USING DIAMOND CORE BIT TO DETERMINE THE SUITABLE OPERATING PARAMETERS IN DRILLING SOME MARBLE ROCKS

Mostafa M. Elbeblawi [1], Mohamed A. Sayed [2], Gamal Y. Boghdadi [3] and Helal H. Hamd_Allh [4, *]

Stuff members in the Mining & Metal. Eng. Dept., Faculty of Engineering, Assiut University

Received 26 December 2012; accepted 15 January 2013

ABSTRACT

In this study four marble rocks were drilled by diamond core bit using a fixed laboratory-drilling machine at 400 and 1200 rpm, rotational speed, and over a range of weights on bit (WOB) 45, 60, 75, 90, … 225 Kg. Operating parameters of the drill bit such as WOB, penetration rate (PR), torque (T) and drilling specific energy (SE) were continuously monitored during the drilling trials. The effects of these parameters on the penetration rate were examined, and the effects of formation properties on the drilling rate were examined. Relationships between WOB and both PR, torque T and SE were described and the relationship between PR and SE was determined. Graphs are presented which can be used to predict diamond-drilling performance easy and fast.

***Kay words**: Penetration rate, rotary speed, Weight on bit, Specific energy, Marble rocks*

1. Introduction

Diamond bit drilling is one of the most widely used and preferable drilling techniques because of its higher rate of penetration and core recovery in the hardest rocks, the ability to drill in any direction with less deviation, and the ability to drill with greater precision in coring and prospecting drilling. [1, 2]

Diamond core drilling (Exploration diamond drilling) utilises an annular diamond-impregnated drill bit attached to the end of hollow drill rods to cut a cylindrical core of solid rock. The diamonds used are fine to microfine industrial grade diamonds. They are set within a matrix of varying hardness, from brass to high-grade steel. Matrix hardness, diamond size and dosing can be varied according to the rock which must be cut. Holes within the bit allow water to be delivered to the cutting face. This provides three essential functions; lubrication, cooling, and removal of drill cuttings from the hole. [3]

The penetration rate is generally accepted to be one of the most important parameters in mine planning and cost estimation. An accurate prediction of penetration rate from rock properties and drill operational parameters is of vital importance for the efficient planning of projects. [4]

The drillability of a rock depends on, among other things, the hardness of its constituent minerals and on the grain size and crystal form. Quartz is one of the commonest minerals

* Corresponding author.
Mining & petroleum Eng. Dept., Faculty of Engineering, Al-azhar University, Quena

in rocks. Since quartz is a very hard material, high quartz content (SiO2) makes the rock very hard to drill and causes heavy wear, particularly on the drill bits, we say that the rock is abrasive. Conversely, a rock with a high content of calcite is easy to drill and causes little wear on the drill bits. [5, 6]

In an engineering study of rotary drilling, the factors which affect rate of penetration (PR) are mostly grouped

into formation parameters and rig/bit related parameters. These factors include personnel efficiency, formation characteristics (strength, hardness, abrasiveness), mechanical factors (weight on bit, bit type, rotary speed), hydraulic factors as well as drilling fluid properties. [7, 8]

Recording drilling parameters is a useful and economical technique for acquiring geomechanical information of rock mass parameters The specific energy (SE) can be defined as of the energy necessary to drill a determined volume of rock (MPa).[8,9,10]

All drilling trials were carried out at two main rotary speeds low speed (400 rpm) and high speed (1200 rpm).

Lengths of core produced from the testes are measured and time taken for the drilling is monitored so the penetration rate calculated is equal length of core /time. Note, the average penetration rates were estimated from the drilling trials at low and high speed for one load and the same load.

The aim of this paper is to:

1- Determine the relationships between some operating factors in diamond core drilling such as WOB, RPM, SE and Torque with penetration rate in some marble rocks.

2- Determine the Suitable operating parameters, which give the best value of (PR) and low value of drilling specific energy.

2. Egyptian marble and its occurrences

Marble is a crystalline, compact variety of metamorphosed limestone, consisting primarily of calcite (CaCO3), dolomite (CaMg CO3) or a combination of both minerals. Pure calcite is white, but mineral impurities add color in variegated patterns.

Commercially the term marble is extended to include any rock composed of calcium carbonate that requires polish, including ordinary limestone. The term is further extended to include stones such as alabaster, serpentine and other soft rocks. Marble is a durable stone in dry atmosphere only when protected from rain. The surface of marble crumbles readily when exposed to moist or acidic environment. Purest form of marble is statuary marble, which is white with visible crystalline structure. The distinctive luster of statuary marble is caused by the reflection of penetrated light from the surfaces of inner crystals. [11]

Marble stratigraphy; marble is found in Middle Eocene nummulitic limestone formations. Lithology: Marble exhibits different structures: botryoidally structure, banding, cockade structure, vugs and cavities. [12]

In terms of geological definition, it is a metamorphosed limestone produced by recrystallisation under condition of thermal and also regional metamorphism. In commercial parlance almost any rocks consisting of calcium and/or magnesium carbonate which can take polish easily more, especially unmetamorphosed limestone are termed as marble. [13]

3. Petrography of the study marble rocks

The different types of marble rocks are collected from two locations, two types white and black marble from Wadi El Miah marble quarry and another two types from Elshikh Fadl marble quarry.

3.1. The co-ordinates of the locations are:

3.1.1. Wadi el-miah

Latitude	25°	05'	56.50"	N.
Longitude	33°	47'	49.90"	E.

3.1.2. El sheikh fadl

Latitude	28°	20'	49.44"	N.
Longitude	31°	48'	18.99"	E.

3.2. Wadi el-miah marble

3.2.1. Black marble

The hand specimen is usually black and fine grained and characterized by white veins showing foliation and fine to medium grain type composed mainly of calcite and traces of quartz fig (1), (2).

3.2.2. White marble

The hand specimen of marble is white in color and intersected by grey veins and massive to fine grain in texture. Under the microscope it is mainly of calcite and some nacre of quartz. Calcite is subhedral crystal and quartz is anhedral fig (3), (4).

3.3. El shikh_ fadl marble

3.3.1. Sunny marble

The hand specimen of marble white to brownish in color, fine grained in size and containing some lenses of quartz with some fractures. Under the microscope composed it is mainly of calcite and some traces from quartz and iron oxides as accessories. This rock containing some fossils types fig (5), (6).

3.3.2. Yellow marble

The hand specimen marble white to brownish in color and fine grain in size. Composed mainly of calcite, and some quartz traces and iron oxides as accessories fig (7), (8).

