

Influence of Fluids on the Essential Parameters of Rotary Percussive Drilling

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ABSTRACT

The main objective of the work presented in this paper was to investigate the cutting efficiency with respect to drilling fluid composition by determining and comparing experimentally obtained values for specific energy and rate penetration.

The description of a test rig for commercial rotary-percussion drills follows. The rig is equipped with several instruments for the continuous monitoring of the most significant drilling process parameters: blow frequency, rotation speed, drilling fluid flow rate, power and drilling speed.

The results of a test programmer that was carried out with a type GBH 8/65 DCE Bosch electrical rotary-percussion drilling machine on granite are finally reported and commented. It is considered quite encouraging that the performance of the machine investigated is comparable to those reported in the literature for conventional pneumatic and hydraulic drilling machines in dolomites, a rock that opposes a much lower resistance to rock breakage than granite.

The results thus analyzed demonstrate that to addition of certain reagents to the flushing always corresponds an increase in rock drill ability, with consequent increase in drilling rates of the rocks tested.

KEYWORDS: Percussive drilling; Crushing; Specific Energy; Fluids; Efficiency

INTRODUCTION

Drilling and drilling technology play a major role in the Algerian Mining Industry. In fact it would be fair to say that the optimization of drilling parameters is an integral part of the economic success or failure of any mining operation (Onederra, 2001). Operators and manufacturers are continually exploring ways of reducing costs and increasing productivity by enhancing drill penetration rates and decreasing perforation drill bit wear.

Drilling and rock cutting are the principle concerns in all underground and surface mining operations as well as in the oil petroleum industries (Bullock 1984). In open cut operations the need to be competitive with world markets has place a heavy demand on excavation technology, placing a solid weighting on the necessity to be able to drill and blast considerable tonnages of ore in the quickest possible times. Underground operations rely on excavation (Onederra *et al.*, 2001) technology to increase production of continuous miners and long wall Shearer's in collieries as in jumbo and stop drilling machines in metalliferous mines. In recent years the need for increasingly deeper boreholes and the

introduction of higher formation temperatures encountered have placed a heavy reliance on the drilling industry to focus more attention on improving the technology of drilling and drilling fluids for the oil and petroleum industries. (Nistimatsu, 1972). The thrust force and torque produced during drilling contain important information related to the quality of the hole and the wear of the drill bit (Marta *et al.*, 2005).

You have been confronted with the problem of examining the effects of influencing factors, which affect drilling efficiency and the challenge of determining the parameters under which the drill best performs. The following work details an investigation into the factors affecting drilling efficiency and productivity with a special emphasis placed on the effects of introducing chemical enhancers to drilling fluids. The most efficient rock removal mechanism would be the one that requires the minimum energy to remove a unit volume of rock.

Basic concepts of drilling and drilling fluid technology

Drilling fluids have been utilized from as early as the 19th Century with their primary function being to remove cuttings from the face rotary drills. As time moved on in the 20th Century, engineers have paid an increasing amount of attention to the composition and functions of drill fluids and they have slowly evolved from primitive mixtures of mud and water into complex mixtures of fluids and solids

The complexity of such fluid compositions and the availability of the array of chemicals and mud's have introduced much interest and field studies by engineers and the like in order to maximize drilling potential whilst keep costs within the limits of the average drilling operation.

MATERIALS AND METHODS

The investigation into this work topic required the construction of a fully contained drilling unit. Many modification and alterations were made to the rig and auxiliary measuring devices over the construction and initial testing phase before the final set up was decided on. There are still many adjustments that could be made to the structure and its components to increase the ease of operation and accuracy of results. These will be discussed later.

The laboratory Drilling Machine

A laboratory rotary-percussive drill was built to simulate practical drilling operations.(Fig.1).shows a schematic representation of the testing layout. Both diagrams indicate the main components of the operation, which are:

A: Accelerometer, R: Rotary-percussive drill, G: guide, r:rolls, Z:ballast lead paling, S:Potentiometer sensor, M:Amplificatory, D-S: Data-shuttle, V:Digital indicator of progress, E: Computer, F:Flushing fluid system, H: injection system, P:Hydraulic Pump, Q: Flussimeter, W: Wattmeter, T: Speed indicator.

The Drill

The drill utilized was the Bosch 8/65 DCE rotary- percussive drill with the following characteristics indicated in Table 1 (Giuliani *et al.*, 1995).

