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REVIEW OF M. G. LOZINSKIY'S BOOK "SURFACE HARDENING AND INDUCTION HEATING OF STEEL"

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Surface hardening and induction heating of steel have recently begun to attract a great deal of attention. The most fundamental works in this field are: V. P. Vologdin's Surface Induction Hardening (Oborongiz, 1947), G. I. Babat's Induction Heating and Its Industrial Application (Gosenergoizdat, 1946), and the book under review. All three books supplement each other.

The book under review is divided into eight chapters, in which a very wide range of problems is examined, relating to the fields of metal studies, electrical engineering, radio engineering, and the design and construction of various induction heating equipment for the surface hardening of metals.

It is intended for engineers and technicians of the machine-building and metal-working industries and partly for students of higher technical schools. These considerations justify the inclusion, in the first chapter of the book, of a review of many problems which are discussed in detail in courses on metal studies, heat treatment, the fundamentals of metallurgy, and the mechanical testing of metals. What is out of place in this chapter is the examination of complex electrical engineering problems and circuits, e.g., the circuit of an automatic photopyrometer, and problems connected with the conductivity and magnetic properties of metals, which are not used in the form in which they are set forth in the book.

The second chapter describes concentrated heating methods for surface hardening purposes other than the induction method, to which the rest of the book is devoted. The author explains and clearly illustrates the use of the gas flame, electrical contact heating, and heating in an electrolyte.

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The third chapter gives elements of the general theory of the electromagnetic field in metals, as set forth in the works of Professor V. K. Arkad'yeva, and examines (with many inaccuracies) elements of the theory of induction heating. The phenomena discussed do not follow each other in a logical sequence, and the treatment is too involved for workers of the machine-building and metal-working industries and too simplified for electrical engineers. Especially superfluous in a work of this type is the paragraph on analogs of the eddy current layer.

Also in the third chapter, Formulas (14) and (15) are identical: Formula (16) is artificial and its use may lead to errors of up to 300% and more, due to neglecting the fact that permeability is a function of field strength; also the use of Formulas (25), (26), and some others may confuse industrial workers. Referring Formulas (46) and (47) to G. I. Babat's book is unwise, since that book is not the primary source. Moreover, in Babat's book, the formulas have additional coefficients which may cause misunderstanding among readers. It is pointless to compare Formula (51), from V. P. Vologdin's book, and Formula (52), proposed by Lozinskiy, as these formulas do not give the same solution, and both may prove suitable or unsuitable for practical calculations, not only in surface hardening, but also in through heating, when the efficiency does not depend on the frequency used. Formulas (55), (56), and (57) for determining the "optimum frequency" do not live up to their name since the results they give are much too high and are refuted by much experimental data.

The fourth chapter not only examines problems relating to the design and manufacture of inductor coils but also those concerning the actual technology of surface hardening. The elements of calculations for determining such quantities as the power factor of the inductor coils, active and reactive powers, etc., are unfortunately not systematized and cannot be used for the practical solution of problems. The last conclusion is substantiated by the author's own statement on page 166: "The optimum number of turns on an inductor coil is usually determined experimentally" whereas in reality, calculating the number of turns on the inductor coil determines to a considerable degree the design of all the other circuit elements in a high-frequency furnace.

The graphs on page 154 do not fully correspond to the real operating conditions of high-frequency furnaces. According to them, the values of capacitance are determined from the resistivity and permeability of the heated metal, while actually I changes little in induction heating, and consequently C remains practically constant during the heating period.

It is impossible to agree with the author's recommendation that the sheet thickness for magnetic circuits be selected from the relationship

$$\Delta_{max} \leq \approx ? \frac{20}{\sqrt{f}} \text{ mm} .$$

This indicates that at a frequency of 50 cycles, a sheet thickness of about 3 mm (instead of 0.35 mm) could be used.

We also regard the standards given in the book for copper tubes, rods, wire, and sheet as superfluous; references would have been sufficient.

The fifth chapter gives information on high- and medium-frequency generators. The author, objectively setting forth the advantages and drawbacks of each type of generator, essentially retracts his earlier and undoubtedly erroneous assertions about the advantages of vacuum-tube oscillators over the whole range of frequencies used (Vestnik Electropromyshlennosti, 1937 - 1938). Every type of frequency converter that could possibly be used in induction heating is examined.

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By virtue of the nature of the material it contains, this chapter can be understood only by electrical engineers, but for them the treatment of many problems is elementary and needs considerable amplification. For example, problems connected with the true operating conditions of frequency converters are not dealt with at all, although they are of exceptionally great importance in the industrial use of high-frequency furnaces.

Paragraph 1 of the fifth chapter which is devoted to oscillatory circuits, cannot be used directly for analysis or calculation of the operating conditions of high-frequency furnaces, as it does not consider such concepts as the coefficient of plate coupling in circuits with vacuum-tube oscillators or the coefficient of autotransformer ratio in circuits with machine or ionic converters.

Particular remarks on this chapter. In the circuit of Figure 248a, the "choke coil 2" is usually connected on the primary side of the transformer and serves not as a high-frequency choke, but as a short-circuit current limiter if spark-over occurs in the lightning arrestor. The dimensions of the units in Formula (27) and in the numerical example appended are incorrect. The circuits in Figure 258 unnecessarily duplicate those in Figure 256. There is an erroneous reference to Figure 153 instead of Figure 154 (page 271). In Table 33, there is no data on the 100-$\mu\mu$fd ceramic capacitors produced by the "Proletariy" Plant. There is an erroneous reference to Figure 146 instead of Figure 145 (page 333).

The sixth chapter is devoted to machine tools and attachments for surface hardening. This group of problems, on which there is less literature than the others, is very appropriate in the present book.

The seventh chapter "Practice of Surface Hardening Using High-Frequency Heating" supplements Chapters II, III, and others and could have been incorporated in them without detriment to the book.

The eighth and final chapter contains information on the use of induction heating of steel for types of plastic or heat treatment of metals other than surface hardening. Installations for heating hollow ware by placing special magnetic conductors inside them are briefly examined at the beginning of the chapter. In spite of the fact that comparatively few of these installations are used in industry, their popularization is undoubtedly desirable since they are effective and cheap.

Problems involved in the induction heating of metals directly in an electromagnetic field for hot stamping or forging are examined in somewhat greater detail in this chapter.

The account of the use of induction heating of blanks in plastic metal working will undoubtedly be utilized by our industry.

Some points on the eighth chapter. the values of f_{max} given on pages 415-416 from Figure 404 and Formulas (20) and (22), six times as great as f_{min} from Formulas (21) and (22), have no practical meaning since, when taking account of the whole set of conditions of heating metals with an internal source of heat as applied to through heating for forging, the depth of current penetration is of no importance. The footnote on page 416 on using 50 cycle. to heat 150-200 mm diameter blanks for forging is incorrect and contradicts Formula (21) and Figure 404.

In spite of the above mistakes and inaccuracies, the work under review will undoubtedly attract many readers of different specialties and be of considerable assistance in extending the use of induction heating in industry.

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