

ACCUMULATION OF ENERGY IN THE CONDITIONS OF STEAM-GAS COMBINED CYCLE

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Abstract: The article deals with the accumulation of energy in the form of hot water. The big accumulators of heating plant are a little expanded in the Czech Republic. Preferably they can be used for example for steam-gas cycles which work in the mode of heating plant. The collection of heating energy in the static accumulator proved as economic for example in the energetic headquarters of providing support services for the Czech transmission system. The possibility of how to effective use the condensate from the node of steam pipe to reduce its own consumption of electricity is indicated in the article.

Keywords: Accumulation of heat energy, accumulator of heat, steam-gas combined cycle, combined cycle, central supplying of heat.

1. INTRODUCTION

The amount of heat supplied from steam-gas combined cycle to hot-water and steam network is certainly directly proportional to the outdoor temperature. The supply of heat energy to networks of central supplying of heat (CZT) have specific limit of power for sources of this type at regular intervals of season. The source works as a power station during the most days of heating season which provides so-called support services (PpS) for the Czech transmission system (ČEPS) and the source participates in quality assurance and reliability of electricity supply. The support services of ČEPS are system services: secondary regulation (SR), tertiary regulation (TR), dispatching backup (DZ_t), quickly starting a 15-minutes backup (QS15) etc. More about it is in [1]. The above mentioned power limits of supply of heat to the network CZT occurs in time when the source provides support services of SR and TR. From the course of supply of heat during the 24 hour cycle (see Figure 2) are seen the night falls and the morning rises of the heat consumption in housing and manufacturing sectors. These changes can be estimated and the operation of conventional heating plant accommodate to that in advance. When the heating plant works as power station during that time limit which electric power is managed by requirements of ČEPS it is necessary to wipe out the heat load of the network in the most possibility extend. How should we to achieve the economic process of this source? One of the most effective methods is for example heat accumulator. This article outlines its basic principles and the operational capacity and the change leading to increases of economic is outlined.

2. ACCUMULATION OF THE ENERGY DURING OPERATION OF STEAM-GAS CYCLE (PPC)

Steam-gas units producing heat and electricity by combined way are destined for covering the base load of system CZT during winter season. Because the system CZT in which are these sources included is not large, they work mostly in the colder months of the year (for example from November to April). The remainder of the year they can work as a steam heating plant for steam from another facility of company. The PPC cooperate with other energy units during peak or summer seasons,

i.e. three medium-pressure steam boilers and four high-pressure steam boilers. Furthermore, two hot-water gas boilers and unpressurized hot-water accumulator are parallel connected to exchange station. The simplified technologic structure of the source is in Figure 1.

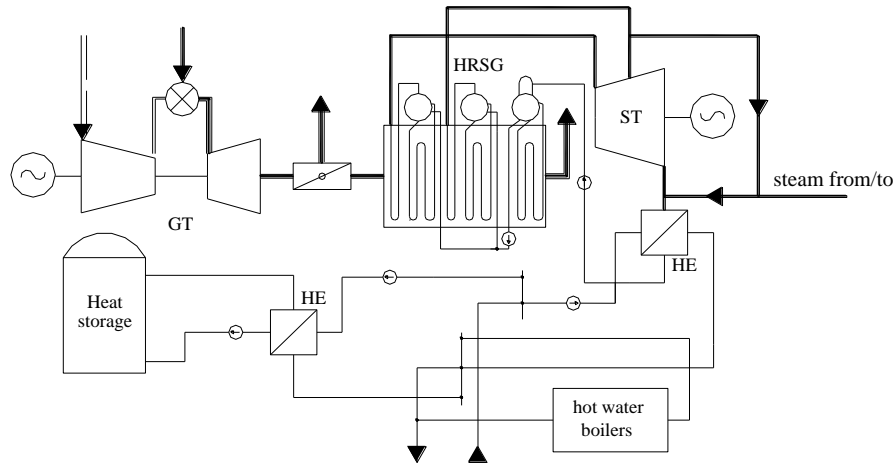


Figure 1: The Simplified technologic scheme of the PPC.