Table 1: Rotary percussive drill characteristics

Characteristic	Unit of measure	Values (range)
Power Input	W	1050
Speed of rotation	Rad/s	12.56—26.17
Cadence	Hz	21.7—44.2

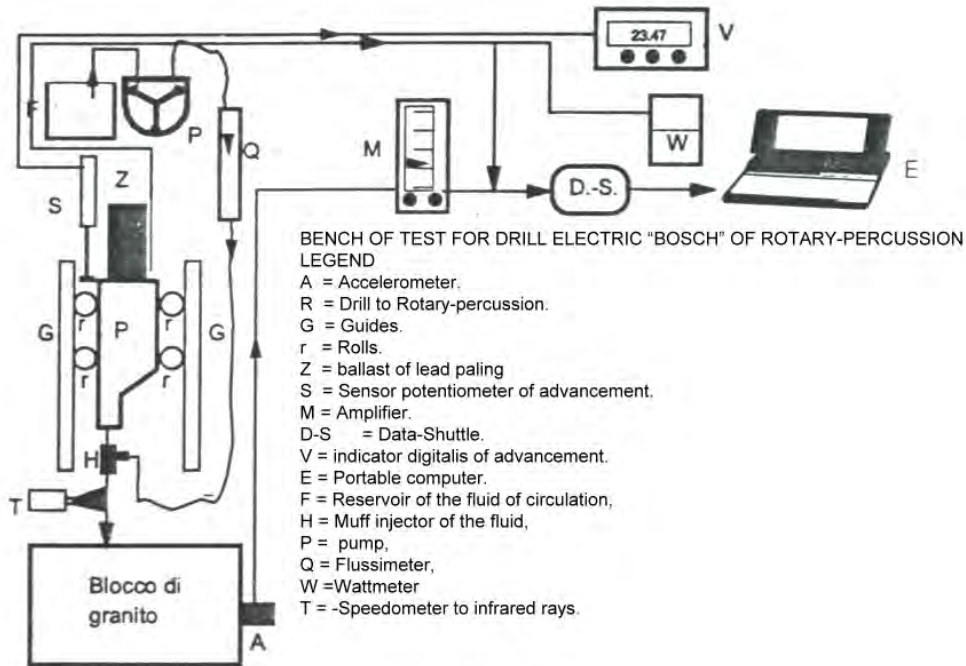


Figure 1: Schematic representation of drilling operations

Testing Procedure

For successful results it was essential to adhere to a rig testing procedure to ensure that all steps were carried out accordingly and also to reduce the effects of human error. As more holes were drilled, minor of the adjustments were made to the procedure to continuously improve the standard of the results achieved and increase the speed and simplicity of the operation. The final testing procedure settled on was as follows:

(i) Adjust vertical position of sample relative to drill. This was accomplished by utilizing a two-way hydraulic jack to either raise or lower the level of the sample plate and then locking into place with lugs in the guide rails.

(ii) Adjust horizontal position of sample relative to drill. Positioning was by manually pushing the sample, mounted on a sliding plate, sideways to the necessary position and once again stabilizing the plate with lugs which slot into the base plate.

(iii) Flushing system turned on. Flushing rate was 8.33cm³/s for tests with water and kept at 1M/l for chemical solution.

(vii) The wattmeter monitored. Readings for power were recorded at certain intervals, say, 1s drilled in the sample.

At the completion of each session of drilling data for each test for parameters such as

The corresponding data was then plotted and comparisons could be drawn between tests with regards to differences in flush rates, morality and concentration of solutions.

The drill tests have been programmed according to:

Cadence's of percussion and correspondent speed of rotation as in the Table 4; Every couple of cadence percussion and speed of rotation corresponding to thrust of 188.35, 288.45 and 384.55 N;

The fluids were water and ArmacT would act as a hardness reducer in comparison to water, whereas the ArmacT would have the effect of inhibiting drilling (The concentration of the ArmacT is 0.01 M/l).

The durations of execution of the single hole have been established based on preliminary tests, a length of hole was pierced around the 130mm; measure of the real volume;

Evaluation of the reproducibility of the tests: for every formality of execution of the holes, it has been performed five perforations and calculated the average and the discard quadratic mean of the following parameters:

- Length of hole;
- Consumption of energy;
- Real volume;
- Cadence of percussion;
- Speed of rotation.

Table 2: Filed regulation of the rotary-percussive drill.

Position	Speed of rotation (rad/s)	Cadence (Hz)
1	12.56	21.70
2	16.75	26.67
3	18.84	33.33
4	20.93	36.67
5	23.03	40.00
6	26.17	44.17

The Rock

The rock samples

The sample used in this project was a typical granite stone. Samples of the granite were cut to size no larger than 500mm * 500mm * 500mm and cast in concrete to stabilize them.

Flushing Fluids

Two substances were chosen to be investigated as flushing fluids in order to study their characteristics and any differences which may occur when drilling in sample granite. The fluids were water and ArmacT solution of concentration 0.01 M/l

Table 3: Field Regulation Used

Position	Speed of rotation (rad/s)	Cadence (Hz)
4	20.93	36.67
6	26.17	44.17

Assessment of results

The results of tests are given in Table 4 were in at tests at flush rate of water whereas done with flush rates of ArmacT solution (0.01 M/l).

