IMPROVE TO EFFICIENCY OF COMBINED HEAT AND POWER SYSTEMS FUEL-GAS PREHEATER CONTROL ALGORITHM

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ABSTRACT : In the classical system, an industrial company, which needs both electricity and process heat, provides its electricity demand from a steam boiler found in its own plant area. On the other hand, electricity is usually generated in utulity thermal power plants which have approxiametly 35 % efficiency. About 50 % of the thermal energy of fuel is rejected to atmosphere by condenser in steam turbine power plants. In this paper, it is aimed to improve efficiency of combined heat and power systems using fuel gas preheater control algorithm.

INTRODUCTION :

Change in fuel prices have lead to investigate the methods and the alternatives for energy cost minimization in several industrial applications. One of the most popular solutions is concluded to be the combined heat and power system principle the sequential production of electricity and heat, steam or useful work from the same fuel source.[1]

Cogeneration facility has been used several industrial process as chemical, petrochemical, refinery, mining and metals, paper and pulp, food-processing, and electric power generation. The three most significant factors effecting a combined heat and power system projects are: (1) availability and financing, (2) acceptable economic payback period, and (3) ability to satisfy regulatory requirements. Most combined heat and power system projects providing their base process steam and/or heating and drying thermal loads, in addition to satişfying internal electric energy needs (except possibly during demand peak), are easily proved to have an economically attractive payback period.

SYSTEM FUNCTION AND DESIGN

The objective of the system is the preheating of the fuel gas during premix mode of gas turbine operation to approximately 200 ^{o}C for increasing the efficiency of the power plant.

Therefore IP (Intermediate Pressure) feedwater is extracted at the outlet of the IP economizer and discharged to the condensate preheating system upstream of the condensate preheater via the fuel gas preheater.

Upstream of the fuel gas preheater an emergency shutoff valve and downstream a shutoff valve are provided. These valves guarantee immediate isolation of the fuel gas preheater in case of malfunction of the preheater or the preheating system such as leakage's or overtemparature downstream of the preheater.

During normal operation the pressure on the water side is always higher than on the gas side. Therefore fuel gas can't penetrate in the water system. Leakage's of water into the gas side are detected in the heating
system by level controllers in each section of the fuel gas preheater. Depending on the value of the leakage's the fuel gas preheating system will be shut down controlled with a limited temperature gradient or immediately by closing the emergency shutoff valve.[2]

During stand still of the system the pressure on the water side can be lower than on the gas side. In this case the motorized valves upstream and down stream of the fuel gas preheater are closed. Possible penetration of gas in the water system or steaming is rejetcted by the level controller on the water side.

A sampling point in the highest point is provided. During the start-up of the system it has to be vented and refilled, if the pressure or the level is lower than a fixed value. Fuel gas preheater scheme gives in Fig. 1. Sub control groups and MATLAB simulation results give after acceptation.

