SCO_2 closed Brayton cycle for coal-fired power plant: an economic analysis of a previous technical optimization

Supercritical CO_2 Power Cycles Symposium

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INTRODUCTION

The main conclusions concerning the previous technical sensibility analysis [1] are the following: a recompression cycle is mandatory because the secondary compressor "partial flow" stream enable to gain significant efficiency (+4.5%pt compared to basic Brayton cycle layout without recompression stage). Furthermore, double reheat architecture (3 turbines) offers interesting efficiency improvement at "moderate" turbine inlet temperature (about +1.5%pt at 620°C turbine inlet temperature).

OBJECTIVE

This paper intends to complete the described technical analysis done in 2016 [1] by achieving an economic evaluation of the described sCO2 Brayton cycle architecture in order to assess the economic impact on a technical optimization result. The economic analysis is done by using equipment cost correlations found in literature (when available) or internally built (see methodology section below).

METHODOLOGY

The CAPEX is composed of direct costs (purchased equipment, piping, electrical, civil work, transport, direct installation, auxiliary services, instrumentation and control, site preparation) and indirect costs (mainly engineering, supervision, start-up) [2; 3]. All this costs can be expressed as a function of the cost of components: $CAPEX = (1 + x_1 + x_2) \times \sum(component\ costs)$ where x_1 and x_2 are respectively linked to direct costs (x_1=26%) and indirect costs (x_2=8%) [2; 3].

Each component cost is expressed as follows: $cost_{component}(\$) = a \times (Parameter)^b \times f_p \times f_t$ where "a" and "b" are empirical coefficients that depend on components and f_p and f_t are pressure and temperature factors whose aim is to simulate the use of high grade material requirement (expensive material) when the maximal pressure and the temperature rise. The "parameter" represents the "characteristic power" of each component (heat duty for heat exchanger and boiler, and electricity power for turbomachineries).

DISCUSSION AND PERSPECTIVES

These results shows that the economic evaluation of sCO_2 Brayton cycles is complementary and the sole technical performance criteria is not sufficient to expected the best economic solution (economic optimum does not fit the performance optimum as depicted on fig.2). Thus economic evaluation can lead to different solution, especially when comparing several solutions. That is why further development of this methodology are foreseen in our team.

Two main perspectives are expected: first, improvement of the economic model (refinement of component cost models, addition of Levelized Cost Of Electricity (LCOE) module…) and then, application of the cost evaluation method on the whole sensibility analysis carried on in the related paper [1] in order to assess the economic impact of suggested technical improvements (e.g. the number of reheats…).

