Control of Iron Ore Extraction to Reduce Dilution in GoharZamin Mine

Morteza Ghaffari[1], Ali Mirdar Mansour Panahi[2], and Mahnaz Hassani[3]

[1]Master of Mining, Islamic Azad University, Sirjan, Iran
[2] GoharZamin Mine's Affairs Management
[3]Substitute for GoharZamin Mine's Affairs

Abstract
Dilution in mining operations is a very important and technically and economically effective factor. The dilution factor in a surface mine varies for different levels. This difference is due to changes in the grade distribution and mineral placement shape with the tailings at the structural boundaries. By creating the dilution, tonnage of the input materials to the processing plant increases, and the grade decrease. This increases the operating costs of the plant. In this paper, several methods of dilution control during extraction operations are performed in the fronts located within the boundaries of the mineral with tailings in Goharzamin iron ore mine. The method of extraction and separation operations in mixed fronts can play an effective role in reducing the percentage of dilution and increasing the efficiency of extraction operations. With the implementation of these methods, it is observed a reduction in the rate of dilution and proper separation of iron ore from tailings while maintaining a high rate of production in mixed areas.
Keywords: Dilution, Separation, Open Pit Mines, Iron Ore Mine, GoharZamin Iron Ore Company

Introduction

Goharzamin iron ore mine is located in Kerman province, 50 km southwest of Sirjan city. The study area is structurally located in the southeast of the Sanandaj-Sirjan metamorphic belt and the drop edge of Kheyrabad-e Kaffah salt flat. The mine has a reserve of 643 million tons of ore. The purpose of mining is the economic extraction of minerals. But the phenomenon of dilution, which is the mixing of tailings with minerals, has a significant impact on the direct and indirect costs of mining.

Addition of tailings reduces the ore grade and increases the input tonnage to the processing plant. Dilution reduces the grade of mineral and then costs to compensate for the grade defect. Dilution control in active and working mines is often done by grade control, which is the most important controllable part of mine profitability. In a general division, dilution is divided into two categories: planned or internal and un-planned or external. Numerous cases of dilution will be subject to internal dilution. This means that the ore or tailings is completely inside the other. External dilution is the result of the juxtaposition of geological structures. Dilution increases the operating cost of the processing plant because the input tonnage to the plant increases by diluting. In addition to affecting the short-term income of a mine, the overall value of the mining project will be reduced in the long time. Dilution can also be effective in reducing the rate of production. The reasons for the dilution are related to 1- The structure or shape of the deposit 2- Due to the estimation error at the location of tailings boundaries with the mineral 3- Explosion 4- Operational errors. Identifying mixed areas before the extraction operation to achieve the desired economic value should be on the agenda. The movement of ore due to fire has an adverse effect on the separation of ore from tailings and will lead to a reduction in grade. This leads to a reduction in mineral production for a long time, undesirable material handling and ultimately reduced profits. Explosion motion monitoring has shown that bottom flitch of explosion has more horizontally move than top flitch. The explosion moves the rock, making it more difficult to distinguish between ore and tailings. Mines must accept some dilution at the time of explosion and extraction operations. But this mixing should be kept to a minimum. In surface mines, the parameters that can affect the degree of dilution are either related to the deposit or mining. Stair height in surface mines is a parameter affecting dilution and related to mining. Increasing the height of stairs can lead to increased dilution. The dilution rate is calculated directly by the number of tailings extracted as the total amount of tailings and ore extracted according to Equation (1).

$$w / (w + o) \times 100\% = \text{percentage of dilution}$$

In this equation w is extracted tailings and o is extracted ore. The presence of dilution in the fronts located at the boundary between tailings and minerals, is obvious, but the intensity of mixing of tailings and minerals should be reduced by performing appropriate extraction operations. Other definitions of dilution are presented in table 1.

Table 1. Different definitions for calculating dilution

row	definition
1	(Extracted tonnage) / (Extracted mineral tonnage)
2	*Non − diluted grade obtained from drilled holes / grade of samples taken from discharge points*
3	*Difference between loaded tonnage and fired tonnage / fired tonnage*
4	*grade of un − diluted reserves / grade of the same ton in the ore plant*

2. Discussion plan

One of the reasons for the development of dilution is operational errors and the method of execution of extraction operations after firing at the site of tailings and mineral boundaries. So that the extraction operation in such areas should not be done according to the usual methods, but by performing various separation operations, before and during loading, the intensity of dilution in these contaminated fronts can be greatly reduced. According to the geological information obtained from the explosion holes, the condition of placing the deposit can be determined. Based on this data, the most appropriate method for separation operations can be selected. The proposed methods increase the extraction speed by reducing the cost of bulldozing operations and maintaining the accuracy of separation operations. By performing different loading, the separation can be done with high accuracy by the loader himself, which will increase the efficiency of the extraction operation. In this article, three methods of separation operations for different conditions in fronts that have a tailings boundary with the mineral, are proposed and presented.

