PROCEEDINGS OF THE 3RD INTERNATIONAL SYMPOSIUM ON HEAT TRANSFER AND ENERGY CONSERVATION

Volume 1

Editors in Chief

Hua Ben , Guo Zengyuan and Ma Chongfang

SOUTH CHINA UNIVERSITY OF TECHNOLOGY PRESS

3rd ISHTEEC

Proceedings of

The International Symposium on Heat Transfer Enhancement and Energy Conservation

(Guangzhou, P. R. China January 12-15, 2004)

Volume 1

Editors in Chief
Hua Ben, Guo Zengyuan, Ma Chongfang

Editors
Zhu Dongsheng, Chen Qingli, Gao Xuenong

South China University of Technology Press

The proceeding is available from:

The Key Laboratory of Enhanced Heat Transfer

& Energy Conservation, Ministry of Education,

School of Chemical Engineering

South China University of Technology

Guangzhou, 510640, The People's Republic of China

Tel: 86-20-87114568

Fax: 86-20-87114140

Published by South China University of Technology Press

Printed in ELITE GUANGZHOU PRINTING CO.,LTD

First Published 2004

Guangzhou 501640, The People's Republic of China

ISBN 7-5623-2019-5

TK•3

Price US$ 200.00

Honorary Conference Chairmen

Lin Yuanhe (China)
Liu Huanbin (China)
A.E. Bergles (USA)

Conference Chairmen

Hua Ben (China)
R.L. Webb (USA)
Ma Chongfang (China)

Scientific Committee Chairmen

Guo Zengyuan (China)
Noam Lior (USA)
Ma Chongfang (China)

Scientific Committee

A.E. Bergles (USA)
Cai R.X. (China)
Cheng L. (China)
Cheng P. (H.K. China)
Cheng S.W. (China)
C. Cortés (Spain)
Deng X.H. (China)
I. Dincer (Saudi Arabia)
M. Feidt (France)
C.A. Frangopoulos (Greece)
Guo L.J. (China)
Guo Z.Y. (China)
Han F.Y. (China)
T. Hirose (Japan)
Hua B. (China)
Huang S.Y. (China)
M.L. Hunt (USA)
N. Imaishi (Japan)
J.D. Jackson (U.K.)
T. Kashiwagi (Japan)
Yu.A. Kuzma-Kichta (Russia)
A.I. Leontiev (Russia)
Ling M. (China)
LI Z.X. (China)
V J.H. Lienhard (USA)
Lin Z.H. (China)
N. Lior (USA)
Ma C.F. (China)
G. Manfrida (Italy)
F. Meunier (France)
Ni W.D. (China)
F. Peterson (USA)
D. Poulikakos (Switzerland)
Qian Y. (China)
J.W. Rose (UK)
M.A. Rosen (Canada)
A. Saito (Japan)
Shen H. (China)
Shi M.H. (China)
D.W. Sun (Ireland)
K. Suzu ki (Japan)
Tao W.Q. (China)
S.N. Tay (Singapore)
G. Tsatsaronis (Germany)
Tu S.D. (China)
Wang R.Z. (China)
Wang S.W. (H.K.,China)
B.W. Webb (USA)
R.L. Webb (USA)
W.M. Worek (USA)
Xu J.Z. (China)
Yang X.X. (China)
Yuan X.G. (China)
Zheng D.X. (China)
Zhou Z.T. (Taiwan, China)
Zhu D.S. (China)

Organization Committee Chairman

Yang Xiaoxi (China)

Deputy Chairman and Secretariat

Zhu Dongsheng (China)

Organization Committee

Zhu Dongsheng, Yin Qinghua, Gao Xuenong, Peng Deqi, Liu Tao, Ji Jun, Wu Huijun, Dong Linqin, Chao Yinghui, Wang Wen, Min Jinchun, Zhang Zhengguo, Jiang Xiang, He Lu, Li Xiaoxin, Liu Chao

List of Reviewers

A.E. Bergles (USA)
C. Cortés (Spain)
C.A. Frangopoulos (Greece)
Guo Z.Y. (China)
N. Imaishi (Japan)
Yu.A. Kuzma-Kichta (Russia)
Lu E.X. (China)
Qian S.W. (China)
Sun D.W. (Ireland)
S.N. Tay (Singapore)
Tu S.D. (China)
Wang S.W. (H.K.,China)
R.L. Webb (USA)
Zhang Y.J. (China)
Zhou Z.T. (Taiwan, China)
Cheng L. (China)
M. Feidt (France)
Guo L.J. (China)
Hua B. (China)
J.D. Jackson (U.K.)
Li Z.X. (China)
Ma C.F. (China)
Shi M.H. (China)
Tao W.Q. (China)
G. Tsatsaronis (Germany)
Wang R.Z. (China)
B.W. Webb (USA)
Zeng B.Y. (China)
Zheng D.X. (China)
Zhu D.S. (China)

