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Relevance of Geology and Physicomechanical Parameters in Predicting Rock Bursts

Rodhe Krishna[1], Ahmed H. Ahmed[2], Buda Besa[3] and Sunday Mulenga[4]
(1, 3, and 4 are professor, senior lecturer and lecturer in the Department of Mining Engineering. 2 is a lecturer in the Department of Geology)

Abstract: This paper describes the seismological approach for predicting rockbursts in mining. Geological, physico-mechanical and mining factors, which are also contributing parameters to cause rockbursts, are considered. While it is still not possible to eliminate rockbursts hundred per cent, perhaps the risk of their occurrences can be minimised if it's some indications can be predicted. Several inaccuracies are still inherent in the analysis of the results obtained in methods proposed. The largest source of error lies in the assumption made in determining the stress distribution associated with each rock breakage. The fracture theory may not be adequate in explaining some of the more complex rock fracture phenomenon caused due to the change in stress. As such, it is important to understand the physics of rocks in order to reduce the possibility of rockbursts.

Keywords: rockburssts, rock fracture, stress-strain relation, tactical planning, distressing, geological properties

Introduction

Rockbursts are one of the most dreadful operational hazards of mining. While it is still not possible to eliminate them, perhaps the risk of their occurrences can be minimised if its occurrences can be predicted. Some notable studies have been reported on the phenomenon of rockbursts, Cook et al (1966), Chamber of Mines (1933, 1972, 1977), McGarr and Wirbold (1967), Steel and Ortlepp (1972), Sportt, wood et al (1978). Although considerable attention was given to collecting observed data on rockbursts, particularly during the early stages of research, it was appreciated that more detailed investigations were necessary in order to identify and classify the role of the principal factors.

However, it was realised soon that purely practical attempts to solve rockburst problems were insufficient and inadequate. The need for formal investigation of mechanism of rockbursts was recognised and the corresponding measures to be taken to prevent their occurrences.

However, laboratory research work was undertaken which was arrived at clarifying the behaviour of rocks under stress and in particular, to identify examine the deformation characteristics and mechanisms of failure of brittle rocks. Significant achievements were made in understanding the mechanism of the rockbursts as a result of such investigation work.

In the meantime, theoretical studies were carried out by Salmon (1964) who successfully applied the theory of elasticity to simulation of the behaviour of the rock mass surrounding mining excavations and thereby provided an efficient method for the study of the stress configurations around underground openings induced by mining.

High stress concentrations can be induced in the vicinity of the openings causing new fractures in the solid rock. Some traditional methods of predicting rockbursts such as statistical analysis, deformation method, Seismoaccoustic method, the method based on the electric conductivity of the rock, a method based on the heat conductivity of the rocks and radio isotope methods. However, the supersonic method, the heat conductivity and the radio isotope method are still in the stage of theoretical or experimental stage and have not yet been sufficiently developed. The development of strategic planning has shown the reduction and even prevention of rockbursts. These include mile layout and sequencing, stoping geometry, backfill support, partial extraction and stope preconditioning. The tactical mining techniques can minimise the impact and also the damage resulting from rock bursts. Appropriate support systems such as rock grouting and belting etc. and distressing will give added advantage in mitigating rockbursts.

Traditional Methods of Measuring Rockbursts: Their Merits and Demerits

The earlier researches have shown that to conduct rockbursts, the …and deformation zones around the workings should be studied to determine the loci of the rockbursts and their energy.
The following methods were used:

1. Statistical analysis
2. Deformation method
3. Seismoaccoustic method
4. The method based on the electric conductivity of the rocks
5. Seismological method

The supersonic method, the heat conductivity method and the radioisotope method are still in the stage of theoretical and experimental stage and have not yet been sufficiently developed.

Statistical Method

The results obtained were systematically analysed which show a relationship between the number of rockbursts and the geological conditions, the depth of deposits, the type of winning methods.

Deformation Method

In this method, deformation and movement of the strata were determined both in the workings and on the surface, above the deposits. Because they are simple to use, deformation methods can be extensively used. These instruments are based on the mechanical, hydraulic and electric principles. The instruments used must be of great precision

Seismoaccoustic Method

When the loading exceeds the elastic limit of the rock, micro seismic disturbances are set up. This phenomenon can be used for investigating the destructive process in rocks. The problem in this case is to determine whether theses indications occur from disturbances arising from strata, which in case of rock bursts lasts for a very short period i.e. a few seconds.
This method is generally used as a normal operating practice to predict rockbursts.

The Seismological Method

In this method, mechanical parameters of the rock in which the rockbursts occur…the instrument used should be quick recording seismographs are placed within the area of the rockbursts (preferably VEGIG seismography.

The other equipment required is the galvanometric photo-recorder. All the seismic stations have to be connected by telephone which transmits time signals through the chronometer (quartz crystal clock). The radio time signal is recorded simultaneously directly on charts. In this system, the time indication on the charts are precise to within $\pm$ 0.2 seconds.

From the transit time caves for wave P, the average spread of their propagation V_p and V_s can be determined. By analysing the field of seismic waves, the mechanism of the forces in the rock bursts can be investigated.