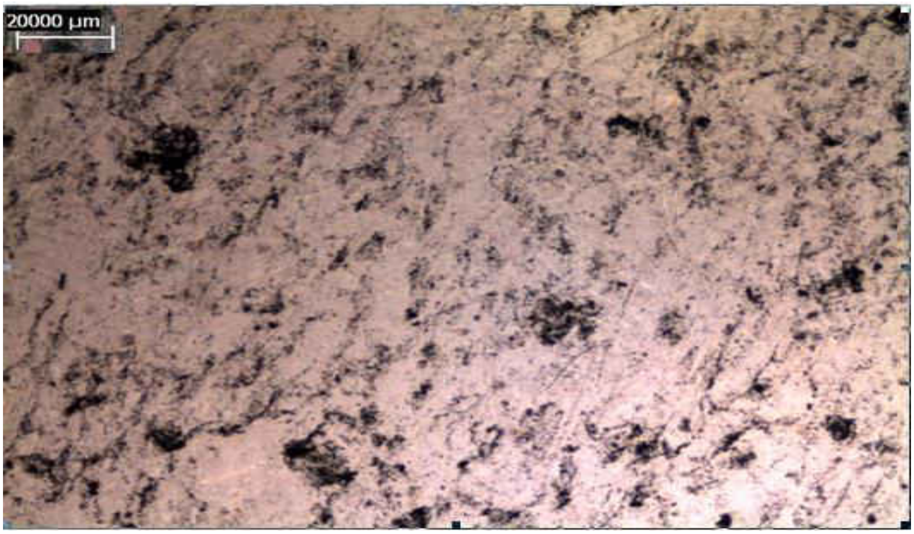

Fig. 1. Photo micrograph in Black marble showing the calcite

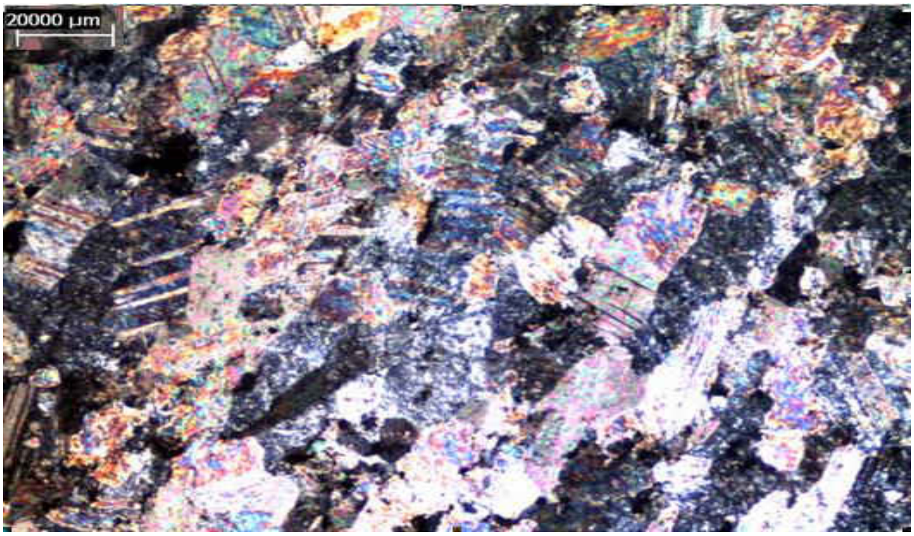

Fig. 2. Photo micrograph in Black marble showing the Quartz

Fig. 3. Photo micrograph in White marble showing the Calcite

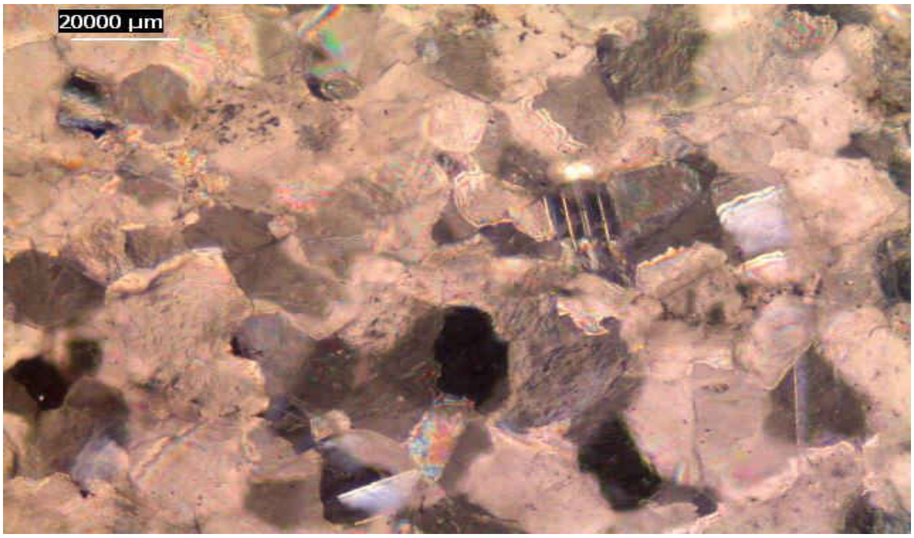

Fig. 4. photo micrograph in White marble showing the Quartz

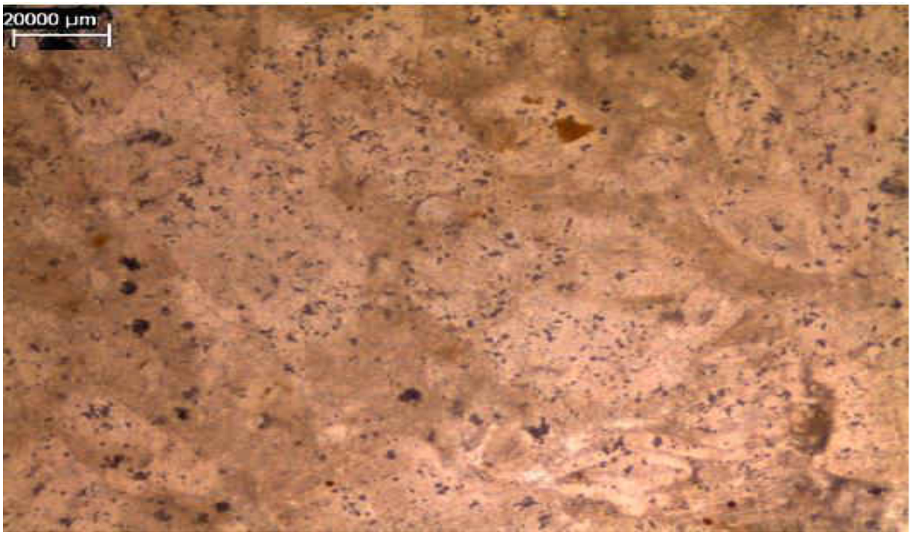

Fig. 5. Photo micrograph in Sunny marble showing the Quartz

Fig. 6. Photo micrograph in Sunny marble showing the fossils.

Fig. 7. Photo micrograph in Yellow marble showing the calcite

Fig. 8. Photo micrograph in Yellow marble showing the quartz.

4. Properties of the tested rocks

In this study physical and mechanical properties such as density, porosity, compressive strength, tensile strength and coefficient of friction with its standard deviation, are given in Table (1).

Table 1
Average physical and mechanical properties of the tested rocks.

Marble Rock type	Density gr/cm3	Porosity %	Compressive strength	Tensile strength	Coeffi.Of friction
Black	2.99 ±0.006	1.01 ± 0.140	585.98 ± 59.7	137.21 ± 3.86	0.65
White	3.10 ± 0.007	0.66 ± 0.099	623.02 ± 31.62	170.02 ± 7.60	0.70
Sunny	2.87 ± 0.007	2.51 ± 0.170	439.15 ± 60.12	105.47 ± 3.19	0.99
Yellow	2.56 ± 0.006	2.32 ± 0.120	439.15 ± 60.12	111.46 ± 13.74	0.81

5. Experimental work

In the current research four types of the marble rocks from different places in Aswan (Eastern desert) and

El-Minya in Egypt were tested. Rocks prepared as blocks of dimensions(20cm×15cm×15cm), Blocks tested in the laboratory by diamond drilling machine the inside diameter of the used bit 38 mm with 40 mm outer diameter. Applied load, actual speed, length of borehole (length of core) and time of drilling are recorded. All drilling trails were carried out at low speed equals 400 rpm and high speed equals 1200 rpm. Rotary speed in the tests measured by laser speedometer. Water used as a drilling fluid for cooling the bit and remove the cuttings.

