2024 ENGINEERING INSTITUTION OF ZAMBIA SYMPOSIUM

DECISION MAKING FOR AN OPTIMIZED COBALT AND COPPER DISSOLUTION AS ASSISTED BY THE MULTI-CRITERIA ANALYSIS

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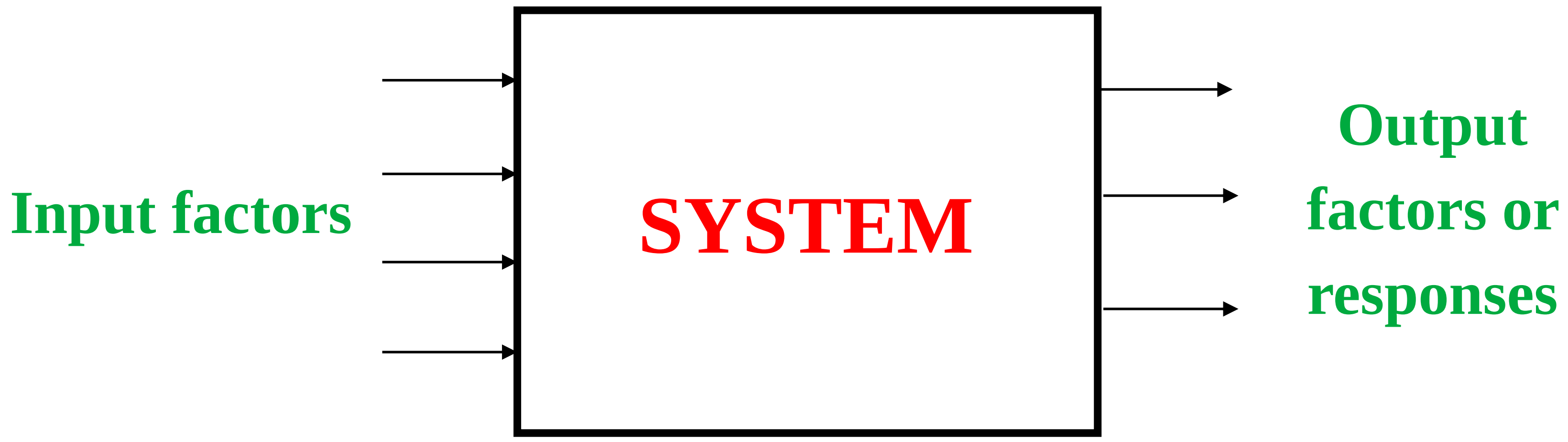
Co-Cu ore dissolution optimized by means of MCDA

Outline of the presentation

Co-Cu ore dissolution optimized by means of MCDA

- **Context of the study**

- **The system being studied is the leaching (dissolution) of Cu-Co ore**
- **The leaching system is modeled as a MIMO (multiple-input and multiple-output)**



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- **Context of the study (cont'd 1)**

