

Preface

The material collected in this book reflects the historical development of the technologies of induction and direct resistance heating and represents a synthesis of the information and experience that the authors have accumulated in their activity of academic research and collaboration with industry.

The first part of the book is devoted to deepening the theoretical knowledge on the electromagnetic and thermal phenomena that determine the heating process. This theoretical approach was developed since the beginning of the twentieth century. At that time, the design of heating installations was based on analytical solutions of Maxwell's equations for simple geometries, experimental tests and the use of the "ruler" as a mean for calculations.

Although there was no discontinuity in the technological development, crucial steps were the industrial growth, in particular of the automotive industry, after World War II, the introduction of computers in universities and research institutions and the development of numerical methods for computation of electromagnetic and thermal fields.

As regards the last point, a milestone for the technologies dealt with in this book can be considered the works of Hegewaldt, Holmdal and Sundberg, Kolbe and Reiss, who in 1963, independently but almost at the same time, presented the first numerical solutions for 1D coupled electromagnetic and thermal problem in non-linear systems and a 2D numerical solution of the electromagnetic problem in a linear system.

The way for numerical calculations of heating systems was open, but it took a long time, more than 25 years, for computer simulations to become a widely used design and research tool.

Analytical and experimental methods continued to prevail in industry during the period 1960–1990, when development and use of computer simulations were mainly limited to academia and research institutions for theoretical studies. In this period several new analytical solutions have been developed in the form of infinite series of Bessel or exponential functions for different geometries, since the availability of computers allowed the calculation of a number of harmonic terms sufficient for obtaining accurate results.

Since then, more powerful computing means and increasingly sophisticated numerical procedures have been progressively available, so that analytical methods were gradually abandoned while the use of numerical programs has become customary not only in research but also in industrial design.

The content of Chap. 4 reflects this situation, since it presents a set of results which are based in part on infinite series expansion of analytical solutions and in part on the use of numerical methods.

The choice to present in the same volume results of analytical and numerical solutions stems from the belief of the authors that a profitable use of numerical methods is based on a preliminary deep knowledge of the different phenomena that affect the heating process. This knowledge is acquired in the best way from the analysis of several case studies conducted in the past.

Finally, in Chap. 5 useful information for the numerical calculation of electro-technological installations are given to the designer.

Induction and Direct Resistance Heating

Theory and Numerical Modeling

Lupi, S.; Forzan, M.; Alifеров, A.

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