SCHOOL OF MATERIALS AND MINERALS RESOURCES ENGINEERING

UNIVERSITI SAINS MALAYSIA

A SECONDARY CURRENT DISTRIBUTION IN A ZINC ELECTROWINNING CELL

By

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DECLARATION

I hereby declare that I have conducted, completed the research work, and written the dissertation entitled “Secondary current distribution in zinc electrowinning cell: a study via computational modelling”. I also declared that is not has been previously submitted for the award of any degree or any diploma or other similar title for any other examining body or University.

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LIST OF ABBREVIATIONS AND SYMBOLS

d1	Interelectrode distance
d2	Thickness of cathode plastic edge strip
d3	Thickness of cathode
d4	Thickness of anode
d5	Thickness of anode edge strip
l1	Length of cathode edge strip
l2	Distance between the end of the cathode edge strip and the wall of the cell
l3	Length of anode edge strip
l4	Length of the active anode
l5	Length of the active cathode
Wa	Wagner number
K	Conductivity of the solution
l	Length
j	Electrode current density
j_0	Exchange current density
a_a	Anodic charge transfer coefficient
a_c	Cathodic charge transfer coefficient
F	Faraday constant
R	Gas constant
T	Temperature
η	overpotential for the electrode reactions

PENGAGIHAN ARUS SEKUNDER DI DALAM SEL ELEKTROHAN ZINK

ABSTRAK

Kajian dijalankan adalah untuk menguji pengagihan arus sekunder di dalam sel elektrolehan zink dalam usaha untuk meningkatkan dan memahami keseregaman pengagihan arus. Kajian ini dijalankan dengan bantuan pengiraan permodelan. Kajian ini menggunakan perisian COMSOL Multiphysics sebagai alat dalam memodelkan pengagihan arus dalam sel elektrolehan zink. Tujuan kajian ini adalah untuk menyiasat kesan ke atas pengagihan arus apabila parameter yang berbeza digunakan. Kajian menggunakan parameter yang berbeza untuk melihat corak perubahan apabila menambah atau mengurangkan nilai parameter. Untuk pengagihan arus, beberapa parameter telah digunakan seperti ruang antara elektrod, ketebalan anod, penebat, anjakan katod, dan suhu. Berdasarkan keputusan simulasi, parameter di atas menunjukkan kesan positif kepada keseragaman pengagihan arus.

SECONDARY CURRENT DISTRIBUTION IN A ZINC ELECTROWINNING CELL

ABSTRACT

The study investigates the secondary current distribution in a zinc electrowinning cell in order to improve and understand the uniformity the current distribution via computational modeling. The research used COMSOL Multiphysics software as powerful tools in simulating the current distribution in a zinc electrowinning cell. The purpose of the study is to investigate the impact on the current distribution when operational and design parameter are varied. The study used different parameters in order to see the pattern changes when adding or reducing the value of the parameters. For the current distribution, some parameters have been used such as interelectrode space, thickness of anode, insulating edge strip, cathode displacement and temperature. Based on the simulation, parameter above shows positive impact to the uniformity of current distribution.

CHAPTER 1

INTRODUCTION

1.1 Introduction of zinc electrowinning cell

Zinc hydrometallurgy has been the dominant innovation of the present extractive metallurgy of zinc metal, and its production represents over 80% of the total quantity. Nonetheless, there is lack of high energy consumption for zinc hydrometallurgy, and around 75% of the total energy consumption happens in zinc electrowinning. In this manner, the key of saving energy and enhancing economic effectiveness for zinc hydrometallurgy is to reduce the power consumption during the zinc electrowinning process (Li et al. 2014). Hence, intensive research has been conducted to lower energy consumption or increase current efficiency per mass of zinc produced.

The electrowinning step has been enhanced over the most recent two decades to decrease the capital and working costs. The cathode-anode spacing has been diminished to reduce the cell voltage. As the electrowinning plants have turned out to be more compact and effective, good electrode alignment is required. Indeed, even little deviations from correct alignment can give an increased tendency to short circuits and loss in current efficiency. If there is no polarization, the local current density increases inversely to the local decrease in distance between anode and cathode surface (primary current distribution). The polarization is beneficial to the current distribution, and reduces the negative effect of misalignment (As 1995).

The nonuniformity of the current distribution is caused by different design factors, such as spacing, thickness, and position of electrodes and their insulating edge strips. Thus, the purpose of this experiment is to observe the changes in terms of electrical potential for known critical operational and design parameter. To precisely predict the current distribution between electrodes, a numerical model is presented. The complicated interrelations between electrochemical and electromagnetic phenomena are considered. An efficient optimization method, called sampling-based sensitivity approach, is applied to the Multiphysics design problem of an electrowinning cell (Choi et al. 2015).

1.2 Problem Statement

Generally, people need to investigate the electrowinning cell performance by observing the result of metal recovery. For those who deal with electrowinning cell inspection such as metallurgist, it will need them to bring a lot of stuff. The work is done by taking a lot of sample and each sample safely keep so that the result will not deviate too much from theory. Those things would make the task become troublesome and a lot of time required.

Recently, with arise of technology, computational modeling has been used in solving problem related to natural system in physics, chemistry, and biology. For those who deal with electrowinning cell, a few questions emerge among themselves. The questions are:

1. Is it possible to create a mathematical model which is representative to the physical system by using a computational modelling?
2. What is the impact on the current distribution when operational and design parameter are varied?
3. What is the changes in term of electrical potential for known critical potential and design parameters?

