THE OPTIMAL SIZING OF MULTISTAGE HEAT EXCHANGER SYSTEMS

by

ANEES R. SIDDIQUI

A Thesis
submitted in fulfilment of the requirement of the
Degree of
DOCTOR OF PHILOSOPHY

Department of Mechanical Engineering
Indian Institute of Technology
New Delhi-110016

Nov.1982

To

My Loving Parents

CERTIFICATE

This is to certify that the thesis entitled 'THE OPTIMAL SIZING OF MULTISTAGE HEAT EXCHANGER SYSTEMS' has been prepared under our supervision in conformity with the rules and regulations of the Indian Institute of Technology Delhi. We further certify that the thesis has attained a standard required for a Ph.D. degree of the Institute. The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma

(Dr. Ashok Malhotra)
Mechanical Engineering Deptt.
Indian Institute of Tech.
New Delhi-110016.

(Dr. O.P. Chawla)
ITMMEC
Indian Institute of Tech.
New Delhi-110016.

ABSTRACT

The optimal sizing of heat exchanger systems consisting of one or two cold streams being heated by several hot streams is investigated in detail in the present work.

The technique employed for optimization is the Discrete Maximum Principle. The mathematical model used permits controlling the final temperature of cold stream as well as some or all the hot stream final temperatures, in case of single cold stream system. Auxiliary water coolers are included in the system in order to control the hot stream final temperatures. The model used allows the use of different cost coefficients (usually assumed invariant) and different heat transfer coefficients at different stages. The costs for the heat exchangers were ascertained through a market survey and empirically related to their heat transfer area through non-linear relationships.

Optimal recurrence relations relating the parameters of neighbouring heat exchanger stages are developed for a general heat exchanger type and a general class of cost functions. Several simplified solutions for specific heat exchanger type and cost functions are then obtained as special cases.

A numerical procedure is developed for carrying out the calculations on a digital computer. The speedy determination of the size of the first heat exchanger in the chain corresponding to the required solution (usually a problem in such techniques) is a part of the numerical procedure.

The methods developed in the present work are illustrated by optimizing a few petroleum refinery chains. The influence of various input parameters, particularly the cost exponent, on the optimal results is examined. The accuracy of the results is verified through a numerical perturbation test.

TABLE OF CONTENTS

Page