Sponsors

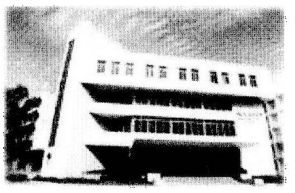
Ministry of Education, China
National Natural Science Foundation of China
K.C. Wong Education Foundation, China
Guangzhou Bureau of Science and Technology, China
Guangzhou Association of Science and Technology
Guangdong Kelon Electrical Holdings Co., Ltd
Shunde Shenling Air-conditioning Equipment Co., Ltd
Five Star Solar Energy Co., Ltd

Organizer

South China University of Technology, China

Cooperating Organizers

The Key Laboratory of Enhanced Heat Transfer & Energy Conservation, Ministry of Education, China



School of Chemical Engineering, South China University of Technology, China

Tsinghua University, China

Beijing University of Technology, China

PREFACE

It is an honor to participate in this important conference as one of the Honorary Conference Chairman. Indeed, it is a great personal pleasure to see so many friends of long standing among the Chinese and worldwide attendees. This year is the 20th anniversary of my first visit to China. In spite of the dramatic growth of electronic communications, I feel that the most significant advances in technology will be realized by personal contact. This conference provides the direct communication of technical information, and the opportunity to formally and informally learn more about the material presented. Cyber-conferences will never replace real symposia, such as this one.

I was privileged to attend the first International Symposium on Heat Transfer Enhancement and Energy Conservation in 1988, also held in Guangzhou. At that time, I talked about the impact of enhanced heat transfer on energy conservation. It is clear that energy conversion and utilization systems depend on temperature gradients. By reducing these gradients or making them more effective, through enhancement of the heat transfer coefficient in heat exchangers, there will be better use of energy resources. While it is necessary for the entire world to "conserve energy" ,it is particularly important for China to do so.

An increase in the Chinese standard of living will require an increase in the per-capita use of energy. Given China's large, and expanding, population, a sharp change in the national energy budget is expected. This may not be possible from the standpoints of geopolitical factors and environmental protection. The demand in energy is present in all sectors – industrial, residential, and transportation. The primary fuels of choice are oil and natural gas, but there is a widening gap between domestic supply and needs. It is predicted that over 8 million barrels of oil a day will be imported by China in 2015, up from about 2 million barrels a day at the present time. It is no surprise that Chinese energy companies have been seeking supplies outside the volatile Persian Gulf, for reasons of natural security. Oil especially affects the transportation sector. The number of cars on China roads increased over 50% in 2002, to 20.5 million vehicles. Even after the rapid growth tapers off, the number of cars is expected to grow by 10% per year, from 2005 – 2010. Considering that a modern automobile has as many as 7 heat exchangers, the opportunities for energy conservation through enhanced heat transfer are evident. The improvement of industrial and residential heat exchangers is also a major opportunity. But the rapidly escalating use of energy in China has led to an increase in pollution. For instance, China's booming auto market is not only consuming gasoline at an alarming rate, but also emitting pollutants that contribute to China's deteriorating environment. A prosperous and healthy China will require greater efficiency of energy utilization, so that there is a reduced rate of growth of energy consumption. Coincident with that, the pollution from cars, power plants, etc. must be reduced. Advanced combustion engines offer the prospect of greater fuel economy and reduced emissions. Diesels are also possibility, as they are more efficient than gasoline-engine cars of comparable output. It is argued that they are just as clean, if not cleaner, than spark-ignition engines. Turning to power plants, local coal now provides 60% of electricity output, but natural gas is being pushed hard as a cleaner fuel. This provides new options for heat recovery in boilers.

In my view, China has a unique opportunity, as well as a mandate, to employ the latest conservation technologies as energy use escalates. This will reduce the energy resources that are needed and reduce pollution. Included in the mix of energy resources are renewable, such as wind and solar. It is expected that this symposium will provide the technologies and discussions that will lead to a secure energy future for China.

Arthur E. Bergles
Honorary Chairman, ISHTEE
Honorary Professor, Beijing University of Technology

Contents

Section 1 Enhancing Heat Transfer in Processes

Section 2 Enhancing Heat Transfer Techniques