Editor

Nikos Mastorakis

Principles of Finned-Tube Heat Exchanger Design for Enhanced Heat Transfer - *2nd Edition*

by

Dipl.-Ing. Dr. Friedrich Frass

Translated and Edited by

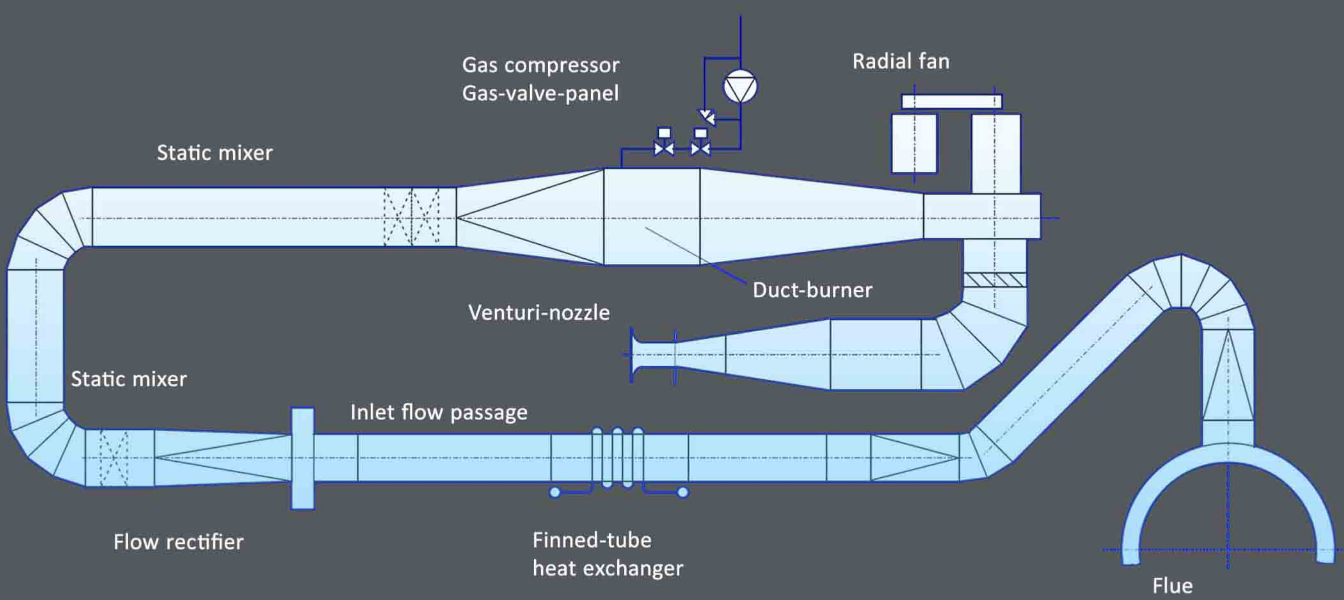
Dipl.-Ing. Rene Hofmann

Dipl.-Ing. Dr. Karl Ponweiser

Institute for Thermodynamics and Energy Conversion

Vienna University of Technology

Vienna, Austria



Principles of Finned-Tube Heat Exchanger Design for Enhanced Heat Transfer - 2nd Edition

Principles of Finned-Tube Heat Exchanger Design for Enhanced Heat Transfer - *2nd Edition*

by

Dipl.-Ing. Dr. Friedrich Frass

Translated and Edited by
Dipl.-Ing. Rene Hofmann
Dipl.-Ing. Dr. Karl Ponweiser

Institute for Thermodynamics and Energy Conversion
Vienna University of Technology
Vienna, Austria

Published by WSEAS Press
www.wseas.org

ISBN: 978-960-474-389-6

Principles of Finned-Tube Heat Exchanger Design for Enhanced Heat Transfer - *2nd Edition*

Published by WSEAS Press
www.wseas.org

All papers of the present volume were peer reviewed by two independent reviewers. Acceptance was granted when both reviewers' recommendations were positive.
See also: http://www.worldses.org/review/index.html

ISBN: 978-960-474-389-6

World Scientific and Engineering Academy and Society

Preface

The present work was carried out at the Institute for Thermodynamics and Energy Conversion of the Vienna University of Technology in the course of several years during my activities as a scientific researcher. This work is based on measurements done on the experimental facility for heat transfer, described in the appendix, as well as on accompanying studies of the literature and reports about measurements taken using other methods.

My most grateful thanks go to o. Univ. Prof. Dr. W. Linzer for providing the impulse for this research and for the support during realization.

Many thanks to the Simmering Graz Pauker AG, as well as their successor company Austrian Energy and Environment, for allocating resources during the construction of the test facility and for providing, together with Energie und Verfahrenstechnik (EVT), the finned tubes.

