

## Evaluation of factors affecting in tricone rotary bits wear of drilling machines in Open Pit Mines - A Case Study

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### Abstract

Extraction and exploitation is one of the important parts in the field of mines and mining industries. Blast hole drilling is the first stage of the production cycle in open pit mines which account for a large part of the exploitation costs. In operational processes, bits are one of the most sensitive and important parts of drilling, due to the type of application and high costs. Wear of these tools are an important parameter for estimating the efficiency of drilling equipment in mining projects. Wear of drilling bits is a function of various factors, some of which are related to machinery, operational parameters and management parameters, and some are dependent on the conditions and rock properties and rock mass and the surrounding environment. Examining the parameters affecting the tricone rotary bits wear can prevent wasting time and additional costs of the drilling process. Therefore, in this study, the evaluation of the factors affecting the tricone rotary bits wear in Sarcheshmeh copper mine has been investigated. For this purpose, the tricone rotary bits wear has been calculated through weight loss and by determining the effective parameters, the relationship between these factors and the tricone rotary bits wear has been determined through statistical methods. Then, using sensitivity analysis, the effect of input parameters on the target is determined. The results of these analyzes show that all the parameters of the study except the Chemical Index of Alteration (CIA), porosity and Equivalent Quartz Content (EQC) on the desired output (the tricone rotary bits wear) and small changes in their amount lead to fundamental changes in the tricone rotary bits wear.

**Key words:** *Drilling, Wear, tricone rotary bits, Statistical method, Sensitivity analysis.*

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## **Extended Abstract:**

### **1. Introduction**

Drill bits with a high degree of sensitivity and vulnerability are one of the most basic components in drilling efficiency, which have the highest drilling costs in open pit mines. Wear destroys the surface of the bits and reduces the efficiency of the device and makes it difficult to achieve the optimal penetration rate. This will result in the loss of time in the drilling process which will have a lot of cost. Examining the parameters affecting the wear of bits can prevent the wastage of time and additional costs in the drilling process by reducing the effects of wear.

### **2. Materials and methods**

In general, the effective parameters in the wear of drilling bits can be analyzed in three sections: rock properties, operation parameters and management parameters. Among these parameters, operation parameters are controllable parameters or dependent parameters. Parameters related to rock properties are considered as uncontrollable parameters or independent parameters in the process of drilling bits. Based on the studies of various researchers, the physical, mechanical, structural and environmental properties of the rock and operational parameters have been studied. In this study, among the physical properties affecting the wear of tricone rotary bits, 7 parameters are density, porosity, Equivalent Quartz Content (EQC), silica content ( $\text{SiO}_2$ ), alumina content ( $\text{Al}_2\text{O}_3$ ), the average grain size (GS) and rock texture (TC) and, among the mechanical properties, there are three categories of strength parameters (Uniaxial Compressive Strength (UCS) and Brazilian Tensile Strength (BTS)), hardness indices of rock (Schmidt hammer (SH) and Mohs hardness) and abrasion indices of rock (Schmiazek F-abrasivity factor (SF-a) and Rock Abrasivity Index (RAI)) and among the operational parameters of Weight On Bit (WOB) and bit rotation speed or bit Revolutions Per Minute (RPM) has been investigated.

Apart from the parameters studied by the researchers, due to the importance of weathering and alteration of rocks and structural joints and discontinuities on the drilling process and bits wear, chemical alteration intensity index (CIA) and rock mass classification systems such as Rock Mass Rating (RMR) And Geological Strength Index (GSI) has also been studied in this study.

After selecting the effective parameters, the range of changes of each of them is determined to cover all conditions. In this research, in order to evaluate the factors affecting the tricone rotary bits wear in Sarcheshmeh copper mine, through the weight loss of wear, 29 bits have been calculated. The database is used to determine the effective physical, mechanical, structural properties of rocks and operational parameters using laboratory studies (chemical analysis, study of thin sections and laboratory tests), field studies and database in Sarcheshmeh Copper mine research and development center, created based on 10 different rock samples. Then the type of relationship between input and output parameters is determined. To determine the relationship between the studied parameters and the tricone rotary bits wear, the effect of each of these parameters on the wear rate has been determined separately.

### 3. Results and discussion

Based on the analysis of the results, not all variables have a good relationship with the tricone rotary bits wear. Among the physical properties of rocks, only the average grain size and texture coefficient has a significant relationship with the dependent parameter (the tricone rotary bits wear). In the other variables, there is no definite trend that indicates a low correlation of these parameters with the wear rate or the range of changes in the values of the parameters is too small to turn these parameters into a characteristic and cannot be described as a variation.

According to the results obtained from the mechanical properties of rocks, all parameters except the Mohs hardness show a significant relationship with the dependent variable, which indicates the high correlation of these parameters with the wear rate. Apart from physical and mechanical properties, the relationship between the bit wear rate and two structural properties has been investigated, which shows that the dependent parameter has a direct and significant relationship with the GSI and RMR classification systems.

Also, the relationship between the operational parameters with the tricone rotary bits wear has been determined, which shows a good trend and a significant relationship between the dependent variable and the tricone rotary bits wear and the rotational speed of the drilling bits.

Then, using sensitivity analysis, the magnitude of the effect of input parameters on the target is determined. The results of these analyzes show that all the parameters of the study except the CIA, porosity and EQC on the desired output (the tricone rotary bits wear) and small changes in their amount lead to fundamental changes in the tricone rotary bits wear.

### 4. Conclusion

Bits are one of the main tools of drilling operations and they are responsible for breaking and crushing the stone. The bits are worn during drilling due to various parameters and the bits need to be replaced, which leads to a lot of time and cost. Analysis of drilling bits in terms of wear can be a good step to reduce mining costs in the priority of companies and other factors related to the project. In this study, in order to evaluate the factors affecting with the tricone rotary bits wear in Sarcheshmeh copper mine, through the weight loss, the wear of 29 bits has been calculated. Using laboratory studies (chemical analysis, study of thin sections and laboratory tests on 10 rock samples), field studies and database in Sarcheshmeh Copper Mine Research and Development Center, a database to determine the effective physical, mechanical and rock structural properties and operational parameters are created. Then the type of relationship between input and output parameters is determined. Finally, using sensitivity analysis, the amount of impact of input parameters on the target is determined. The results of these analyzes show that most parameters, except for the CIA, porosity and EQC to rock, affect the tricone rotary bits wear.