The operation of the hot-water accumulator is influenced by these factors:

- The needed of heat energy of CZT network,
- The current sort of the heat sources – from the perspective of economic or amount of fuel,
- The instantaneous electric power required by ČEPS – it is for factories supplying the SR and TR,
- The actual size and direction of the system imbalance – for sources which do not provide the PpS.

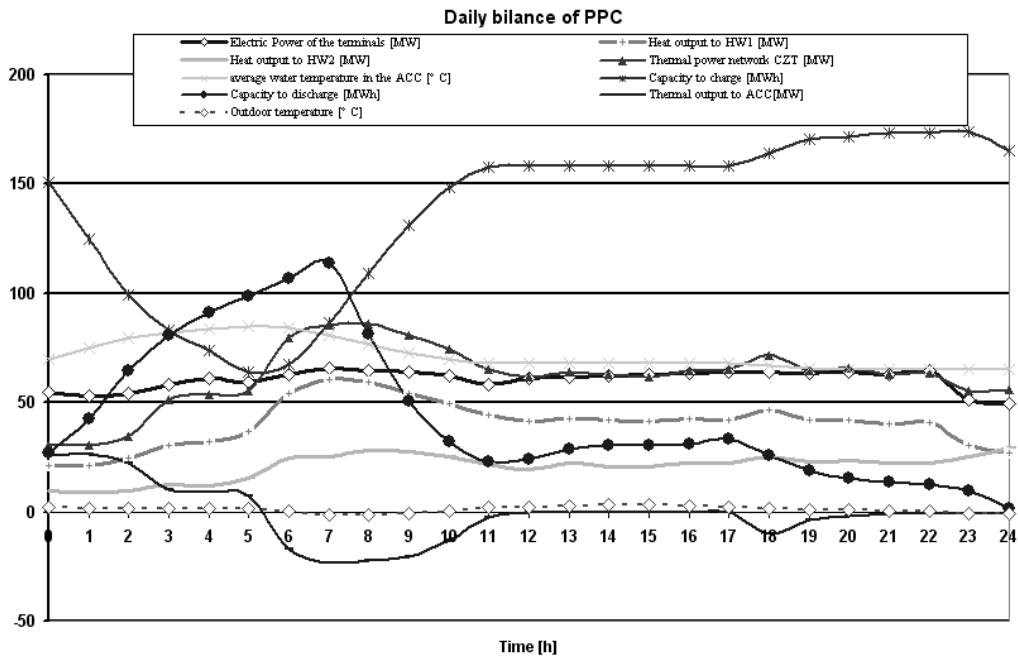


Figure 2: Daily balance of PPC

The heat energy is collected (charge) during the reduced power consumption from the heat network and almost steady to increasing electrical load of power units (generators of gas and steam tur-

bins). The heat energy is discharged during the increases consumption from hot water and steady or decreasing the production of electricity.

3. THE PRINCIPLE OF HEAT ACCUMULATION IN THE ACCUMULATOR

It is necessary to ensure perfect temperature stratification of the water for maximum utilization of the accumulated energy in the accumulator. The principle of thermal stratification is based on the difference of specific masses of hot and cold water. The cooler (heavier) water clings to the bottom and the warmer water climbs up. Therefore, hot water is fed to the top part of accumulator and cold water is fed to the bottom part during charging and discharging respectively. The slim vertical storages are used for the natural keeping temperature fluctuation in the volume of the storage due to buoyant forces. There is the natural thermal stratification of the volume and it is easy to maintain. The stratification installation is used with advantage to achieve of the uniform stratification for large industrial applications of the heat accumulators. The installation is responsible to minimize the turbulent flow. It used difference between cold and hot water again. The hot water is led off during discharge and fed in during charge to the top part of the installation always. The cold water is fed off during charge and fed in during discharge to the bottom part of the installation. See Figure 3.

