Energy best practice for Dong Suh Food Industry at Bupyang, South Korea

SUMMARY

With the growing cost of energy in South Korea, the energy intensive plants are now looking at energy cost-cutting measures to improve their profitability. Dong Suh Food (DSF) plant has recently developed an energy management program to reduce energy costs. This program utilises many energy best practices. Energy best practice projects are the energy saving projects utilising current best practice to reduce energy cost for the process or equipment. As part of an ongoing energy management program DSF has already reduced energy consumption significantly, which has added to the bottom line of their profit.

HIGHLIGHTS

- Reduction in greenhouse emissions by over 2150 tonnes of CO_2 equivalent per year
- AUD$490 000/year energy cost reduction for an investment of $900 000
- 1800 MWh/year reduction in electricity usage
- 26 000 GJ/year reduction in oil consumption
- 400 kW reduction in demand load.

BACKGROUND

DSF is a coffee manufacturing plant located at Bupyung, South Korea. The plant produces freeze-dry and spray-dry coffee. Coffee manufacturing is an energy intensive process. The plant uses 30 370 MWh/year of electricity at a cost of AUD$3 million per year. Various types of fuel are used in the plant with a total thermal load of 678 000 GJ/year costing AUD$7.3 million per year.

THE CHALLENGE

In May 2000 an energy efficiency study of the DSF plant was commissioned by the process optimisation team. A number of energy best practice (EBP) projects were identified through this study. Completed projects include:

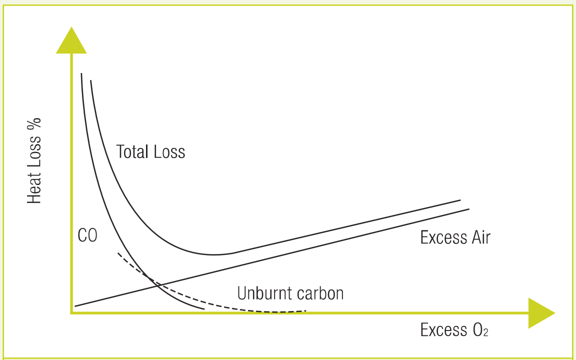
- Borsig chiller boiler heat recovery and combustion control
- energy management control system
- economiser for steam boiler
- air compressor intake relocation.

This case study examines the first and second projects in detail. Summary information only is provided for the others.

THE SOLUTION

Borsig chiller boiler heat recovery and combustion control

The freeze-drying process used by DSF to dry their coffee requires very low temperatures of approximately –40°C. This is achieved through an ammonia–water absorption chiller, which is fuelled by the hot combustion gases from a dedicated boiler. Precise combustion control for this boiler is an important function as it controls boiler efficiency and the level of air pollution. Perfect combustion in a boiler is not practical, so excess air is generally used to ensure that the level of unburnt hydrocarbons is kept low. To a certain point, excess air increases boiler efficiency, but it also increases heat loss through the stack flue gas. However excess air can be trimmed by controlling the level of oxygen in the stack flue gas. This is illustrated below. Note that total heat loss curve shows a minimum before increasing with excess oxygen concentration. This minimum indicates the optimum operating condition, and the challenge is to achieve this optimum condition in a cost effective and efficient manner. In addition, using heat recovery from combustion gases to pre-heat the feed air stream will also increase boiler efficiency.



Boiler heat loss versus excess air (note that O_2 is the control variable)

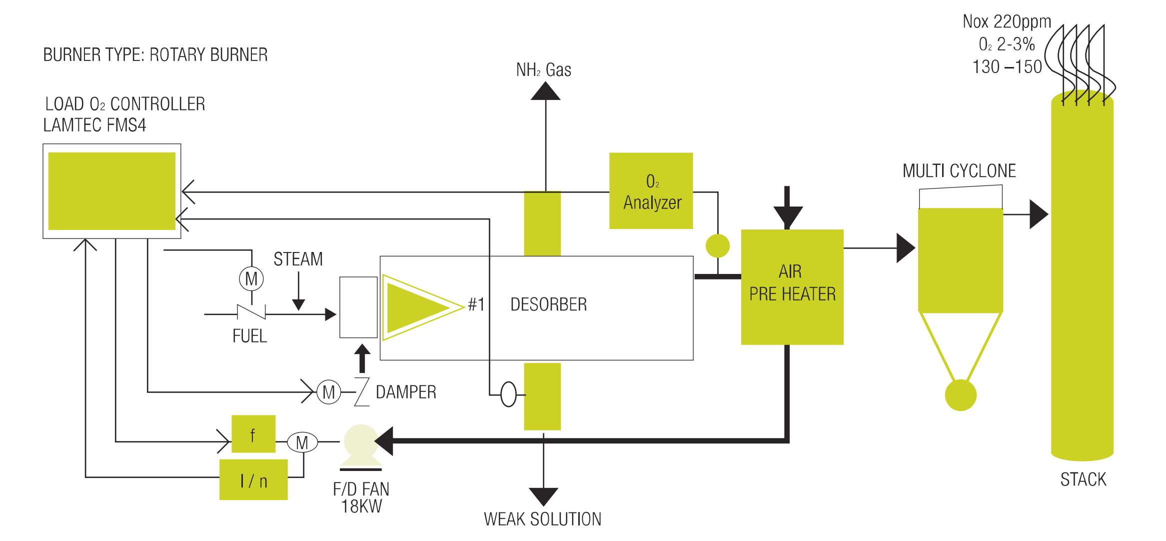
As mentioned previously, this unit drives an ammonia–water absorption chiller that is used to provide low temperatures for freeze-drying coffee.