Results of previous studies on the seismic activity of rockbursts have shown that for the individual area, a statistical relationship exists between the recurring rockbursts value N, and the corresponding energy E, which is empirically
$\text{Log } N = A - Y \log E$
Where A is the seismic activity i.e. the number of rockbursts of the energy unit E_o.
Y = constant – its value falls between 0.3 when there is no activity to 0.6 when mining activities are taking place.

The relationship between the values A, Y, E_{max} and their development with time offer new possibilities for predicting rockbursts.

Experiences from Past Studies

From the general laws of rock failure, the surface of focal region which is practically the main source of seismic waves…

By using seismic methods, the researchers have attempted to determine the origin of the bursts and the results obtained are quite appreciable.

It is further reported that the strain energy release rate attains the critical value of the rock mass. The crack propagation will take place. The crack propagation has been found to increase exponentially with the stress intensity factors and some other parameters. A general expression for crack progation velocity is given by (Wiederhorn and Boez, 1970) as follows:

$V = V_O \text{Exp} - \frac{Q}{RT} [\text{Exp} \frac{V(\sigma_{max} - \sigma_0}{RT} - 1]$

Where V = crack propagation velocity
V_0 = A material constant
Q = activation energy
R = Gas constant
T = Activation volume
σ_0 = Threshold stress which must be …to cause crack proration
σ_{max} = Maximum stress at a distance from the crack

The mechanism of rockbursts as reported by previous researchers indicate that the strain energy release rarely exceeds the critical value and the seismic energy i.e. radiated in the form of kinetic energy which is subjected to tensile waves followed by compressive waves, then followed by tensile waves and so on.

Due to the low tensile strength of rock materials, the compressive waves cause local violent crushing and rockbursts.

The total static and dynamic stresses are magnified in such a short period that rock structures are disintegrated dynamically and explode violently to cause rockbursts. This may cause severe damage to underground excavations and even structures and can be hazardous to mine personnel and others. This dynamic process usually causes a huge fracture zone.

The analysis of these reports endeavoured to …guidelines giving fundamental principles in the alleviation of the rockbursts hazards that include excavation layout, excavation support system, uniformly in strain energy release rate and geometrical features and dynamic energy mainly by avoiding short edges. In order to reduce the potential occurrences of rockbursts, it is necessary to eliminate or achieve improved control of the conditions in which rockbursts can occur.

High stress concentrations and high strain energy release rate should be avoided. These features should be considered in the design stage of the mining operations. The development of effective strategic planning has shown merit in the reduction in the control of rockbursts.

The developments in tactical mining techniques can effectively minimise the damage resulting from rockbursts. The importance of appropriate support systems for instance grouting and bolting and effective distressing techniques cannot be undermined.

Effects of Geology and Physico-Mechanical Parameters

Two main factors, geology and physicomechanical, properties of rockbursts are the geological and physiological characteristics (Whittaker 1984).

The microstructure of rock is complicated as being composite like materials. They are composed of grains of various sizes, shapes and mineral compositions which are finally cemented together to form these materials. The grains have different anisotropic physic-chemical and mechanical properties. Micro cracks, heterogamous features, anisotropic properties, micro fissures and voids are commonly present in rocks. Some of these characteristics are formed during their formation whereas the others have been newly created during tectonic disturbances through chemical and physical erosion.

Induced stress concentration isgenerally referred to as locked in stresses. Tan and Kang (1981) report that the locked-in stresses are directly related to rockbursts in a manner:

(1) Increasing local stress intensity
(2) Conversion of potential energy to kinetic energy releasing the locked-in stresses and causing the conversion of potential energy to give rise to seismic activities.

Role played by major weaknesses such as fault fractures and dykes are known to cause local anomalies which in turn give rise to localised rockbursts. Seismic investigations have indicated that a large number of seismic events had their epicentres at or close to fault planes, fractures and dykes.

The analysis of the physical and mechanical properties of rocks based on laboratory tests, the following parameters seem useful to indicate the centre (epic) of the rockbursts. These are:

- Young’s moduls of elasticity
- Shearing modulus of elasticity

- Lame's elasticity parameters
- Modules of compressibility

Where $K = \frac{V_p}{V_s}$

These elastic properties can change under the influence of the changing stress conditions in the rocks. The changes in the mechanical properties of the rock which changes the spread of the speed of the seismic waves as a result of disturbance caused in the area.

Concluding Remarks

The discussion in this article has endeavoured to draw attention to guidelines giving the general principles of rockbursts mechanics which are applied in underground excavations.

In order to reduce the potential occurrence of the rockbursts, it is necessary to eliminate or achieve informed control of the conditions in which the rockbursts can occur. High stress concentrations and high strain energy release rate should be avoided. These factors should be considered in the design of mine structures and mining operations.

The development of effective strategic planning has evidently shown merit in the reduction and even prevention in addition to control of rockbursts. These developments include mine layout and sequencing, stoping geometry, backfire support, partial extraction.

The objectives of these design principles will achieve the ultimate goal of rockbursts alleviation.

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