BETTER WEAR MATERIALS IMPROVE ELKVIEW PLANT AVAILABILITY*

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ABSTRACT

Westar Mining Ltd., who operate a metallurgical mine with a capacity of 7.2million clean tonnes per year found itself with a change in the world demand only requiring 6.0million clean tonnes per year. With the extra plant capacity a consensus decision was made to change the mining methods to 100% raw coal recovery and reduce plant yields. The total recovery for the mine caused the plant to make some major changes in maintenance wear areas and this paper is intended to explain the route we took to keep our downtime to a minimum.

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INTRODUCTION

Westar Property and Coking Coal Specifications

Westar Mining Ltd. is a Canadian coal mining company in which 67% of shares are held by the British Columbia Resources Investment Corporation and the remaining 33% held by a consortium of Mitsubishi and nine Japanese steel companies.

Presently, Westar has two operating coal mining operations, Balmer and Greenhills, both being located in the south east corner of British Columbia. Coal is extracted from the Kootenay formation which covers 596 square kilometres (Fig. 1). Clean coal capacity for the Balmer and Greenhills operations is 7.2 (at 78% yield) and 2.8 (at 75% yield) million tonnes per year respectively.

The Balmer operation which is the subject of this paper is now 97% surface mining and coal is mined from the lowest of 15 coal seams. This seam is referred to as number 10 seam and has a thickness varying up to 15.2 metres. Number 10 seam is a low sulphur coking coal with a volatile content varying from 20 to 24% and 9.5% ash after washing. Other characteristics are shown in Table 1.

Due to the prevailing economic situation in 1983 it was necessary for Westar to re-evaluate its operating methods and one of the areas examined was the method of open pit coal recovery.

CHANGE IN COAL RECOVERY METHOD

Previously, it was estimated that 1.07 metres of coal was lost from the seam due to the mining method of removing and dumping the overlying portion of coal which is rock diluted.

Due to a lower demand for coal, a reduction in price and an increase in operating costs it was essential to consider ways to operate more efficiently and economically.

Since the coal preparation plant was not operating at full capacity, it offered the opportunity to improve coal recovery in the pit. The overlying rock diluted coal was recovered (Figure 2) and passed through the coal preparation plant on a trial basis. This proved to be successful, although resulting in a reduction in yield and clean coal capacity.

An economic analysis of improved pit recovery and reduced stripping requirements versus increased plant costs due to the additional rock dilution, demonstrated clearly that pit recovery should be maximised.

A very significant net impact of this change in estimated clean coal reserves is plus 17%.

If 1983 figures are used as a base percentage the following is derived.

Table 1 Balmer Metallurgical Coking Coal Specifications

Total Moisture	8.0%
Inherent Moisture	1.5%
Ash	9.5%
Volatile Matter	20-24%
Fixed Carbon	65-69%
Sulphur	0.32-0.52
Calorific value (dry ash free)	8,600k cal/kg
F. S. I.	6.8
Hardgrove Grindability Index	80-100

Fig. 1

Table 2 The Impact on Recovery Due to Change

Seam Thickness	Old Recovery	New Recovery	% Change
15.2 m	14.0 m	14.9 m	+6.5
6.0 m	4.8 m	5.7 m	+18.8
3.0 m	1.8 m	2.7 m	+50

Table 3 The Effect on Yield and the Plant due to change

	1985 Budget	1984	1983
Raw Coal Input (tonnes)	9,253,700	7,143,200	6,679,100
Total Clean Coal (tonnes)	6,200,000	5,000,500	5,226,200
Yield	67%	70%	78.2%
Refuse (tonnes)	3,053,700	2,142,700	1,442,900

Table 4

	1985	1984	1983
Raw Coal Input (tonnes)	139%	107%	100%
Total Clean Coal (tonnes)	119%	96%	100%
Yield	86%	90%	100%
Refuse (tonnes)	212%	148%	100%

From the above it can be appreciated that the coal preparation plant is now subjected to two significant effects per amount of clean coal produced. One is a considerable increase in total raw coal input to process and the other is a major increase in rate and total of refuse for processing and disposal.

