Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 81 (2015) 390 – 398

Energy Procedia

69th Conference of the Italian Thermal Engineering Association, ATI 2014

Optimization of solar integration in biomass fuelled steam plants

A.Amoresano[a],G.Langella[a,]*,S.Sabino[a]

[a]*University of Naples "Federico II" – Department of Industrial Engineering*

Via Claudio 21 – 80125 Naples, Italy

Abstract

This paper is focused on solar-biomass integration and presents a thermodynamic analysis of solar power utilization replacing the steam bleeds of a regenerative Hirn cycle plant, biomass fuelled, in feedwater pre heating process. In solar-biomass integrated configuration an energy conversion efficiency of solar energy has been evaluated in order to compare the use of solar energy in solo and hybrid configurations. Such efficiency has been adopted as optimization parameter for the best hybrid plant configuration, varying steam pressure and regeneration parameters.

Peer-review under responsibility of the Scientific Committee of ATI 2014

Keywords: solar energy; biomass; thermodynamic optimization;

1. Introduction

Solar energy is widely the most abundant among renewable sources but some crucial limits are related to its exploitation, especially for electric power production. First of all it's a low density source so it needs to be concentrated in order to reach high temperatures of fluids involved in thermodynamic cycles. High concentration allows high temperatures of fluids and so high cycle efficiencies. However the higher is concentration, the higher are thermal losses of solar collectors, plant complexity and costs.

The second fundamental limit of solar source is its discontinuity, due to night-day alternation and weather condition.

*Corresponding Author . Tel: 0039 081 7683275; fax: 0039 081 2394165

E-mail address: giulange@unina.it

Peer-review under responsibility of the Scientific Committee of ATI 2014

doi:10.1016/j.egypro.2015.12.108

Energy storage facilities allows to generate electricity from sun continuously, but this involves additional cost. For all these reasons electricity production costs by solar plants are still high and not competitive with other source options, if not with specific incentives.

One of the ways to reduce solar energy costs, also avoiding storage systems, is the solar integration in plants fed by other sources available with continuity(i.e. biomass). A particular approach of solar-biomass integration has been presented, evaluated and discussed in this paper.

Hybridization of solar plants is not a new concept. About thirty years ago Mc Donald (1986) [1] investigated hybrid plants combining CSP (concentrated solar power) with biomass, using dish systems. In this case no plants were built due to high costs and technological constrains.

Another approach of solar integration, proposed by Ying et al.[2] , is the use of solar energy to replace the extracted steam from turbine bleeds, to heat the feed water in regenerative Rankine plants. He evaluated the integration by an exergy merit index, in different cases.

In several cases of solar-biomass hybridization, there is rather a biomass integration in a solar plant: a biomass fired steam boiler is integrated into a CSP plant water-steam cycle or a biomass fired heater is integrated in the thermal oil or molten salt cycle, substituting sun when it's not available[3][4][5][6].

Fresnel systems have been investigated too for solar-biomass integration [7][8][9][10], but no reference plants are yet available for this CSP option, although it has the advantage to reach high fluid temperature, up to 500 °C and so high conversion efficiencies.

Nomenclature

h	specific enthalpy [kJ/kg]
m	total mass flow rate [kg/s]
P	power delivered by the plant [kW]
Q	thermal power [kW]
T	temperature [°C, K]

Greek symbols

Δ	variation
ε	heat exchanger efficiency
η	efficiency

Subscripts

1bl	with only the first bleed
2bl	with only the second bleed
coll	collectors
g	global
IN	inlet
l	limit
max	maximum value
m	mechanical
nobl	without bleeds
oil	diathermic oil
ORC	organic Rankine Cycle
OUT	outlet
r	real
st	steam
SC	solar conversion
tot	total
w	water