UNIVERSITI TEKNOLOGI MARA

TECHNICAL REPORT

SOLVING TWO DIMENSIONAL EXPLICIT HEAT CONDUCTION EQUATION BY USING FINITE DIFFERENCE METHOD

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ABSTRACT

A Laplace's heat conduction equation is derived and then solved before identifying the temperature distribution of aluminium using the same equation. The heat conduction equation was derived from the First Law of Thermodynamics before applying Fourier's Law of Heat Conduction and then solved using central finite difference method and Gauss-Seidel iterations. The temperature distribution of aluminium was calculated using a different set of boundary equations than the one used for the first heat equation. Three different number of nodes, 2x2, 3x3 and 8x8 were used to solve the heat equation to see how it affected the accuracy of the temperature distribution. The solution then was graphed using MATLAB software. It was found that the more nodes used, the more accurate the temperature distribution calculated. All the results gained were compared with previously published work for validation.

1 INTRODUCTION

1.1 Research Backgroud

A partial differential equation (PDE) is when the function u depends on more than one variable. It can be used to formulate and solve the problems in the fields of science, engineering and mathematics with the higher order equations used to model waves in dispersive media and elasticity particularly in plate and beam mechanics and image processing. Some of the essential linear PDEs include heat equation which is in parabolic form, wave equation which models vibrations and acoustics and is in hyperbolic form, Laplace's equation which is homogeneous and Poisson equation, the non-homogeneous counterpart and both is in elliptical form (Olver, 2014). Applications of elliptic PDEs can be found across various areas of science and engineering. In analysis and computation for boundary value problems for elliptic PDEs, potential theory is especially important (Aziz et al., 2017) and potential theory is defined as the general theory of Laplace's equation (Emery, n.d.). Laplace's equation depends on spatial variables x and y and has no time dependence meaning that it describes steady state temperature distributions. The solution for Laplace's equation is often called harmonic functions (Tornberg, 2011).

According to the Editors of Encyclopædia Britannica (2010), heat conduction involves the transfer of energy and entropy between adjacent molecules meaning through direct contact. Jean Baptiste Joseph Fourier (1768-1830) first formulated heat conduction process described by partial differential equations through what is now known as the Fourier's Law of Heat Conduction (Zecova & Terpak, 2015) which states that the heat flux is directly proportional to the negative gradient of temperature and the area at right angles along with the thermal conductivity of the materials (Marín, 2011).

Problems arises naturally in the context of electrostatics, gravity and surface reconstruction to name a few hence active research has to be done out of necessity. As a result of steadfast research over the years, numerous numerical methods such as finite difference methods, finite