Figure 2 ILLUSTRATIVE CROSS-SECTION SHOWING MINING RECOVERY PARAMETERS

In order to accommodate the new method of recovery, it was necessary to consider the impact of the change and develop the necessary steps to be taken.

STRATEGY DEVELOPED TO MEET THE CHANGE IN COAL RECOVERY

Although the raw coal tonnage rate into the plant is basically the same, the larger total raw product had to be considered in two main aspects.

One was the operational capability of the plant equipment to process the lower yielding product and hence, the increase in rate and total of discard for disposal.

The other was that availability of the plant must be kept extremely high in order to process the total increased annual raw coal input. This must be achieved in spite of the increase in abrasive material causing accelerated wear and tear of equipment in the raw coal and refuse circuits, which results in increasing maintenance demands.

Operational Capability of Equipment

In order to process this new raw coal product a trial run confirmed that the following was necessary.

- (a) It was necessary to bring into operation a standby Primary heavy media vessel and its associated sump pump to supplement the vessel in each of the two circuits A & B. Also changes at the discharges of circuit A and B pre wet screens were required so that one third of each discharge was directed to the third vessel. (Figure 3 shows simplified single circuit—not actual A & B circuits).
- (b) The increase in coarse refuse promoted the use of a spare 100 ton truck for haulage to the dump. This allowed the scrapers previously used for hauling and levelling to concentrate on levelling the dump.

Plant Equipment Availability

The plant is capable of operating 7,000 hours annually and equipment availability reached 95% at a yield of 78%.

Experience has proved the wisdom of shutting down the plant 100% for one shift and 50% on alternate circuits A and B for another shift each week to carry out maintenance. Otherwise a 24 hour day, 7 days a week is operated.

Over the years there has been a continuing policy of trying to maintain a high availability associated with reducing maintenance time and costs. Particular attention has been devoted to problem areas, using common sense, good maintenance practices and taking advantage of new techniques and materials as they became available.

The remainder of this paper is devoted to identifying problems and describes the steps taken or being taken to alleviate those problems and keep downtime to a minimum.

DOWNTIME PROBLEMS DUE TO WEAR AND MATERIAL USED

Wear and Materials

The main downtime problem has been the relatively short life of equipment or components, especially those items subject to constant abrasive, impingement or corrosive wear. These mainly comprised of screens, chutes, headboxes, distributors and piping systems. Since there is now about twice the amount of abrasive refuse to handle, this problem has become more acute.

Figure 3 ELKVIEW PLANT Simplified Single Line Flowsheet

In order to combat this situation, various materials have been considered and experimented with for the great variety and number of wear areas. Materials currently used are stainless steel, abrasive resistant metal, sheet rubber, high molecular plastic, polyurethane, teflon, fibre glass and ceramics. Each of these materials has an application where it appears to be the most successful, but the one that has proven to be superior in the majority of instances is ceramics. Following is a brief reference to each material and its application, excepting that, ceramic material is discussed in more detail due to its extensive use and interesting background.

Stainless Steel

All the screens with the exception of one prewet screen are fitted with stainless steel mesh panels which are bolted into place. This material is very successful for this application provided severe and direct impact is avoided. Trials with stainless steel panels in other abrasive wear areas proved to be unsatisfactory.

Abrasive Resistant Metal

This material is used mostly in chutes such as raw coal and refuse discharges, underflow for rapped sieve bends and refuse piping systems. This appears to be the best material to resist the combination of impact and severe abrasion wear. Plates are usually welded as liners in chutes and piping is manufactured from this material.

Rubber Sheeting (Linatex)

Rubber sheeting has restricted use in this plant only being fitting in the underpan of the prewet screens, although a further application in the filter tub is being considered. It has good qualities for light duty abrasive areas and is comparatively cheap to use, being glued into place as a liner.

High Molecular Plastic

Blocks of this material have been bolted to each side of the underside of vessel elevator flight bars, and has resulted in greatly reducing frictional wear on the flights and side driving chains. Hold down boards of this material are also bolted onto the insides of the side cheeks of primary screens.

