12CNIT-2022 - EXTENDED ABSTRACT

Preliminary exergy analysis of ASTEP system

Fernando Varela[1], Mercedes Ibarra[1], Antonio Rovira[1]

[1]Dept. Energy Engineering, UNED, 12 Juan del Rosal St., Spain, e-mail: fvarela@ind.uned.es

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TOPIC: ENERGY, EXERGY AND ECONOMIC ANALYSIS OF THERMAL POWER PLANTS

1. Introduction

The ASTEP concept was proposed within the European Project with the same name (Application of Solar Thermal Energy to Processes). It consists in the integration of a rotary Fresnel collector and a Phase Change Material (PCM) Thermal Energy Storage (TES) connected in series with the collector, to demonstrate the viability to cover the energy demands of industry processes with solar thermal technologies.

The concept will be tested in two industrial sites with different demands and meteorology. The maximum working temperature will be 240ºC, and the heat thermal fluid is Therminol 55®. The demand studied in the first case (Mandrekas, Greece) is a boiler producing steam at 175ºC and two chillers to cool water at -5ºC.

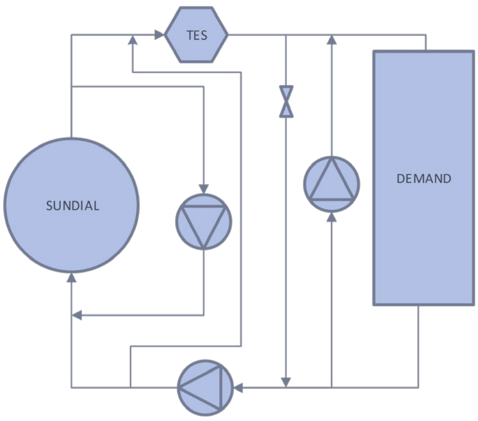

Figure 1. Layout for the ASTEP concept.

This work aims to assess the exergy analysis of the concept.

2. Materials and method

The starting point for the analysis is a numerical simulation of the plant performed in Matlab®, which provides temperature, pressure and mas flow data of the thermal fluid in every needed point of the scheme, and PCM cell temperatures every 15 minutes during an entire year.

For the exergy analysis, an exergy balance formulation for each element of the plant has been used:

$$\frac{d\Phi}{dt} = \sum_e \dot{m}_e \psi_e - \sum_s \dot{m}_s \psi_s + \dot{\Phi}_Q + \dot{W} - \dot{I} \quad (1)$$

Where ψ is the flow exergy of a current, $\dot{\Phi}_Q$ the exergy of the heat flow and $\dot{I} = T_0 \cdot \dot{\sigma}$ is the irreversibility. The analysis of the absorption machine ais limited exclusively to the heat exchanger due to its intrinsic difficulty and will be analised specifically in other work.

Climatic data of the site are obtained from the software Meteonorm®.

3. Results and discussion

The exergy analysis is resumed in the following chart:

Table 1. Exergy losses (MWh/year).

Receiver	Salt HX	Boiler	Chiller	Pumps & Valves
97.64	0.47	0.35	0.074	0.28

As energy losses in the receiver are remarkably higher than the others due to its low exergy performance (about 10%), they are usually taken out of the study.

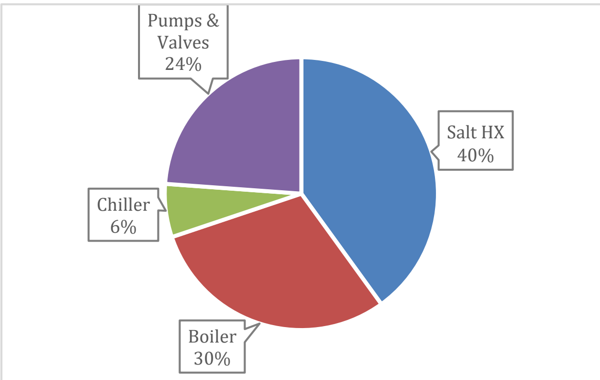

Figure 2. Distribution of exergy losses.

4. Conclusions

Majority exergy losses are located in the solar receiver, followed a long way behind by the salt heat exchanger, and in the same order of magnitude, boiler and pumps/valves losses.

Aknowledgements

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