MINING METHOD SELECTION METODOLOGY BY MULTIPLE CRITERIA DECISION ANALYSIS - CASE STUDY IN COLOMBIAN COAL MINING

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ABSTRACT

The purpose of this paper is to present an application of the AHP technique to a mining method selection problem faced by a Colombian mining company; in this case we use five decision makers. Next, a final aggregation of criteria priorities by AHP and ENTROPY is proposed for include subjective and objective weighting. Next, VIKOR method is performed to present a compromise solution; VIKOR is used to solve the problem without decision makers dependence; the weights for VIKOR are aggregated using an a priori λj subjective weighting obtained from AHP method. Whereas entropy weighting provides a dynamic and objective assessment of all criteria, AHP weighting determine all decision makers preferences. Finally, an analysis of the results is carried out to derive conclusions in relation to the effects of the modeling processes of both techniques.

Keywords: Multicriteria decision making, selection problem, AHP, VIKOR, Entropy weighting.

1. Introduction

A mining company wants to choose the most suitable alternative for extracting coal deposit located on the western side of Cerro Tasajero, Norte de Santander, Colombia. This site was carefully studied by an interdisciplinary group of Geologists and Engineers (among others).

Table 1. Technical parameters Seam 20
Source: Own development based on information from the mining company

Parameter	Quality
Thickness	between 0.90 m y 2.10 m
Depth	600 m
Type	Patty/Tabular
Grade distribution	Uniform
Plunge	Entre 12° y 20°
RSS (rock substance strength)	Very Narrow
RMR (rock mass rating)	between 21 y 40

2. Literature Review

The selection of extraction methods in mining is one of the oldest challenges of humanity and has been studied widely, about the most relevant scientific literature begins with the first qualitative classification schemes extractive methods selection (Boshkov and Wright 1973). In subsequent studies a classification system divides underground mining into three groups based on ground conditions assigning each type of support required (Morrison 1976). Laubsher (1981) proposes a selection methodology for underground mining method based on the RMR system (rock mass rating). The first approach to a quantitative selection method is developed when David E. Nicholas (1981) with a numerical approach for the selection of extractive method (Selection Procedure - A Numerical Approach); in this method a scale is formulated for the weighting of each extraction method. Subsequently Hartman (1987) developed a qualitative selection scheme based on reservoir geometry and ground conditions to choose the extractive method. Next, (Miller et al 1995) modified the Nicholas method adding several criteria. At present there are some approaches to the problem of mining method selection by MCDA which include the application of fuzzy logic (2004 Bitarafan and Ataei Karadogan and others 2008) and we can find varied applications of AHP (Alpay and Yavuz 2009 , Azadeh et al 2010 and Bogdanovic et al 2012).

3. Hypotheses/Objectives

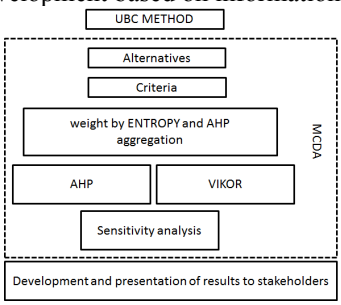
This study wants to contribute to mining planning and design process. The problem of selecting the mining method becomes the most important aspect of mining activities, and you should select the method that best fits the unique criteria of each location, such as spatial, geological, hydrogeological, geotechnical and other considerations such as economic, technological and environmental factors. The performance of a subjective and objective methodology will try to support the hard process of select the most suitable mining extraction alternative.

4. Research Design/Methodology

For MCDA will be taken as valid alternatives which have a positive weighting to apply the technique UBC (Miller-Tait et al., 1995) thereby eliminating alternatives that are not only technically feasible and applicable alternatives left. While there are a good amount of extractive methods, this problem only considers 9 of the 10 methods described in (Nicholas 1993) and (Hartman & Mutmansky 2002): Alternative 1 (Open pit), alternative 2 (Block caving), alternative 3 (Sublevel Stopping), alternative 4 (sublevel caving), alternative 5 (long wall), alternative 6 (room and pillar), alternative 7 (Shrinkage Stopping), alternative 8 (Cut and fill), alternative 9 (Square set).

Criterion 1 Spatial characteristics of the deposit.
Sc1. Size - Maximize
Sc2. Shape - Maximize
Sc3. Plunge - Maximize
Sc4. Depth - Maximize
Criterion 2 Geological and hydrogeological conditions and geotechnical properties.
Sc5. Distribution - Maximize
Sc6. Rock mass ratings (RMR) - Maximize
Sc7. Rock substance strength (RSS) - Maximize
Criterion 3 Economic considerations
Sc8. Performance rate - Maximize
Sc9. Production - Maximize
Sc10. Capital Investment - Minimize
Sc11. Productivity - Maximize
Sc12. Comparative costs of possible mining methods. Minimize
Criterion 4 Technological factors
Sc13. Mine Recuperation - Maximize
Sc14. Dilution - Minimize
Sc15. Flexibility - Maximize
Sc16. Selectivity - Maximize
Criterion5 Environmental Considerations
Sc17. Stability of the openings - Maximize
Sc18. Subsidence or effects on the surface of excavation - Maximize
Sc19. Health and safety conditions - Maximize