The tests took noticeably longer there with water and therefore the graphs tended to be longer, as shown. The data was then taken from these graphs and tabulated in Table 4 to calculate penetration rates and specific energies for each test case, The results of Table 4 have been graphed in the same manner as for water and ArmacT solution in figures 02, 03 and 04 show the results of the ArmacT on the same graphs are also compared with the results obtained with water

Comparisons between values obtained for penetration rate whilst using water as a drilling fluid and using ArmacT solution (0.01 M/l) an versus thrust and versus cadence (Figs. 2 and 3). Comparisons between values obtained whilst using ArmacT solution as a drilling fluid gave the greatest penetration rate in versus thrust in compared with the water (graph 3). From this graph 4 it would appear that the ArmacT solution was quite inhibiting when compared to water at the same flush rate. Every obtained for specific energy in versus cadence of the ArmacT solution was highest than that of just water (graph 5). Contributes also to higher penetration rates because of higher efficiency in the formation and removal of cuttings from below the drill bit during (Onederra, 2001) the instant in which the drill bit crushes the rock.

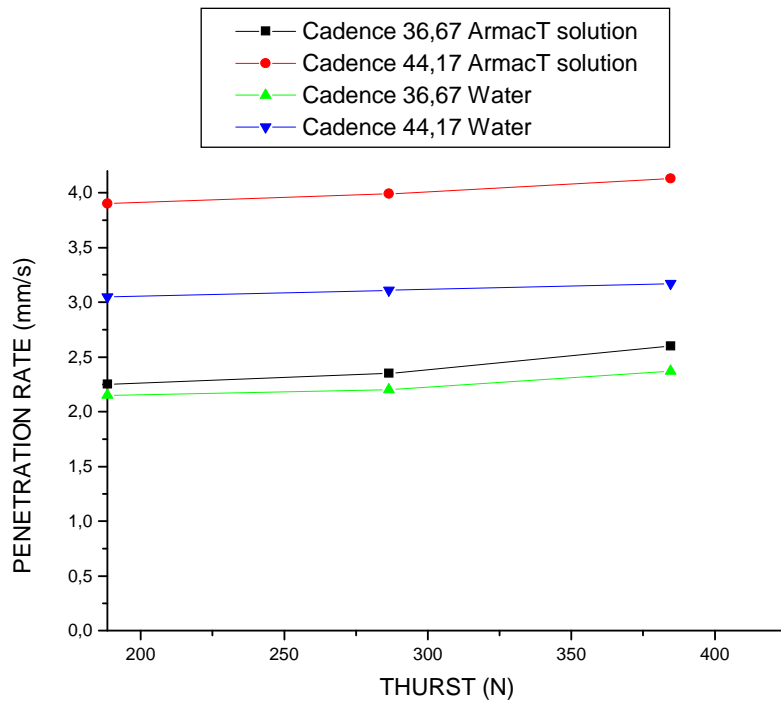


Figure 2: Penetration Rate versus Thrust and Constant Cadence

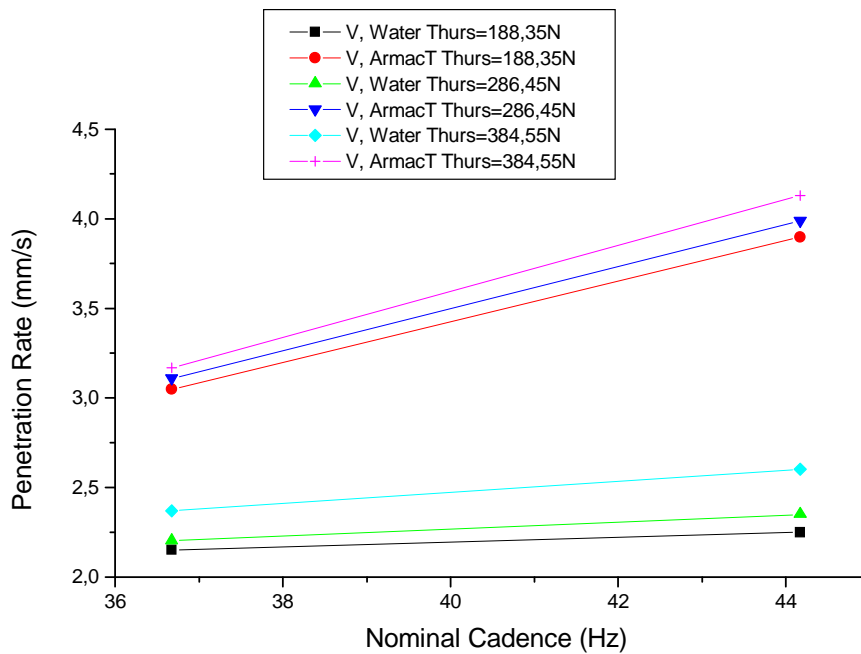


Figure 3: Penetration Rate versus Nominal Cadence

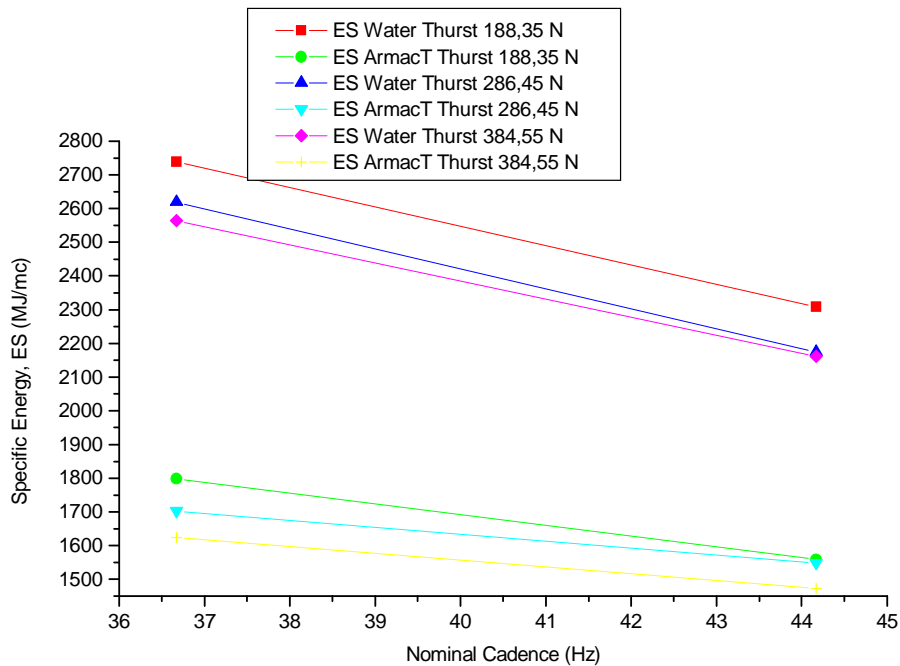


Figure 4: Specific Energy versus Nominal Cadence

DISCUSSION AND CONCLUSIONS

The primary objective of the project was to investigate cutting efficiency of a drill respect to drilling fluid composition by determining and comparing experimentally obtained for rate perforation and specific energy, by utilizing two primary flushing agents namely water, and ArmacT solution in granite stone definite variations in rate perforation and specific energy. According to experiences one notes that the use of ArmacT has given surprisingly results are concerning the consumption of the specific energy, either the increase of the penetration rate in comparison with water Besides the family of curves correspondent to the cadence most elevated it denotes a coarser deposit.