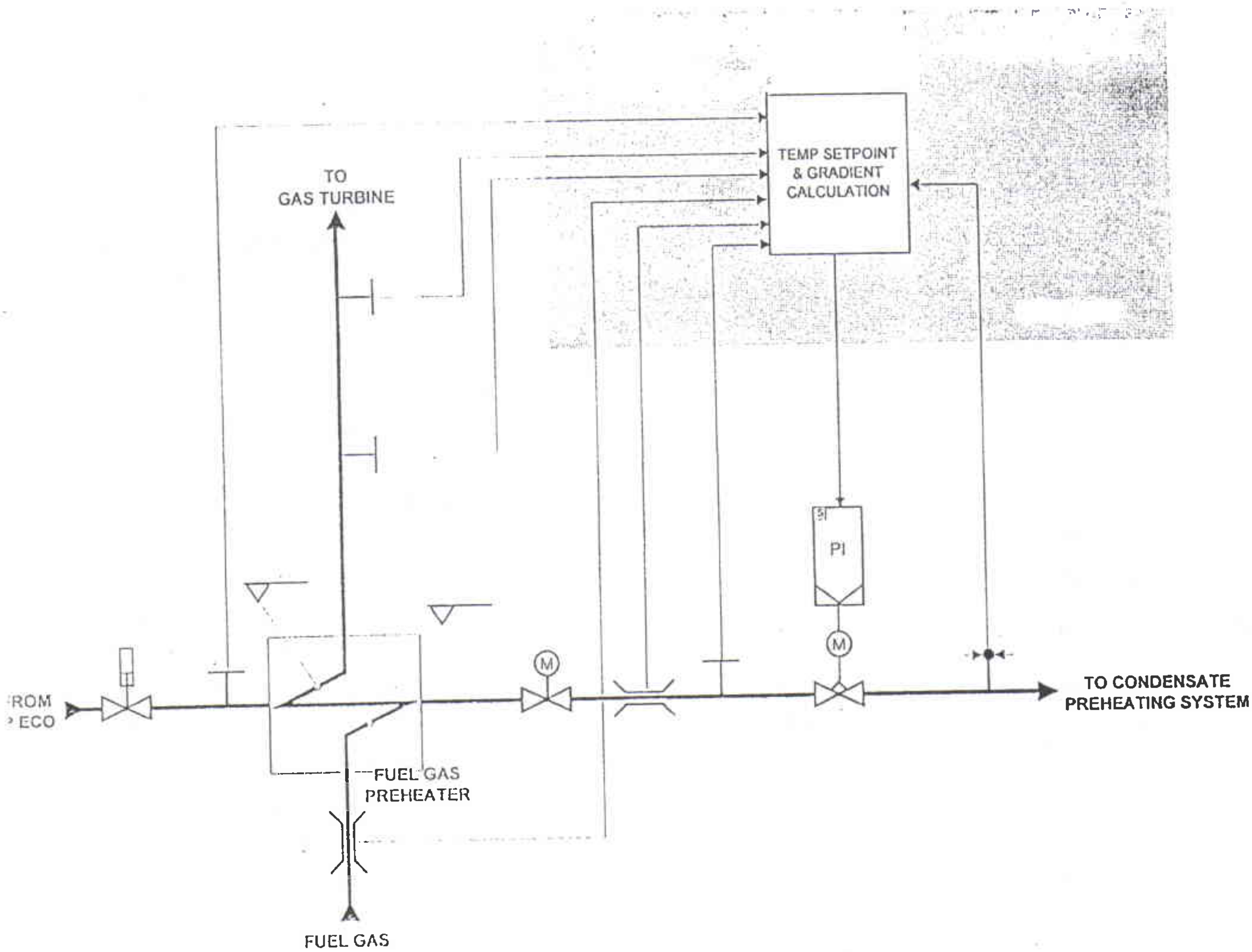

Fig. 1 Fuel Gas Preheater System

SYSTEM START-UP AND SHUT-DOWN

The fuel gas prehating system downstream the emergency shutoff valve is filled backwards via the control valve from the main condansate system.

Start-up

The system is taken into operation, when the gas turbine has reached the premix mode of operation and the IP part of the HRSG(Heat Recovery Steam Generator) is in operation. The fuel gas preheater is automatically filled and vented according to the indicator in the vent line by activating of the vent sub loop control. As soon as the pressure and level criterions are fulfilled and the vent valve downstream the sampling point is closed the ESV(Emergency Stop Valve) and the shutoff valve downstream of the preheater open and the temperature control is activated. The gas temperature behind the fuel gas preheater is increased with a defined gradient up to the operating temperature of the fuel gas by opening of the control valve downstream of the fuel gas preheater.

Shut-down

During shut-down of the system, the gas temperature behind the preheater is reduced with a defined gradient by closing the control valve downstream of the fuel gas preheater. As soon as the control valve downstream of the fuel gas preheater is fully closed the emergency shutoff valve upstream of the fuel gas preheater and the motorized valve downstream of the fuel gas preheater are closed. The fuel gas preheater is now completely isolated from the water/steam cycle.

The protection shut-down of the SGC(Sub Group Control) of the fuel gas preheating system will be initiated if

- the ESV is closed or
- the feedwater temperature downstream the preheater is too high (>MAX2) or
- water is detected on the gas side of the preheater (>MAX2) or
- the water level in the fuel gas filter is too high (>MAX2) or
- thq fuel gas ESVs of the GT are closed or
- the feedwater supply is off or
- the IP system of HRSG is off.

SYSTEM CLOSED AND OPEN LOOP CONTROLS

IP feedwater is extracted behind the IP economizer and routed to the fuel gas preheater.

Fuel Gas Preheating Temperature Control

For adjusting of the fuel gas temperature the eco extraction water mass flow is controlled by the control valve. The control valve closed when the preheating is switch off. If the preheating switch on the fuel gas temperature is kept on a specified setpoint. This value is compared with the actual gas temperature downstream the fuel gas preheater. The maximum temperature gradient is limited to 1 K/s during start-up/shut-down. The water temperature downstream the fuel gas preheater is limited to avoid evaporation downstream of the control valve.[3],[4].

The task of the fuel gas temperature control is:

- to keep the fuel gas temperature during premix mode of gas turbine operation to approxiametly 200 ^{0}C for increasing the efficiency of the power plant
- to control the economizer extraction mass flow for adjusting of the fuel gas temperature
- to limit the water temperature downstream the fuel gas preheater to avoid evaporation downstream of the control valve
- to fill the fuel gas preheater system backwards via the control valve from the condansate system

Fuel Gas Preheating Inlet Vent Control

During filling backwards of the preheater via the control valve from the condansate system or in case the fuel gas preheater is not in operation the motorized vent valve will open. In case of fuel gas preheater operation the valve is kept closed in order to avoid bypass flow[5]. Control algorithm gives after acceptation.

Preheater Vent Control

The vent valve will open if the preheater is filled backwards via the control valve from the main condansate supply and the preheater level is less than a fixed value. As soon as the level exceeds the fixed value the valve will close again. If the level falls below the fixed value during preheater operation the vent valve is kept closed and an alarm is initiated. Control algorithm gives after acceptation.

CONCLUSION:

Combined heat and power studies are initiated to evaluate cost-effective alternatives and to select the most appropriate options. This is achieved by performing technical feasibility and economic cost benefit study to rank and recommend alternatives. Determination of technical feasibility includes realistic assessment of each application with respect to environmental impact, regulatory compliance, and interfaces with an utulity. An economic payback analysis determines the payback period which is then compared to client financial goals. The selected design can be further developed during subsequent detailed feasibility study to obtain a more comprehensive technical definition of the project and improved accuracy of cost estimates. Many clients elect to proceed directly to the engineering and design phase upon comparison of the initial technical and economic evaluations. After obtaining client authorization to proceed with a project, detailed engineering, design, procurement, construction, and start-up activities can be initiated.

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