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HYDRAULIC MINING: A PANACEA FOR EXTRACTION OF SOFT ROCKS AND MINERALS

Ahmed H. Ahmed[1] and Radhe Krishna[2]

[1]Lecturer in the Department of Geology [2]Professor in the Department of Mining Engineering

University of Zambia, School of Mines

ABSTRACT

Hydraulic Mining uses kinetic energy of fluid (mostly water) to break the rock and mineral. In this method cutting rate is directly proportional to both water pressure and flow rate.
This can also be used for transporting rock and mineral in the form of slurry from the extraction face of the surface. This is particularly finding its application in exploiting precious stones where explosives are not favored due to its damaging effect in the stones. Hydraulic mining by enlarge productive, economic and safer. The paper describes this developing technology.

***Keywords**: Kinetic energy, Slurry, Hydromonitor*

INTRODUCTION

Hydraulic mining which includes breaking of rocks and minerals, is transporting from the working face to the pit bottom and finally hosting of material in the form slurry. This uses kinetic energy of fluid (generally water unless the mineral is likely to react with it) for breaking and to form slurry for its transportation. Although it is back dated to 125 years (1891), however, the first commercial publication began in 1957 in Utah and Colorado (USA) for transporting gelsonite to a distance of 116km through a pipe. Following this, ores of copper, gold, iron, limestone and phosphorate. The longest to date pipe is 435km for transporting coal in Arizona.

PRINCIPLE OF WORKING

Hydraulic mining utilizes kinetic energy of water jet breaking rock. The effectiveness of cutting rate depends upon nozzle of water jet, flow rate of water, pressure force and power (Fowless etal, 1968). Other important operating factors are the distance of water jet and the rock on which it is being applied, the rectangle which the water jet stream impacts on the face and jet travel rate (Jeremia,1979). The effects of several nozzle parameters are shown in Figure 1

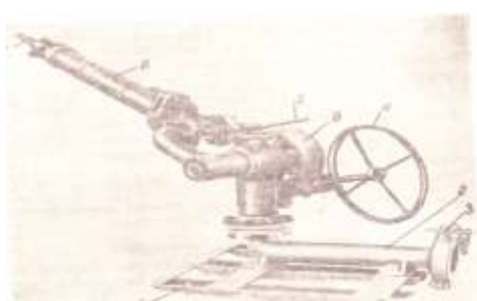
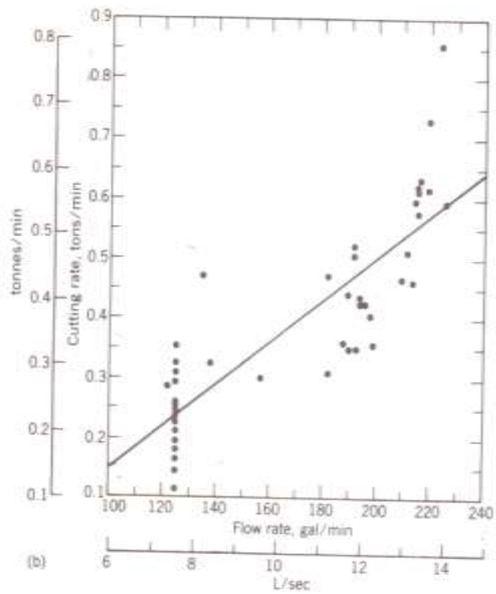


Figure 1. Hydromnitor

1-skid, 2water pipe, 3-quicvk release device, 4-steering wheel, 5-handle, 6-shaft, 7- nozzle, 8-gear box

. In general, high flows of water associated with low pressure are most suitable for the breaking of soft minerals (Wood, 1980). Research by Wood shows that the breaking rate is directly proportional to both pressure and flow rate (Figures 2 and 3).