There a few parameters that govern the flow pattern of current distribution. Each parameter would affect the current distribution but the question is, how big the effect is? The investigation of the electrowinning cell is important especially when involving the electrical consumption and the amount of metal recovery.

1.3 Possible Solution to the Problem

There are two ways to handle this problem. One is by using experimental setup. Experiment research is running for the most part in labs with regarding to fundamental research. The advantages of using experimental design are that it provides the opportunity to identify cause-and-effect relationship and in some extent, it gives a higher internal validity result. One major limitation of experimental research is that the studies are typically conducted in artificial laboratory setting. The outcome may not give or demonstrate the actual state of the problem. In addition, in this specific research, time, cost and space are also the issue. At the point when laboratory experiment been conducted, time taken to get the outcome might be too long. Moreover, to run this experiment, a real or artificial set up need to be developed, which is very costly.

Computational modelling is the other answer to solve the problem and we preferred to practice this method instead of using experimental method. It has turned into an essential part of science and engineering. A computer simulation is simply a translation of real world condition into a virtual form. Computational modelling is fundamentally solving mathematical models with the aid of computer. Mathematical models are mathematical interpretation of anything particular interest (system with many features and parameter). This method will simplify the complexity of the problem as we deal with a lot of parameter such as, electrode distance, cathode displacement and electrolyte conductivity. Besides, boundary condition should be considered to solve the problem. By doing computational modelling, possibly we are not getting the exact answer but rather giving a fundamental framework on what will happen in the electrowinning cell. it helps us to anticipate and at any rate give us an overview on what occur on the electrowinning cell.

1.4 Motivations

The practice of the computational modelling to model the various system would make some tedious work become easy to handle. The simulation make the physical system presented become simpler for the people to see pattern changes and specifically can anticipate the system for the future. In this case, the investigation is about the secondary current distribution in a zinc electrowinning cell via computational modelling. The investigation is to study the optimized cell structure of electrowinning cell in order to achieve a uniform current distribution.

The investigation is conducted for a several important reasons. First, this investigation is made to see the ability of the computational modeling approached in modeling the electrowinning cell and current distribution system. It is essential to see the capability of the computational modeling in solving the Multiphysics problem. Other than that, the investigation is run to study the correlation of the few parameters involved into the design changes for the zinc electrowinning cell.

The reasons above are very important when it involves field work. In the industry field, it is revealed that the zinc cell house is responsible for approximately 80% of the energy used by an electrolytic zinc refinery (Choi et al. 2015). In this case, it is important to study about the optimized cell structure of zinc electrowinning, which can improve the uniformity of electrode current distribution. By doing so, we can plan the best solution for that kind of the problem. The solution is not for short term period only, but for the future also.

1.5 Objectives

The main objectives of this project are:

1. To create a mathematical model which is representative to the physical system by investigated electrometallurgical recovery of zinc.
2. To investigate the impact on the current distribution when operational and design parameter are varied.
3. To observe the changes in terms of electrolyte current density distribution for known critical operational and design parameters.

1.6 Outline

The thesis report consists of five chapters. The first chapter about the overview of the project, the fundamental aspects on zinc electrowinning cell, the problems that we are confronting, the possible approaches to solves the problem and the objective of the thesis. In the second chapter, it is about the fundamental of electrowinning cell, previous study and experimental procedures that have been done before related to the zinc electrowinning cell, a short clarification about COMSOL Multiphysics and lastly the mathematical equation that govern in this experiment.

In chapter three, we are discussing on the procedure and methods used in conducting this experiment and designing the model. The instructions on how to define the variables and constant that is used in the equation is also shown. The crucial part in this thesis lies on chapter four where results from the modelling are shown and discussed. The discussions are based on the changes of electrolyte potential distribution, current density distribution and design of the optimum electrowinning cell structure.

Last part would be chapter 5, where the conclusion of this experiment was made based on the objective outline. Not to forget the future work also been discuss to enhance the understanding of the secondary current distribution in a zinc electrowinning cell.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss about the fundamental facts and thoughts on how the research about the secondary current distribution in a zinc electrowinning cell using COMSOL Multiphysics is done. Furthermore, this chapter is a reference so that the research can be done precisely. The chapter begin with the fundamental facts about the zinc electrowinning cell. Several equations that related with the secondary current distribution are presented so that it will be easy to correlate with one another. Then, the chapter continues with a few literature reviews about the electrowinning cell. The outline about the past work will give an idea how mathematical modelling work. The result from the previous work also been discussed in this chapter.

As the research conducted is about the computational modelling, it is important to preview the software used for this work. The chapter discussed about the important of using COMSOL Multiphysics software and works that have been done in COMSOL that related to zinc electrowinning cell. At the end of this chapter, the discussion continues with the mathematicising the physical system using COMSOL Multiphysics. This part will explain about the governing equation and boundary equation which assume as an important part in describing the model based on the physics’ law and condition.

2.2 Current Distribution

An electrochemical cell is described by the relation of the current it passes to the voltage cross it. The current-voltage relation depends on diverse physical phenomena and is fundamental to performance. In a battery or fuel cell at zero current (equilibrium), a theoretical maximum voltage can be extracted, but we want to draw current to extract power.

At the point when current is drawn, there are voltage losses; equally, the current density may not be uniformly distributed on the electrode surfaces. The performances and lifetime of electrochemical cell, for example, electroplating cells or batteries, is often improved by a uniform current density distribution. Bad design lead to poor performance, such as:

- Substantial losses and shortened lifetime of electrode material at practical operating currents in a battery or fuel cell.
- Uneven plating thickness in electroplating.
- Unprotected surfaces in cathodic protection system.