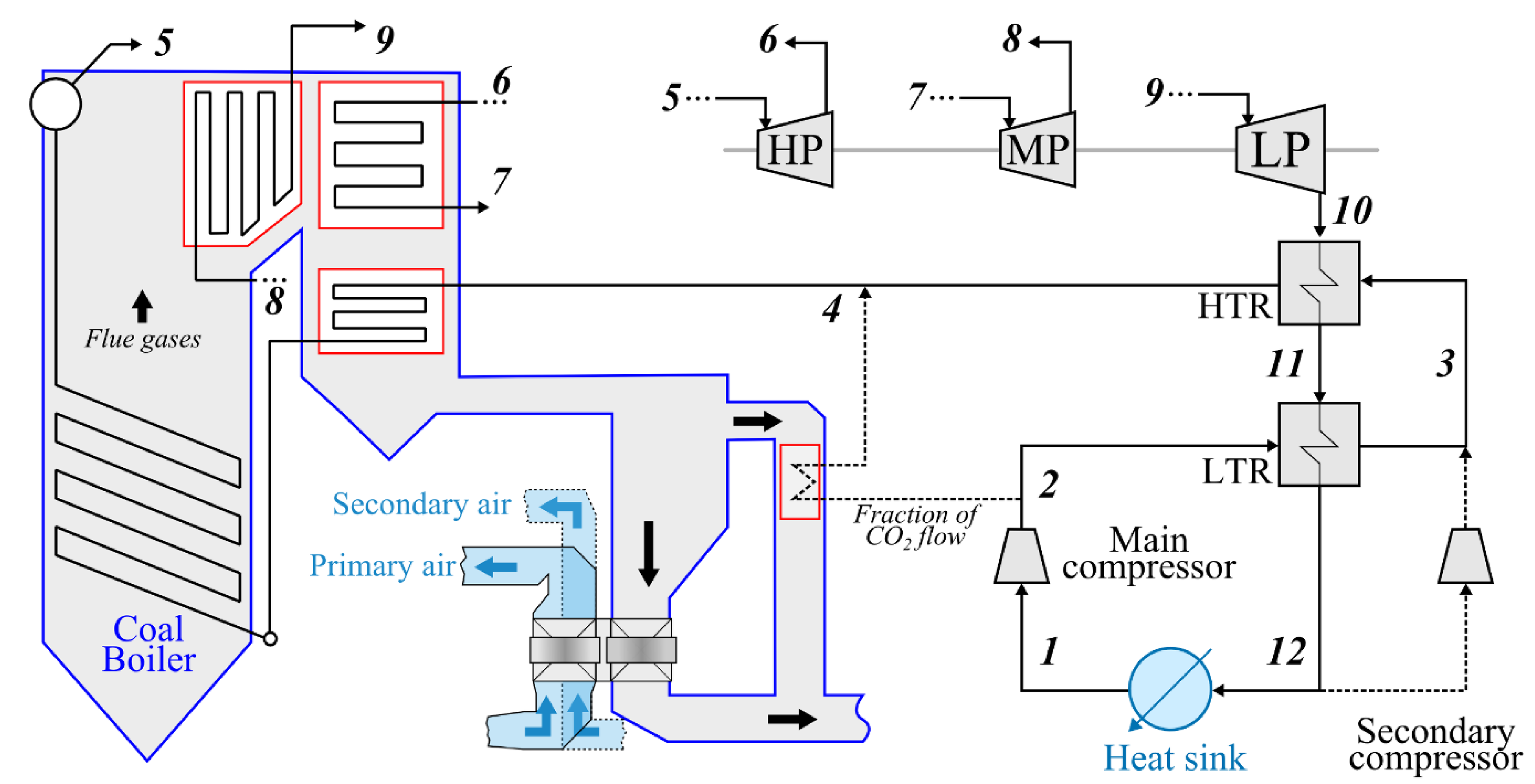

Figure 1: Process Flow Diagram (PFD) of suggested coal-fired power plant configuration in [1]

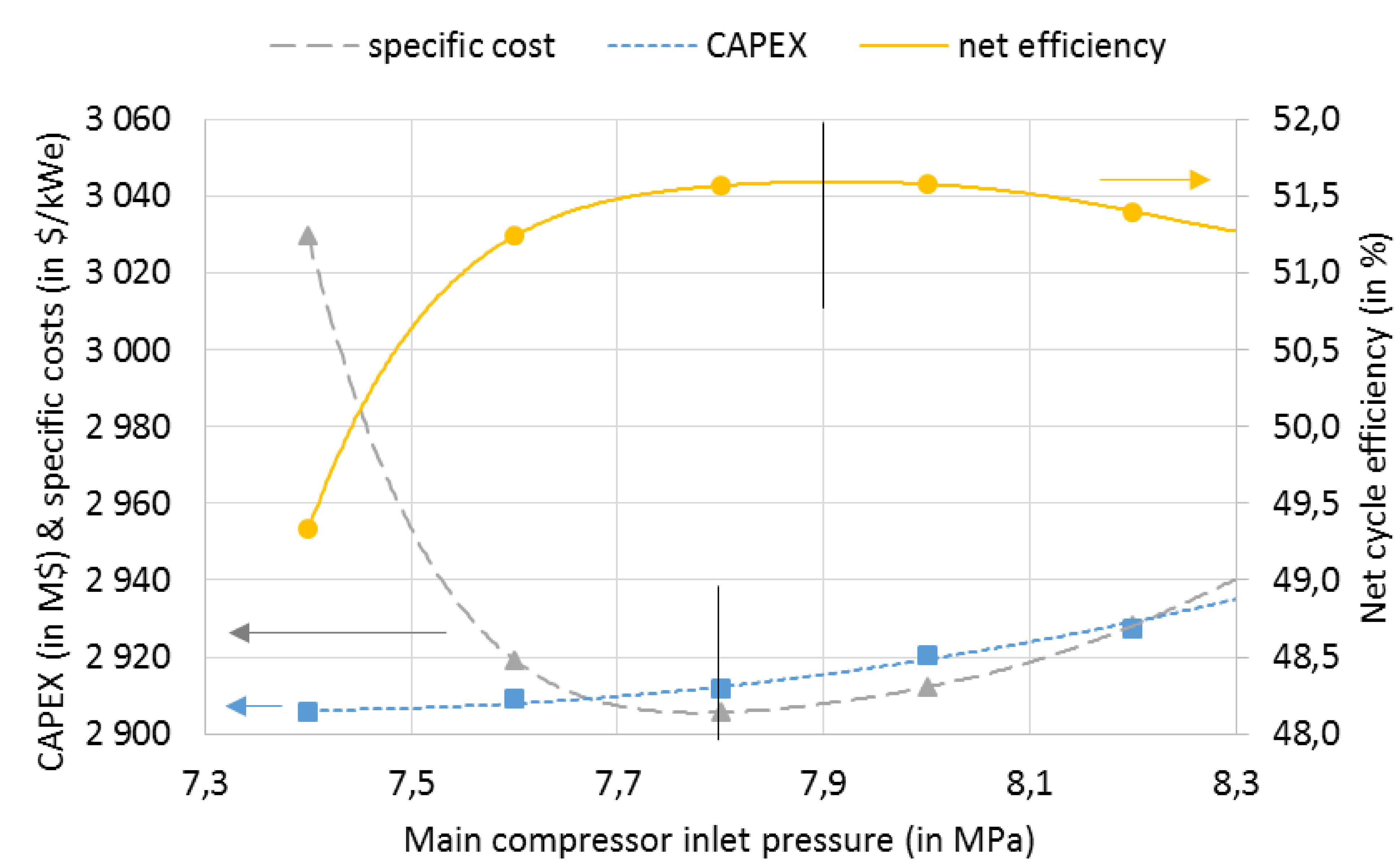

Figure 2: Net cycle efficiency [1] as a function of the main compressor inlet pressure (yellow solid line, right axis), CAPEX (blue dotted line, left axis) and specific costs (gray dashed line, left axis)

REFERENCES

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