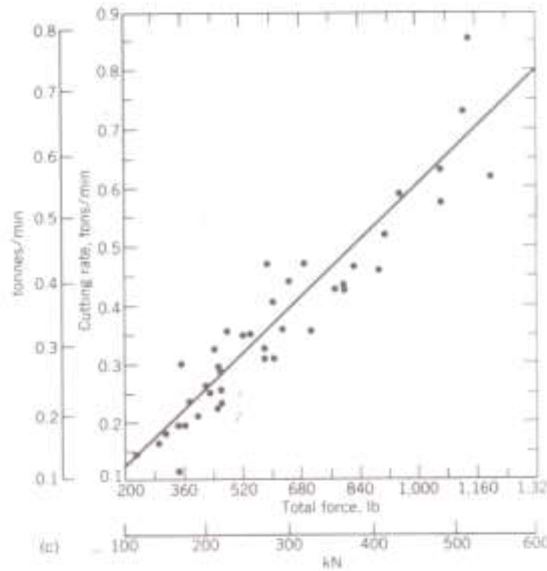


Figure 2: correlation between nozzle pressure And flow rate of water

Figure 3: Effect of flow rate on cutting rat

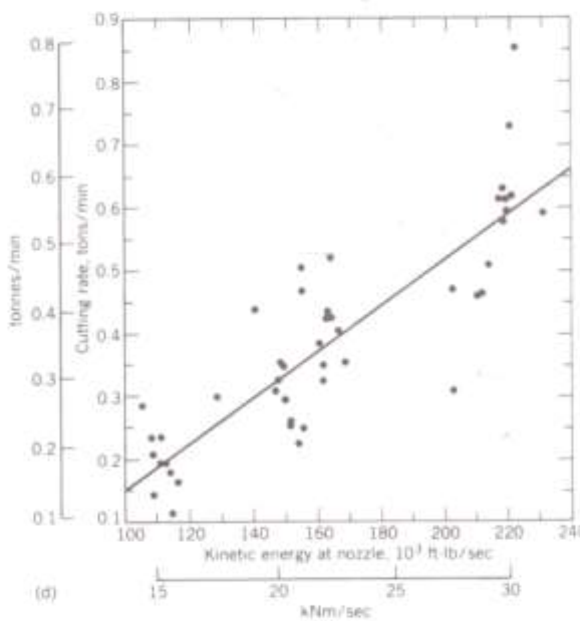


Figure 4 Effect of kinetic energy on cutting rate (source for figures 2,3and 4 after Fowkes and Walace, 1968)

Successful hydraulic mining requires that the threshold nozzle pressure must be greater than the rock compressive strength which the design parameters for operational hydraulic mining, should be as suggested in Table 1.

Table 1 Design parameters for nozzle and water flow rate

Material	Nozzle		Flow rate of water m3/sec
	Diameter (mm)	Pressure (Mpa)	
Soil	38 - 152	0.7	0.16
Bituminous coal	15 - 30	11.7	0.08
Soft sandstone	16.0	34.5	0.02
Antracite	10- 12	6.9	0.03
Hard rock	05 – 2.5	170	0.01

Source: Wood 1980

Figure 4 shows a simple layout showing sublevel caving with hydro monitor (remedy controlled), flume, control board, flume and water jet. It is important that the wall rocks must remain stable for the period of mining of the mineral. The face length may be over 60 – 125m depending upon geological and geotechnical factors of the host rock.

WORKING LAYOUT OF HYDRAULIC MINING (PROPOSED)

Hydraulic mining is adaptable to several extraction methods among which room and pillar mining, sublevel caving are most popular. However, for the success of hydraulic mining it is important to consider gradient of the mineral which should be in excess of more than 5^0 (to facilitate its movement), thickness (not less than 0.75m or more). Strong roof and floor and above all the hardness factor of rock (described in the next section).

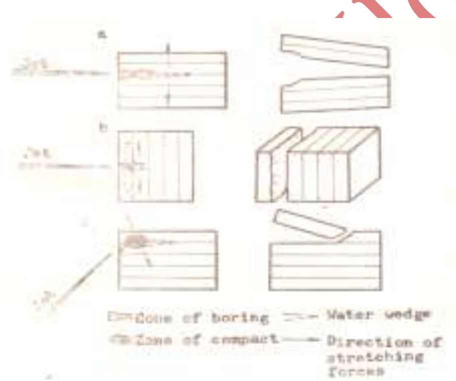


Figure 3: Mechanism of breaking coal by Hydro monitor taking advantage of cleat planes

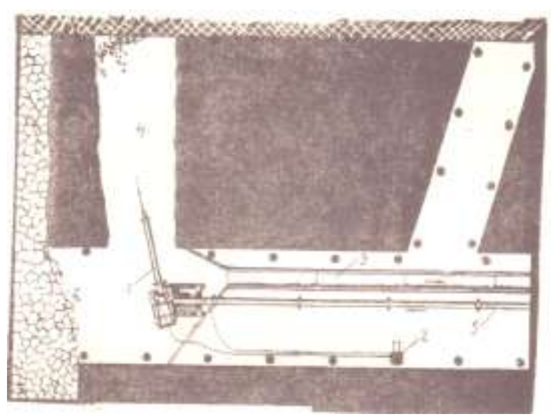


Figure 4: Sublevel caving showing hydromonitor and flume

DETERMINATION OF HARDNESS FACTOR OF ROCK/MINERAL

It is necessary to determine hardness factor of the rock/mineral to determine capacity of hydro monitor. The Research Institute VNII Gidrougolm the CIS (former USSR) has developed an empirical relationship for determining the required capacity of hydro monitor in terms of strength of coal. The minimum water pressure for effective breaking of coal is given by an empirical formula.

