.

![Figure 1. Relative Magnetite Consumption Before and After Training](image)
A reduction in water treatment chemicals at the preparation plant was also noted. This reduction resulted from two items. Prior to the training, the low molecular weight anionic polymer was being added directly into the feed stream going to the refuse thickener. After the training, the low molecular weight anionic polymer was diluted with fresh water and added into the feed stream going to the thickener further back in the process. This allowed for more mixing time before interacting with the high molecular weight anionic polymer that is being added at the thickener center well. The second, and most important, was raising the awareness of the technicians as to the hourly cost of chemicals being used in the plant and how minor reductions in chemicals can have a significant impact on costs. The chemical reductions achieved represent an annual savings of approximately $10,000. Figure 2 shows the reduction in chemical usage relative to the actual usage in January 2004. The figure shows a continuing trend of reduced chemical costs since the training was completed in December 2003.

Figure 2. Relative Chemical Cost - 2004
CONCLUSIONS AND RECOMMENDATIONS

Preparation plant training courses were developed for two mines in Illinois. At the mine where the training was completed, it was successful in improving employee awareness of the processes used within the coal preparation plant. The success was evident in significant operating cost reductions achieved at the plant.

Conclusions

- Training at one site has produced cost savings amounting to approximately $50,000 annually or $0.03 per clean ton processed.
- Savings in production costs are the direct result of improved employee awareness of the coal preparation process, which leads to better operating decisions.

Recommendations

- Training should be incorporated into an organization’s on-going optimization or process improvement programs. Programs can be tailored to fit the needs of an organization at that time and grow with the organization as its processes mature.

ACKNOWLEDGEMENT

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