Simulating current distribution enables better understanding to avoid such problems. The current distribution relies on a few factors:

- Cell geometry
- Cell operating conditions
- Electrolyte conductivity
- Electrode kinetics (“activation overpotential”)
- Mass transport of the reactant (“concentration overpotential”)
- Mass transport of ions in the electrolyte

Numerous application benefit from suitable simplification when modeling. If one of these factors dominates the cell behavior, the others should not have to be considered. As an outcome, successive approximations are introduced by the classification of primary, secondary, and tertiary current distribution.

2.2.1 Primary Current Distribution

The primary current and potential distribution apply when the surface overpotential can be neglected and the solution adjacent to an electrode can be taken equipotential surface. Calculation of primary current distribution and resistance represent initial step toward analyzing and optimizing an electrochemical system (Sulaymon & Abbar 2012). The cell resistance calculated can be coupled with calculation including mass-transfer and kinetic effects to optimize approximately a given cell configuration.

Calculation the primary current and potential distribution involves solution of Laplace's equation (Sulaymon & Abbar 2012). Solution methods are analytically and numerically, the analytical methods involve the method of image, separation of variable and Shwarz-Christoffel transformation. The Shwarz-Christoffel transformation is a powerful tool for solution of Laplace's equation in system with planar electrodes. This method was used by Moulten (Sulaymon & Abbar 2012) which gave a classical solution for the primary current distribution for two electrodes placed arbitrarily on the boundary of a rectangle. Moulten represented the current distribution by the following equation:

$$\frac{i}{i_{av}} = \frac{v \cosh v / K\left(\tanh_2 v\right)}{\left|\sinh v - \sinh\left(2xv/L\right)\right|} \qquad \text{Eq. 1}$$

Where v = l/2h, x measured from the center of electrode, L= 2h, (K)is the complete elliptic integral of the first kind tabulated in reference. Primary current distribution determines by geometric factors alone. Thus, only the geometric ratios of cell are a parameter. Wagner number expresses the ratio of the polarization resistance at the interface over the ohmic resistance in the electrolyte approaches to zero in this case (Sulaymon & Abbar 2012).

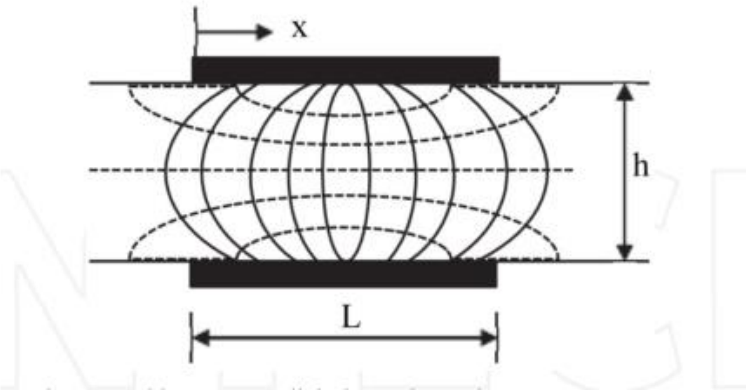

Figure 2.1: Current and potential lines in parallel plates electrode (Sulaymon & Abbar 2012).

2.2.2 Secondary Current Distribution

Right when slow electrode kinetics are taken into consideration, the electrolytic solution close to the electrode is no longer an equipotential surface. The result of calculation is secondary current and potential distribution (Sulaymon & Abbar 2012) . Secondary current distribution predominates if the ohmic resistance is lower than the kinetic resistance. The general impact of electrode polarization is to make an infinite current density at the edge of electrode is eliminated. The impact also make the secondary current potential nearly uniform than the primary current distribution. Using a numerical method to predict the current distribution is a crucial step in the rational design and scale-up of electrochemical reactors and in engineering analysis of electrochemical processes.

2.2.3 Tertiary Current Distribution

The combine impacts of activation and concentration polarization give rise to changes in primary current distribution resulting in what is known as tertiary current distribution. Due to concentration variation, the potential of the solution does not obey the Laplace's equation. At the point when the concentration at surface of electrodes approach to zero, the limiting current condition occurred. That point also limiting the distribution of current by the mass transfer rate through the diffusion layer (Sulaymon & Abbar 2012) . Figure 2.2 shows the three types of current and potential distribution.

