An Analysis of
Direct Resistance Heating
of a Circular Sheet Metal
Using Finite Difference Techniques

A Thesis
by
PASDUNKORALE ARACHCHIGE JAYANTHA

Submitted in Partial Fulfillment
of the requirements
for the Degree of

Master of Science
in
Industrial Mathematics

I grant the University of Sri Jayewardenepura the nonexclusive right
to use this work for the university's own purposes and to make single
copies of the work available to the public on a not-for-profit basis if
copies are not otherwise available.
Abstract

This report presents results of a numerical study on direct resistance heating of a circular metal sheet of uniform thickness. It is shown that the electrical current density of the plane sheet satisfies the continuity equation while the electrical potential satisfies the Laplace equation if there is no variation of physical properties of the material. The power balance equation which describes the temperature of the circular plate is obtained.

Initially, we obtain numerical results of the above equations when a circular sheet blank is heated by passing an electrical current through a diameter. The results show that the electrical current density, heat generation and temperature near the diameter are higher than those of the other points of the plate.

Assuming that the circular sheet blank is heated by passing the electrical current through several diameters in a staggered pattern, we find the numerical solution of the above equations. These results show that the final temperature distribution has a pattern and the temperature near the center is higher than other points when the temperature at the boundary is maintained at room temperature.
# Contents

1 Introduction
   1.1 Direct Resistance heating ........................................ 1
   1.2 Heat Treating Applications ....................................... 2
   1.3 Direct Resistance System Configuration ......................... 3
   1.4 Present Problem .................................................. 4

2 Formulation of the Problem ........................................ 6
   2.1 Power Balance Equation .......................................... 6
   2.2 Heat Generation .................................................. 10
   2.3 Continuity Equation ............................................. 11

3 Potential and Current Density Distributions .................... 15
   3.1 Electrical Resistivity ........................................... 16
   3.2 Thermal Conductivity ............................................ 16
   3.3 Specific Heat .................................................... 17
   3.4 Electrical Potential and Current Density ....................... 18
   3.5 Finite Difference Method ....................................... 19

4 Temperature Distribution ........................................... 23
   4.1 Power Balance Equation .......................................... 23
   4.2 Numerical Method ............................................... 24
   4.3 Stability Analysis ............................................... 25

5 Numerical Results .................................................. 31

6 Discussion and Conclusions ....................................... 40

   References .......................................................... 42

A Appendix ....................................................................... 44