Air pre-cooling technologies for gas turbine plants

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Introduction

* Gas turbine(GT) based power plant is one of the common electricity production methods all over the world. However, the efficiency of the GT power plant is significantly reduced in hot seasons of the year (because of hot intake air to the gas turbine). Pre-cooling of intake air is able to increase the efficiency and output power of the GT pants [1,2].

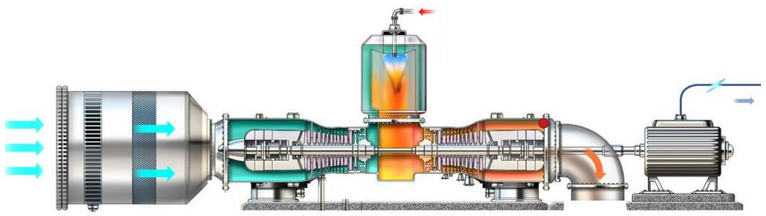

Figure1:Schematic of gas turbine

* Gas turbine based power plant can be in the form of simple or combined cycle as shown in figure 2 and 3 respectively.

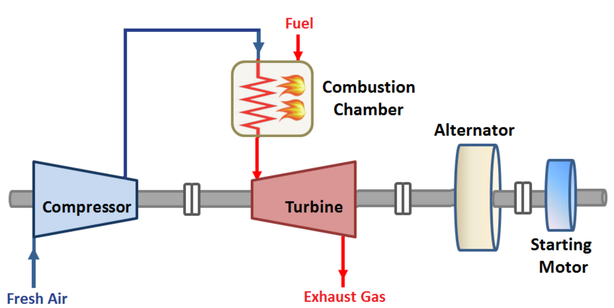

Figure2: Schematic of simple GT cycle

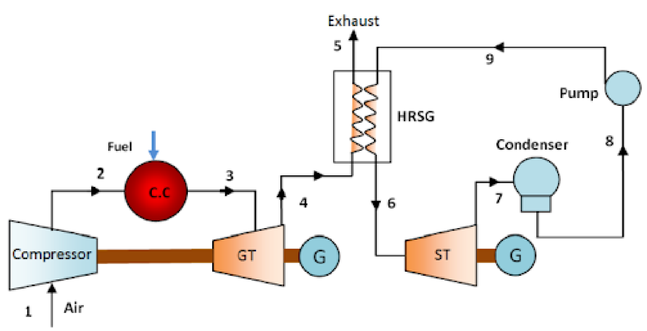

Figure3: Schematic of combined GT+ ST cycle

Conventional pre-cooling technologies

Conventional pre-cooling technologies used in both simple and combined cycle gas turbine (GT) based power plants include:
1. absorption refrigeration, 2. vapour compression refrigeration, 3. direct evaporative and indirect evaporative cooling, and 4. earth- air heat exchanger etc.

*Evaporative cooling

Direct Evaporative cooling (DEC) and Maisotsenko Indirect evaporative cooling (M-cycle IEC).

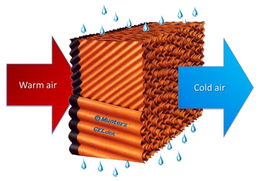

Figure 4: Schematic of DEC tech

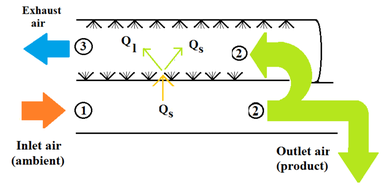

Figure 5: Schematic of M-cycle IEC tech

*Absorption refrigeration (AB) technology:

Absorption refrigeration is a device that uses exhaust gas of gas turbine based power plant to run and cool the intake air to the gas turbine.

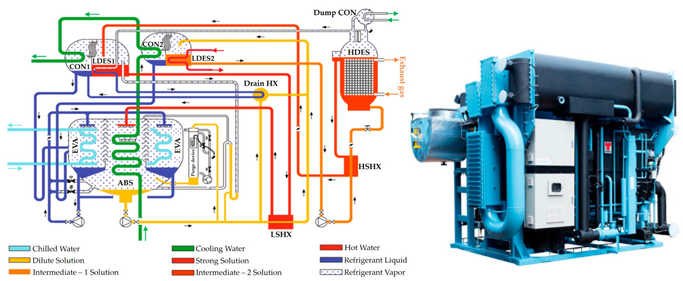

Figure 6: Schematic of AB tech

*Air-earth heat exchanger (AEHE):

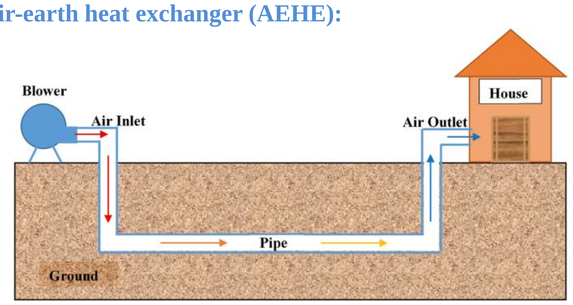

Figure 7: Schematic of AEHE tech

New more cost-effective pre-cooling tech for GT plants

Two novel pre-cooling technologies are proposed:

1. hybrid indirect evaporative + absorption refrigeration (M-cycle IEC and AB cooling) technology ;

2. Thermal Diode Tank (TDT) enhanced AEHE (AEHE+TDT): Thermal Diode tank (TDT), an invention by Eric Hu, is able to harvest the cold energy from ambient air at nights and/or in winter and to charge it into underground to lower the soil temperature near the air-earth heat exchanger (AEHE), so the performance of the AEHE can be improved.

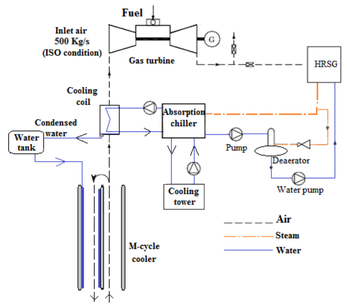

Figure8: Schematic of integration of M-cycle and AB tech on GT

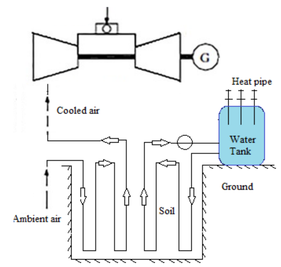

Figure9: Schematic of Thermal Diode Tank (TDT) enhanced AEHE

Aim and specific objectives

Aim:

Develop a better understanding and a cost effective intake air pre-cooling mechanism for gas turbine based power plants (both simple and combined cycle).

Objectives:

- Exploring the analytical-theoretical models
- Developing or modifying a GT based power plant simulation model
- Developing validated analytical-theoretical models of Maisotsenko indirect evaporative cooler (M-cycle IEC) and other refrigeration and cooling technologies
- Combining the models above to form the study tool for evaluating the cost-effectiveness of various pre-cooling technologies
- Using the study tool to undertake sensitivity studies of different combinations of different cooling technologies
- Modeling a TDT enhanced earth-air heat exchanger and assessing its performance (improvement).

References

[1] Kakaras, E., Doukelis, A. and Karellas, S., 2004. Compressor intake-air cooling in gas turbine plants. Energy, 29(12-15), pp.2347-2358.

[1] Basrawi, F., Yamada, T., Nakanishi, K. and Naing, S., 2011. Effect of ambient temperature on the performance of micro gas turbine with cogeneration system in cold region. Applied thermal engineering, 31(6-7), pp.1058-1067.