The weight on bit is applied by using loads which are suspended by a movable wheel by a wire rope. The wheel is fixed into the machine gear axis. Hence the load is transferred into the bit. This transfered load is checked up and measured using proving ring.

6. Results and discussion

The following are the relationships between (WOB via PR), (WOB via Torque), (WOB via SE) and (PR via SE) at low and high speed.

6.1. Relations between WOB and PR at low and high speed

Penetration rate at low and high speed for different WOB in the tested rocks are shown in the table (2)

Table 2
Results of PR and SE at low and high speeds for tested rocks at different WOB

WOB	Black marble				White marble				Sunny marble				Yellow marble			
	Low speed		High speed		Low speed		High speed		Low speed		High speed		Low speed		High speed	
	PR, nm/sec	S.E, Mpa	PR, nm/sec	S.E, Mpa	PR, nm/sec	S.E, Mpa	PR, nm/sec	S.E, Mpa	PR, nm/sec	S.E, Mpa	PR, mm/sec	S.E, Mpa	PR, mm/sec	S.E, Mpa	PR, nm/sec	S.E, Mpa
45	-	-	-	-		-	0.43	1219	-	-	-	-	-		0.17	3566
60	-	-	-	-		-	0.47	1488	-	-	0.45	2192	-		0.29	2787
75	-	-	0.67	1212	-	-	0.56	1561	-	-	0.46	2681	0.17	1977	0.51	1981
90	-	-	0.68	1433	0.11	3172	1.07	980	0.19	7789	0.71	2084	0.19	2123	0.99	1225
105	-	-	0.80	1421	0.15	2714	1.37	893	0.21	8222	0.88	1962	0.24	1961	1.30	1088
120	0.21	1946	0.89	1460	0.23	2023	1.85	756	0.21	9397	0.94	2099	0.27	1992	1.41	1146
135	0.24	1915	1.01	1447	-	-	-	-	0.22	10091	1.04	2134	0.27	2241	1.35	1347
150	0.28	1824	1.20	1353	0.39	1491	-	-	0.26	9487	0.71	3474	0.32	2101	1.20	1684
165	0.3	1873	1.34	1333	0.47	1361	-	-	0.27	10049	-	-	0.35	2113	-	-
180	0.31	1977	1.55	1257	0.57	1224	-	-	0.28	10571	-	-	0.39	2068	-	-
195	0.33	2012	-	-	0.88	859	-	-	0.32	10021	-	-	0.44	1986	-	-
210	0.34	2103	-	-	1.59	512	-	-	0.34	10157	-	-	0.48	1961	-	-
225	-	-	-	-	-	-	-	-	0.38	9737	-	-	-	-	-	-

Relation between WOB and penetration rate PR in Marble rocks at two rotary speeds (400 rpm) and (1200 rpm) were represented by curves in figures (9), (10), (11), and (12). The trend line for the results is that increasing WOB produces an increase in PR up to a maximum point. However, from the experimental data in table (2), a further increase in WOB causes constant or little increase in PR. The effect of rotational speed on PR of the bit is clear in the curves and data in table (2), increasing rotary speed produced an increase in the PR. At WOB 210 kg PR in (Black marble) was about 1.6 times that at min. 120 kg. There is also an increase in PR in rocks (White marble), (Sunny marble) and (Yellow marble) with increased WOB. PR in rocks (White marble), (Sunny marble) and (Yellow marble) at WOB 210,225 and 210 kg was about 14.5, 2 and 2.8 times that at 90, 90 and 75 kg respectively in the low speed. In high speed PR in rock (Black marble) at WOB 180 kg was about 2.3 times that at 75 kg. PR in rocks (White marble), (Sunny marble) and (Yellow marble) at WOB 120,150 and 150 kg was about 4.3, 1.6 and 7 times that at 45, 60 and 45 kg respectively.

