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COMPARATIVE ANALYSIS OF TRIGENERATION SOLUTIONS

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ABSTRACT

In this paper, three variants of trigeneration energy production systems are compared. The three variants are: decentralized system of individual power supply with heat, cold and electricity (SAICF), centralized system of heat, cold and electricity supply (SACCF) with decentralized consumer distribution and centralized heat supply system, cold and electricity (SACCF) with centralized distribution of consumers.

The comparative analysis is made according to the values of the tour/retour temperatures for the same type of cogeneration plant, which includes the specific installations of a GCC: cogeneration plants (GCI), the peak thermal once (ITV) and cold production plants, formed in the most general case from the absorption type (IFA) and compression type (IFC).

KEYWORDS: simultaneous production, energy, cogeneration, trigeneration, consumption

1. INTRODUCTION

Etymologically, corresponding to „cogeneration", which means simultaneous production of two forms of energy (electricity and heat) and trigeneration is the simultaneous production of three „energy products": heat, electricity and cold. This will be the meaning of the notion of trigeneration, used in this work, as by most energy specialists.

Similar to cogeneration, trigeneration must meet the specific conditions of combined energy production, even more it presupposes the existence of cogeneration. However, some conditions have specific aspects related to cold-producing installations and the simultaneousness of cold consumption, with those in the form of heat and electricity. These conditions are:

-heat and electricity production takes place in the same installations, cogeneration plants (GCI) while the cold is produced in special installations, refrigeration plants (IF);

-the simultaneity of heat and electricity generation is the condition imposed by cogeneration, while the cold may or may not be produced simultaneously with them, depending on the type of cold consumer (technological cold) in the industry or to ensure microclimate conditions in air conditioning enclosures;

-primary energy used to produce heat, electricity and cold is the same in the case of cold produced from heat or electricity from cogeneration plants;

-peak consumption of cold may or may not use the same form of primary energy as the cold produced on account of heat or electricity produced by cogeneration plants.

Comparing the conditions that define the notion of cogeneration, with those for trigeneration, the following contradictions appear, from the point of view of the combined production:

- cold production facilities are separate from those producing electricity and heat;
- demand in the form of cold can be non-simultaneous with that of electricity and heat, which are simultaneous;
- as a form of energy, the cold is still heat, but at another thermal level, so thermodynamically the trigeneration defined above is also a system of bi-energy, similar to cogeneration;
- trigeneration necessarily presupposes the existence in advance of cogeneration.

In conclusion, from a thermodynamic point of view, trigeneration does not produce three forms of energy and does not meet the conditions of uniqueness of the production plant and those of simultaneity of the cold, the, with electricity and heat.

Basically, however, because technically the solution for producing electricity, heat and cold is already known as trigeneration, in this paper the notion is used as a conventional expression.

2. CONCEPT OF THE HEAT AND COLD SUPPLY SYSTEM (SACF) IN TRIGENERATION PLANTS (CTG)

The concept of creating a SACF assembly based on the trigeneration solution consists in the way in which the functional connections between the cogeneration plant, the cold production plant and the heat consumers, electricity and cold are made [2].

The variants presented in the paper present the basic variants of the assembly of a SACF, taking into account:

- degree of centralization/decentralization of heat and cold production;
– location of refrigeration plants (IFs) in relation to cogeneration plant-specific installations (GCCs): at the GCC, at the trigeneration plant (GCT), at consumers of cold, or as intermediate sources, located between the GCC and consumers, within the remote transport system (TS), similar to centralised thermal points (PTC) for consumer heat supply, generally for hot water supply (CQacc) and heating (CQi);
– structure of energy demand of consumers, for hot water supply (CQacc), heating (CQi), electricity supply (EC) and cold (CF) for air conditioning and/or technological purposes [1].

3. POWER SUPPLY SYSTEMS IN TRIGENERATION STRUCTURE

Figure 1 shows three power supply solutions in trigeneration mode.

Figure 1 (a) shows a decentralised system of individual heat, cold and electricity supply (SAICF).

