A Book on Electroheat: Worth a Look.

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I recently bought a book called Foundations of Electroheat: A Unified Approach. By A. C. Metaxas, Fellow of St John's College University of Cambridge UK
500 pages $185 ISBN 0 471 95644 9, John Wiley 1996.
For anyone interested in the many ways of delivering electroheat this book is well worth a look. It is based on courses on Electroheat given in the engineering dept of Cambridge University. Here Metaxas combines mathematical treatment of the principles of electroheat with descriptions and sketches of a wide variety of industrial applications. He graciously acknowledges his debt to the many colleagues who have devoted their careers to the subject and quotes sources both in the text then in a reference list covering five pages in section 9.11.

There is a searching analytical treatment of the modes of heat generation and distribution in materials when subjected to electromagnetic fields. The materials can be conductors, insulators or anything in between. Metaxas demonstrates that one compact mathematics and physics toolbox can bring understanding to a diverse range of applications. This is my reading of what brings "Unified Approach" into the title.

In the section on properties of materials Metaxas begins " The prime purpose of utilising electrical energy in the processes considered in this book is either to elevate the temperature to effect annealing, curing, sterilising or melting, to supply the necessary energy for drying as in dielectric or infra-red heating techniques, to provide sufficient energy for welding or cutting materials or to promote plasmas for a number of important industrial applications."

He describes and gives values for the properties of materials relevant to the heating process. These include electrical and thermal conductivity, specific heat, permittivity, dielectric loss and moisture content.
Metaxas shows many worked examples and calculations of induction heating in metals and dielectric heating in non-metals.

There is a section on applicators for electromagnetic heating. This includes:
Clamps for connecting ac power directly onto a metal rod.
The three-phase electrode set up for ohmic heating in an electrode boiler or molten glass tank.
Various shapes of copper coils for induction heating of metal parts and continuous profile.
Magnetic yoke arrangement for transverse flux, improving coupling for thin strip.
Parallel plate arrangements for applying HF electric fields to lossy dielectric materials.
Clamping applicators for HF welding of PVC.
Microwave traveling wave applicator for sheet material.
Microwave horn applicator for heating material in a conveyer tunnel.

The same section covers power sources. It is a given that the ultimate source is the 50 or

60Hz public supply, so this section concerns conversion and control, stopping short of automatic feedback control.
The silicon controlled rectifier (SCR) is shown, first as a simple modulator of ac power, then as a controller of the rectifier providing the high-voltage dc supply to a magnetron, then as a rectifier/inverter circuit for delivering medium frequency power to induction heaters.
50 and 60Hz three-phase transformers in saturated core mode are featured connected as high efficiency frequency triplers.
Thermionic tube and solid state amplifying and switching devices are shown in various oscillator circuits.
For microwave power generation the magnetron is described in some detail, along with its high voltage dc supplies.
Chapter 5 covers the ionized state of a plasma; described by Metaxas as "a state of gaseous material which contains a fair number of ionized particles resulting from the application of an external energy source"……. "may be in the form of dc or ac voltages of frequencies up to the microwave region and beyond"
Three regions of the plasma's voltage/current curve are defined, with their relevance to industrial processing:
Normal glow - about 0.1 to some 50mA; energy source for the CO2 laser; plasma chemistry and surface treatments, e.g. etching, assisted chemical and physical vapor depositions, ion implantation, oxidation and sputtering.
Abnormal glow – about 0.5 to 50A; glow discharge carburising and nitriding for surface treatment such as case hardening of ferrous and other components.
Arc discharge – 1 to 10000A; Energy source for the Nd:YAG and Ruby lasers; plasma chemistry; plasma arc for cutting, welding or spraying; plasma furnaces; arc furnaces for metal melting; arc welding.
A detailed treatment with diagrams and circuits follows, covering lasers, arcs and electron beams.
Chapter 6 covers heat pumps and energy recovery, infra-red heating, air knife technology, induction applications, electrochemical processes, UV curing and ovens and furnaces.
Chapter 7 deals with heat and mass transfer.
Chapter 8 describes the ever growing use of computers and numerical techniques in electroheat calculations and processing.
Some 70 pages of industrial applications and case studies follow, then ten appendices on mathematical topics and material properties.
The author index covers six pages and the subject index sixteen.
For me the strength of this book is in the variety of industrially proven techniques revealed and explained to the processor and developer.

Link to Metaxas's work http://www2.eng.cam.ac.uk/~acm/eug.html

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