The schematic of the boiler system, including the modifications, is shown at right.

Implementation

The modifications to this unit are typical of an energy best practice project and consists of:

- heat recovery from the boiler flue gas to preheat air; and
- variable speed drive using O_2 trim control for the forced draft fan on the boiler.



The schematic of the boiler system

The results achieved from the modifications above are in line with expectations obtained from the energy audit and are as follows:

- Flue gas temperature dropped from 240°C to 150°C
- The oxygen concentration in the flue stack reduced from around 5.5% to 2.5%.

Note that the first result is a direct consequence of installing an economiser on the stack flue gas to pre-heat the boiler feed air. The second result is a direct consequence of monitoring the level of oxygen in the stack flue gas and controlling it to achieve optimised heat loss and efficiency.

The benefits

- Reduction of greenhouse gas emission by over 550 tonnes of CO_2 equivalent per annum.
- Reduction in fuel oil consumption of 7067 GJ/yr, saving AUD$95 500 from installing variable speed drive on forced draft fan
- Reduction in electricity consumption of 234 MWh/yr, saving AUD$18 500/yr from installing variable speed drive on forced draft fan.

Energy management system

The refrigeration or chilling system and air compressor system are the major energy consumer in food industries such as dairies and food processing plants. The capacity and size of most old refrigeration systems has increased in relation to plant and hence the system configuration is not always optimal. In the majority of these cases, the control system is either manual or PLC based upon stepping and sequence control. Although these controllers provide complete automatic control, they do not provide optimal control with respect to energy cost. The energy consumption of the refrigeration and air compressor plants can be minimised by implementing an optimal control system, which in addition to providing complete automatic control will also provide **optimal unit commitment** or selection of compressor to match the demand.

Implementation

The installed EMS system manages and controls the following utility services.

Air compressors

- Automated control
- Optimal control of compressors to meet air demand
- Monitoring of key performance indices such as:
  - air leakage index
  - utilisation factor
  - energy index (Nm^3/kW)

Chillers and pumps

- Optimal selection of refrigeration compressors
- Fully automated control of chillers and pumps

Cooling tower fans and pumps

- Cooling tower temperature controlled on ambient temperature
- Pumps automatically controlled to maintain desired pressure set-point

Demand management system

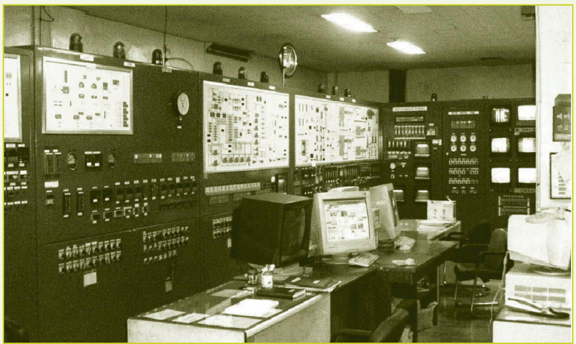
- Monitoring of demand and electricity consumption
- Demand prediction, to provide information for action to reduce demand cost
- Comparison of energy target with actual consumption

The benefits

The energy management system has been operational for four months, and the following figures are based on the available data:

- reduction of greenhouse gas emission by over 192 tonnes of CO_2 equivalent per annum
- reduction in electricity consumption of 1456 MWh/yr
- reduction in demand load of 400 kW
- reduction in electricity costs of AUD$156 000/yr

In addition to the obvious economic and environmental benefits, the EMS has significantly improved the ease of operation of the plant. Prior to this installation, the operators were required to follow a procedure for manually opening and shutting valves during start up and shut down of individual compressors. Under this mode of operation, it was safer to have more compressors running than necessary, hence energy consumption was higher than required.



Control room showing energy management control system

Economiser for steam boiler

An economiser is an air to water heat exchanger. The flue gases leaving the boiler are used to heat the feed water and can increase the efficiency by 4%. In this particular project, the following results were obtained

- Reduction in greenhouse emissions by 1400 tonnes of CO_2 equivalent per year

Flue gas stack from boiler fitted with economiser

- Reduction in fuel oil consumption of 19 000 GJ/yr
- Reduction in fuel cost of AUD$110 000/yr

Air compressor intake relocation

A good example of how a simple modification can reap economic and environmental benefits is the effect of moving the air inlet for the air compressors from inside the compressor room to outside (as shown below).

This simple modification contributed a reduction in electricity consumption of 92 MWh/yr, corresponding to a reduction in greenhouse emissions equal to 12 tonnes/yr of CO_2 equivalent and a cost savings of AUD$7300/yr.

Air compressor—air inlet relocated to outside compressor room

THE FUTURE

With the success of all the energy saving projects, the company has a plan to implement a number of other energy saving projects.

LESSON LEARNED

A properly designed energy management project with energy best practice will always provide the economic benefit.

Although heat recovery to preheat boiler feed air is not uncommon, using O_2 trimming with VSD is not very common. This project has shown that it can provide more savings and should be adopted in all medium to large boilers.

PROJECT DETAILS

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