Polyurethane

In a never ending effort to use the best materials available, polyurethane is being tried out on one prewet screen as an alternative to stainless steel meshes. It was necessary to install an underframe which is receptive to the adaption of modular polyurethane panels, these are shaped with underside projecting nipples which lock into the underframe when hammered down. Panels which are usually 12 inches square are available with a wide range of apertures allowing a quick change for replacement or differential screening. It is too early to fully assess the qualities of polyurethane for this purpose, but with the exception of the impact area first indications are favourable.

Teflon

Liners of this material, bolted and glued into position have proved successful in preventing a build up of cake at the filter discharge ports.

Teflon wipers socketted in position remove cake very efficiently from the filter discs.

Fiberglass

Although this material is not a competitor to other materials for abrasive wear areas it is proving

Table 5 Typical Physical Properties of Cerasurf AD-85

Compressive strength	280,000 p. s. i.
Flexural strength	43,000 p. s. i.
Tensile strength	22,000 p. s. i.
Modulus of elasticity	32×10^6 p. s. i.
Specific gravity	3.4
Hardness	9.0 mohs scale
Open porosity	zero (gas tight)
Water absorption	None
Color	white

ideal for machinery guards. It is light and convenient for handling and will not rust or corrode.

Ceramics

Of all the materials used in the plant for corrosive or abrasive areas, ceramic material is used most extensively. Applications are all types of chutes, cyclone and centrifuge discharge boxes, vessel sump feeds, headboxes, distributors and in pipe elbows. Ceramic tiles or bricks are available in all shapes and sizes for different flat or contoured applications, and the ones used in this plant are all cemented in position with epoxy resin.

There are three main types of wear resistant ceramics.

- 1. High purity, high density aluminium oxide. (bauxite and natural ore)
- 2. Silicon carbide
- 3. Silicon nitride bonded

The type used on the plant is COORS Cerasurf AD-85 aluminum oxide ceramic, (the other two types being available for special applications).

Composition of Cerasurf AD-85 is

- 85% aluminum oxide
- 10% matrix of silica oxide
- 5% trace oxides and binders

Aluminum oxide is an appropriate choice of wear resistant material since it has been used for many years as cutting or grinding wheels in metal finishing operations.

Table 6 Hardness Comparison

Material	Hardness (Mohs scale)
Diamond	10
Sapphire	9
Cerasurf AD-85	9
Topaz	8
Quartz	7
Tool steel	6.5
Silica	6
Carbon steel and glass	5.5

Other characteristics of Cerasurf AD-85 are that it is inert and has extremely good corrosion resistance. It has one half the weight of, and one third the expansion of steel and is a good insulator, hence its use on the space shuttle. It is more brittle than and does not have the tensile strength of steel. Temperatures of 3000°F can be tolerated but one hour cyclic shocks must be limited to 350° to 450°F.

The many shapes and sizes of ceramics are produced by high pressure injection moulding followed by kiln firing at 2600°F or more during which there is a 20% reduction in size. Ceramic tiles or bricks are available with a thickness varying from 1/8 inch to 2 inches and maximum other dimensions are standard brick size 4 1/2 × 9 inches. The minimum thickness used in the plant is 1/2 inch.

Success of wear resistance ceramics is very dependant upon the quality of the attachment and until experience is gained in this technique it is wise to employ professional assistance. Although ceramics used in the plant are cemented in position, they are available with holes for bolting or with metal backing or inserts for welding. Exact shaping of the last tiles in position can be by scoring, chipping, heat shock or by cutting with a diamond blade.

Cost of installed Cerasurf ceramic is about 30% more than equivalent abrasive resistant plate, but since the abrasive wear life is 10 to 40 times longer it is more cost effective.

OTHER PROBLEMS AND STEPS TAKEN TO REDUCE DOWNTIME

Design Problems

Due to unsatisfactory performance and excessive maintenance time, redesign has taken place on the following, coal dryer (feed screws-discharge screws and bed rods), screens, sprays, vessel elevators, paddle wheels, filters, piping systems, conveyors, chutes, headboxes and discharge boxes.