- **In this system (leaching of ore),**

  Some input parameters may exhibit interactions

  Some output parameters or responses may be correlated

  Certain input and output variables may have dependencies or independences

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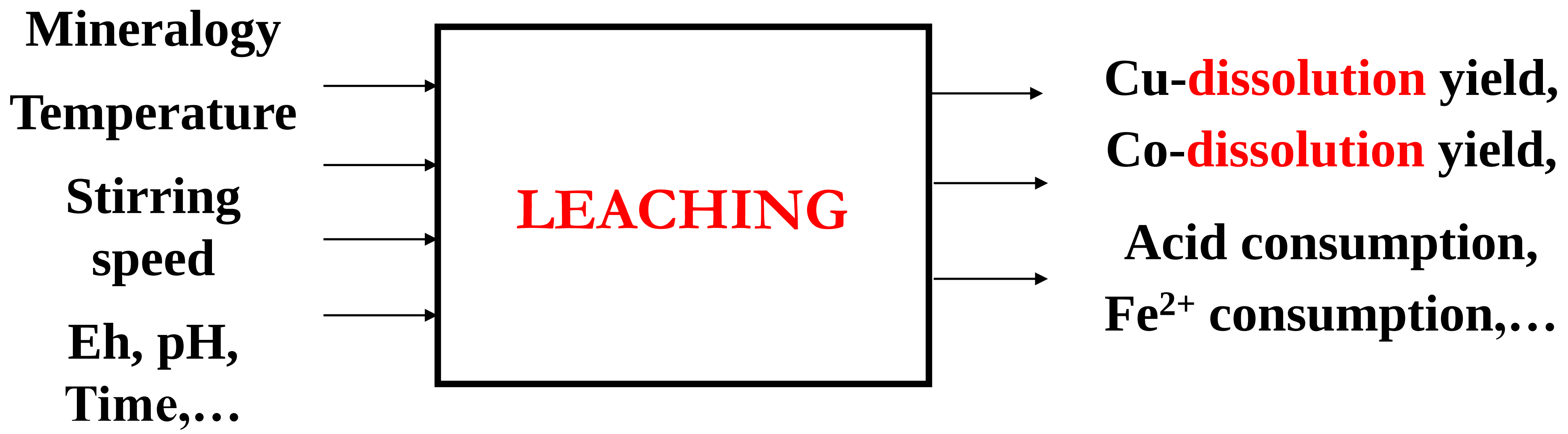
- **Context of the study (cont'd 2)**

- **Schematically**



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- **Motivation of the study**

- **To improve the dissolution of Cu-Co ore, MCDA is employed**

MCDA allows us to select one or more optimal solutions, in the Pareto sense, from a discrete set of possible solutions.

MCDA is used for the following reasons:

- ✓ **It enables the representation and hierarchical decomposition of complex problems into separate elements.**
- ✓ **It logically groups and classifies elements according to coherent and logical criteria.**

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- **Aim and objectives**

- **The purpose of this study is to optimize and analyze the factors that influence the recovery of Cu and Co.**

- **The specific objectives of the study are as follows:**

  - ✓ **To examine the relationship between input and output variables.**

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- **Aim and objectives (cont’d)**

- **The specific objectives of the study are as follows:**

  - ✓ **To assess the influence of each input parameter on the dissolution of Cu and Co**
  - ✓ **To establish the criteria for optimizing the recovery of Cu and Co.**
  - ✓ **To determine the optimal conditions for the dissolution of Cu and Co from a complex ore.**

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- **Background**

- **Tapia et al., (2023) have drawn up a table showing how uncertainty is assessed in sustainable system planning using multi-criteria decision analysis methods**

- **Mbuya and Mulaba (2023) suggested MCDM (multicriteria decision making) methods by showing the importance of using these methods to study a leaching system, with multiple inputs and multiple outputs (MIMO), optimized by the response surface methodology (RSM) and artificial neural networks (ANN).**

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- **Background (cont'd 1)**

- Baloyi and Meyer (2020) evaluated multi-criteria decision methods in detail to develop a mining method selection model.
- Among multicriteria decision methods, the Analytical hierarchy process (AHP) method is well known, very popular, widely used and documented (Gass and Rapcsak, 2004; Mardini et al., 2015; Perzina and Ramik, 2014; Patia et al., 2023).
- Several works that have used AHP have been reported in the literature (Rauscher, 2003; Kostagiolas, 2012; Abdullah et al., 2013; Saranya et al., 2021).