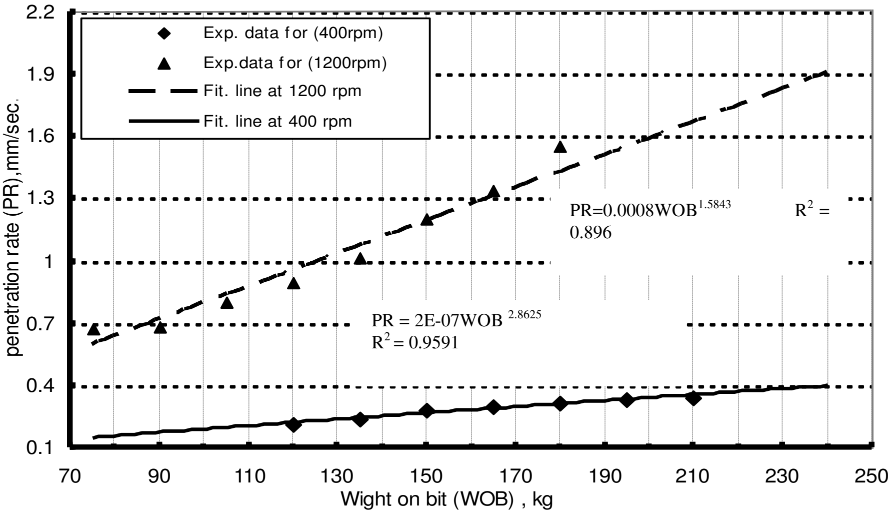

Fig. 9. Relation between WOB and PR at 400 rpm and 1200 rpm for Black Marble

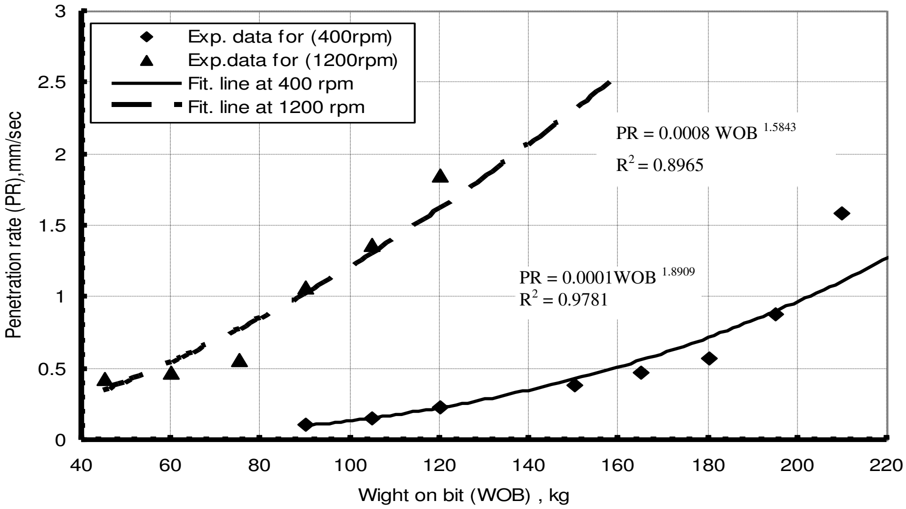

Fig. 10. Relation between WOB and PR at 400 rpm and 1200 rpm for White Marble

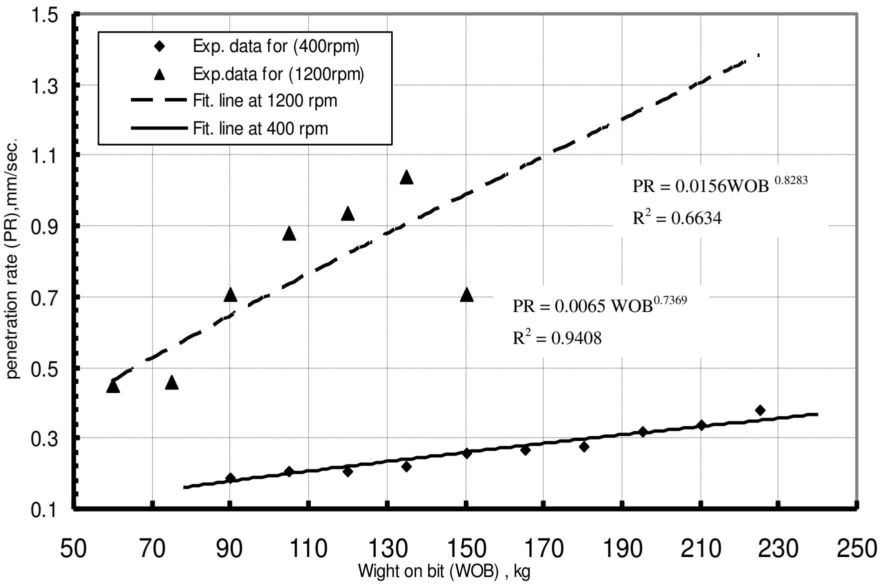

Fig. 11. Relation between WOB and PR at 400 rpm and 1200 rpm for Sunny Marble

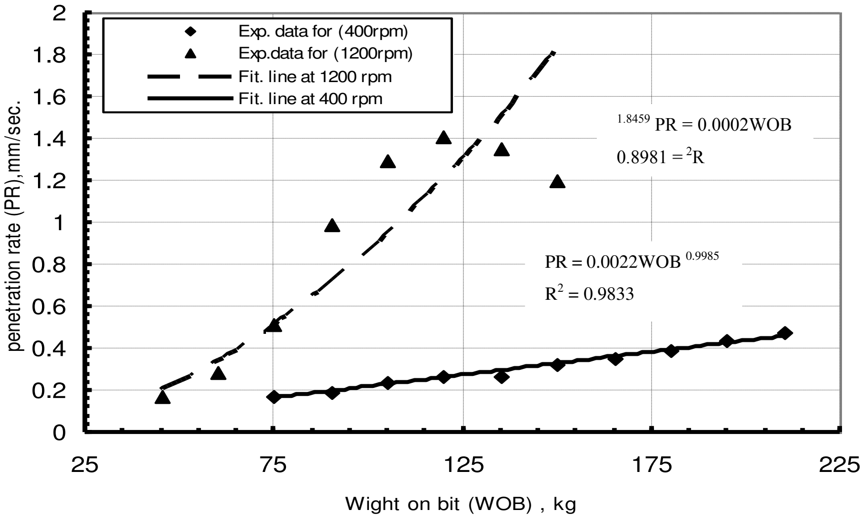

Fig. 12. Relation between WOB and PR at 400 rpm and 1200 rpm for Yellow Marble

6.2. Relations between wob and torque

Torque is defined as the force required to turn the drill rod, which leads to the bit rotation against the resistance to the cutting and friction forces. [14] Rotary torque is an indicator of what is happening at the drill bit. Relationship between Torque (T) and weight on bit (WOB) is linear. The torque is found to be dependent on the weight on bit to the power of 1.1 according to field measurements. [15]

$$\mathbf{T} = \frac{2}{3}\,\mu\,\mathbf{F}_v\,\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}$$

T = resisting torque, N.M　　FV = applied thrust, KG　　μ = Coefficient of friction

r_o = outside radius , m　　r_i = inside radius , m

Table (3) gives the values of torque for the tested rocks which are calculated at different WOB. Relations between WOB and T are illustrated in the figure (13) as an example; there is a linear relation between WOB and T .

Torque value increases with the increase in WOB in the four rocks.

Table (3)
Values of torque for the tested rocks at different WOB

WOB	Black marble Torque, N.m	White marble Torque, N.m	Sunny marble Torque, N.m	Yellow marble Torque, N.m
45	-	6.35	-	7.34
60	-	8.46	35.88	9.78
75	9.83	10.58	44.85	12.23
90	11.79	12.69	53.82	14.67
105	13.76	14.81	62.79	17.12
120	15.72	16.92	71.76	19.56
135	17.69	-	80.73	22.01
150	19.65	21.15	89.70	24.45
165	21.62	23.27	98.67	26.90
180	23.58	25.38	107.64	29.34
195	25.58	27.50	116.61	31.79
210	27.51	29.61	125.58	34.23
225	-	-	134.55	-

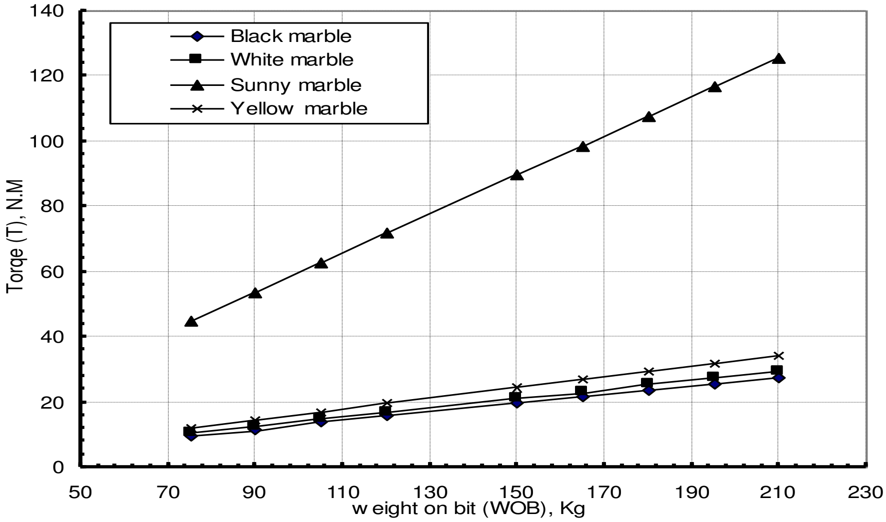

Fig. 13. Relation between weight on bit and torque in marble rocks

6.3. Relations between WOB and SE at low and high speed

The specific energy (SE) is defined as the energy required for excavating unit volume of rock .It is a useful parameter that may also be taken as an index of the mechanical efficiency of a rock-working process .Specific energy is directly linked to the cost used in drill the hole, so the specific energy is the clear indication on the drilling performance in the rocks drilled in this study. By definition it can be defined as input energy to the output PR. The SE equation can be expressed in terms of drilling parameters can a follows [2, 16, 17]

$$SE = 2\pi * NT / A * PR$$

SE = specific energy; MPa. N = rotary speed, rpm .