1- Platform method

The platform separation method is used when, based on the information obtained from the blast holes, it is determined that the ore is located at the bottom flitch throughout the pattern and the tailings are on it at a higher height. In this method, the extraction operation begins by placing the loader in the end direction of the pattern length after the explosion. The loader moves in a reciprocating motion across the width of the pattern. This continues until the boundary between the materials is defined. The height of the material exploded by the bulldozer decreases with the movement of tailings material towards the loader and their loading, and the advance on the separation boundary continues. Then, by creating a sloping access path, a platform is created to place the tracks on the separated material in front of the loader. Therefore, as the loader advanced into the pattern and the tailings operation was performed, an ore platform at the bottom of the explosive pattern remained. Upon completion of the disposal, the ore platform is loaded by the remaining separation operation. According to figure 1, in fact, the platform separation method tries to make the mineral, located at the bottom and at a low height of the pattern, into a platform which allows the loader to be loaded without mixing, by placing the tracks on it, and move towards the end of the pattern.

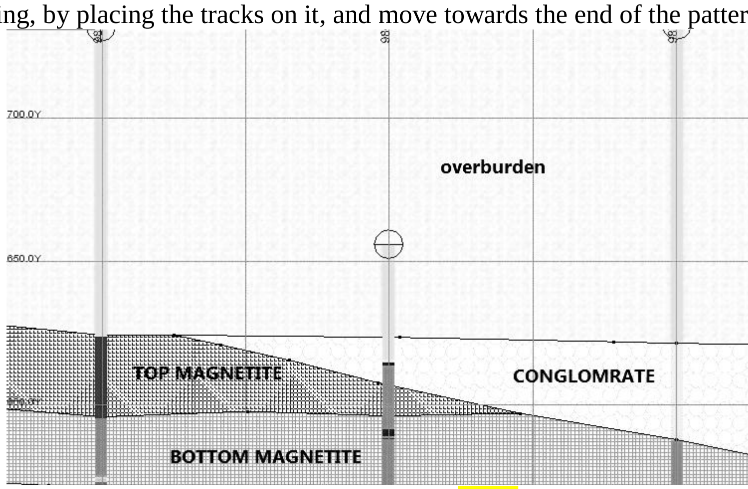

Fig.1. Existence of high-height waste on iron ore

2- Ramp top method

In some cases, information from explosive holes indicates the presence of a low-altitude mixing boundary above the pattern. In this case, by placing the loader from the top of the exploded pattern, the extraction operation begins in a sloping direction along the length of the pattern. In this case, loading is done by creating a sloping path from one end edge of the pattern to the border. The trucks are placed at the top of the pattern and also at the ramp created on the crushed material from the explosion, perform the loading operation.

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

The ramp continues to advance along the length of the pattern until the separation boundary is defined. After creating the ramp completely in line with the length of the pattern, in the next step, the loader loads the ramp against the direction of its construction and proceeds to the entrance of the ramp. With performing the second stage of the separation operation, the boundary between the tailings and the mineral, which are in fact the constituents of the ramp, is completely cleared, (figure 2).

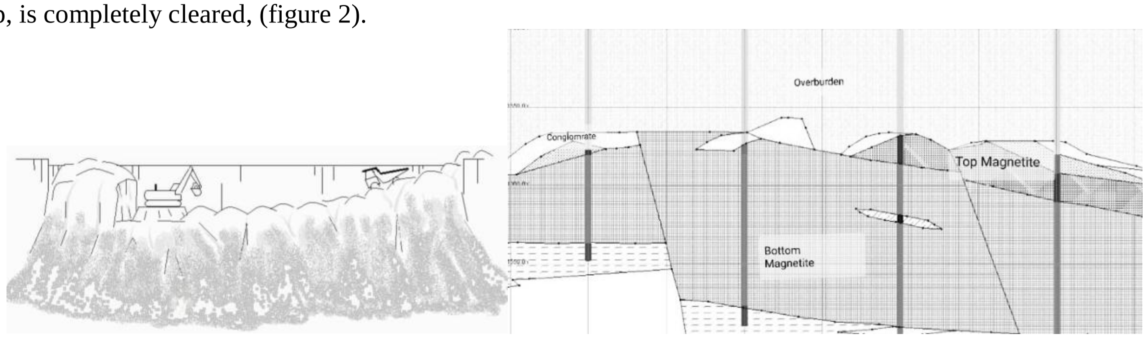

Fig. 2. Creating a ramp top to perform extraction and separation operations simultaneously

3-Interlayer separation method

Sometimes the exploded pattern contains several layers of ore and tailings. In such cases, we will have a very high dilution by performing the usual loading operations. In these geological conditions, in order to extract the ore and reduce the dilution percentage, the extraction operation is performed by bulldozing operations for separation. This separation method is much more common and widely used in mines.