Like any decentralized - individual - power supply system, this SAICF is characterized by [1]:

- CTG includes the specific installations of a GCC: cogeneration plants (GCI), peak thermal installations (VIT) and cold production facilities, formed in the most general case, from absorption (IFA) and compression (IFC);
- the energy supply of the consumer from the contour (C) is made through direct networks of connections between the CTG and the consumers, specific to each form of energy consumed;
- the cold consumer (CF) is fed with cold energy form, for air conditioning and/or technological purposes, through a network link , direct from IF, the, using a cooling agent whose parameters are corresponding to the conditions imposed by the destination of consumption. Where:

CTG - trigeneration plant; C-energy consumer; CQacc - heat consumer in the form of hot water; CQi - heating consumer; CE - electric energy consumer ; CF - cold consumer; ICG - cogeneration plants; ITV - state-of-the-art thermal installations; IFA, IFC - absorption-refrigerated plant, respectively, with mechanical vapour compression;
SEE - electrical network connecting with the power system; RTQacc - thermal network of hot water consumption and its recirculation; RTQi - thermal hot water network, or hot water, hot water, tour/retour, for heat supply of the heating consumer; RE - the local electrical network (at consumer level - C) for electric power supply; RTF - cold water thermal network, tour/retour, for cold supply to the consumer.

Figure 1 (b) is a centralized heat, cold and electricity supply system (SACCF). It is characterized by:

- CTG, which includes the same installations as in variant (a).; - the heat transport system uses hot water, tour/retour, while its distribution system comprises the centralized thermal point (PTC) and the distribution network system. They are separated, for hot water and recirculation, respectively RTQi - two pipes tour/retour of hot water for heating;
- the cold transport system (RTF) includes the cold agent network (cold water), tour/retour, product centralized in IF of CTG, being distributed to consumers. This system implies that all consumers of cold (C1...C3) are of the same type, admitting the same cooling agent, with the same parameters. This is the case, in general, of the consumption of the cold for the air conditioning of the spaces, in order to ensure the microclimate parameters for the satisfaction of the conditions of the normal development of human activity, according to the rules imposed by the need for cold air conditioning.

Figure 1 (b) uses the following abbreviations [1]: TS - energy transmission system; SD - energy distribution system; RTQ - energy transmission networks; RDQacc, RDQi - heat distribution and recirculation networks, respectively hot water for heating, tour/retour;

a.

b

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c.