Vibration

The operating vibration on screens has caused premature fatigue and fracturing of side cheeks and cross members. Modifications include reinforcing on the side cheeks around the exciter bearing area with large plates bolted into position. Welded cross members are replaced with box section members welded onto end plates, which are then bolted to the side cheeks. Instead of conventional nuts and bolts used in tolerance fit holes, huck bolts held in tension whilst nuts are hydraulically compressed in position have been used in interference size holes. Huck bolts have been very successful in this vibratory environment and should removal of a bolt be required the nut has to be removed with a torch. The original screen supports of pneumatic tires were replaced with marshmallow (solid rubber) type supports which have a longer life and require less maintenance.

Alternative Equipment

Because of the relatively short life and high maintenance costs of some equipment, alternatives by other manufacturers were considered and installed with success.

This occurred in the case of several gearboxes and slurry pumps. Changing the variable speed gearboxes on the vacuum filters with electronic type frequency speed control of the electric drive motor has been a tremendous success. A complete variation of speed is provided whilst maintaining full load torque at all speeds. Stopping and starting is very smooth resulting in less stress.

Due to frequent burnouts the vessel elevator motor service rating was changed from 1.5 to 2.0 resulting in no further burnouts.

OTHER FEATURES WHICH SAVE DOWNTIME AND COSTS

Pipe Elbows

Maintenance of the great number of piping elbows was very frequent and two features were developed to reduce that frequency.

- (a) Many elbows changed to increased curvature, e.g. 1.5D to 3D.
- (b) Elbows are now manufactured symmetrically which allows for turn around due to impingement wear and thus doubles life.

Target Plates

Although materials are experimented with for various applications to find the one most suitable, it is worthwhile to provide target plates as sacrificial components arranged for easy and speedy replacement. This applies in chutes and boxes and particularly on screens where the target plate is positioned to lessen the impact on the screens whilst preserving 100% screening capability. Another feature adopted is to install a small dam in front of the feed onto the screens which forms a protective bed of material in the impact area.

Simplification

The four individual hydraulic control systems at the loadout were converted to one electrohydraulic system which simplified the arrangement and reduced maintenance whilst providing a safer working environment.

Screen spray bars were changed to a single central discharge point equipped with a spring loaded deflector plate that allows for easy flushing and cleaning. Magnetite recovery has also improved on appropriate screens fitted with this modification.

Standardization

Twenty-four types of varying angled elbows were used at the desliming distributor outlets and these have been reduced to two sizes of angle.

Piping systems have been standardized where possible so that only a few pre-bent spool pieces are necessary as spares for high wear areas.

Valves have been standardized to the one type which had proven to be most satisfactory (Dezurik).

Vessel or Box Entries

Short lengths of pipe were welded onto vessels, the other end terminating in a bolted type flange coupling for pipe continuation. When these short lengths required changing due to abrasive wear it was very time consuming and sometimes a very awkward job.

These short lengths have now been changed to oversized pipe welded onto the vessel, the other end terminating in a compression type coupling. The continuation pipe is now extended through the oversize pipe and into the vessel thus eliminating all wear on the oversize pipe so that it never has to be changed.

Accessibility of Equipment

It is almost inevitable that with a large complex plant, that it will be difficult sometimes to work on equipment due to extensive piping systems interfering with access. Piping systems have therefore been rerouted to provide adequate clearance. Permanent working platforms have been erected to

improve access and safety.

Monorail mounted lifting equipment has also been installed in required areas.

Control and Monitoring

When the conventional operational control system at the coal loadout had to be relocated, the system was upgraded by installing control using a programmable controller (P.C.). In addition the p.c. allows for the very efficient monitoring of the environment hazard of methane gas.

Modern sonic sensing of raw and clean coal silos product level is being installed which will feed data into the programmable controller.