The loading system starts the extraction operation from one side along the length of the pattern. The separation operation is also started by the bulldozer along the length of the pattern towards the loader. The remarkable point in this method is that loading and bulldozing operations must be done simultaneously; because if the bulldozer operation is stopped, the loader will enter the contaminated area as the loading operation progresses. This leads to an increase in the percentage of dilution. On the other hand, if the loading operation is stopped, the depreciation of the bulldozer operation will increase and it will be stored on the load.

After reaching the separation boundary, the operation of the bulldozer can continue in the same direction as before, i.e., in the direction of the loader or in the opposite direction. This method is very useful in case the separation boundary is widely repeated in the extraction block, (figure 3).

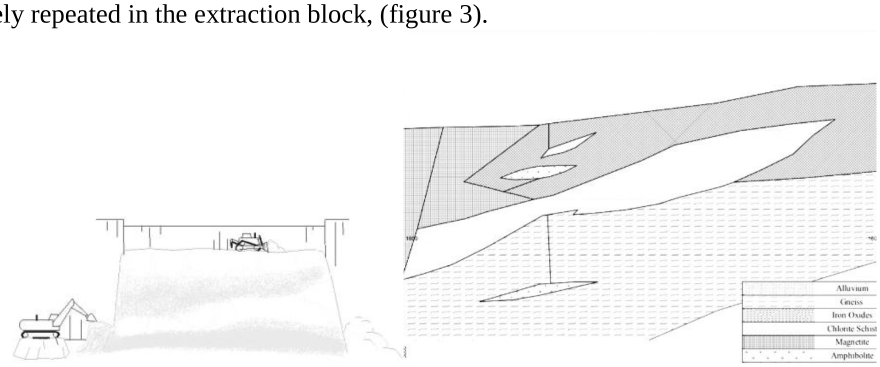

Fig. 3. Interlayer separation

Conclusion

The phenomenon of dilution is very effective as a result of the economics of mineral extraction. After identifying the boundaries of tailings and ore by geological information in the extraction blocks, the control of dilution in the last step is the responsibility of the extraction operation. With the help of the proposed methods and the development of new methods, the experts of the extraction operation plan can implement the separation operation as accurately as possible in order to reduce the dilution percentage and present their experiences in different mixing zones as practical methods such as those described in this article.

References

Advances in reducing large volumes of environmentally harmful mine waste rocks and tailings", Department of Applied Sciences , University of Québec at Abitibi-Temiscamingue (UQAT)

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

Mohseni M. Atai M. Kakai R. 2018. Evaluation and Prediction Models in Underground Metal Mining Workshops, First National Conference on Modeling in Mining Engineering and Related Sciences.
Atai M. 2005, Special topics of underground mining, Shahroud University of Technology, 933 p.
4. Poniewierski, J .2016." Block Model Knowledge for Mining Engineers – An INTRODUCTION" Senior Mining Consultant, Deswik
5. Ebrahimi, A.2013." An Attempt to Standardize the Estimation of Dilution Factor for Open Pit Mining" World Mining Congress, Montreal
6. Amirá, R. Morales, N and Cáceres, A.2018." Analysis of the Impact of the Dilution on the Planning of Open-Pit Mines for Highly Structural Veined-Shaped Bodies" 27th International Symposium on Mine Planning and Equipment Selectionc
7. Charles Mtoni, M.2018." Ore Dilution Estimation Model in Tanzania Southern Highland Zone: A Case of New Luika Gold Mine" International Journal of Science and Qualitative Analysis, pp. 7-12
8. Leite, F. Domingo, J. F. Carrasco, I. Gouveia, V. Navarro, I. Lozano, F.2014."Dilution, ore grade and blast movement calculation model" Elsiever Ltd.
9. Eshun, P. A. Dzigbordi, K. A. 2016 . "Control of Ore Loss and Dilution at AngloGold Ashanti, Iduapriem Mine using Blast Movement Monitoring System", Ghana Mining Journal, Vol. 16, No. 1, pp. 49 – 59
10. Xingwana,L.2016. " Monitoring ore loss and dilution for mine-to-mill integration in deep gold mines: a survey-based investigation" The Southern African Institute of Mining and Metallurgy
11. Soltanmohammadi, H. Osanloo, M. Sami,A. Malekzadeh,Sh. 2010." Selection of practical bench height in open pit mining using a multi-criteria decision making solution" Journal of Geology and Mining Research Vol. 2(3) pp. 48-59
12. Wang ,W. Huang,Sh. Wu, X. Ma, Q. 2011." Calculation and Management for Mining Loss and Dilution under 3D Visualization Technical Condition"Journal of Software Engineering and Applications