THIRD QUARTERLY TECHNICAL REPORT

on

DOE/EE/15394--T3

GRANT NO. DE-FG01-96EE15394

THE KELASTIC VARIABLE WALL MINING MACHINE

UNITED STATES DEPARTMENT OF ENERGY
INVENTIONS AND INNOVATION DIVISION

April 1, 1997 to July 1, 1997

GRANTEE: KELASTIC MINE BEAM COMPANY

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This is the Third Quarterly Technical Report, the last such report of Grant No. DE-Fg01-96EE15394. A Final Technical Report will be forthcoming within the specified period of time. The Third Quarterly and the Final will include all work completed to date even though the project did not reach all objectives originally planned. However, work will continue on the project to completion under alternative funding.

The Project Team accomplished two tasks during the third quarter: preparation and presentation of professional papers; and development of simulation models and sub models of the hypothetical Variable Wall Mining installation.

Our paper entitled "Gob Canopy Roof Support for Difficult Natural Conditions" was submitted for presentation at the 16th Annual International Ground Control Conference at Morgantown, WV. This conference is sponsored by the West Virginia University Department of Mining Engineering. This paper deals with a critical component of the longwall mining face where the VWM system is to be installed. The hydraulic roof support systems is required not only to protect the face operation, but to provide the thrusting force for engaging the cutting elements against the coal face. The thrusting action is to be automated in synchronous operation with the rotating augers and gas flow controls.

The project team also continued its search for the suitable animation software to be adapted to the underground mining systems. Meanwhile work is progressing along the lines of updating the original open loop flow diagram that was presented in the US Bureau of Mines Report, "A Feasibility Study of a Safety Oriented Mining System" on May 24, 1974.

The flow diagram deals with the automatic control of the thrusting, advance, and rotation of the auger train which both cuts (extracts) and transports the coal across the face. The team is integrating the control systems into a deterministic

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mathematical equation for optimizing the mining and material flow rate in the operating system.

The model consists of many components each of which is constrained by mechanical features, including component output-input flow matching, which are problems the model would tend to answer. The initial values of the matching parameters are arbitrarily selected by expert estimations. These components establish boundary values which might in some cases also be assumptions. At some later time, these assumptions and the mechanical designs underlying them would be adjusted heuristically. This protocol would be continued until no glaring bottlenecks appear. The initial assumptions are shown in Table I.

Table II presents the initial mechanical design and performance characteristics of the Variable Wall Mining Machine. The rotating auger actually performs two related functions: The auger flights move the extracted coal across its face to the receiving conveyor at the head gate; the 1/2 " steel flights also function as a structure to hold the bits for cutting the coal from the solid face. Thus, there exists a fixed relationship between the rate of extraction and the conveyor flow rate because both the extraction and transport relate to the rotational speed. Some adjustment of the quantitative relationship can be had by the speed of advance of the cutting bits into the solid face.

Certain operational parameters are variable. For example, the extracted coal falling into the face conveyor should equal the flow capacity of the conveyor. This becomes a mechanical design problem in part for the VWM system as opposed to a conventional longwall system because the dimensions and speeds of the extracting and conveying components of the VWM are in part identical. There is some latitude however. While the screw conveyor capacity is a direct function of the rotating speed of the auger its maximum capacity is set by the rotation. But the extraction rate can be varied to load the conveyor at lower rates. The extraction rate is varied in two ways: the entire string of augers is not sumped into the face as a unit but auger section by auger section, i.e. in waves. The rate of sumping can also be varied so that the bit penetration is less than 4 inches per auger revolution.

The long range plan is to integrate the current deterministic equations in a suitable animation program with a number of adjustable and controllable parameters. This will enable coal operators and engineers to visualize how the variations can affect the safety, cost and production levels of the system. This approach will also demonstrate how the model can create a virtual comparison between existing mining systems and the Variable Wall Mining system.

Table I

ASSUMED NATURAL CONDITIONS AND MINE SECTION LAYOUT

Coal Seam:

Thickness - 60 inches
Overburden - 900 feet
Inclination $\pm 2\%$ grade
Methane Content - 300 ft³/ton
Hardness - 60 Hargrove
Strength - 2500 psi
Energy of coal fracture - 0.25 kwh/ton.
Floor Strata - Hard clay, dry
Roof Strata - Sandy shale

Mining System:

Retreating longwall with Variable Wall Miner
Panel length - 5000 ft.
Face Length - 500 ft.
Gate Entries - 3 head, 3 tail
Power - 2300 volts, 3000 kW

Transportation:

Main Haulage - 72" belt conveyor @ 600 ft./min.
Panel Entries - 60" belt @ 400 ft./min.

