

ADVANCED RECLAMATION TECHNOLOGY IN GRADING

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A study of reclamation track-type dozers in regrading of surface stripped coal mine operations was conducted by Peabody Coal Company in northeast Arizona. The purpose was to demonstrate the efficiency of new dozer blades used in recontouring surface stripped coal land.

These specialized non-conventional dozer blades were compared with conventional blades for three years. The results demonstrated the increased volume was significant to reduce reclamation costs per cubic yard.

Land reclamation is a necessity wherever coal companies are surface stripping. It is costly for the operator, and as a function over which he has no direct income. However, it is required by law and public demand, so coal companies will continue to recontour disturbed lands. Recontouring is a major part of reclamation with at least 80 percent of the total cost of reclamation going toward grading. All surface coal mining operators are interested in reducing the costs of reclamation. While operating costs of equipment continue to increase, one solution to lower cost of reclamation may be to increase the volume of cubic yards of spoil to be moved per hour by utilizing the existing equipment and adding modified recontouring tools.

A demonstration of dozer blades, designed for recontouring area-mine spoils and showing their effect for reclamation was conducted by Peabody Coal Company, Arizona Division, at the Kayenta Mine operations in northeast Arizona. This demonstration involved 263 acres and showed a significant reduction in reclamation costs as well as fuel savings over tests that were done utilizing conventional equipment.

The site chosen for this reclamation study was Kayenta Mine operation in northeastern Arizona. The Kayenta Mine operation produces eight million tons of coal annually and disturbs approximately 250 acres. The coal from the mine is transported via conveyor and railroad to the Navajo Power Plant at Page, Arizona. The typical stripping width crest to crest spoil of this operation ranges from 120 feet to 135 feet. The material is a sandy shale that is extremely low in moisture content.

The primary purpose of the study was to continue to introduce and transfer technically efficient and cost-effective recontouring technology to the surface coal mine industry. This northeastern Arizona

demonstration was set up specifically to provide additional data to previous studies that had been done in Kansas and Texas. This study specifically was to demonstrate the effectiveness and efficiency of specific equipment utilized in recontouring surface mine land.

For two years nonconventional dozer blades utilized by existing equipment was compared to conventional equipment and blades in regrading spoil. The increased volume capacity of modified blades developed for previous studies resulted in the design of a new center flow blade that would bolt onto standard push arms of a Caterpillar D9-H dozer. The specialized blades included in this study were: one twenty foot Center Flow Blade, one thirteen foot deep U blade, and a forty-eight foot angle blade mounted on two offset side by side Caterpillar D9-H dozers. The Center Flow Blade in this test was manufactured by Russell and Sons Construction Company. Funding for the test was made available by the U. S. Bureau of Mines, Spokane, Washington office.

The dragline spoil banks which are generally from 120 feet to 135 feet distance crest to crest were slightly irregular in this test. Although a long box cut spoil bank was associated with the contouring activities, the primary test was within a pit closure that was associated with the recontouring activities of Kayenta Mine. This type of grading involved high dirt volumes and long distance pushes for the dozers. Recontouring operations at Kayenta Mine are not particularly affected by the seasons. However, the summers are hot and dry, and this creates some dust problems for the equipment which, in turn, imposes more frequent machine maintenance requirements. In addition, ash from coal seams which had spontaneously combusted in prehistoric times is occasionally encountered at the operation which again emphasized the need for an

effective maintenance program.

The grading test was performed on a day-to-day basis on the first shift only. The team consisted of four operators, one foreman-supervisor, and one maintenance foreman. The supervisor kept records, observed the performance of the team members so as to encourage and increase the quality of the performance, and was responsible for helping the team meet schedules. The maintenance person kept the equipment in top operating order, assured a clean working environment, fueled the equipment and kept all associated records. Each operator usually operated one specific tractor. This process allowed the supervisor to monitor both tractor and operator efficiencies. This one man, one machine concept seems to increase the operation's efficiency.

Training was carried out to instruct the operator in the specific methods for recontouring techniques to be used with the specialized equipment. This training included sessions that provided audio-visual aids and actual field practice supervised by an instructor who had previous experience on these types of dozers.

Slope take-down methodology taught the operators to make maximum use of gravity to move the dirt with less effort and decrease unproductive tractor time. Under this methodology, the operators were instructed to work in a series of short pushes to the reposed slope, rather than making a steep cut and immediately creating a final grade condition.

Measurement of the spoil relocation distance supports the observation that this process is highly effective in the amount of dirt moved per push. Moreover, the process avoided the tractors expending unproductive energy climbing back up the entire length of the steep slope after each push.