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- **Background (cont'd 2)**

- **AHP was developed by Saaty and then extensively studied and refined (Saaty and Peniwati, 2008; Saaty, 2008).**
- **The AHP method integrates various criteria to arrive at a justified choice of technology. When the decision is made using this method, it is considered to be rational, systematic, and correct.**
- **It provides a complete and rational framework for structuring decision-making, representing, and evaluating elements, in order to link them to objectives and evaluate alternative solutions (Roy, 2005).**

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- **Methodology**

- The laboratory conducted leaching tests by combining varying quantities of crushed ores, which passed through a 75 µm sieve, with sulfuric acid (98% H_2SO_4) in a 1000 mL beaker.
- These tests followed the Taguchi L_{25} experimental design (5^5).
- The parameters investigated included time (2, 2.5, 3, 3.5, and 4 h), percentage of solid (20, 25, 30, 35, and 40%), stirring speed (500, 600, 700, 800, and 900 rpm), sulfuric acid concentration (40, 50, 60, 70, and 80 g/L), and Fe^{2+} ion concentration (2, 3, 4, 5, and 6 g/L). Mechanical agitation was used, and the temperature was maintained at 60 °C.

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- **Methodology (cont’d 1)**

- **Multi-criteria decision analysis is used in conjunction with the Taguchi approach to optimize the leaching process of Cu-Co ore. Among the various MCDA methods, the Analytic Hierarchy Process (AHP) is the one utilized in this study.**

- **The 5 steps of AHP are: (1) Establish the hierarchical structure, (2) Perform binary weightings, (3) Determine the eigenvectors, (4) Calculate the consistency ratio (CR) and, (5) Establish final priorities**

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- **Methodology (cont'd 2)**

- **Three hierarchical levels have been established. Level 1 focuses on the objective, which is the optimization of Cu dissolution. Level 2 examines the parameters under study, namely time, solid percentage, agitation, acidity, and ferrous ion concentration, and compares them to the objective.**
- **Lastly, Level 3 delves into the specific terms of each parameter. For instance, in the case of acidity, the values considered are 40, 50, 60, 70, and 80 g/L.**

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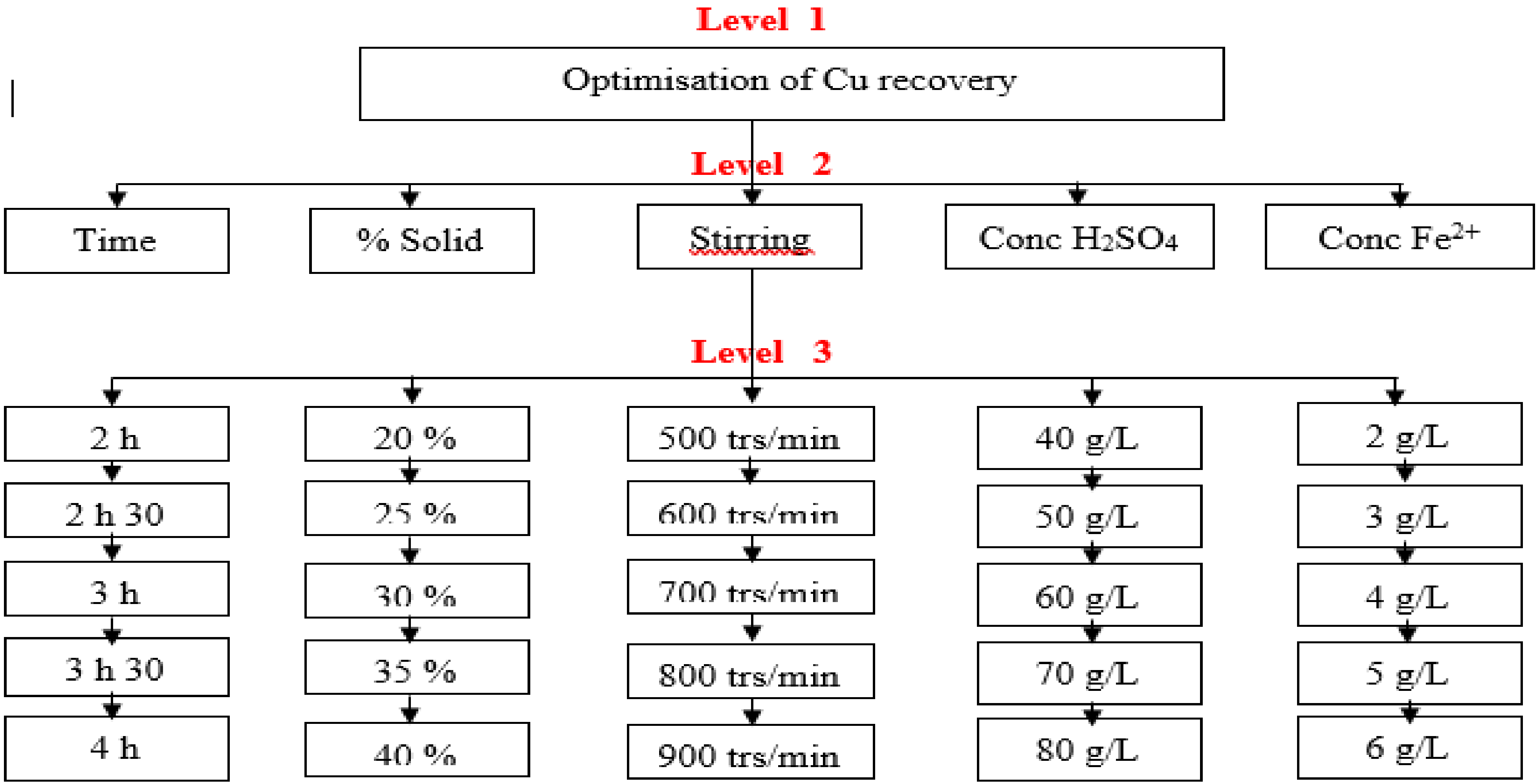
- **Methodology (cont'd 3)**