T = resistance torque, Nm. A = area of the bit, mm^2.

PR = penetration rate. M/hr.

Specific energy was calculated from the above equation for all testes in high and low speeds, and the values are given in table (2). A curve fitting was made for experimental data. Relations between WOB and SE with correlation coefficients are given in figs (14), (15), (16) and (17). In the figures the trend line behavior varies according to rock type and rotary speed. The best values of SE which give best values of PR were 512 and 1961 Mpa at WOB 210 Kg in rocks white and yellow marble at 400 rpm respectively.

The best values of SE which give reasonable values of PR were 1824 MPa and 7789 MPa at WOB 150 and 90 Kg in black and Sunny marble at 400 rpm. The best values of SE which give best values of PR were 1257 and 756 Mpa at WOB 180 and 120 Kg in rocks black and white marble at 1200 rpm respectively. The best values of SE which give reasonable values of PR were 1962 MPa and 1088 Mpa at WOB 105 Kg in sunny and yellow marble at 1200 rpm respectively.

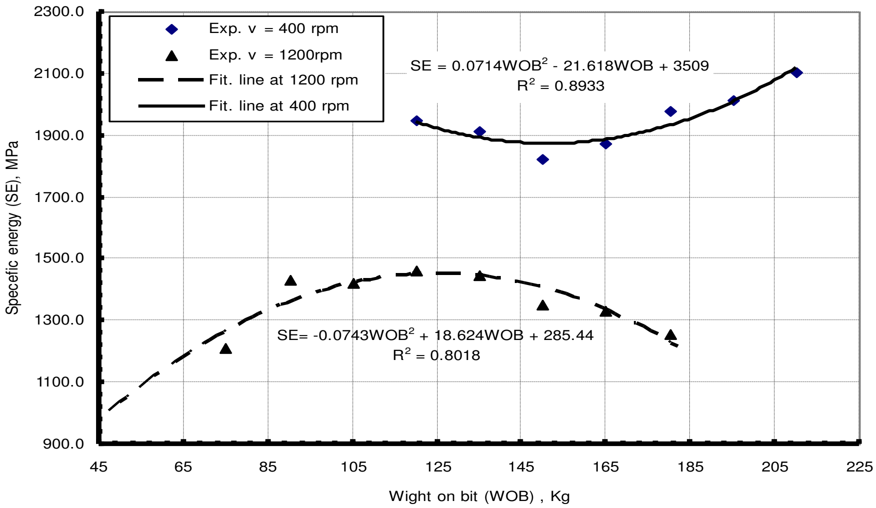

Fig. 14. Relation between (WOB) and (SE) at 400 rpm and 1200 rpm for Black Marble rock**.**

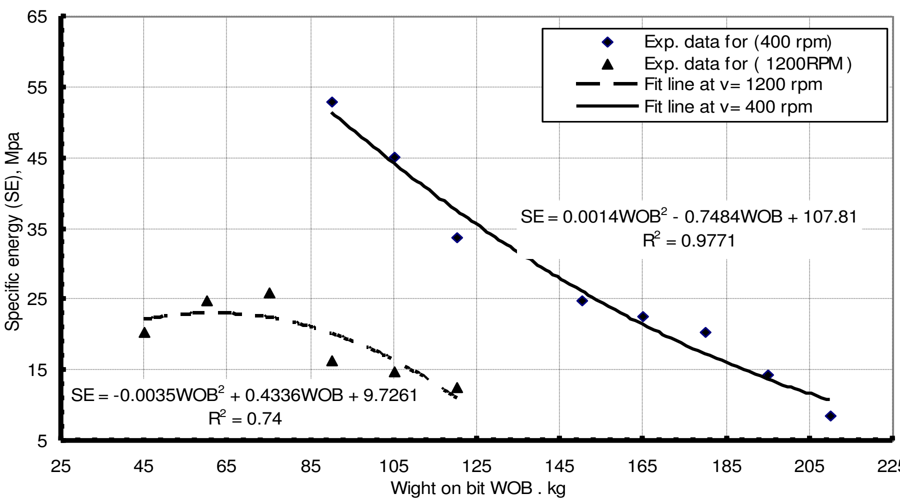

Fig. 15. Relation between (WOB) and (SE) at 400 rpm and 1200 rpm for white Marble rock.

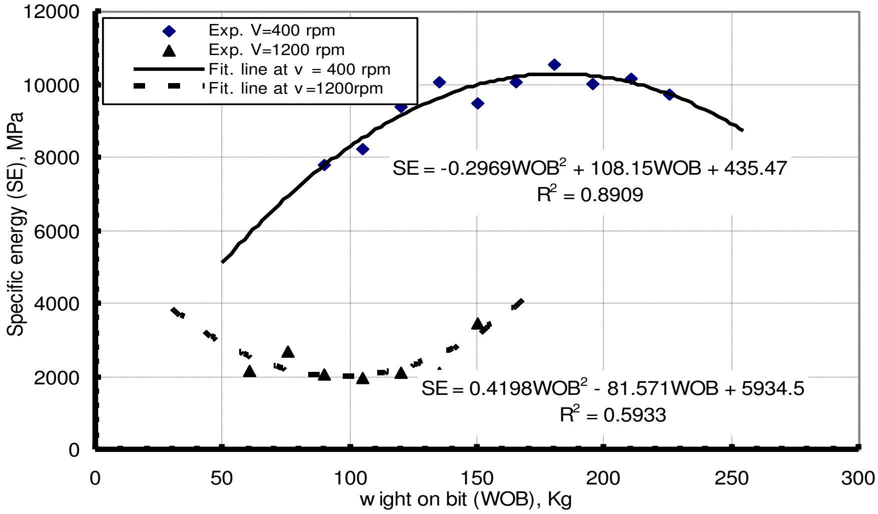

Fig. 16. Relation between (WOB) and (SE) at 400 rpm and 1200 rpm for Sunny Marble rock

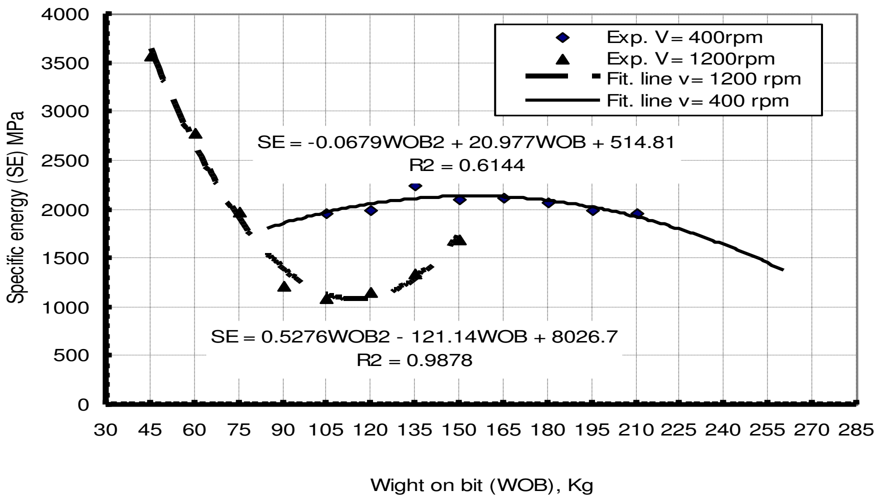

Fig. 17. Relation between (WOB) and (SE) at 400 rpm and 1200 rpm for Yellow Marble rock

6.4. Relations between PR and SE at low and high speed

Table (2) gives the different values of the SE and PR in all rocks. Figs. (18), (19) show the relationships between PR and SE in black marble at low and high speed respectively. The SE decreases with the increase in the PR to 1850 MPa, and with the increase of PR, SE increases to 3103 MPa at low speed (400 rpm). For the high speed (1200rpm) SE decreases with an increase in the PR.