Plant Maintenance Procedures

Any successful operational facility depends to a large extent on the quality of its plant maintenance procedures and its operational and maintenance personnel.

Procedures of equipment identity and history, preventative maintenance functions, recording, planning, scheduling, spare parts and inventory are all essential features. In addition the ability to carry out performance and economic evaluations using computer aids is desirable.

Apart from general maintenance practices, oil sampling of gearboxes, vibration checks of main equipment and instrumentation checks are scheduled regularly.

Frequent examination of equipment in a running state is carried out continuously using natural human senses and instrumentation. This is particularly valuable in monitoring results of modifications.

MATERIALS, METHODS, BENEFITS AND EQUIPMENT

Following is Table 7 which itemizes lists of materials, methods and benefits.

Table 8 then identifies plant equipment and indicates the appropriate material and/or method used, with type of benefit obtained.

Table 7 Itemised List of Materials, Method Used and Benefits

Materials	Benefits	Methods
1. Ceramics	30. Reduce time costs	10. 1 1/2 to 3D elbows (symmetrical for turn around)
2. Abrasive resistant plate	31. Reduce downtime	11. Standardization (24 types to 2 distributor elbows)
3. Linatex (rubber)	32. Reduce material costs	12. Design change
4. High molecular plastic	33. Reduce inventory	13. Huck bolts to replace standard type
5. Polyurethane	34. Extend life	14. Dam to create impact bed
6. Fibreglass	35. Improve reliability	15. Variable frequency motor drive.
7. Teflon	36. Operational	16. Change to marshmellow supports.
8. Stainless Steel	37. Improve control and monitoring	17. Use target plates for impact.
		18. Programmable controller
		19. Change to improved pipe entry.
		20. Ultrasonic sensing
		21. Increase motor service factor
		22. Oil sampling
		23. Change of type
		24. Simplify hydraulics
		25. Improve equipment accessibility

Table 8 List of equipment with indication of materials and/or method used with benefits as applicable

Equipment	Materials				Method								Benefits					
	Item	#	applied		Item	#	applied					Item	#	as	applicable			
Screens	3	4	5	8	12	13	14	16	17	22	25	30	31	34	35	37		
Pumps					23							30	31	32	33	34	35	
Sprays					12							32	36					
Vessel elevators	2	4			12							30	31	32	33	34	35	
Paddle Wheels					12							30	31	32	33	34	35	
Filters	1	3	7		12	15	21					30	31	32	33	34	35	36
												37						
Piping	1	2			10	11	12	19	25			30	31	32	33	34	35	
Loadout					18	24						30	31	32	33	34	35	36
												37						
Conveyors					12							30	31	32	33	34	35	36
Vessel Mag Separator					23							30	31	32	33	34	35	36
Dryer feed & discharge screws					12							30	31	32	33	34	35	36
Distributor	1											30	31	32	33	34	35	
Chutes & head boxes	1	2			12	19	25					30	31	32	33	34	35	36
Equipment platforms					12	25						30	31	35	36			
Dryer fan blade	2				23							30	31	32	34	35		
Equipment guards	6				23							30	31	32	33	34		
Gear reducers					22	23						30	31	32	34	35	36	

CONCLUSION

There is a continuing requirement to strive for improved performance of equipment consistent with good economics and a safe environment.

Although the aims are applicable to a plant in a settled state of operation, they become more acute when there is an increase in operational demand.

Partly due to twice the amount of abrasive refuse per clean ton of coal being processed and discarded, maintenance costs in 1985 are showing a 30% increase over 1983.

Even though wear components, e.g. screen meshes are changed more frequently, equipment availability has been maintained at the previously achieved figure of 95%.

To keep the increase in maintenance costs relatively low and maintain 95% equipment availability, reflects on the maintenance staff of what is the largest plant of this type in North America.

The success of adopting new materials and techniques with subsequent trials and proving, depends mostly on the capability, inventiveness, patience, perseverance and resourcefulness of the maintenance staff.

A change in the mining recovery method, created an additional challenge to operating and maintenance personnel which could only be resolved by the personal effort and dedication of those people.