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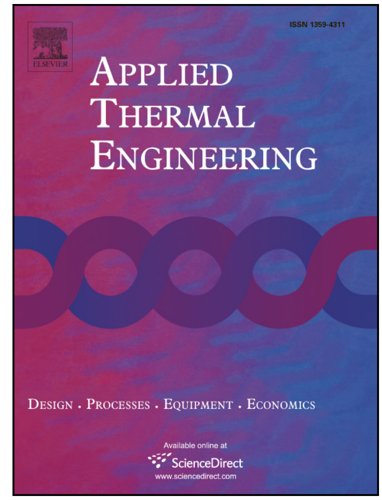

Research Paper

Design Methodology of Organic Rankine Cycle for Waste Heat Recovery in Cement Plants

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Design Methodology of Organic Rankine Cycle for Waste Heat Recovery in Cement Plants

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Abstract

An organic Rankine cycle (ORC) is similar to a conventional steam cycle energy conversion system, but uses organic fluid, such as refrigerants and hydrocarbons, instead of water. A renewed research interest in ORC focuses on its progressive adoption as a premier technology for converting low and medium temperature i.e. 80°C < T < 300°C heat resources into power. Available heat resources are solar energy, geothermal energy, biomass products, surface seawater, and waste heat from various thermal processes. This study presents a design methodology for an ORC. The design is conducted based on the actual data from a local cement factory. The working fluid directly affects the efficiency of the cycle. The fluid choice is fundamental for a good cycle performance because the optimal thermos physical properties depend on the source temperature. This study illustrates the results of an organic Rankine cycle combined with a gas turbine to convert the gas turbine waste heat into electrical power. The R134a working fluid is chosen for the design. Consequently, approximately 1 MW power can be generated using an ORC. Exergy analysis is performed using actual data from the industry, showing that most of the exergy loss is in the working part of the turbine.

Keywords: Design of ORC; R134a, Heat Transfer Coefficients, Exergy

NOMENCLATURE

ORC	Organic Rankine cycle
Q	heat rate (kW)
h	enthalpy (kJ/kg)
m	mass flow rate (kg/s//)
U	overall heat transfer coefficient ($kW/m^2.K$)
A	area (m^2)
D	diameter (m)
K	thermal conductivity of pipe (W/mK)
NuD	Nusselt number
Pr	Prandtl number
μ	dynamic viscosity ($N.s/m^2$)
ρ	density (kg/m^3)
V	velocity (m/s)
λ	parametric length of tube (m)
S_Q	transverse tube spacing (m)
NTU	number of transfer units
f	Darcy coefficient of friction
L	length (m)
W	work done (kW)
Re	Reynolds number
E	exergy (kJ)
μ_b	base fluid viscosity $\left(N.\frac{s}{m^2}\right)$
μ_w	fluid viscosity at the wall of pipe $\left(N.\frac{s}{m^2}\right)$

Subscripts

g	gas
i	inlet
l	liquid phase
o	outlet
cold (c)	fluid at cold side