Figs. (20), (21) illustrate the relations between PR and SE in white marble at low and high speed respectively. The SE decreases with the increase in the PR, at PR = 1.24 mm/sec. SE was at a min. value 300 Mpa and with the increase of PR, SE increases to 500 Mpa at low speed (400 rpm). In the high speed (1200 rpm) SE decreases with the increase in PR.

Figs. (22), (23) illustrate the relations between PR and SE in Sunny marble at low and high speed respectively.At low speed the specific energy (SE) increases with the increase in the PR, till a maximum point of 10350 MPa and then decreases beyond the value of PR = 0.32 mm/sec. At high rotary speed the specific energy decreases with the increase in the penetration rate till 2040MPa and then inceases beyond the value of PR=0.85 mm/sec.

Figs. (24), (25) illustrate the relations between PR and SE in yellow marble at low and high speed respectively. In the low speed (400 rpm) SE decreases with the increase in the PR. At high rotary speed (1200 rpm) the SE decreases with the increase in PR, at PR = 1.2 mm/sec. SE was at min. value 1200 Mpa and with the increase of PR, SE increase to 1400 Mpa.

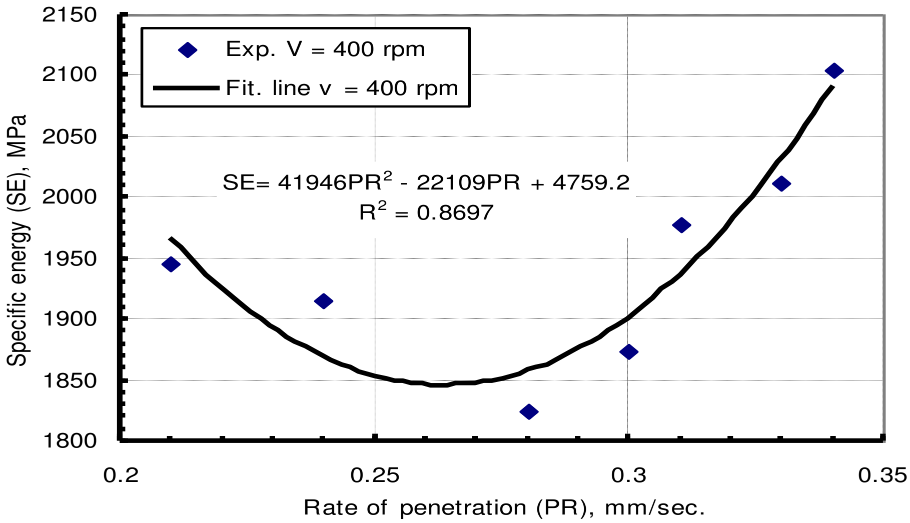

Fig. 18. Relations between penetration rate (PR) and specific energy (SE) in Black Marble at low speed

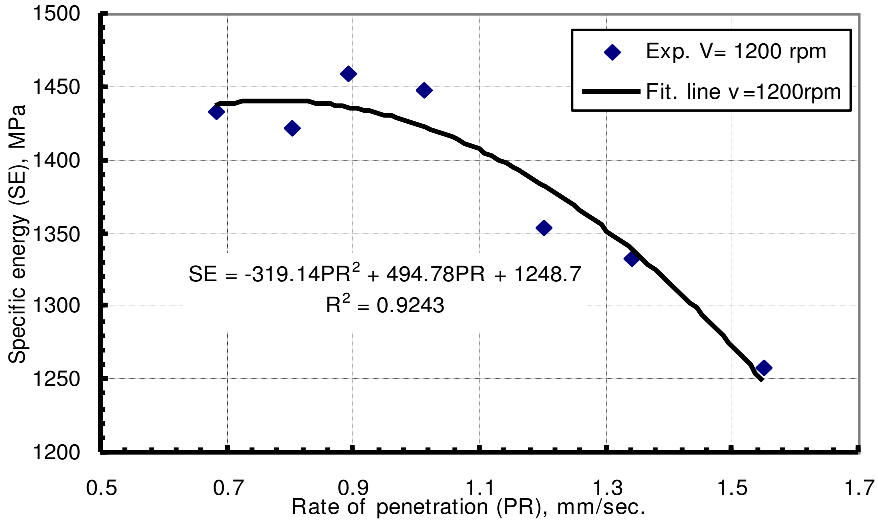

Fig. 19. Relations between penetration rate (PR) and specific energy (SE) in Black Marble at high speed.

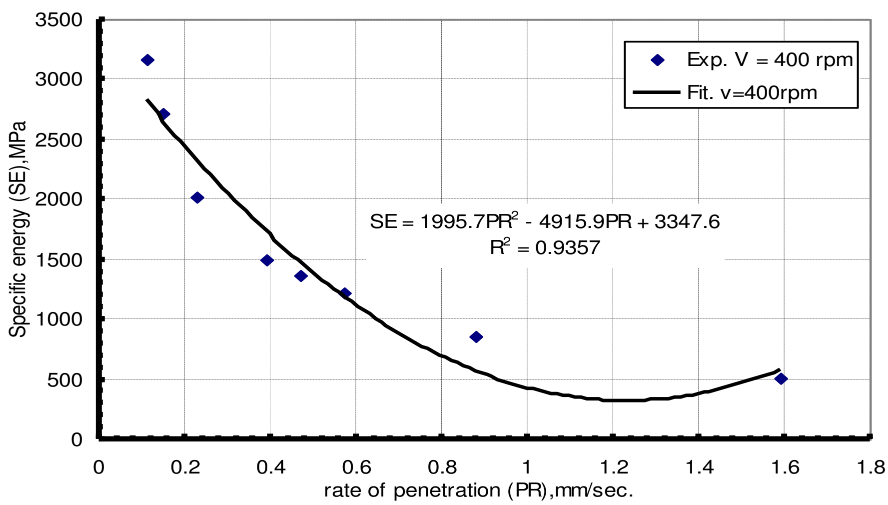

Fig. 20. Relations between penetration rate (PR) and specific energy (SE) in white Marble at low speed