Besides initial training and constant supervision assistance on the job, group training sessions continued throughout the effort. Safety sessions were held once a week to bring operators to a high level of safety awareness. Finally, the operators were provided ongoing feedback, both on the job and through a report of tractor fuel efficiency. The operators were shown on the report with their tractors fuel efficiency and the volume of dirt moved.

The recontouring work efforts were measured over a thirteen month period and included a total of 263 acres of spoil. The primary study included approximately 178 acres of irregular spoil and 85 acres of box cut spoil within the pit closure. The work included a pit enclosure, and the recontouring of a 5 to 1 final slope, as well as occasional spoil fire and heavy dust conditions. The nature of this recontouring activity increased the level of effort over those normally experienced.

The recontouring of the pit closure actually included a double wide pit which, at some locations, the bottom of the pit would exceed 200 feet in width. This reclamation area was required to have

positive drainage which necessitated some areas being filled in excess of 30 feet above the bottom of the original coal removed area. Within the 178 acres, a total of 2,000,687 bank cubic yards of spoil were relocated. With an estimated swell factor of 25 percent for the pit closure, as well as a 25 percent correction for rehandle, a 1.5 swell factor total was used for estimating the total amount of material moved. Over four million loose cubic yards were handled by bulldozers in contouring the pit closure. Based on this volume, it was estimated 22,000 loose cubic yards per acre were required to be moved. Utilizing the dozer fleet of Caterpillar D9-H dozers, the total project consumed 36 tractor hours per acre with an average of 630 loose cubic yards per tractor hour at the completion of the project.

The challenge associated with finding the most efficient tools to recontour and reclaim area mine spoil has been around for a long time. The 20 foot center flow blade is a product of work toward a continuing goal to increase this production. The intent was to build a blade that would increase the load action in order to increase load carrying capacity and shorten the time required to regrade coal mine spoil. Several major design considerations have been taken into account in the development of the center flow blade. The angle of the blade had to be such that the dirt stayed alive on the blade and flowed easily and continuously towards the center. The blade had to be strong enough to withstand wear expected in rough, rocky, changing spoil conditions of the northeast Arizona mine site. The blade also had to be maneuvered easily by the tractor under full load conditions.

A prototype blade, meeting all of the design requirements stated above was designed, built and tested. Three months into the Kayenta Mine demonstration, the blade was brought to Arizona for the first of several tests. Since that time it has remained in continuing service with no damage or functional problems experiencing only normal wear in the performance of its required tasks. Experience with the blade resulted in modifications that allowed it to operate more efficiently in conditions of Kayenta Mine's dry soil; however, the basic design concept remains unchanged.

The prototype Center Flow Blade design has the following characteristics:

1. Cutting edge length 20 feet.
2. Blade width 20 feet.
3. Blade height at center 62 inches.
4. Blade height at center 46 inches.
5. Panel radius 40 inches.
6. Panel width 10 feet.
7. Weight 8,600 lbs.
8. Material T-1 steel

The blade was mounted on a standard Caterpillar D9-H dozer.

The 20 foot Center Flow Blade design has a unique feature about it. The radius at the center is 40 inches; however, the outside radius is 30 inches. The purpose of reducing the outer extremities of the blade is to make the dirt curl upwards and inwards. This design attempts to make the straight blade retain a load of dirt over long distance pushes through blade design and dirt action rather than physically containing the dirt in the blade using a wing containment concept.

High tensile strength steel was to be used extensively in the fabrication of the blade frame, as well as abrasion resistant steel for the blade face. Since rocks were a prime problem in this particular operation, a weight saving compromise was developed utilizing of T-1 steel 100 percent through this blade. The blade passed some of the initial tests with good results. The positive response of the operator on whose tractor the blade was mounted, left no doubt in their minds of the observers that it had the operator's acceptance. Early observations also showed the blade carried sufficient load on the longer pushes to make the operator work the tractor in a lower gear. This indicated that the blade load was in excess of 20 loose cubic yards. In a topping-out demonstration, the wide overhand blades, coupled with the blade tilt capabilities, caused dirt to actively move in front of the blade. Another advantage to this blade is its utilization as a finishing tool. By making one pass forward, cutting lightly with the cutting edge, and then back dragging in a float hydraulic position, the blade performed extremely well as a finishing tool.

