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Performance parameters for the design of a combined refrigeration and electrical power cogeneration system

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Abstract

This paper discusses the conservation of energy in a cogeneration system. A steam power cycle (Rankine) produces electrical power 2 MW and steam is bleeded off from the turbine at 7 bar to warm a factory or units of buildings during the winter or to supply a steam ejector refrigeration cycle to air-conditioning the same area during the summer. In the summer this system can be as alternative solution instead of absorption. Certainly the ejector refrigeration unit is more economical than absorption unit. The ratio of electrical power/heat is varied into the region (0.1–0.4) and the evaporator temperature of the ejector cycle is varied into the region (10–16 °C). A computer program has been developed for the study of performance parameters of the cogeneration system.

Keywords: Cogeneration; Survey; Heat recovery; Steam; Water; Ejector system; Air-conditioning; Simulation; Performance

Paramètres de performance pour la conception d'un système mixte production de froid/cogénération

Mots clés : Cogénération ; Enquête ; Récupération de chaleur ; Vapeur ; Eau ; Système à éjecteur ; Conditionnement d'air ; Simulation ; Performance

1. Introduction

Generally the cogeneration systems are saving energy systems. There are many factories and units of buildings that need electrical power and heat energy or air-conditioning during the winter or summer, respectively. Generally a cogeneration system for air-conditioning uses waste heat or exhaust gases in order to feed an absorber unit.

In this paper the absorber unit has been replaced by steam ejector refrigeration system. The plan in Fig. 1 covers these requirements. This plan contents steam power cycle with the below characteristics.

Power of cycle: 2 MW
Maximum pressure of cycle: 20 bar
Maximum temperature of cycle: 360 °C
Minimum pressure of cycle: 0.2 bar
Bleeding off pressure: 7 bar

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Nomenclature

EUF	energy utilization factor
FESR	fuel energy savings ratio
h	specific enthalpy (kJ kg^{-1})
$\dot{m}$	mass rate (kg s^{-1})
P	pressure (bar)
$\dot{Q}$	heat transfer rate (kW)
s	specific entropy (kJ kg^{-1} K^{-1})
T	temperature (°C)
$\dot{W}$	work rate (kW)
w	mass entrainment ratio

Greek letters

η	efficiency
υ	specific volume (m^3 kg^{-1})

Subscripts

1, 2,…	cycle locations
a, *b*,…	ejector locations
B	boiler
COC	cogeneration electrical and refrigeration power
COH	cogeneration electrical and heat power
CE	condenser (CE)
CR	main condenser (CR)
DFH	deaerating feedwater heater
e, E	evaporator
g, GE	heat generator (GE)
G	generator (G)
GEE	heat generator (GE), stream 15-10
GER	heat generator (GE), stream 6-9
m	mechanical
p	pump
PR1	condensate pump
PR2	feedwater pump
R	Rankine
T	turbine

Deaerating feedwater heater pressure: 3 bar
Turbine and pump isentropic efficiency: 85%
Boiler efficiency: 90%
Turbine mechanical efficiency: 95%
Generator (G) efficiency: 98%

And steam ejector refrigeration cycle with the below characteristics.

Heat generator (GE) pressure: 6 bar (saturated steam)
Condenser (CE) temperature: 50 °C
Evaporator (E) temperature: 10 °C, 12 °C, 14 °C, 16 °C
Heat generator (GE) efficiency: 85%

The steam ejector refrigeration system produces enough advantages [1], and [2].

- Operating cost is very low
- Reliability
- Maintenance cost is also low
- Simplicity of operation

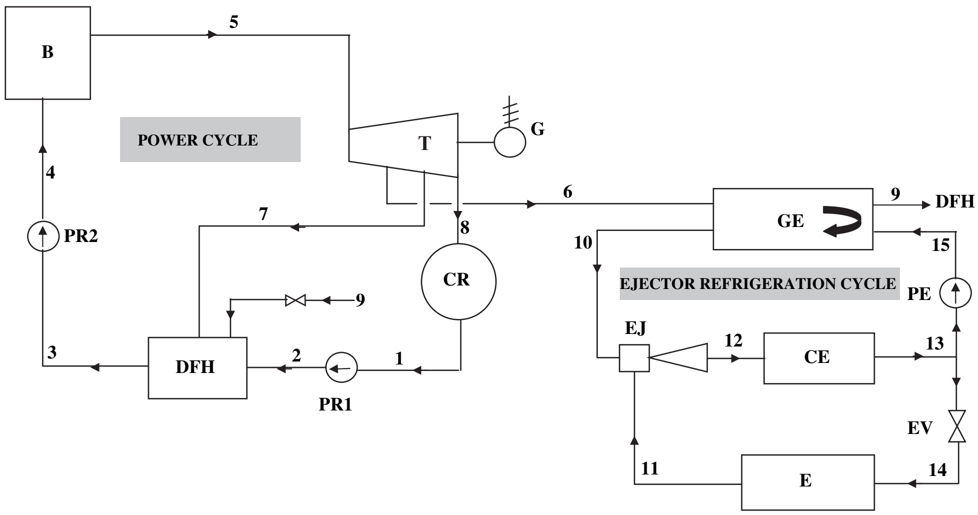

Fig. 1. Schematic view of combined refrigeration and electrical power cogeneration system (B: boiler, T: turbine, G: generator, CR: main condenser, PR1: condensate pump, DFH: deaerating feedwater heater, PR2: feed water pump, GE: heat generator, EJ: ejector, CE: condenser, E: evaporator, PE: pump, EV: expansion valve).