Pef = 50.f zetospheres (1 atm= 1.07kpa)

Where Pef = minimum effective of water pressure and

F = Protodyakonv pressure index of hardness

PROTODYAKONOV APPARATUS is a simple field test apparatus (Figure 5) in which 2.4kg weight falls from a height of 60.0 cm on irregular levels of material. The volume of fines below 0.5mm was determined in a special volume meter. A trial number of blows can be used to estimate the numbers required for the subsequent tests on new charge. A plot of current of fines against number of blow it generally linear, making it easy to interpdate the number of blows for 10ml (milliliter) of fines. This version of the test is quiet suitable for use in the field. The compressive strength is then approximately co = 2.67 x (R.IHN) in Mpa

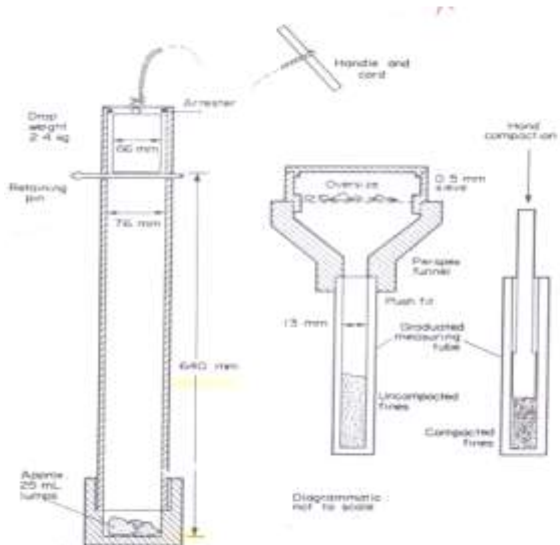


Figure 5: Protodyakonov apparatus for determining hardness number (RIHN)of rock

HAMMER AND PENKNIFE TESTS

A number of other simple field tests are available for the purpose namely, pocket knife and geological hammer for the rock up to 200 to 250 MPa strength. Estimation of rock strength by field methods is always approximate.
Table 2 shows five classes of rock usually required for rock mass classification system.

Table 2 Field test estimation of compressive strength by penknife and geological hammer (which in terms converted to hardness index)

Table 2 Field test estimation of compressive strength by Penknife and Geological Hammer
These are converted to hardness index

Sample Specification (approximately 10cm cube or sphere)		**Approximate Compressive Strength**	**Class**
1. Easily scrapped by penknife	Weak	0 - 25	V
2. Can be deeply scratched by penknife	Moderately strong	25 - 50	IV
3. Requires 3 or 4 moderate blows of hammer to break specimen	Strong	50 - 100	III

4. Requires a number of heavy hammer blows to break specimen	Very strong	100 - 200	II
5. A number of heavy blows only to chips the specimen	Extremely strong	Over 200	I

Source: Wood, 1980

MOTIS SCALE HARDNESS TEST

In this category another test developed by Motis (1882) which can be used in the field. The Motis scale hardness uses 10 common minerals as standards, with tac (hardness = 1) as the first softest and diamond (having hardness = 10) as the hardest. On this scale, calcite has a hardness of 3 and quartz of 7. This hardness in turns, converted to parameters useful to know whether that particular rock/mineral is suitable for hydraulic mining.

SOME POSITIVE AND NEGATIVE ASPECTS OF HYDRAULIC MINING

The common positive aspects of underground hydraulic mining in comparison with the conventional mining technology are:

- The method is simple and continuous
- Gives higher output (OMS)
- lower cost of extraction
- less number of support required
- large size mineral in abstract
- less dusty
- operations are safer
- low labour requirement
- intrinsic safely from electric sparking and hence no danger of weather or coal dust explosion
- long life of tools, few break downs

Among the negative aspects are hydraulic mining the method needs large amount of water for the entire operation. Ventilation system of mine becomes a bit complicated especially when many production faces are in operation and mineral losses maybe slightly higher (up to 30 – 35%). However, these shortcomings are already being taken care of and the solutions seem to be promising.

CONCLUSIONS

Hydraulic mining is a comparatively new mining technology and the most suitable for soft rock mining that includes precious stones such as diamond, emerald, amethyst, tanzanite etc. It is a productive economic and safe technology. It has a vast scope of improvement in terms of developing appropriate hydromonitor capable of breaking even harder rock and to match with this, a more powerful high pressure pumps which are already in the process of development. No doubt, hydraulic mining has a great future.

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