The total area of the collectors $A_{t,col}$ is calculable by the relation:

$$A_{t,col} = \frac{P_e}{DNI \cdot \cos i \cdot \eta_{col} \cdot \eta_{turb} \cdot \eta_a} \quad (26)$$

Inserting in eq. (26) the values $P_e=50.10^6$ W, DNI=800, cosi=0.964, and the efficiencies obtained by VIVASOL, equal, in the case of variable flow rate, to $\eta_{col}=0.641$, $\eta_{turb}=0.326$, $\eta_a=0.98$, an area of collectors $A_{t,col}=316593$ m^2 is obtained.

Each collector having an area of 576 m^2 (100 m x 5.76 m), 550 parabolic collectors are necessary. The design mass flow rate results to be m=0.741 kg/s. Each collector having an area of 576 m^2 (100 m x 5.76 m), 550 parabolic collectors are necessary. The design mass flow rate results to be m=0.741 kg/s. In the case of constant flow rate, with m=0.75 kg/s, one obtains instead $\eta_{col}=0.708$, $\eta_{turb}=0.338$, $\eta_a=0.98$, $A_{t,col}=270927$ m^2 and 470 collectors.

The size of the collector field is therefore determined by the plant operating mode. Table 5 reports the values of annual electrical energy production (MWh/year) and of annual average power (MW) of a plant with 550 collectors located in Crotone and in Almeria, operating the plant at variable flow rate and at constant flow rate with and without reheating. Looking at the table, one observes that the maximum electrical production of 124080 MWh/year is obtained in Almeria with reheating and a mass flow rate m=0.4 kg/s; in Crotone, this maximum value is of 102500 MWh/year. Reheating is therefore more convenient for Almeria, where there is a direct irradiance 12% higher than that of Crotone.

CONCLUSIONS

This work presents a model able to evaluate the hourly and yearly performances of thermodynamic solar plants provided with parabolic linear collectors, utilizing atmospheric air as heat transfer fluid as well as working fluid in an open-type Brayton-Joule cycle. The plants were studied in two operating modes: at variable flow rate and constant temperature at the outlet of the collectors, and at constant flow rate and variable outlet temperature. The influence of some parameters such as direct irradiance, mass flow rate and collector length on the performance of the plant was studied. Moreover, a variant of the plant was also considered, in which the fluid is reheated after a partial expansion in the turbine. In all calculations the limit temperature of 580°C for the air flowing in the collectors was respected, in order to prevent the deterioration of the radiative properties of the absorbing tubes. Table 5 reports the values of annual electrical energy. The results obtained demonstrate a very good performance by this type of plant, which utilizes the ambient air in place of the expensive and more problematic fluids such as synthetic oils and molten salts used in already constructed plants; it is very simple from the constructional point of view and does not need any water because the working fluid in the engine is the air and the intercooling of the compressor can also be done by atmospheric air. The absence of water makes this plant very attractive for its installation also in arid regions. Moreover, if a larger and more constant production of electrical energy is needed, this plant can be very easily hybridized by adding a fuel combustion chamber.

The performances of these plants are comparable and sometimes even superior to those of the Spanish oil and water steam plants with Rankine cycle, which present average yearly global efficiencies near 16% [15], against the 18-19% achieved by our plants. Use of the reheating can be convenient in some localities, since it increases the average yearly efficiency of the plant.

A prototype turboair plant should be constructed in order to test its real performance in the field.

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