ORDRE DES INGÉNIEURS DU QUÉBEC

SESSION OF NOVEMBER 2019

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|---|
| Any documents allowed<br>Calculators: authorized models only<br>Duration of the exam: 3 hours |

# 14-MI-A7 Rock Fragmentation
# Total 100 points

**PART A (55 points for this part)**

**Question A1 (4.5 point)**

In a rock with a high drilling rate index (DRI) (for example 75), the rotary drill operator applied a rotational speed of 100 rpm and a thrust force of 12 KN/inch$^2$ in diameter. Now, this same drill rig will drill into a harder rock that is characterized by the lower DRI value (DRI = 40).
A) Should the rotation speed be changed? If yes, specify whether it is a rise or fall. Justify your answer.
B) What would be done with the unit thrust force? Should it be increased or reduced?

**Question A2 (4.5 points)**

What parameters should be considered in assessing long-term drilling productivity?

**Question A3 (5 points)**

What penetration rate can be achieved during percussion drilling? List and define some parameters of percussion drilling.

**Question A4 (5 points)**

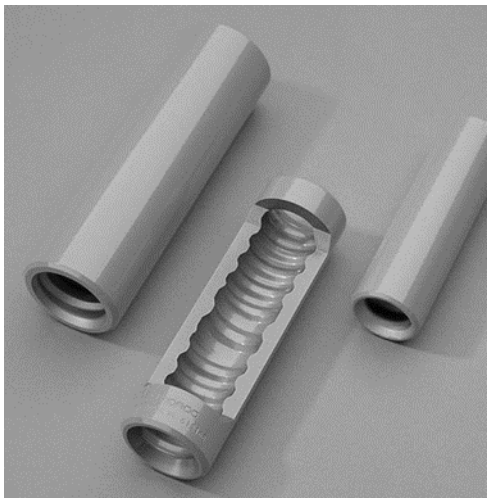
Describe and compare the principles, advantages and disadvantages of two "Top-Hammer" and "DTH" hammer drilling technologies and indicate the applications in which each of them offers the most advantages.

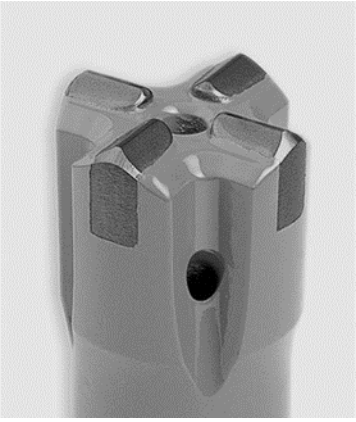
**Question A5 (6 points)**

Identify the objects below (each item: 1.5 points)

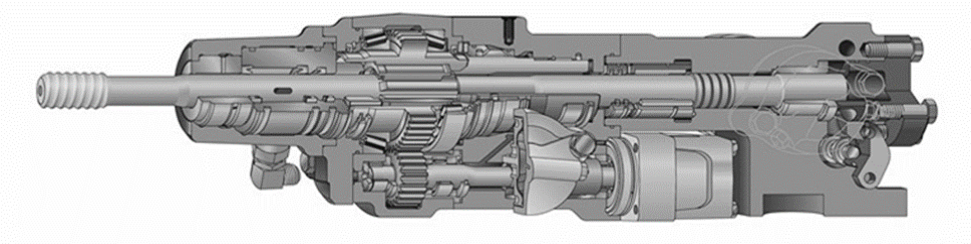
A)

B)





C)



D)

**Question A6 (30 points)**

You are planning the drilling for the bench blasting. The rock to drill is dolomite: with density of 2.85 t/m$^3$; Mohs scale hardness: 4.0 and abrasivity index: 4.

You may have at your disposal a type of Atlas Copco FlexiROC T35 (hammer percussion out of hole) self-propelled crawler drill, the parameters of which are shown in Table 1 below.

1. Determine the maximum penetration rate that can be achieved (5 points).

2. Calculate the drilling time of a hole indicated in Table 2 (10 points).

3. Evaluate the monthly capacity of equipment considering technical, operational and organizational factors (5 points).

4. If the monthly production achieved by this equipment is to be 75000 tonnes of ore and the volume of influence (B * S * H) of each hole is 124.7 $m^3$, estimate the monthly consumption of bits (cutters) and extensions under the conditions given (it can be imagined the life of elongation is 4500 m and the life of cutting is 850 m) (10 points).

**Table 1**

| Drilling machine | **FlexiROC T35** |
|---|---|
| Hammer type | COP 1840+*<br>Out of the hole |
| Power | 20 kW |
| Air pressure | n/a |
| Total length of the slide | 7140 mm |
| Hammer stroke / rotation head | 4240 mm |
| Available rod train | T38, T45 ou T51 |
| Length of extensions / tubes | 3660 |

* - comparable to the Sandvik HL 700 hammer (formerly Tamrock).