Furthermore, I would like to thank our colleagues at the laboratory of the institute, M. Effenberg, H. Haidenwolf, W. Jandejsek, M. Schneider as well as R. Steininger, for the construction and assembly of the experimental facility in the lab and for altering the assembly many times in order to be able to examine other finned tube arrangements.

I also thank my colleagues at the Institute who gave me advice, particularly during the implementation of data collection and analysis.

The efforts of many individuals helped contribute to the development of this book. I would especially like to take this opportunity to thank Dipl.-Ing. Rene Hofmann whose encouragement and priceless assistance proved invaluable to the success of this work.

Finally I would like to thank Dr. Karl Ponweiser providing the impulse for doing further research on the experimental facility for optimization of heat transfer enhancement.

Dipl.-Ing. Dr. Friedrich Frass
Institute for Thermodynamics and Energy Conversion
Vienna University of Technology

Table of Contents

Abstract

In designing and constructing heat exchangers with transverse finned tubes in cross-flow, it is necessary to know correlations for calculating heat transfer and pressure drop. In addition to the common use of the Reynolds and Nusselt groups of dimensionless numbers, heat conduction in the fins also has to be accounted for in calculating heat transfer. A reduction coefficient termed “fin efficiency” is therefore introduced, by which the actual heat transfer coefficient is multiplied in order to get the apparent heat transfer coefficient. “Fin efficiency” is computed according to the laws of heat conduction under the assumption that the actual heat transfer coefficient is uniformly distributed across the fin surface.

Introducing geometrical constants for the fins, that is fin height, fin pitch, and fin thickness, into the equations for heat transfer and pressure drop makes these equations more bulky than the one for bare tube heat exchangers. Moreover, there is no self-evident characteristic dimension for a finned tube, as is the case with tube diameter for bare tubes, therefore many different proposals for the characteristic dimensions exist, which are in turn needed for setting the Reynolds and Nusselt dimensionless number groups. Some authors even use different characteristic dimensions for the Reynolds number and for the calculation of heat transfer and pressure loss.

Due to the complex geometry of finned tube designs, equations for heat transfer and pressure loss are derived mostly from experiments. When using for design purposes the equations obtained, a thorough knowledge of the condition of the tested finned tubes is necessary, i.e. of the materials and shape of fins, tubes and mode of attachment. For steam boilers and high pressure heat exchangers in the process industry, spiral finned tubes are commonly used today; here a ribbon of steel is wound spirally around a boiler tube and welded to it. For these finned tubes, coefficients of heat transfer and pressure loss are higher than for tubes with circumferential fins. Finned tubes are mostly arranged in bundles, which may be arranged staggered or in line. The later coefficients of heat transfer are in fact approximately only two thirds compared to staggered arrays. Therefore, many more staggered finned tube bundles have been tested. The equations for heat transfer in finned tube bundles give the results for a certain number of rows in longitudinal direction. For a smaller number of rows in staggered bundles, heat transfer is lower, while for in-line bundles it is higher.

With air coolers and heaters, tube bundles often have continuous fins, which may be easier to manufacture as long as fin pitch and the tube diameter are small. The equations for heat transfer and pressure loss are somewhat different for such tube bundles with continuous fins as compared to serrated finned tubes. In order to achieve a very small air-side pressure loss, extended tubes of various shapes may be used in the place of circular tubes, when fluid pressure in the tubes permits non-circular tubes. In some cases, corrugated or wavy fins are used, whereas corrugated fins increase heat transfer and wavy fins have a better ratio of heat transfer to pressure loss.

Professor Friedrich Frass is a retired scientist who worked for more than 40 years at the Department for Power Systems and Applied Thermodynamics at the Vienna University of Technology in Austria.

He was born in Vienna in 1940 and he graduated from the Vienna University of Technology (Austria) in 1964 with a Master degree in Mechanical Engineering and in 1967 with the Ph. D. Degree in Mechanical Engineering.

Friedrich Frass started to work as an assistant at the Department of Applied Thermodynamics, Steam Boilers and Nuclear Reactors. During the first 2 years, he was sent as a trainee for several months to a firm for steam boiler design and to Siemens at Erlangen for the design of nuclear power reactors. In cooperation, F. Frass designed and built a test rig for the examination of two phase flow of water and steam mixtures at high pressure in horizontal and in inclined tubes. The phase distribution of water and steam was measured by a gamma ray emitting isotope.

From 1989 to 2005 F. Frass designed, built, and operated a test installation to measure heat transfer and pressure loss of finned tubes in cross flow at temperatures up to 400 °C. The result of this attempt is a book about this topic, beside of many other papers in national and International Journals. As scientist F. Frass held lectures on nuclear power reactors and on cleaning of flue gases of steam boilers in respect of pollutants as SO_2, NO_x and others for many years. In 2005, F. Frass retired but kept in continuing collaboration with the department.

ISBN 978-960-474-389-6
9 789604 743896 >