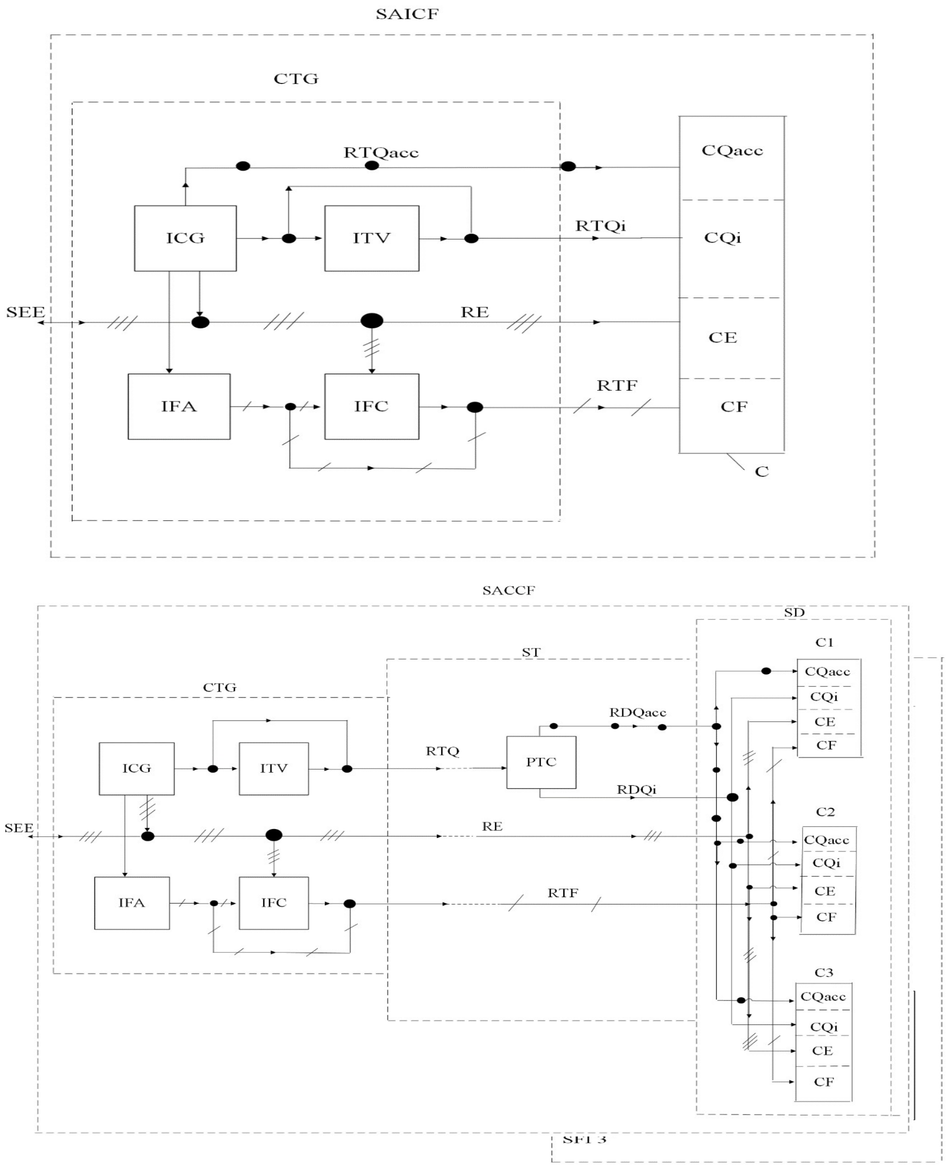

Figure 1 Trigeneration solutions: a. SAICF b. SACCF with centralized distribution; c. SACFF with decentralized distribution

C1...C3 - consumers. The rest of the abbreviations and the legend are identical to those used in variant (a).
Figure 1 (c) shows another variant of a SACCF in which the following differences occur:
- cold installations are no longer located within the CTG contour, but as a centralized station (SFC) located in the consumer area, like PTC, as well, both fed with the same thermal agent - hot water tour/retour [3];
– as a result of the new location of the SFC, the number of transport networks is reduced to two: one hot water (tour/retour) and the power supply network.

Heat and cold distribution are done in the same way as in the previous scheme. Important is that the solution for feeding in parallel with hot water, both PTC and SFC assume that throughout the year this will ensure the highest parameters of those imposed on one hand by PTC and SFC power supply [4]. This means that due to SFC, during its operation, the temperature of the hot water in the RTQF network will not be able to drop below about 110-120 C (at the entrance to the SFC), even if for heating in PTC it could work with a lower temperature, according to the thermal adjustment graph imposed at the entrance to PTC [1].

The increase in the average temperature of the hot water in the variant (b) will determine:
- the increase in annual heat loss for the new RTQF network compared to RTQ variant (b) (for the cold supply period, RTF will have that thermal regime as RTQF);
- if the ICG of the GCC are steam turbines, the increase in the average annual temperature of the hot water delivered from their counter-pressure or adjustable outlets will lead to the decrease of the annual electricity production in cogeneration regime, with all the adverse technical and economic effects arising from it: the increase of the unit cost of the energy produced by GCC.

4. CONCLUSIONS

The conclusion is that in the case of variant (b), heat and cold distribution are made separately for each type of consumption (a.c. Qi, F). This SACCF is characteristic of the centralized supply of heat, cold, electricity of several consumers of the same type, with the same structure of consumption and the same general conditions imposed during power supply.

Variant (c) presents a third alternative of achieving SACCF, from the point of view of SF location and PTC. In this situation the retour of the RTQF network is common, from PTC and SFC, during the operation of the SFC, the average temperature will be lower than the retour resulting from the PTC. This has the following positive consequences [1]:

– in the case of ICG steam turbines, determine the increase in the achieved cogeneration index, which will increase the production of electricity in cogeneration;

– in the case of ICG with gas turbines, or with internal combustion engines , will increase the average logarithmic temperature difference on the recuperating boiler, which will reduce its heat transfer surface, so it will reduce the related investment;

– in the case of ICG with MAI, the heat recovery scheme will necessarily be serial type, since during the operation of the SFC the tour temperature of STQF will always be over 100°C.

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