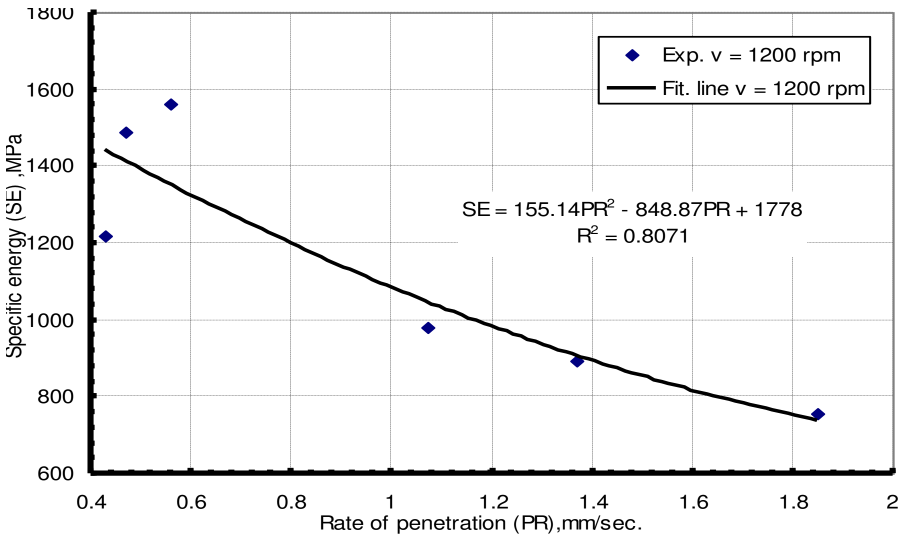

Fig. 21. Relations between penetration rate (PR) and specific energy (SE) in white Marble at high speed

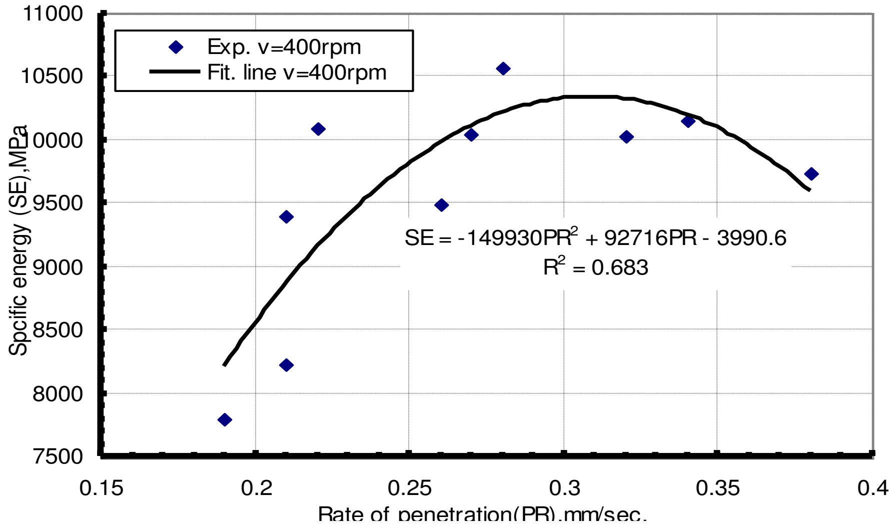

Fig. 22. Relations between penetration rate (PR) and specific energy (SE) in Sunny Marble at low speed

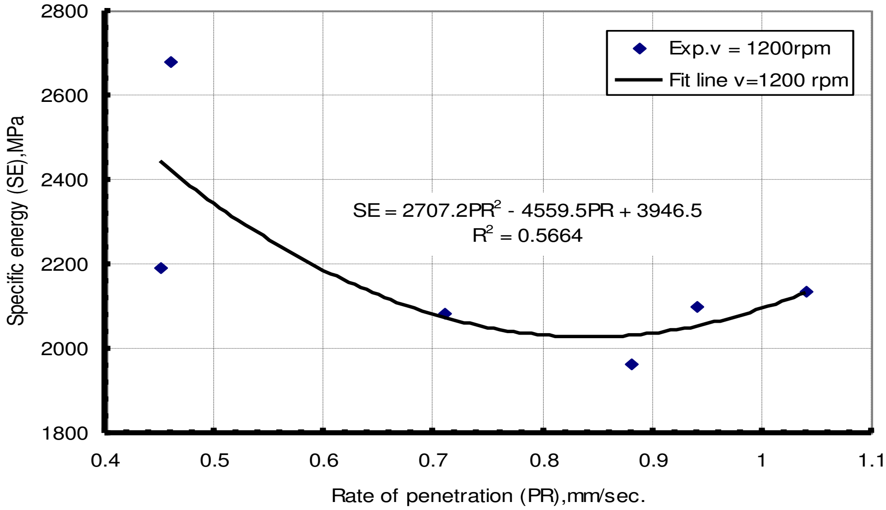

Fig. 23. Relations between penetration rate (PR) and specific energy (SE) in Sunny Marble at high speed

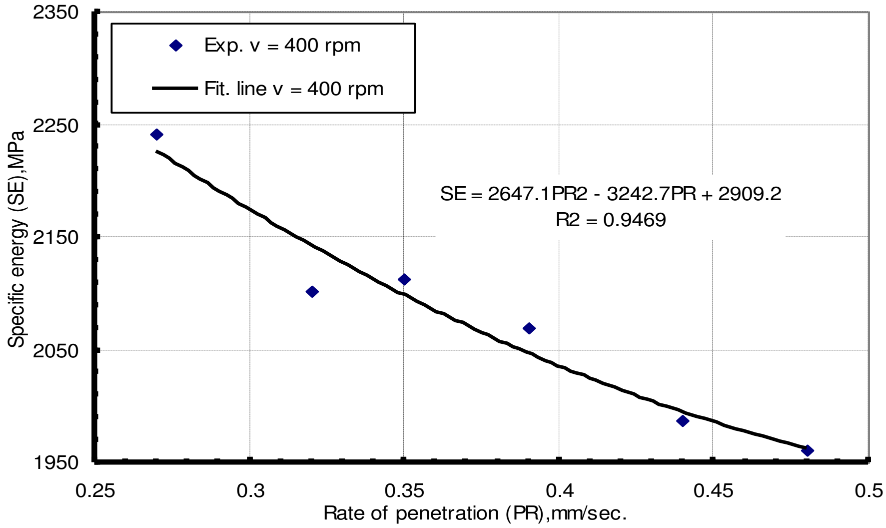

Fig. 24. Relations between penetration rate (PR) and specific energy (SE) in Yellow Marble at low speed

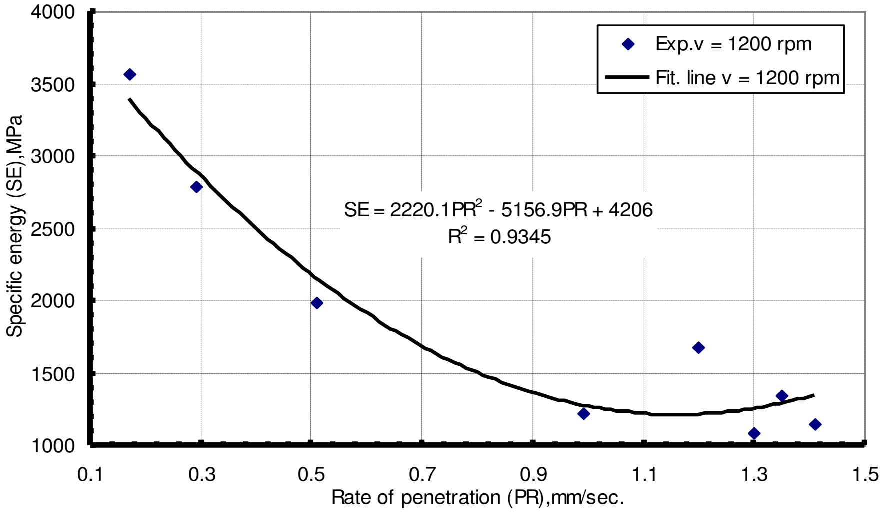

Fig. 25. Relations between penetration rate (PR) and specific energy (SE) in Yellow Marble at low speed