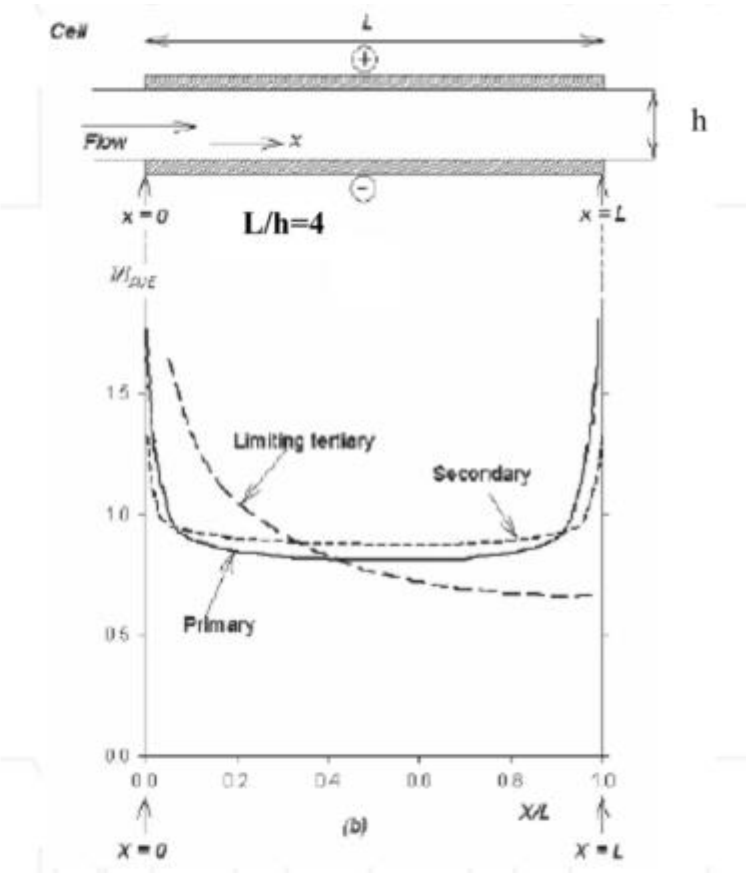

Figure 2.2: Current distribution in parallel plate electrode (Sulaymon & Abbar 2012).

2.3 Increase current efficiency by addition of organic inhibitors

A present method for zinc production is its extraction from acid zinc sulphate electrolytes by electrolysis with aluminum cathodes and anodes made of lead-silver (1%) combination (Ivanov 2004) . The problematic thing in electrowinning is when there is a presence of more electropositive ions than zinc, for example, Ni, Co, Sb, Ge, etc. During the electrolyte purification, most of the impurities are removed, yet a specific amount that is adequate to initiate a process known as 'zinc redissolution' remains. By the addition of organic compounds to the electrolyte, it is conceivable to constraint this process, thus, able to produce zinc with high current efficiency and good quality.

The experiments were performed with industrial electrolytes provided from Plovdiv Non-Ferrous Metal Enterprise and had the following basic composition (g L^{-1}): Zn^{2+} 50-55, H_2SO_4 125-130, Mn^{2+} 5-6. Metal impurities with the concentrations studied were added to the electrolytes. Inhibitor used in this experiment is called IT-85, which contain of these two organic substances, 300 g L^{-1} EAA and 20 g L^{-1} TEBA.

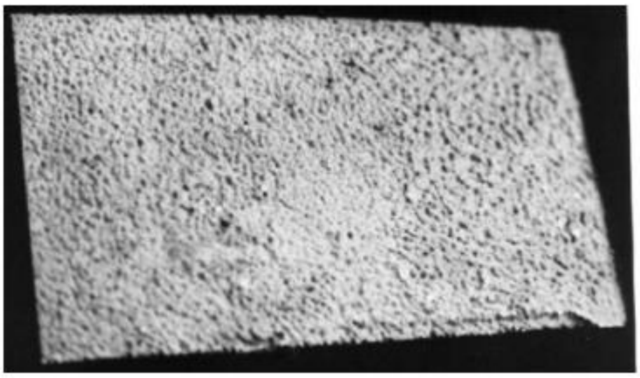

Figure 2.3: Surface of Zn coating obtained from industrial electrolyte without additive

As an outcome, in the bath containing just impurity metal ions, the zinc produced is strongly perforated, oxidized, and powdered at its detachment from cathode. While, with the presence of inhibitor additives, the zinc produced is light grey and is thick, smooth, without pitting and dendrites on the surface or edge. In the bath containing inhibitor, the current efficiency is considerably higher than the zinc produced in the bath containing only metal impurities (Ivanov 2004) . The addition of inhibitor in the electrolyte reduce the content of impurities in the zinc coating and enhances the quality of cathodic metal.

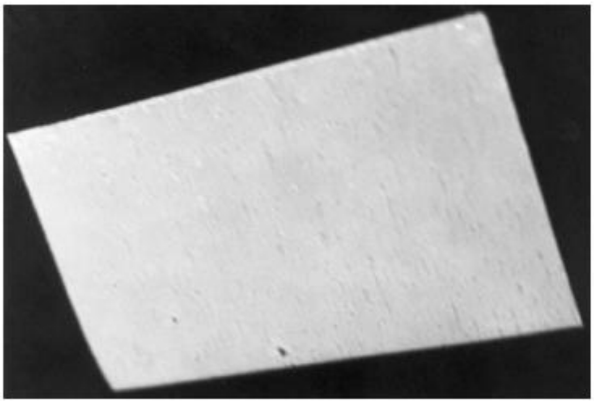

Figure 2.4: Surface of Zn coating obtained from industrial electrolyte containing inhibitor

2.4 Investigation on current distribution at the electrode in zinc electrowinning cell

The title of the experiment is “A Fully Optimized Electrowinning Cell for Achieving a Uniform Current Distribution at Electrodes Utilizing Sampling-Based Sensitivity Approach”. This research has been introduced by Nak-Sun Choi, Dong-Wook Kim, Jeonghun Cho, and Dong-Hun Kim and was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF). This research is conducted to find an optimized cell structure for zinc electrowinning. This is important because the optimized cell structure can enhance the uniformity of electrode current distribution, hence the current efficiency is improving and local dendrites in the electrowinning process can be prevented. The uniformity of current distribution is investigated through the comparison with three cell designs (i.e. initial, optimized and empirically obtained ones) via mathematical modeling.