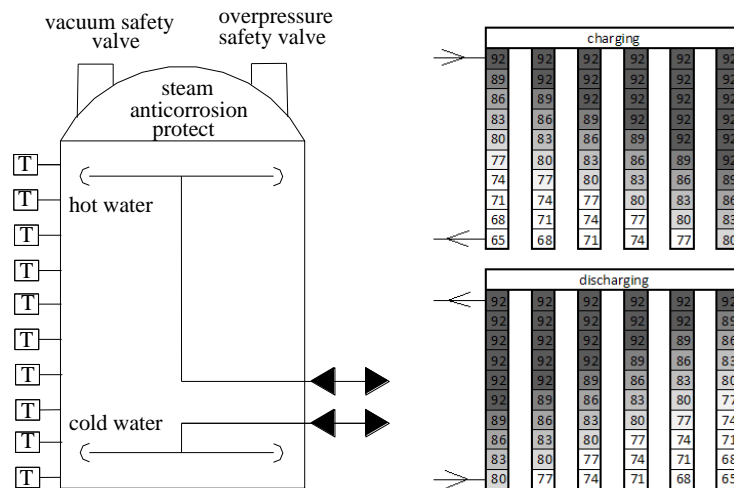


Figure 3: The heat accumulator

3.1. OPERATING STATES

The cold water is pumped to the secondary side of the plate exchangers (DV) during the charge through the lower stratification installation. The plate exchanger pressure separated the circuit of accumulation from the circuit of exchange station. The “charging” water, i.e. water from exchange station has on the primary side of the DV. After the passing heat transfer surface of secondary side the hot water returns from the top installation and it uniformly fills the space in the accumulator which is released by cold water. During the discharge is fed the cold water to the bottom part of installation and it forcing hot water. The hot water is going through secondary side of the DV where it transmits its energy to the primary side of the DV.

4. MEASURES FOR THE REDUCE OF OWN CONSUMPTION

During the operation of the accumulator there is danger of the surface corrosion. This might be creates particularly in places that are not flooded. For this reason it is necessary to implement any anti-corrosion measures to the area of the storage cap. The displacement of corrosive oxygen by steam is seems as appropriate for this type storage. The existing project use for create of steam of resistance heater with total electric power of 90 kW. The regulation of heater is discrete and it is con-

trolled by steam pressure in the canopy area of the cylindrical storage. That operation is expensive in view of the fact that the anti-corrosion protection system is in operation 8760 hours in year.

It was mentioned above that steam-gas source has opportunity to cooperate with other sources for example with plan, which main production unit consists of four high-pressure steam boilers. These two plants are connected through a steam network, which ends and starts at the PPC. The amount of consumption and supply from and to the steam respectively depends on the immediate operating state of steam-gas unit. Generally, during operation of the PPC in the end node of steam piping it is not steam flow, thereby it is reduce the steam temperature due to heat loss and condensation occurs. Therefore, it is perfectly appropriate to the chosen location to install the condensate trap based on the thermodynamic principles of condensate trap. Through properly designed drainage the layer of the condensate is drain from the bottom of steam pipes. The production of condensate is the result of heat loss of the steam pipes (large temperature difference between steam and surroundings). The thermal insulation can reduce the heat loss but it cannot suppress it.

The inclusion of a suitably dimensioned expander for the thermostatic trap it could use loses steam for example for needed of anti-corrosion protection of the accumulator. It can be used a product of DUKLA [7] as appropriate expander. In the expander is separate steam from expanding condensate. The condensate is fed through a nozzle to area with lower pressure and together with this the steam is separated. The amount of steam that leaves the expander is proportional to the amount of the condensation product to the difference between the enthalpy of condensate before expansion and after it. The rest of condensate which does not evaporate is taken away for further processing. It is necessary to equip the expander by bypass for ensure of constant parameters of steam (e.g. for increased flow of the steam in the steam pipes, i.e. reduced condensation). The bypass will regulate the pressure of steam released from the expander. Because during a sufficient flow of steam (e.g. by connecting of large appliance) there are not cooling and the condensate production is smaller. See Figure 4.