Figure 1. Proposed methodology for mining method selection
Source: Own development based on information from the mining



5. Data/Model Analysis

Figure 2. Aggregation of weigths
Source: Own development based on information from the mining company

								Aggregation	Aggregation
	D1	D2	D3	D4	D5	geometric mean wj	entropy wj	λwj	geometric mean wj
C1	0,390	0,206	0,156	0,090	0,029	0,157	0,173	0,118	0,162
C2	0,061	0,405	0,180	0,377	0,230	0,257	0,130	0,168	0,193
C3	0,226	0,032	0,458	0,255	0,533	0,264	0,329	0,473	0,324
C4	0,113	0,081	0,031	0,117	0,074	0,093	0,212	0,081	0,134
C5	0,210	0,276	0,176	0,161	0,133	0,229	0,155	0,159	0,188

Figure 3. Hierarchy and AHP results
Source: Own development based on information from the mining company

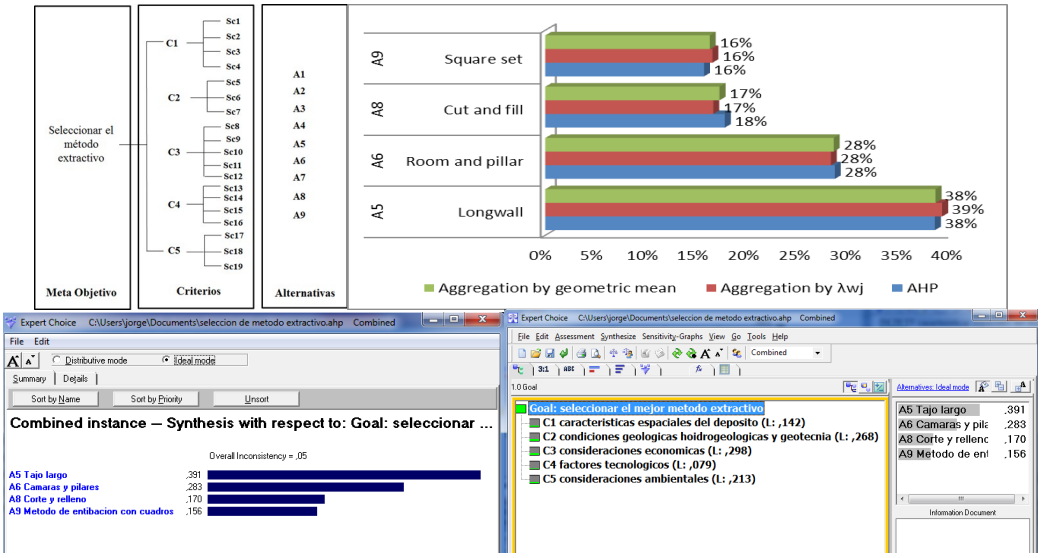
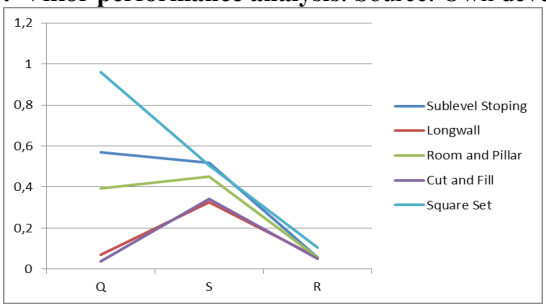


Table 2. VIKOR results. Source: Own development

Figure 3. Vikor performance analysis. Source: Own development



6. Limitations

The limitations of this study are the time for apply the a priori λwj aggregation in the performance of VIKOR method. For the final paper, this issue will be solved and the final data will be presented with a new analysis. The software used to implement the AHP technique is Expert choice ®, but for the final paper it will be used also Super decisions ®. An extension of 5 pages isn't enough for describing the UBC, ahp and VIKOR method, for UBC we suggest reader to consult (Miller-Tait, Pakalnis, & Poulin, 1995), AHP (Bellver & Martinez, 2013) and for the VIKOR method (Aghajani Bazzazi, Osanloo, & Karimi, 2011) and (Opricovic & Tzeng, 2004). For a detailed study of this problem we suggest to review two own documents about it, in it we show the evolution of the authors knowledge in this subject.

1. http://www.enid.unal.edu.co/2012/memorias/fscommand/recursosmateriales/31.pdf

2. https://drive.google.com/file/d/0B4g9XmTGucs8amtkWXltU1lhU0E/edit?usp=sharing

7. Conclusions

The results Vikor, show a set of compromise solutions (cut and fill - long wall) which are accepted by experts involved in the decision process. The results of the AHP method show decision makers preferences for "long wall" in this particular problem. The overall inconsistency was 5%. Finally for this deposit the company used long wall method, a finding consistent with the subjective and objective analysis proposed in this methodology. The results obtained in this work allow evidence as this Methodology Vikor-AHP, works to improve the process of decision-making, since it allows structured in a logical way a lot of information, both the problem and the possible solutions that can be pose.

8. Key References

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