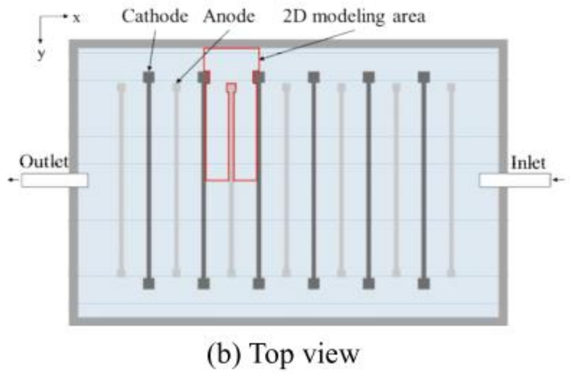

Figure 2.5: A schematic view of a zinc electrowinning cell

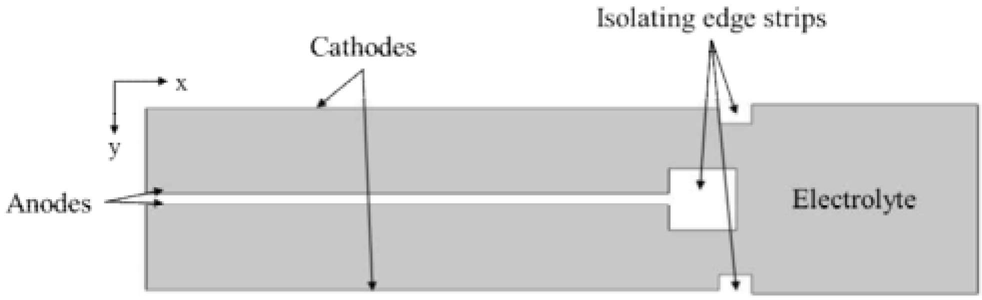

Figure 2.6: A two-dimensional finite element model

All chosen geometric parameters are shown in Figure 2.7. The parameters are selected and optimized as design variable. The design variables values between three different designs are compared with each other in Table 2.1. The design objective is to find a fully optimized cell structure, which can give a more uniform current distribution. The electrochemical simulations at samples were carried out with a commercial Multiphysics software package, called COMSOL. `

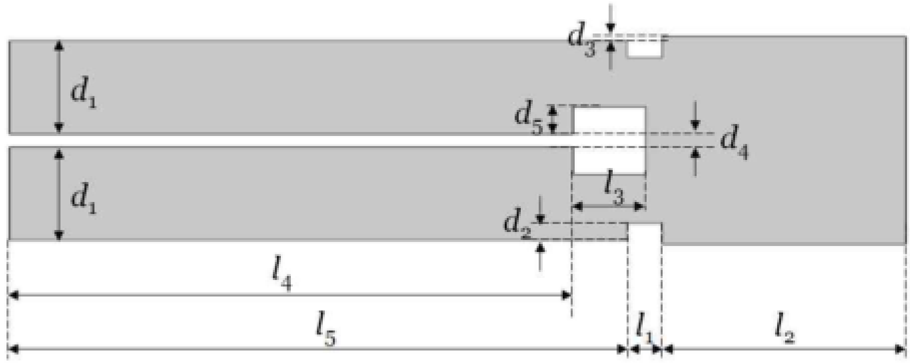

Figure 2.7: Ten design variables shaping an electrowinning

Table 2.1: Comparison of design variables between three different designs (unit: mm)

	Lower bounds	Initial design	Empirical method	Proposed method	Upper bounds
d_1	34	44	44	34	54
d_2	4	8	8	11.97	12
d_3	1	2	2	3.32	5
d_4	3	6	6	3	9
d_5	3	13	13	3	20
l_1	7	17	17	9.72	27
l_2	107	117	137	126.63	147
l_3	25	35	35	37.84	45
l_4	200	271	271	286.20	350
l_5	200	297	277	290.82	350

The Multiphysics simulator was well combined with the sampling-based sensitivity approach in order to optimize the whole cell structure for zinc electrowinning cell. The outcome show that the optimized cell provides a higher uniformity of cathodic current distribution when compared with other cell design. Thus, the proposed cell design is very effective in preventing the local dendrites and improving the current efficiency in electrowinning process.

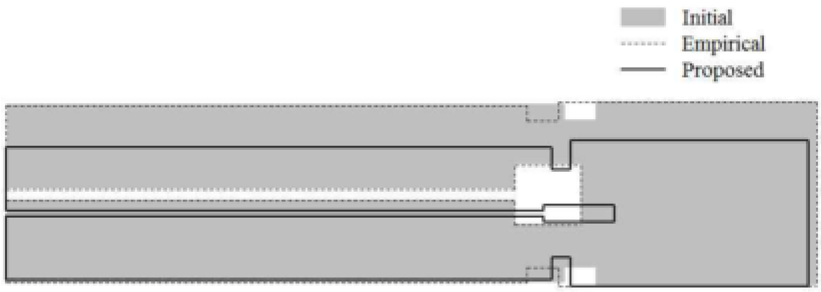

Figure 2.8: Three different cell structures

2.5 Usage of COMSOL Multiphysics

2.5.1 Why use COMSOL Multiphysics?

COMSOL Multiphysics is one of the modeling software or solver for various physics and engineering applications, especially coupled phenomena or Multiphysics. Multiphysics normally involve solving coupled system of partial differential equations. They are few example of physical simulation that involved coupled system such as electric and magnetic field for electromagnetism, pressure, and velocity for sound. The COMSOL Multiphysics simulation facilitates all the steps in the modelling process which are characterizing your geometry, meshing, indicating your physics, solving, and then visualizing your results. Besides, it gives options for user to freely mix the physics interface into new Multiphysics combination as well as couple with any application specific module. In addition, COMSOL Multiphysics gives the option for the user to determine their own partial or ordinary differential equation and link them with other physics interface.

