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Sizing curve for the design of thermal stabilizer of a diesel engine powered trigeneration system

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Abstract

Integrating absorption chillers with diesel engine generators makes possible the use of its rejected energy for meeting cooling energy demand. The performance of such an absorption chiller is sensitive to the temperature at its desorber section. In hot water driven double effect absorption system, the temperature of hot water is to be maintained between 170 ^{0}C and 165 ^{0}C. A hot water storage tank is therefore proposed to be integrated so as to maintain the water temperature within allowable limits. Sizing of such a hot water storage referred to as a thermal stabilizer is therefore an important objective. One such technique proposed is a sizing curve method based on thermal stability time. A generalized methodology for generating a sizing curve for a cooling load is presented in this paper. The method offers a simplified approach for sizing of thermal stabilizer for a given diesel generator catering to combined power and thermal demands. This sizing methodology is illustrated for a 180 kW diesel engine based trigeneration system catering to fluctuating cooling and power loads.

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1. Introduction

Trigeneration with reciprocating engines as prime movers involve recovery of energy rejected from engines and using this energy to satisfy cooling and heating demand of a given load. This is known to be beneficial in reduction in energy use and carbon emissions [1].Energy recovered from exhaust gases is commonly harnessed using suitably designed heat exchangers[2,3].Absorption chillers come in different configurations and types which affects its performance [4].Systems approach in analyzing trigeneration systems has been used in many studies indicating the desirability of trigeneration [5].

Trigeneration systems are required to satisfy the variable power demand or variable thermal demand depending on the load curve and the mode of operation of diesel generator. Diesel generators operating in electricity demand following mode would operate at part loads at times. Part load behavior of engines would result in corresponding reduction in output of absorption chillers. To compensate for this an hybridization strategy of using a compression chiller along with absorption chiller has been recommended [6]. This strategy makes it possible to operate the diesel generator closer to its rated capacity while catering to the combined heating, cooling and power demand.

For variable thermal demand, trigeneration systems should include a thermal storage. A reduced thermal demand would require the surplus recovered energy to be dumped. Thermal storage should be sized to reduce the energy to be dumped. Larger thermal storage volumes would however mean more surface heat losses. Thermal storage sizing has to be done remembering these constraints. This paper proposes a sizing methodology for sizing a thermal storage of diesel engine based trigeneration system integrated with hot water based absorption chiller via a thermal storage for applications with simultaneous heating, cooling and power demandHere introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper.

Nomenclature

A_{st}	surface area of insulated storage tank [m^2]
C_p	specific heat of water [kJ/kgK]
C_{pg}	specific heat of engine exhaust gases [kJ/kgK]
COP	coefficient of performance
d	diameter of storage tank [m]
DG	diesel generator
h	height of storage tank[m]
m_g	mass flow rate of exhaust gases of the engine [kg/s]
m_s	mass flow rate of hot water entering and exiting high temperature desorber [kg/s]
m_f	fuel consumption rate of engine [kg/s]
m_{sr}	mass flow rate of hot water entering and exiting low temperature desorber [kg/s]
m_w	mass flow rate of engine jacket water [kg/s]
P_c	Cooling load in TR
TR	tons of refrigeration
T_{g1}	Temperature of exhaust gases entering exhaust gas heat exchanger [^{0}C]
T_{g2}	Temperature of exhaust gases exiting exhaust gas heat exchanger [^{0}C]
T_s	Temperature of water in the low temperature storage tank [^{0}C]
T_{sh}	Temperature of water in the high temperature storage tank [^{0}C]
T_a	Temperature of ambient air [^{0}C]
q_{stl}	rate of energy losses from storage [kJ/s]
q_r	rate of recovered energy [kJ/s]
q_l	rate of heat energy removed from the storage tank for input to the desorber [kJ/s]
V_{sh}	storage volume of high temperature storage tank[m^3]
ρ	density of water [kg/m^3]