Optimization Strategies and their Applications in Thermal and Power Engineering

优化策略及其热能工程应用

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内容提要

本书以车用燃料电池系统、车用蓄电池散热系统、热处理用真空炉、热成形加热系统为应用对象，系统地阐明优化模型、全局优化、多目标优化策略，并进行了不同方法之间的比较研究。首先，介绍基于解析解、分析数据库、响应面法、最小二乘法等理论的优化模型，探讨提高优化效率的途径。然后，说明基于遗传算法、梯度法和实验设计法、遗传算法和梯度法的全局优化策略，讨论得到全局优化结果的可靠有效方法。最后，阐述基于线性加权法、理想点法、宽容序列法的多目标优化策略，揭示多目标优化策略的实质。本书将为优化工程实际问题提供坚实的理论基础。

作者简介

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Introduction to research team

We belong to the institute of renewable energy & energy conservation and emission reduction of Wenzhou University in China. The objective of our research team is developing basic theorem and technology for renewable energy & energy conservation and emission reduction. Recently, we have carried out more than 20 research projects including the projects funded by National Natural Science Foundation of China, Planned Science and Technology Project of Zhejiang Province in China, Natural Science Foundation of Zhejiang Province in China, Planned Science and Technology Project of Wenzhou City in China and etc. Also, we have published more than 100 papers including more than 30 SCI journal papers published in the International Journal of Precision Engineering and Manufacturing, Journal of Thermal Science and Technology, Journal of Mechanical Science and Technology and etc. Simultaneously, we have more than 20 patents including 6 international patents. Furthermore, our standing research results were combined into an academic book which published by Sichuan University Press.

Specially, Dr Li Feng-Xun from Ludong University have contributed to this book so much. Therefore, our research team has decided to include Dr Li as the 3rd author of this book.

Preface

Engineering consists of a number of well established activities, including analysis, design, fabrication, sales, research, and the development of systems. The design of systems is a major field in the engineering profession, and the design should be optimized under the condition of considering the performance and the cost.

The detailed contents of this book are as follows:

Chapter 1: The introduction to the optimal design was performed for better understanding of the following chapter.

Chapter 2: The modeling strategies for optimization were introduced; the advantages and drawbacks of the modeling strategies were discussed.

1st part of Chapter 2: The modeling strategy based on finite concept was introduced through optimizing thermoforming preheating process.

2nd part of Chapter 2: The modeling strategy based on design of experiments was introduced through optimizing the cooling system for batteries used for hybrid electric vehicles.

3rd part of Chapter 2: The modeling strategy based on analysis database was recommended through optimizing a high temperature vacuum furnace.

4th part of Chapter 2: The modeling strategy based on response surface method was recommended through optimizing the fuel cell system.

5th part of Chapter 2: The modeling strategy based on analytic method was shown through optimizing the preheating process of thermoforming.

Chapter 3: The global optimization strategies were introduced; the advantages and drawbacks were discussed through comparing with each other.

1st part of Chapter 3: The global optimization strategy based on genetic algorithm was introduced through optimizing the cooling system of batteries used for hybrid electric vehicles. Additionally, the modeling strategy based on least square method was used in this example.

2nd part of Chapter 3: The global optimization strategy based on GBM and DOE was recommended through optimizing the cooling system of batteries used for the hybrid electric vehicles again. Additionally, the modeling strategy based on simple approximation was used in this example.

Chapter 4: The multi-objective optimization strategies were introduced, and the performance of each strategy was compared with the others.

1st part of Chapter 4: The multi-objective optimization strategy based on Benson method was introduced through optimizing the cooling system of batteries used for hybrid electric vehicles.

2nd part of Chapter 4: The multi-objective optimization strategy based on layered sequence method was introduced through optimizing the cooling system of batteries used for the hybrid electric vehicles again

3rd part of Chapter 4: The multi-objective optimization strategy based on linear weighted method was recommended through optimizing the high temperature vacuum furnace.

4th part of Chapter 4: The multi-objective optimization strategy based on ideal point method was recommended through optimizing the thermoforming preheating system with a damaged heater.

Chapter 5: The contents of this book were summarized.

The sources of this book are as follows:

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Nomenclature

a	water activity
A	area, m^2
A_{fc}	fuel cell active area, m^2
B	coefficient matrix
c	mole concentration, mol/m^3
c_i	i^{th} coefficient of response surface
C_P	specific heat of ABS sheet, $J/(kg \cdot K)$
D	diffusion coefficient, m^2/s
$\langle D \rangle$	effective diffusion coefficient, m^2/s
D_{eff}	D-optimal assessment index
e	error
E	emitted heat flux or fuel cell open circuit voltage, W/m^2 or V
F	Faraday constant, C /mol
F_{k-j}	view factor from k surface to j surface
g	acceleration of gravity, m/s^2
g_i	i^{th} inequal constraint
G	irradiation, W/m^2
h	convective heat transfer coefficient, $W/(m^2 \cdot K)$
h_i	i^{th} equal constraint
H	error matrix
i	current density, A/cm^2
I	stack current, A
J	radiosity, W/m^2

k	thermal conductivity of ABS sheet, W/(m · K)
K	valve coefficient, kg/(bar · s)
L	half of sheet thickness, m
L_c	characteristic length, m
m	mass, kg
M	molecular mass, kg/mol
n	number of cells
n_d	electro-osmotic drag coefficient
N	molar flux, mol/(s · m^2)
P	pressure or power, pa or W
q	heat flow rate, W
q''	heat flux, W/m^2
R	gas constant or electrical resistance, Ω
Ra_L	Rayleigh number
s	fraction of liquid water volume to the total volume
s_{im}	level of immobile saturation
S	reduced liquid water saturation
t	time, s
t_m	membrane thickness, cm
T	temperature, K
T_∞	environmental temperature, K
υ	dynamic viscosity of air, m^2/s
V	volume or voltage, m^3 or V
W	mass flow rate, kg/s
x	mass fraction
y	mole fraction

Greek symbols

α	thermal diffusivity, m^2/s
β	volume expansion coefficient of air, K^{-1}
β_m	eigen vector
γ	volumetric condensation coefficient, s^{-1}
δ	thickness of diffusion layer, m
ρ_k	k^{th} surface reflection coefficient
σ	Stefan-Boltzmann constant, 5.67×10^{-8} $W/(m^2 \cdot K^4)$
ε	porosity or emissivity
η	viscosity, $kg/(m \cdot s)$
η_n	eigen value
λ	water content or excess ratio
μ	permeability, m^2
μ_r	relative permeability, kg/mol
ρ	mass density, kg/m^3
σ_m	membrane conductivity
Φ	Relative humidity
ω	humidity ratio

Subscripts

a	dry air/average
act	activation loss
an	anode
atm	atmospheric
c	center/capillary
ca	cathode
com	compressor
conc	concentration loss
conv	amount caused by convection
e	environment
elec	electric power
evap	evaporation
f	final
fc	fuel cell
gen	generated
GDL	gas diffusion layer
h	heater
H_2	hydrogen
H_2O	water
in	inlet/input
ini	initial
inf	infinite
l	lower/liquid water
m	membrane
max	maximum
memb	across membrane
N_2	nitrogen
ohm	ohmic loss
out	outlet
O_2	oxygen
para	parasitic
rad	amount caused by radiation
req	requirement
s	ABS sheet
u	upper

Contents