COMSOL Multiphysics software can make a quick prediction of the Multiphysics problem. By utilizing this software, people can spare cost and time. Before having this software, people need to spend a lot of time and cost in a lab to develop the model manually. Another cost will be added if the experiment need to repeat or having the problems. Other than that, a manpower need to involve in order build up the model and once again, the cost would be increase.

When dealing with Multiphysics problem, it will certainly involve a few parameters or variables that need to control and search for. This would be a problem for those who are running the experiment in a lab since they must set up another model for each time variables changed. The COMSOL Multiphysics software has the solution where it can be used to simulate the behavior of parameters that under investigation at different conditions.

2.5.2 Example of work done in COMSOL related to your work

Choi et al. (2015) had conducted an experiment on a Uniform Current Distribution at Electrodes of Zinc Electrowinning Cell. The aim of this work done is to find an optimized cell structure for zinc electrowinning, which can enhance the uniformity of electrode current distribution. In this experiment, he changes the design of the cell structure to see which design could give the best result. Hence, he come up with three different cell structure and made an attempt to test the model efficiency by using COMSOL Multiphysics. It is agreeing that using CFD simulation, it save a lot of time and can be performed without actual experimental work. With help of COMSOL software, this experiment can be run with many parameters without spend huge budget on it.

2.5.3 Finite Element method in COMSOL

Finite means having a limited nature, completely determinable in theory or in fact by counting, measurement, or thought. Finite element method is a numerical technique for finding approximate solutions to boundary value problems. It is uses variations of methods to minimize an error function and produce a stable solution. In the finite element method, a distributed physical system to be analyzed is divided into various discrete elements. The division into element may partly correspond to the natural subdivisions of the structure for instance may be divided into groups of elements corresponding to different material properties (Barrenechea & Knobloch 2017). Most or all model parameters have very direct relationship to the structure and material properties of the system. In the usage of COMSOL, finite element method is act as a guide to machine design. It provides a reliable tool for 2D and 3D analysis for Multiphysics and optimization problems.

2.6 Mathematizing the physical system using COMSOL Multiphysics

2.6.1 Governing equation

Governing equation is Laplace equation for the potential. By solving the Laplace equation, the distribution of the Galvani potential in the two-dimensional interelectrode space and the current density at the electrode could be obtained (assuming constant electrolyte conductivity) (As 1995) . The Laplace equation (Eq. 2) should be solved with several electrochemical boundary conditions.

$$\Delta\varphi = 0 \qquad \text{Eq. 2}$$

Where Δ is the Laplace operator and φ is a scalar function.

2.6.1.1 Wagner Number

The ratio of current density at a point X on an interface to the average current density ($\frac{j_x}{j}$) is called the relative local current density. In describing the current distribution, we are using the function ($\frac{j_x}{j}$) = $f_{(x)}$ (or more generally, ($\frac{j_x}{j}$) = f (x, y, z) where x or (x, y, z) are the coordinates of the points of the electrode-solution interface. The secondary current distribution is that which establishes itself when the influence of the overpotential cannot be neglected but concentration overpotential is negligible. It is often to describe the secondary current distribution in term of dimensionless numbers of the form

$$\mathrm{Wa} = \frac{\kappa}{l}\frac{\mathrm{d}\eta}{\mathrm{d}j} \qquad \text{Eq. 3}$$

Where, K = the conductivity of the solution, $\frac{d_n}{d_j}$ = the slope of the overpotential current curve under the above conditions, l = a characteristic length of the system, for example the radius of disc electrode and W_a = is the Wagner number. It is a quantity which determines the throwing power and characterizes the equalizing influence of overpotential on the current distribution. In case of electroplating, the throwing power is qualitatively defined as ‘the ability of a solution to deposit metal uniformly upon a cathode irregular shape’.

2.6.2 Boundary condition

The choice of spatial coordinate and the boundary conditions depend on the cell geometry and electrode configuration. We can track the transport of the ionic reactant by solving an additional set of transport equations, which are fully coupled with the CFD equations during the simulations.

The total current passing through an electrode is the sum of the current arising from all reactions occurring on its surface. To create a quantitative relationship between the electrode reaction kinetics and its current, the Butler-Volmer expression of (Eq. 4) is used.

$$j = j_0\left(\exp\left(\frac{\alpha_a F\eta}{RT}\right) - \exp\left(\frac{-\alpha_c F\eta}{RT}\right)\right) \qquad \text{Eq. 4}$$

where j is the electrode current density, j_0 is the exchange current density, α_a and α_c are the anodic and cathodic charge transfer coefficients respectively, F is the Faraday constant, R is the gas constant, T is the temperature in Kelvin, and η is the overpotential for the electrode reactions.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Modeling has risen as a major instrument in all branches of science (Igboekwe & Amos-Uhegbu 2011). Models are conceptual description, tools or devices that represent or describe an approximation of a field situation, real system, or natural phenomena. They are not definite description of the physical system or process but are mathematically representing a simplified version of a system. This mathematical calculation is referred to as simulation.

The simulation of secondary current distribution in a zinc electrowinning cell require an appropriate understanding of its design factor. It is because the applicability, reliability, or efficiency of a model relies on how closely the mathematical equations approximate the physical system being modelled. This chapter will show the method to build an electrowinning cell structure based on the mathematical equation. It will start with the mathematical framework as a guide to develop the approximate model. A systematic guide in construct the mathematical framework is done after construction of the mathematical framework through COMSOL Multiphysics.

