CONTROL OF THE NONCONVENTIONAL MACHINERY FOR COMBINED PRODUCTION OF HEAT, COLD AND ELECTRICAL ENERGY

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ABSTRACT

Original nonconventional machinery for heat, cold and electrical energy combined production from natural gas primary energy was designed and installed as subsystem of central boiler house energy system. There are described in contribution the principal, main parts and working modes of this machinery. The approach to the control of this system with possibility to prefer the production of various secondary energies according to working conditions of the whole energy system is described too. The new knowledge of control was obtained by application of modern control and supervising system based on SCADA system with possibility of supervising via Internet.

KEYWORDS: heat, cold, electrical energy, control, supervising

1. INTRODUCTION

The research team from several Slovak research institutions designed the original energy system for transformation of gas primary energy at three secondary energy states (heat, cold and electrical energy). This original nonconventional machinery named as 3G+ was installed in food production factory as subsystem of central boiler house energy system. The complicated energy system was formatted by installation of this machinery into complex system for heat and cold production. Such energy system has to be controlled automatically by defined algorithms. The information is needed about system behavior in real and past time too. It requires paying increased attention to the process control and supervising level too.

2. 3G+ SYSTEM

3G+ system is the machinery consisting of the internal combustion gas engine, electrical motor generator, mechanical heat pump and absorptive cooling unit designed for combined production of heat, cold and electrical energy. The mechanical power output of the internal combustion gas engine is utilized for actuation of electrical motor generator (i.e. for electrical energy production) and for actuation of mechanical heat pump. The heat produced by 3G+ is on two thermal levels:

• high-potential with temperature up to 103 °C from cooling of internal combustion gas engine and its fume exhaust is utilized for food production line and absorptive cooling unit,
• medium-potential with temperature up to 55 °C from heat pump and absorptive cooling unit is utilized for heating.

The cold produced by mechanical heat pump and absorptive cooling unit is utilized for food production line and for air conditioning.

Fig. 1 The functional diagram of 3G+
3. PROCESS CONTROL

The principle of distributed control of the particular section of technology is applied on level of the process control. The most important task of process control system is to provide required heating water temperature for food production line with maximal utilization of combined heat, electrical energy and cold production. For solution of this task the subtask for working mode selection of the 3G+ with emphasis on particular energy production is solved in control system. Working mode is given by requirement for synchronous running of particular equipments of the 3G+ (Table 1). The control of 3G+ is solved as subsystem of the complex energy system control using of a distributed control principle. This subsystem requires more complicated control algorithms for provision of these control tasks:

1. Working mode selection and state monitoring of the 3G+ with emphasis on particular energy production.
2. Control of the cold production by heat pump (HP), by absorptive cooling (AC) and by cold water cooling in storage tank for warm service water pre-heating. The temperatures in particular cooling circuits are measured. The flap valves in particular cooling circuits are actuated according to required working modes and current states of 3G+.
3. Monitoring of the cooling of heat pump compressor and absorptive cooling unit for production of medium-potential heat in storage tank for warm service water.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Code</th>
<th>ICE</th>
<th>G</th>
<th>HP</th>
<th>AC</th>
<th>Description of working mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Basis mode – running of all equipments of 3G+</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>Restricted production of cold and medium-potential heat, not important production of electrical energy</td>
</tr>
<tr>
<td>C</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>Restricted production of cold and medium-potential heat, important production of electrical energy</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>No production of cold and medium-potential heat, important production of electrical energy</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>G as electrical motor, only restricted production of cold and medium-potential heat</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Restricted production of cold and medium-potential heat by consumption of heat energy of boiler house</td>
</tr>
<tr>
<td>G</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Maximal production of cold and medium-potential heat by consumption of electrical energy</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Stop of 3G+</td>
</tr>
</tbody>
</table>

ICE - internal combustion engine, G - generator or as electrical motor, HP - heat pump, AC - absorptive cooling

4. CENTRAL CONTROL AND SUPERVISING

Level of the central control and supervising is realized by SCADA/HMI system D2000 Actis. SCADA system consists of the application server situated in central boiler house and operator consoles situated in office building connected via LAN optical network. SCADA system is interconnected and communicates via three independent communication channels with three types of intelligent equipments installed in the boiler house:
Fig. 2  The structure of control and supervising of energy system with 3G+

- process control system via communication interface RS485 and protocol Paufex DIRAS,
- heat meters via communication interface M-BUS and protocol Premex CALMEX II,
- control unit of the 3G+ via communication interface RS485 and protocol MODBUS Telemecanique TSDX.

Functions of the SCADA system D2000 Actis:
- It gathers data from the technological process and performs their real-time mathematical and statistical processing.
- The system provides users with easy to use graphical environment that enables to display technological process (graphical schemes, diagrams, trends and reports).
- The powerful multi-level alarm system provides for a quick identification of abnormal situations and provides the operator with detailed information.
- The Industrial SQL Archive performs three level of data storing (primary, statistical and long-term), additional storing and processing of delayed data.
The system performs alarm monitoring, operator interventions monitoring and error conditions monitoring.

The system provides advanced features for user rights management.

The system offers several kinds of user consoles – from a complete operator console enabling system configuration (thick client) to a Web console (thin client), which provides access to manufacturing data via Intranet/Internet.

Supervising of the energy system with possibility of the control parameters changing on user’s level is possible:

- by operator of the heat and cold source per console directly in boiler house,
- by workers of the technical department per consoles in the office building,
- by selected organizations sharing on energy system realization per Web console with access via Internet.

It is possible to change only selected parameters on every level of control according to user access rights.

Realized structure of the energy system’s central control and supervising is on Fig. 2. Distant access to the D2000 via Internet is realized by D2000 thin clients, which are ActiveX components in HTML application and displayed by standard Internet browser MS Internet Explorer. D2000 Web Server installed on the same computer as D2000 Actis Application server provides information transfer between kernel of the system D2000 and clients via Internet Information Server and protocol HTTP.

5. CONCLUSIONS

By utilization of the principle of distributed control in conjunction with central control and supervising on the base of SCADA system D2000 Actis was successfully solved problem of the energy system complex control. Values and status archive enables better behavior examination of the whole energy system in according to changing parameters and status of the system.

Web console with access via Internet enables organizations sharing on energy system realization to monitor operation of the installed equipments with information utilization for service purposes, diagnostic, improving technical parameters of equipments etc.

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REFERENCES


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