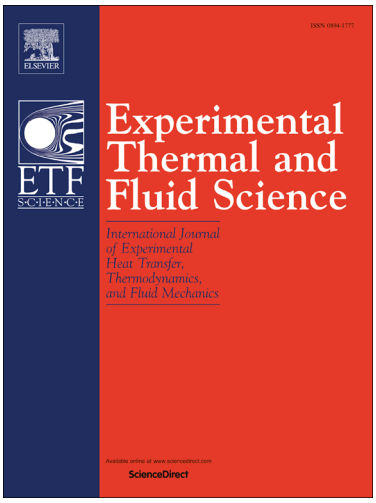

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Experimental Study on Heat Transfer Enhancement of Gas Tube Partially Filled with Metal Foam

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Abstract: This paper proposes partially filling a gas tube with metal foam to further enhance the gas heat transfer capability with smaller pressure loss. A wind-tunnel-type gas heat transfer test system was built to investigate the features and effects of this heat transfer enhancement method. The effects of pore density and filling thickness of the metal foam on the gas heat transfer in the tube were studied experimentally and analyzed by determining the performance evaluation criteria (PEC), a comprehensive evaluation index. The results show that for the same porosity and filling rate, a high heat transfer coefficient can be obtained at high pore density; however, the comprehensive evaluation index of metal foam with a lower porosity is higher. Thus, lower porosity metal foam inserted at a higher filling rate, together with a low Reynolds number, leads to more efficient heat transfer.

Keywords: Heat exchanger; heat transfer coefficient; metal foam; heat transfer enhancement; comprehensive evaluation index.

Nomenclature

K	Permeability[m^2]	T_{in}	Gas inlet temperatures[°C]
C	Inertial coefficient[m^{-1}]	μ	gas viscosity[Pa·s]
ε	Porosity	T_{out}	Gas outlet temperatures[°C]
d_p	Pore diameter[m]	Nu	Nusselt number [-]
h	Heat-transfer coefficient[W/m^2K]	f	Friction coefficient [-]
T_f	Gas average temperature[°C]	D	Equivalent diameter[m]
δ	Wall thickness[m]	Re	Reynolds number[-]
λ	Channel wall thermal conductivity[W/mK]	Δp	Gas tube pressure drop [Pa]
A	Gas tube heat exchange area [m^2]	L	Gas tube length [m]
$\bar{t}_{w1}$	Gas tube inside wall average temperature [°C]	ρ	Gas density [kg/m^3]
$\bar{t}_{w2}$	Gas tube outside wall average temperature [°C]	u	Gas velocity [m/s]
c	Gas specific heat [kJ/(kg·K)]	PEC	Performance Evaluation Criteria[-]
m	Gas mass flow[kg/s]	Pr	Prandtl number[-]

1. Introduction

The use of inserts in heat transfer tubes is a convenient heat transfer enhancement technique, indicating that only a simple modification of an ordinary heat exchanger can improve the heat exchange efficiency. In this regard, the use of porous foam as an effective way to enhance the heat transfer can significantly improve the effective thermal conductivity coefficient of fluid in the tube. First, the internal structure of porous foam is complex and results in a nonlinear enhancement and

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