3.2 Condensed Theoretical Framework

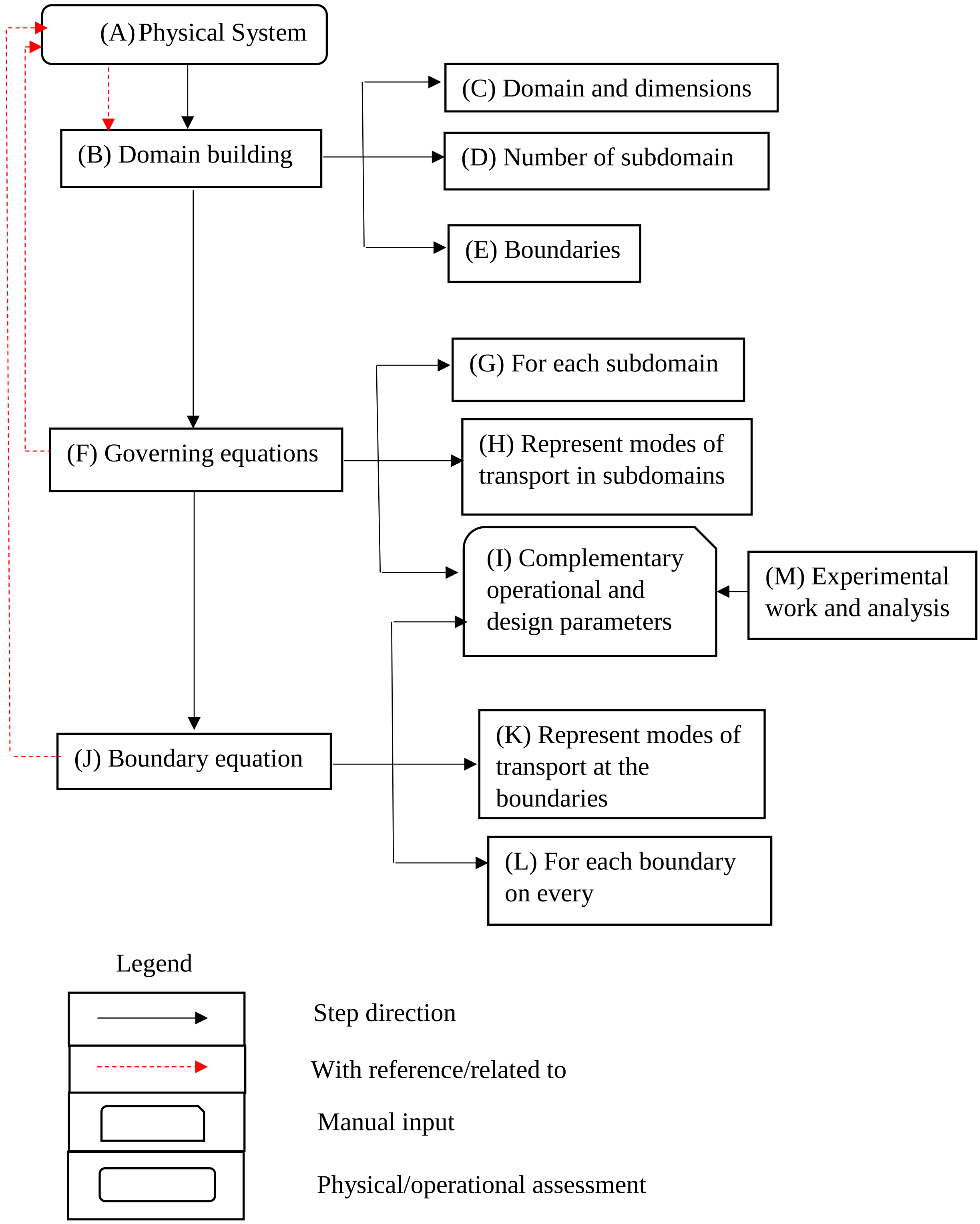

Figure 3.1: Condensed Theoretical Framework

3.3 Methods using COMSOL

3.3.1 Model Wizard

1. Start COMSOL Multiphysics.
2. Go to the **Model Wizard** window.
3. Click the **2D** button.
4. Click **Next**.
5. In the **Add physics** tree, select **Electrochemistry>Secondary Current Distribution (siec)**.
6. Click **Add Selected**.
7. Click **Next**.
8. Find the **Studies** subsection. In the tree, select **Preset Studies>Stationary**.
9. Click **Finish**.