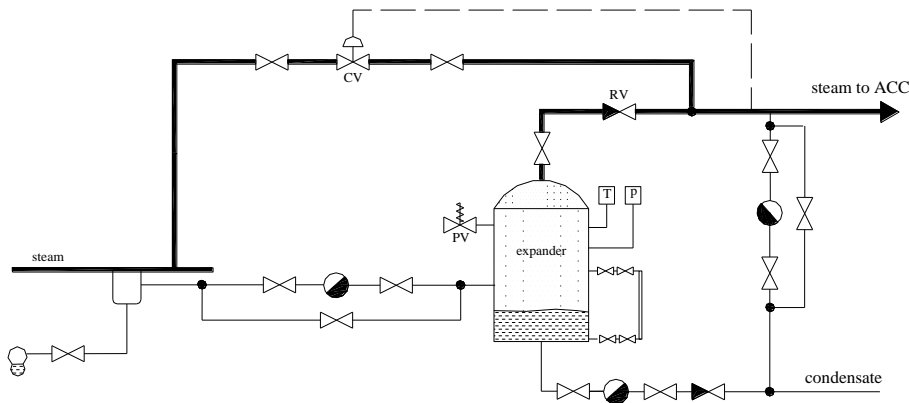


Figure 4: Design of the drainage treatment

For the calculation of required amount of steam inlet it is possible to start from the assumption that the required heat power is obtained as sum of the heat loss of the shell of accumulator, roof of accumulator and heat loss transferred from the water surface. From the above mentioned heat loss it is possible considered the loss through roof and shell of container as constants. The heat transfer by conduction to the water surface depends on the immediate temperature of the water in the top layer of the accumulator – it decreases with temperature increase.

The heat loss of container shell determine from this equation:

$$Q_{shell} = \frac{2 \cdot \pi \cdot v \cdot (g_{st} - g_{out})}{\frac{1}{\frac{D_1}{2} \cdot \alpha_{st}} + \frac{1}{\lambda_{st}} \cdot \ln\left(\frac{D_2}{D_1}\right) + \frac{1}{\lambda_{iz}} \cdot \ln\left(\frac{D_3}{D_2}\right) + \frac{1}{\frac{D_3}{2} \cdot \alpha_{iz}}} \quad (1)$$

The heat loss of container roof determine from this relation:

$$Q_{roof} = \frac{2 \cdot \pi \cdot v \cdot r \cdot (\vartheta_{st} - \vartheta_{out})}{\frac{1}{\alpha_{st}} + \frac{d}{\lambda_{roof}} + \frac{d_{iz}}{\lambda_{iz}} + \frac{1}{\alpha_{out}}} \quad (2)$$

The heat loss by heat transfer of water surface is computed from:

$$Q_w = \pi \cdot r^2 \cdot \alpha \cdot (\vartheta_{st} - \vartheta_{out}) \quad (3)$$

When we sum all above heat losses and when we account to the lowest possible temperature which may occur during operation of the accumulator determine the minimum amount of heat for anti-corrosion protection. The heat in the form of slightly superheated steam will be taken from the system described above. The amount of it we determine from the know enthalpy of superheated steam, enthalpy of hot water in the highest layer of accumulator and the maximum of heat loss of the space above the surface.

5. CONCLUSION

The heat accumulator can be advantageously used in steam-gas cycles, which are operated in combined cycle and during the heating season, providing support services for the transmission grid. The heat accumulator is during excess of thermal power charged and on the contrary in times of scarcity thermal power is accumulated heat energy used to for needs of CZT. For the purpose of storing hot water in storage tanks is important to achieve the perfect temperature stratification of the water. In industrial applications installation are used. The penultimate chapter is focusing on surface corrosion in places that are not flooded with water. They are used electric steam generators. Created steam is injection into the sites of corrosion on the assumption that crowd out oxygen, which helps corrosion. The above described actions of replacing power steam generators will reduce significantly own energy consumption of heat accumulator. Furthermore is achieved a perfect dewatering end node steam pipe, which is reduce the hydraulic fibre during transient conditions. Reducing energy consumption PPC is one of the ways to reduce emissions of carbon dioxide onto the atmosphere.

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