There were many benefits as the result of the utilization of this new Center Flow Blade. The blade increases the load carried per horsepower for a given tractor over a conventional U blade. Blade loading seemed to be easy, requiring less horsepower to load the blade. Efficiency is then gained through the increase of the blade performance rather than through the increase of the tractor horsepower or the requirement of larger equipment. This blade can fill by cutting with either the corner or by utilizing 100 percent of the cutting edge. The center of gravity is closer to the tractor than in the conventionally designed blades which increases traction, mobility, and wear-life of equipment and eliminates the need for a counterweight.

Very few problems have emerged in the development and testing of the Center Flow Blade. There are, however, a few that can be cited. One of the initial observations made was that the blade height on the original Center Flow was sufficient for the dusty conditions in which they were operating. The tractor fan blew ash from the disturbed soil and created visibility problems which slowed the operation down. This was noted during test runs, and an increase in the height of the blade appears to have solved the problems. Secondly, the abrasiveness of the soil at the Kayenta Mine is high and the wear patterns near the outer edges of the Center Flow Blade approximate normal wear

patterns of standard blades. An ultrasonic thickness measurement meter was used to measure on the face of the blade. The meter measures to one thousandth of an inch. A 5/8 T-1 steel blade showed an average wear under .250 inch which is a wear pattern that is higher than a typical Full "U". Other than this normal wear, the blade has continued to be in use and undamaged since July of 1981.

Testing and measurement of dozer performance was closely supervised by photogrammetric surveys taken of this area on a 1 to 500 photo. A grid of cross sections on 100 foot spacing was established across the contour of the pit to establish a pre-grading contour. These areas were digitized to measure cut and fill volumes to establish a total volume of dirt as well as the maximum relocation distance the material was moved. Several field tests have been conducted to begin to evaluate the efficiency of the Center Flow Blade as a recontouring tool. In all tests the Center Flow Blade came out better than the conventional U blade mounted on a similar tractor. Operator reports and general experience reinforced the data so far compiled. Once the blade is put into operation in an area, interest it is continued to remain high. Perhaps, not only due to its efficiency but the versatility both as a contouring and as a finishing tool.

All of the field tests provided a before and after cross section profile, developed by a survey team utilizing 25 foot by 25 foot cross section grid. After the initial cross sections were accomplished, the tractor and blade combination were applied to test areas of the same size. These areas were approximately 100 feet wide and 200 feet long and were designed to simulate a typical reclamation operation. A count was kept on the number of casts applied to each reposal slope, which ran from six degrees to seven degrees on a downhill push. A resurvey gave the amount of material pushed. This figure divided by the number of casts, provided the average cubic yards per load. The primary comparison in one test was a 20 foot Center Flow Blade on a D9-H Caterpillar dozer using a slot type dozing method. This machine had 37 casts of spoil in one hour producing a total of 1,162 bank cubic yards relocated. The blade load figured 31.4 bank cubic yards per blade load. The material weighed 2,600 pounds per loose cubic yard and had a maximum horizontal relocation distance of 96 feet. The average slope condition in this cut was 5.9 favorable degree down hill.

These results were compared against a Caterpillar full U standard reclamation blade that was 15 feet 6 inches wide. In one hour, this machine made 38 casts of spoil moving a total of 792 bank cubic yards. This equates to 20.8 cubic yards per blade load. The horizontal relocation distance was 87.7 feet at a 6.45 favorable degrees average slope condition. This test showed the Center Flow Blade to have advantage in bank cubic yards moved per hour.

It appears that the Center Flow Blade is good, perhaps the best, production blade to be used to achieve efficient reclamation work. The blade is effective in heavy slot dozing and open field pro-

duction as well as finishing. It is also an excellent choice for short distances, when the more effective 48 foot angle blade is not available. The 48 foot angle blade proved to be the least expensive tool to use per cubic yard, but was limited in its application due to the short relocation distance that the material could be economically moved (less than 70 feet).

About its only major limitation seem to be the side cutting which was not as good with the Center Flow Blade as a full U would provide. Further, the wide blade should not be used for push loading scrapers. Additional spot tests tend to confirm data presented here. However, the data is still inconclusive and further tests are required to more clearly establish the blade's range of capabilities. It is expected that a Center Flow Blade, designed to absorb greater horsepower of larger tractors, will out perform conventionally available blades.

Acknowledgements must be given to many people for the overall success of the demonstration. Russell and Sons Construction Company from Eureka, Kansas were the primary contractors and provided the equipment and specialized blades for the demonstration. Jake Howland served as a primary consultant and compiled the production records. The U. S. Bureau of Mines technical project engineer was John Gorris. He provided assistance and recommendations on the modification of the Center Flow Blade and Robert Westbrook served as the field supervisor throughout the duration of the project. The success of this demonstration could not have been as great without the assistance of these people.