The graph of specific energy versus cadence percussion approximately linear functions (Fig. 4); ArmacT had consistently lowest values for specific energy as compared to water at the same flush rate. (Fig. 4) ArmacT had consistently lowest values for penetration rate as compared to water at the same flush rate.

As with all laboratory exercises, as experience in a particular field grows, so does the quality of results achieved. Whilst it is my opinion that additives to flushing fluids in metalliferous and coal mining drilling operations will never be of economic advantage it has been proven that research such as this absolutely vital in areas such as the petroleum industry. The first problem to overcome in understanding these results lies within the degree of accuracy with which they were obtained. Obviously even idealistic results are unbelievable if no attention is paid to eliminating errors of both the mechanical and human kind. A number of major and minor problems were faced during the testing process, each having a different degree of influence on the quality of results acquired.

Table 4: Tests Results With ArmacT in Flushing Fluid and Water: 0,01M/l Concentration; BROUGHT 8.33cm³/s.

Nominal cadence (Hz)	Thrust (N)	Cadence measured (Hz)		Time (s)	Power (W)		Energy (J)		Real Volume (cm ³)		Specific energy Es mean MJ/m ³		Penetration Rate Vmean (mm/s)	
		Water	ArmacT		Water	ArmacT	Water	ArmacT	Water	ArmacT	Water	ArmacT	Water	ArmacT
44.17	188.35	42.72	42.82	30	968	852	29040	25551	12.58	16.40	2309	1558	2.25	3.90
	286.45	42.16	42.65	30	936	853	28080	25572	12.92	16.52	2174	1548	2.35	3.99
	384.55	42.02	42.30	30	950	828	28000	24852	12.96	16.86	2161	1474	2.60	4.13
36.67	188.35	35.48	35.36	60	680	580	40800	34800	14.90	19.40	2738	1799	2.15	3.05
	286.45	35.42	35.10	60	678	560	40680	33600	15.54	19.74	2618	1702	2.20	3.11
	384.55	35.48	35.15	60	666	540	39960	32399	15.80	19.95	2564	1624	2.37	3.17

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