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- **Methodology (cont'd 4)**

- **Pairwise comparisons are carried out for the second and third level of the hierarchy following the Saaty comparison scale. They are carried out based on the signal/noise ratios previously obtained with the Taguchi method.**

- **For each comparison, we chose the most important criterion and expressed the judgment as to its importance.**

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- **Findings and discussions**

- **The chemical and mineralogical composition of the composite ore sample are shown in Table 1**

Table 1: **Chemical and Mineralogical composition of the composite ore**

Elements	Cu	Co	Fe	Zn	Mn	Pb	SiO_2	CaO	MgO
Percentage (%)	3.49	0.20	4.21	0.07	0.91	0.01	57.03	4.74	5.84

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- **Findings and discussions (cont'd 1)**

- **The analysis of the results by the hierarchical analysis process method is done with the objective of optimizing the solubilization of copper, while choosing the best criteria and sub-criteria in relation to the higher hierarchical level.**
- **Examination of the sub-criteria shows us that optimal solubilization of copper is obtained at :**
  - **Time = 2 h; Solid percentage = 20 % ;**
  - **Stirring speed = 600 rpm; Acidity = 80 g/L ;**
  - **Fe^{2+} ion = 2 g/L**

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- **Findings and discussions (cont'd 2)**
- **Pairwise comparison of criteria, Comparison judgment matrix, Priority, Eigenvalue λ_{max}, Random Index (RI), Consistency index (CI), Consistency ratio (CR).**

Table 2: Complete comparison of criteria for copper solubilization

Comparison of criteria	% Solid	H_2SO_4	Time	Agitation	Fe^{2+}	Priority
% Solid	1	2	7	8	9	0.49
H_2SO_4	1/2	1	5	7	8	0.33
Time	1/7	1/5	1	2	3	0.09
Stirring rate	1/8	1/7	1/2	1	2	0.06
Fe^{2+}	1/9	1/8	1/3	1/2	1	0.04
$\lambda_{max} = 5.12$		CI = 0.03122			CR = 2.78 %	

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- **Conclusions**

- It has been demonstrated how this approach assists in making rational decisions regarding the optimization of the leaching process for a composite of Cu-Co ores.

- It is therefore possible to improve the dissolution of a process by synergistic association of optimization methods well established in hydrometallurgy such as the Taguchi method.

The End

THANK YOU FOR YOUR ATTENTION.