Face Transportation VWM auger (screw conveyor):

Auger Flights thickness 1/2" plate with 4" periphery ribbon.
Auger Screw Pitch - 48 inches
Auger Shaft - 11 inches od, 9 inches id, 9 inches solid at bearings.
Auger Section Weight - 3000 lbs.
Area of Orbit Circle - 12.57 sq. ft.
Area of Scroll Circle - 7.88 sq. ft.
Area of Hub (11") - 0.66 sq. ft.
Area of Hub (13") - 0.92 sq. ft.
Net Conveying X-section Area - 6.92 to 7.22 sq. ft.
Linear Velocity - 47 RPM X 4 Pitch = 188 ft./min. (conveying wave)
Time for a 500 ft. Face Transport = 2.66 minutes
Volume of coal in screw conveyor (at 19 T/min. flow) - 4.04 cu. ft./ft.

Roof Support:

Longwall - Hydraulic shields @ 750 tons, yielding force.
Entry - Roof bolts and special trusses.

Table II

DESIGN AND PERFORMANCE PARAMETERS - AUGER MINER

General:

Initial productivity - 19 Tons/minute

Face Excavation:

Bit type - Plumb bob.
Bit lateral spacing - 3 inches.
Bit tip clearance from auger flight - 2.5 inches.
Bit orbit diameter - 48 inches.
Bit penetration 4 inches per revolution.
Rotation pattern - Bottom sumping with vertical cutting.
Initial speed of rotation - 47 RPM.
Initial Sump Velocity = 4 inches per revolution or 15.67 ft./minute
Sump Time = .08 minutes = 4.79 seconds
Horizontal Wave Time (Sump) 3.35 minutes
Horizontal Wave Velocity (Sump) = 104.38 ft./min.
Sump Volume = 4.41 cu. ft. per ft. or 52.9 cu. ft./section
Sump Tonnage = 2.28 tons per section or .198 T/ft.
Sump Production Rate = 29.52 tons/min.
Vertical Shear Velocity - 15.67 ft./min.
Shear Time = .06 min. = 3.83 seconds
Horizontal Shear Wave Velocity - 186.6 ft./min.
Horizontal Shear Time = 2.68 min.
Shear Volume = 1.84 cu. ft./ft. or 22 cu. ft./sect. or .99 T/sect.
Shear Production Rate = 16.6 T/min.
Cusp Height - 24" - 22.8" = 1.2"
Cusp Volume = 0.04 Cu. Ft.
Total Sump and Shear Volume = 6.25 cu. ft./ft., 75 cu. ft./sect.,
Face cut Tonnage = 140.6 Tons

Auger Support Structure:

Bearings - Two per section; 9" id; Oillite or Manganese Bronze.
Section to Section Joints - Quadrature spline
Axial separation of Sections - 0.8 inches
Maximum angle between section - 5.9 degree

Lifting Arms -

Horizontal bit orbit clearance for 2" thick Lifting Arms - 2.5 inches.
Bearings spacing - 105 inch centers.
Lifting Arms pivots (vertical) anchors - Scavenger Board structure.
Auger sumping Force - Roof Support Rams.

Auger sumping Force required - 72,000 pounds/section
Auger Sump Distance - 15 inches.
Auger Shear Force - Hydraulic Cylinders on Lifting Arms.
22,500 pounds/section (+ wt. of auger).
Side Thrust resistance - Lifting Arm/Scavenger Board Cam.

Power and Loading:

Cutting: 1,898.9 HP (peak)
Conveying: 50 T. thrust - 575.8 HP
Drive Motor: 2,000 HP, 950 volts
1,200 RPM for cutting (sumping and shearing) and conveying
Pick-up Conveyor: 20 HP
Sumping and Shearing: 150 HP
Roof Support: Endgate - 75 HP
Tailgate - 50 HP
Extensible Belt: 50 HP
Longwall Roof Support: 200 HP
Total Power required - 2,345 HP less longwall roof support
Total Power required - 2,545 HP including longwall roof supports