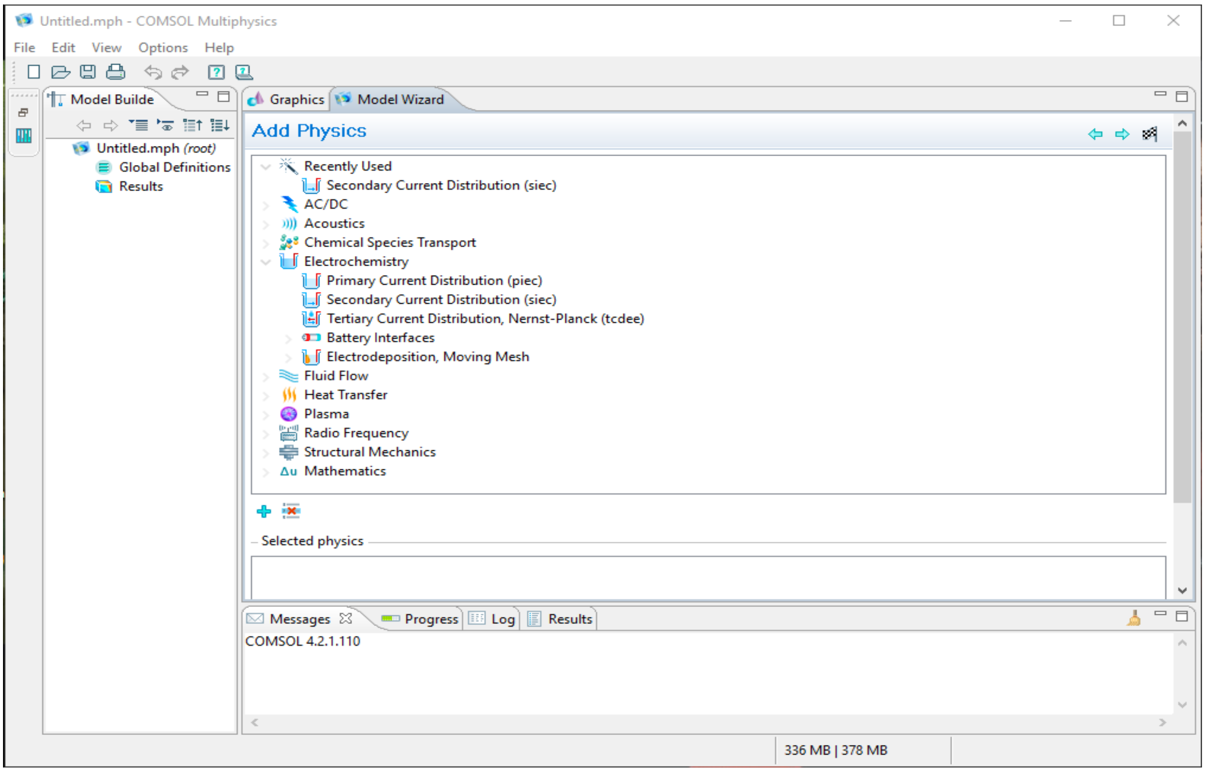

Figure 3.2: Model wizard

3.3.2 Global Definitions

Parameters

1. In the **Model Builder** window, right-click **Global Definition** and choose **Parameters**.
2. Go to the **Settings** window for Parameters.
3. Locate the **Parameters** section. Click **Load from File.**
4. Browse to the model's Model Library folder and double-click the file zn_electrowinning_parameters.txt.

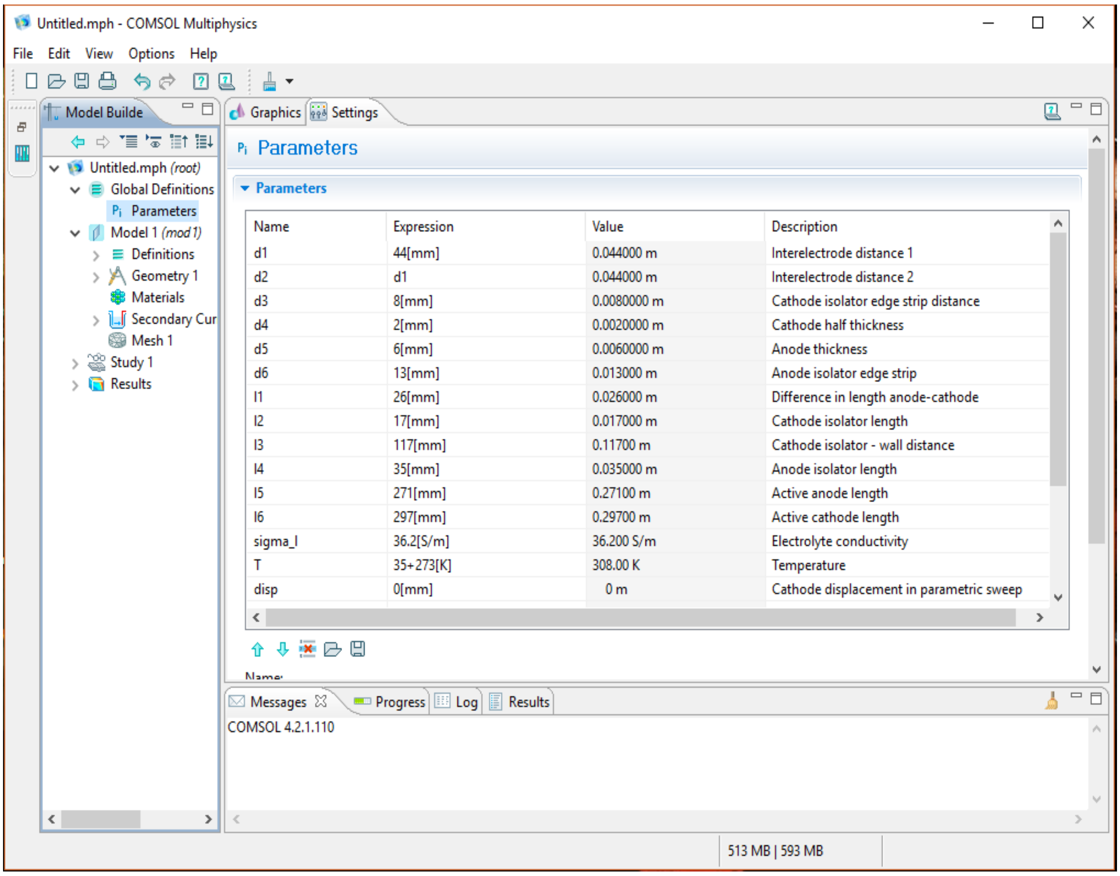

Figure 3.3: Parameters