The drilling parameters with each of these machines are as follows (Table 2):

**Table 2**

| | |
|---|---|
| Hole diameter | 89 mm (3 ½ po.) |
| Hole length | 15,55 m |

**Table 3 The drillability factor of different rocks**

| Rock type | Location | Drillability factor |
|---|---|---|
| Andesite | Messy Rock, Wash., USA | 1.27 |
| Banded Gneiss | Solna, Sweden | .89 |
| Barre Granite | Barre, Vermont, USA | 1.00 |
| Basalt | New York, USA | .56 |
| Calcite | Hanover, Pa., USA | .89 |
| Chalcopyrite | New Guinea | .78 |
| Diorite | Oregon, USA | .34 |
| Dolomite | Hanover, Pa., USA | 1.70 |
| Felsite | Denver, Colorado, USA | .75 |
| Granite | Westchester, N.J., USA | .67 |
| Granite | Snettisham Dam, Alaska, USA | .78 |
| Granite | Newark, N.J., USA | 1.05 |
| Granite | California, USA | 1.10 |
| Granite Gneiss | Hamburg, N.J., USA | .67 |
| Granite Gneiss | Vancouver, B.C. Canada | .89 |
| Hematite (Red) | Sarajevo, Yugoslavia | 1.50 |
| Limestone | Washington, USA | .78 |
| Limestone | Millerville, Va., USA | .89 |
| Limestone | Buffalo, N.Y., USA | .89 |
| Limestone | Bellefonte, Pa., USA | .94 |
| Limestone | Tulsa, Ok., USA | 1.19 |
| Limestone | Saratoga, N.Y., USA | 1.22 |
| Limestone | Portsmouth, N.H., USA | 1.77 |
| Limestone | Davenport, Iowa, USA | 1.79 |

**Table 4: Duration of non-productive action**

| Operation | Approximately duration According to Jimeno et al., 1995 (s) | Approximately duration According to Chugh et al., 1995 (s) |
|---|---|---|
| Displacement of the drilling rig | 60-180 | 120-1270 (for the length of the holes 3-6 m)<br>180-300 (for the length of holes 12-18 m)<br>340 (for the length of holes 30 m) |
| Positioning of the drilling rig | 30-60 | |
| Adding an extension<br>-Automatic system<br>-Manual system | 35-45<br>60 | 45-75 |
| Back hammering | 10-15 | N/D |
| Recovery of Extensions (Time for 1st rod):<br>-Automatic system:<br>-Manual system: | 30-60<br>60 | 90-180 |
| Downhole cleaning | 60 | 30-60 |
| Cutter changing | 90 | N/D |

**PART B (45 points for this part)**

**PART B 1**

**Circle the correct answer: A or B or C or D or E.**

**Question B1-1 (5 points)**

**Which of the following tools could we use in blasting with a delay?**

A) Detonating cord
B) Safety fuse
C) Electric detonator
D) Nonel
E) A and C and D

**Question B1-2 (5 points)**

**Which option is not correct?**

A) Generally, the explosive density is reversely proportional to the sensitivity of the explosives and its particle size is inversely proportional to the sensitivity of the explosives.
B) Generally, the explosive density is directly proportional to the sensitivity of the explosives and its particle size is inversely proportional to the sensitivity of the explosives.
C) Generally, the explosive density is inversely proportional to the sensitivity of the explosives and its particle size is directly proportional to the sensitivity of the explosives.
D) B and C
E) None of them

**Question B1-3 (5 points)**

**Which of the following factors do not depend on the explosive detonation rate?**

A) Specific gravity, type of detonators and sensitivity to impact
B) Specific gravity, type of detonators, particle size and hole diameter
C) Specific gravity and sensitivity to impact and spark and chemical composition
D) A and C
E) None of them

**Question B2 (10 points) - TRUE OR FALSE**

1- The specific charge of explosives is greater in parallel cut than in angular cut;
2- Back break has a relation directly with stemming and has a relation repayment with burden and inclination of the explosive hole;

**PART B3 (20 points for this part)**

**Question B3**

You must calculate all blasting parameters in a limestone open pit mine. Calculate the specific charge quantity of the explosive (Sc) and the size of the rock fragmentation ($\ddot{X}$) and the other parameters for blasting such as Burden (B), Spacing (S), Stemming (J), the height of the blast hole (H), the effective explosive charge height (He). For the calculation, you can use Ash's formula. The characteristics of explosives, rocks and blast conditions are as follows:

1- The mass volumetric rock is 2.5 $gr/cm^3$

2- The explosive is ammonium nitrate fuel oil (ANFO) with the mass volumetric of 0.9 $gr/cm^3$

3- The diameter of the blast hole is 4 inches (4 "). Three sticks of dynamite are used in the blast hole. Both of them are used as primer and the other is used as a booster.

4- The detonating cord and the electric detonators are used.