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Case study of a Conservation Power Plant concept in a metallurgical works

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Abstract

This paper considers application of the Conservation Power Plant concept to integrated resource planning and control in metallurgical works. A structure of local energy saving measures is proposed. The researchers have reviewed optimization issues of combined heat and power plants where secondary power resources of metal manufacturing are recovered to upgrade fuel usage efficiency. It serves as the terminal point where the effect of energy saving is realized in decreasing the total consumption of the natural gas as the primary resource. Similar approach can be used for energy saving organization in large-scale industrial complexes.

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Keywords: Conservation Power Plant, energy efficiency, integrated resource planning, negawatt,.

1. Introduction

Energy saving is the RF policy's preference in all fields of business activities, including the heat and power facilities of iron and steel enterprises. To achieve the goals of energy saving in utilities the advanced nations' experience suggests that integrated resource planning and power control taken in whole, as Conservation Power Plant generating negawatts of power are preferred. Amory Lovins introduced term negawatt in 1989 for utilities [1-7].

However, the analogous approach may be used also for production plants.

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2. The Concept of the Conservation Power Plant for metallurgical works

Generally, energy generation, conversion and consumption are many-staged in complex industrial systems [8-22].

One of the approaches to comprehensive treatment of energy processes alongside energy efficiency is considering them in dual flows of energy – real energy flows and saved energy backflows.

The introduction of conditional flows of saved resources allows showing the structure of energy saving processes as the negawatt generating, converting and consuming structure. It enables us to consider the structure of energy efficiency process as a distributed energy saving plant and thus estimate its efficiency, plan and control its work in the whole. Such approach allows reaching energy efficiency effect in complex plants in a consistent manner.

Real resource consumers implementing energy efficient measures are the sources of saved resources. Converters of real resources are the saved resources converters considered in the context of the dual approach. Saved resources incoming is a dual interpretation of real resources converters' decreasing of the target volume. Obviously, this comes to decrease the real consumed resources at the inlet of the converter dually interpreted as output of the saved resources.

In the fig. 1, suppliers of real resources are consumers of saved resources. They are the final point where the economic effect of energy efficiency is made – this is the reduction of real primary resources consumption.

Below there is an example of a typical structure of the production power unit (fig. 1). The Central Power Plant (CPP) working under the controlling mode of operation is the main part here. This plant is made in accordance with the cross-connection structure where the power boiler (PB) unit, the turbine generator (TG) unit and the main steam collector (C_s.) are its components. Power boilers consume natural gas B_{ng} and blast furnace gas B_{bfg}. If necessary, coke-oven gas and other secondary power resources (SPR) of coke and by-product process can also be used here. Plant's turbine generators produce electrical W_e and heat energy in heating water Q_h. Besides process steam U_s extraction is made through the pressure-reducing and desuperheating station (PRDS) from the steam collector C_s .

Blast-furnace gas B_{bfg} comes to the CPP's boilers from the blast furnace gas main M_{bfg}. The blast-furnace gas main is connected to the primary gas source, i.e. blast-furnace process. Here F_{bfg} is the flare for extra blast-furnace gas burning in the atmosphere, C_{bfg} – blast-furnace gas consumers.

Electric power W_e, heat power Q_h and process steam U_s produced by the CPP come to the electric N_e, district heating N_{dh} and steam N_s networks of the plant. C_e, C_{dh}, C_s – are consumers of electric, heat and steam power accordingly.

The main source of the process steam D_b is the base-load seam power plant (BSPP). Secondary steam sources B_s are additional. As secondary steam sources are variably loaded then steam accumulators (SA) are used for accumulating secondary steam. The flare F_s. is used to discharge extra steam to the atmosphere. If necessary, additional steam ΔD_s is run to the steam network N_s to compensate sudden increase of consumers' steam load.

In the power structure presented here in order to save energy the secondary power resource, i.e. blast-furnace gas, is recovered at the CPP. Thereupon electric power cost price produced at the CPP considerably decreases in comparison with the electric power bought in the wholesale market. As the product cost price of such plants, e.g. rolling ones, highly depend on the electric power price therefore it is necessary to make the CPP produce electric power to the full.

However, such a direct conclusion is not system wide proved. The fact is that the blast-furnace gas consumption volume by the CPP boilers depends on the load. Besides nonlinear extreme dependence of the blast furnace gas consumption on the load is typical for many types of boilers. There is an example in fig. 2 containing power features of the CPP boilers depending on their load.

As a result, the relative blast-furnace gas consumption increases when the load is decreased, therefore relative natural gas consumption decreases and electric power cost price decreases. Thus to have system-based energy saving effect at the considered power facilities it is essential to deal with the totality of problems, including electric power production increase, electric power cost price decrease, natural gas consumption decrease and etc.