A. Zhukauskas, V. Makaryavichyus, and A. Shlanchyauskas THE TRANSFER OF HEAT FROM BUNDLES OF TUBES IN A TRANSVERSE FLUID FLOW*

Reviewed by V. Eva

In power engineering, in industry, and in other branches of the national economy smooth-tube bundles subjected to transverse streamlining are gaining extensive acceptance as heat-exchanger surfaces. While numerous studies have been devoted to investigating the transfer of heat and hydraulic resistance in gas flows, the same cannot be said for liquids. Prior to the appearance of the works published on the transfer of heat from tube bundles by the Institute of Physicotechnical Problems of Power Engineering, of the Academy of Sciences of the Lithuanian SSR, we knew only of articles by Isachenko, Romanovski, and a group of American researchers (Omokhundro, Bergelin, et al.), which dealt primarily with investigations of individual problems in the exchange of heat between tube bundles and a flow of liquid, thus failing to reveal the entire pattern of the heat-transfer process for a wide range of variations in Reynolds and Prandtl numbers. Entirely disregarded were the properties of the liquid, the direction of the heat flow, the temperature head, the positioning of the tubes, and similar factors. To fill this gap in information on heat transfer for smooth-tube bundles, the authors of the book being reviewed here – engaged at the Institute of Physicotechnical Problems of Power Engineering of the Academy of Sciences of the Lithuanian SSR – undertook an extensive range of investigations from 1955 through 1967. In these studies they investigated the transfer of heat and hydraulic resistance of 12 bundles in staggered array and 15 bundles in in-line array, with longitudinal and transverse spaces from 1.008 to 2.6 in flows of water, transformer oil, and air, covering the range of Reynolds numbers from 30 through $1.2 \cdot 10^6$ and the range of Prandtl numbers from 0.71 through 500. Stasyulyavichyus and Samoshka, co-workers at the IPPPE, used 16 bundles to study the transfer of heat for bundles in gas flows for a Reynolds number range from 10^4 through $2 \cdot 10^6$.

However, all of this material remained scattered through various sources until this time, thus greatly hindering its utilization. We should therefore acknowledge the appearance of this monograph by the workers of the IPPPE, who are responsible for the collection of this wealth of material at the Institute on the transfer of heat from bundles into a uniform whole, and for the fact that they arranged this material in a manner that is accessible for a wide circle of readers.

The book is made up of 7 chapters and appendices. The introduction provides a brief review of work done in the field of heat transfer in tube bundles situated in a transverse flow of a gas or liquid.

The second chapter describes the experimental installations, the units, and the research procedures. Two similar experimental installations were used in the tests; in one of these the working fluid was air and water, while transformer oil served as the working fluid in the other. The tests were carried out by the method of local simulation, using water and electrical calorimetry.

The third chapter is devoted to unique features involved in the streamlining of a tube in a bundle. It is demonstrated that the presence of the adjacent tubes alters the streamlining process, as well as the velocity distribution in the boundary layer of the tube. As the Reynolds number increases, the nature of the streamlining changes from predominantly laminar to predominantly turbulent. The chapter also deals with the distribution of velocity about the tube perimeter and in the space between the tubes.

* Izd. Mintis, Vil'nyus (1968).

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The fourth chapter deals with problems of generalizing experimental data on the hydraulic resistance of tube bundles and graphical relationships Eu = f(Re) are presented for all of the bundles investigated. A detailed analysis is given in this chapter for the mechanism of resistance for various bundles as a function of the nature of the streamlining, and proposed theoretical relationships are offered.

The fifth chapter is devoted to average heat transfer. There is an examination of the problems involved in accounting for the effect on heat transfer of the properties of the liquid, the temperature head, and the direction of the heat flow, as well as the streamlining regime and the positioning of the tubes within the bundle. There is a brief consideration of heat-transfer stabilization through the depth of the bundle. Graphs are presented to generalize the experimental data with respect to average heat transfer for all of the bundles investigated here.

In the sixth chapter the special features of local heat transfer for a tube in a bundle are examined. This situation is governed by the streamlining conditions and depends significantly on the nature of the heat flow (q_w = const or t_w = const). Greater light is shed on the effect on local heat transfer as exerted by the positioning of the tubes within the bundle, the number of rows in the bundle, and the turbulence of the flow. A method is proposed for the theoretical calculation of the local heat transfer.

In the seventh chapter the authors compare their results on heat transfer and resistance with the data of other researchers. Good agreement is found. A resume is given in this chapter of the theoretical recommendations. By means of a joint consideration of heat transfer and hydraulic resistance, the conclusion is drawn that compressed bundles are the most effective.

The book represents one of the first to offer extensive material on the transfer of heat in bundles in a liquid flow, where this material was derived through the use of similar installations and with a uniform method. The tests encompassed an extremely broad range of variations in the parameters. A wealth of experience has been accumulated in the study of heat transfer in bundles and with respect to the mechanism of streamlining, so that the authors are now in a position successfully to describe the physical picture of the processes which are taking place, so that this serves as a guarantee of quality for the theoretical recommendations.

The book offers much tabular data and numerous graphs, which can be used for further generalization, in the preparation of normative calculation procedures, etc.

The book is intended for engineers and technicians engaged in research and development of heat-exchanger equipment. It will also be useful for postgraduate students and instructors at higher educational institutions.