VAPORISERS

SELECTION, DESIGN & OPERATION

R A SMITH

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Preface

This book is written for the engineer in the process industries who may wish to design a vaporiser himself, or to check a design offered by a manufacturer or a contractor. Changes in process requirements may lead to alterations in the duty of an existing vaporiser, so its suitability will need to be reassessed. Attention must be paid to safety and to the maintenance of vaporisers and their ancillary equipment. For these activities, it is desirable to have a sound practical knowledge of the types of vaporiser that are available and of the calculations in heat transfer and fluid flow that are needed in design. This book gives advice on the choice of the best type of vaporiser for many of the duties encountered in process plant. The middle chapters deal with calculations. The special problems relating to mechanical design are discussed, but the reader is referred to other documents for mechanical design. No special consideration is given to the boilers used in generating electricity or to the vaporisers used in the air-conditioning or cryogenic industries.

Heat exchangers may be designed on the basis of past experience, using achieved values of the overall heat transfer coefficient to predict how a new exchanger will perform under similar circumstances. This procedure is limited. A fundamental knowledge of heat transfer and fluid flow is needed to produce a procedure for designing heat exchangers for a wide range of conditions. It is over 50 years since William H. McAdams wrote his book *Heat Transmission*, which he described as 'designed to serve both as a text for students and as a reference for practising engineers'. This was followed in 1950 by Kern's *Process Heat Transfer*, which became the main reference on heat transfer for many process engineers. These books gave rational methods for predicting heat transfer in single-phase flow and in condensation, but gave very little on boiling.

More recently, many results have become available on heat transfer in boiling, especially on flow-boiling inside tubes. These results have been described in textbooks, and correlations have been published for predicting heat transfer coefficients in pool boiling and in-tube boiling. Although many aspects of boiling heat transfer have been dealt with very thoroughly, usually to meet the needs of the designers of boilers, there are many gaps in our knowledge, mainly on shellside boiling and the problems that arise in boiling mixtures of organic liquids. An attempt is made in Chapter 7 of this book to present the reader with a procedure for estimating the heat transfer coefficient in varporisers of the many different types, boiling various liquids, in the process industries. This is preceded by a chapter on the estimation of the heat transfer coefficient for the heating fluid, and is followed by chapters on two-phase fluid flow and the application to the design of a vaporiser, with forced or natural circulation.

The main recent advance in design methods for heat exchangers has resulted from the advent of the computer, which is especially useful when it is required to: (1) estimate the amount of fluid flowing across the tubes on the shellside of a shell-and-tube heat exchanger; (2) estimate the amount of recirculation in a natural-circulation vaporiser; and (3) carry out the integration necessary when estimating the required surface area and the pressure drop in a two-phase heat exchanger. Moreover the facility for quick calculations permits the preparation of several alternative designs, so that the most economical and reliable may be chosen. The reader may build up his own computer programs, based on correlations given in this book or elsewhere, to meet his own special needs. Or he may use a proprietary program (the main suppliers are listed).

The book is one of a series on Designing for Heat Transfer. Other books are being prepared in this series to give a similar treatment to the design of other types of heat exchanger. At the moment the following titles are in preparation:

Heat exchangers – Construction and thermal design (single phase)

Condensation and condenser design

R. A. Smith,
Middlesbrough
August 1985

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R. A. S.

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CHAPTER 1

Introduction

The technical manager or engineer in the process industry is often concerned with the equipment that is used to vaporise a liquid. The manufacturers offer him a choice from several, often very different, types when he wishes to purchase a new vaporiser, and many problems arise in the operation of existing equipment.

The vaporisers in use in the process industries cover a wide range of sizes and of duties. However, the same principles of design apply to all. This book deals with vaporisers used for the following duties.

1. A *fired boiler* to generate steam, which may be needed for process heating, power generation or as a process fluid.
2. A *waste heat boiler* to utilise surplus heat in a process fluid (after a high-temperature reaction) to generate steam to supplement that generated in fired boilers.
3. A *reboiler* to provide the source of heat needed to vaporise some of the liquid collected at the bottom of a distillation column, so that it may be returned to the column as vapour.
4. A *vapour generator* to *revaporise* a gas that has been liquefied to facilitate transport and storage, or to vaporise a *heat transfer fluid*.
5. A *vapour generator* to obtain a pure vapour from an impure liquid, as in a desalination plant.
6. An *evaporator* to *concentrate* a liquid.
7. An *evaporator* to produce *crystals* from a saturated liquid.
8. A *chiller* in a refrigeration system to cool a process fluid to a temperature below ambient.

Items (1) and (2) are called 'steam generators'.

Heat is supplied by the combustion of fuel for duty (1) and occasionally for duties (3) to (6). Heat for duties (3) to (6) is usually supplied by condensing steam, but waste heat in a process fluid may be used.