7. Conclusions and recommendations

2. Drilling tests were carried out on four marble rocks by using a fixed laboratory diamond core drilling machine with both for low speed at 400 rpm and high speed at 1200 rpm, weight on bit applied are 45,60,75,90,105,105,120,……………….,210 and 225 kg.
3. Relations between WOB and both PR, T, and SE where given. Also relation between PR and SE were given. From the experimental data drilling performance is dependant on operating parameters especially rotary speed and WOB. Mathematical Equations between parameters are given from trend line in curves.
4. In low speed increasing WOB causes an increase in PR. In black marble rock at a maximum of WOB 210 kg PR was about 1.6 times that of at minimum WOB of 120 kg. PR increases in rocks (White marble), (Sunny marble) and (Yellow marble) at WOB 210,225 and 210 kg was about 14.5, 2 and 2.8 times that at 90, 90 and 75 kg respectively for the low speed.
5. Penetration rate at high speed is more than that at low speed in a specific load. At WOB of 120 kg as an example PR at high speed were about 4.2, 8.04, 4.48 and 5.22 times that PR at low speed in rocks (Black marble), (White marble), (Sunny marble) and (Yellow marble) respectively.
6. Specific energy value varies according to the type of rock and weight; the best values of SE which give best values of PR were 512 and 1961 Mpa at WOB of 210 Kg in rocks white and yellow marble at 400 rpm respectively. The best values of SE which

give reasonable values of PR were 1824 Mpa and 7789 Mpa at WOB of 150 and 90 Kg in black and Sunny marble at 400 rpm respectively.

7. The best values of SE which give best values of PR were 1257and 756 Mpa at WOB 180 and 120 Kg in black and white marble rocks at 1200 rpm respectively. The best values of SE which give reasonable values of PR were 1962 Mpa and 1088 Mpa at WOB of 105 Kg in Sunny and yellow marble at 1200 rpm respectively.
8. We recommend to use the high rotary speed for drilling in the quarry marble, because the high rotary speed gives high penetration rate and low energy consumption.

Refrances

[1] Serhat Akin, and Celal Karpuz " Estimating drilling parameters for diamond bit drilling operations using artificial neural networks" Int. J. Geomech. 8, 68 ,2008

[2] Mostafa M. Elbeblawi, Mohamed A. Sayed, Gamal Y. Boghdadi and Helal H. Hamd_Allh" Effect of operating parameters and formation properties on penetration rate in some sandstone rocks by using diamond core bit". Journal of Engineering Sciences, Assiut unv. , vol. 40 No.2 , pp 581- 594, March 2012, Egypt.

[3] p://www.airdrill.com.au/pdf/The-Drilling-Industry-General/diamond-core-drilling.pdf

[4] N. Bilgin , S. Kahraman "Drillability prediction in rotary blast hole drilling" 1a" International Mining Congress and Exhibition ot Turkey-IMCET 2003, # 2003, ISBN 975-395-605-3

[5] University of a Arizona Mining and Geological Engineering - Rock Excavation Course Notes – Spring 2003http://www.lonestarbit.com/mining/415n.pdf

[6] Gamal Y. Boghdady "Mechanical and geological influences on drilling limestone rock at low rotary speed" Journal of Engineering Sciences , Assiut University , Vol. 38 , No. 1,pp.259-270 , January 2010.

[7] Yusuf Babatunde, Stephen Butt, John Molgaard, Farid Arvani."Investigation of the effects of vibration frequency on rotary drilling penetration rate using diamond drag bit" 45th US Rock Mechanics / Geomechanics Symposium held in San Francisco, CA, June 26–29, 2011.

[8] N. Bilgin, S. Kahraman "Drillability prediction in rotary blast hole drilling" 1a" International Mining Congress and Exhibition ot Turkey-IMCET 2003, # 2003, ISBN 975-395-605-3

[9] B. Celada1, J. M. Galera2, C. Muñoz3, I. Tardáguila3 "The use of the specific drilling energy for rock mass characterisatin and tbm driving during tunnel construction" p://www.geocontrol.es/lista/listado/vdocumento.asp?f=use%20of%20specific%20drilling_celada.pdf

[10] Mohamed A. Sayed and Abdel Nasser M. Abdel Rahman " Using diamond core drilling parameters for identifying the rock type to be drilled" Journal of Engineering Sciences , Assiut University , Vol. 30 , No.4 ,pp.1011-1025, October 2002.

[11] http://www.egyptmarbles.com/industry-info/

[12] 'The Geology of Egypt: An Annotated Bibliography" Farouk El-Baz http://www.googlebookes.es/lista/listado/vdocumento.asp?f=use%20of%20specific%20drilling_celada.pdf

[13] http://ibm.nic.in/imyb2010_marble.pdf

[14] Mohammed Fasheloum "Investigation of drilling parameters indictors" Thesis submitted to the University of Nottingham for the degree of Doctor of Philosophy, April 1997

[15 http://www.fanarco.net/books/Drilling_Engineering_Workbook_-_Baker_Hughes_INTEQ.pdf

[16] Celada, B. Galera, J. M. Muñoz, C. Tardáguila,I. "The use of the specific drilling energy for rock mass characterization and TBM driving during tunnel construction"

http://www.geocontrol.es/lista/listado/vdocumento.asp?f=use%20of%20specific%20drilling_celada.pdf

[17] B. Rashidi "Real-Time Drill Bit Wear Prediction by Combining Rock Energy and Drilling Strength Concepts"
http://dc337.4shared.com/download/07ivPLGr/RealTimeDrillBitWearPredictionbyCombiningRockEnergyandDrillingStrength Concepts

استخدام بنطة الحفر المطعمة بالماس لحساب قيم عوامل التشغيل المناسبة فى حفر بعض صخور الرخام

ملخص:

فى هذه الدراسة تم الحفر فى اربعة انواع من صخور الرخام بإستخدام ماكينة حفرمعملية ثابتة بإستخدام سرعتين لدوران بنطة الحفر سرعة بطيئة 400 لفة على الدقيقة وسرعة عالية 1200 لفة على الدقيقة . وتطبيق احمال مختلفة تتراوح بين 45 و 60 و 75 و 90 .... 225 كجم. عوامل التشغيل فى الحفر هى الحمل المطبق على البنطة و معدل الاختراق وعزم الدوران والطاقة المبذولة . تسجل هذه العوامل بإستمرار اثناء عملية الحفر ويتم دراسة تأثيرها بجانب دراسة تأثير خواص التكوينات الصخرية على معدل الإختراق وعلى كمية الطاقة المبذولة . و تتم دراسة العلاقات بين الحمل المطبق على البنطة و معدل الاختراق وعزم الدوران والطاقة المبذولة والعلاقة بين الطاقة المبذولة ومعدل الإختراق . ويتم رسم منحنيات تعبر عن هذه العلاقات ويتم الحصول على العلاقات الرياضية بين هذه المتغيرات بإستخدام المنحنيات ومن خلال هذه العلاقات نستطيع تعيين افضل قيم لعوامل التشغيل التى تستخدم فى الحفر .