The *VAREL 2* heating and power plant

By Horst Büsing and Friedrich Hutter*

Papier- und Kartonfabrik Varel has an old steam turbine heating and power plant with 2 turbo generators that have an installed electrical capacity of 3.0 MW each and has been operating another heating and power plant with a combined gas and steam circuit since 1989. It was developed in the Eighties by Friedrich Hutter GmbH, Biberach an der Riß/Germany, with the aim of reducing primary energy consumption in the industrial sector. The CH45 combined heating and power plant consists of a 45-tonne steam generator, which feeds a 6 MW steam turbine and is preceded by a 4 MW gas turbine. The gas turbine supplies the oxygen needed to fire the radiation boiler via the flow of gas it discharges. The plant has a fuel efficiency level of 93 % with practically CO-free combustion coupled at the same time with low NO_x emission. The plant has been available for more than 99.6 % of the time after being in operation for 140 000 hours. In the past, Papier- und Kartonfabrik Varel has manufactured 360 000 tonnes of board and corrugated board base paper per year with a basis weight of 100-1 350 g/m² on three machines. The average steam requirement has been about 90 tonnes/hour; the average electricity requirement of the paper mill has reached about 17 MW. It has been possible to cover an average of 16.2 MW by internal electricity generation. The rest of the electricity needed has been obtained via the public mains system. In order to be able to meet the future requirements for process heat and electricity when the capacity is increased as planned to 650 000 tonnes of board and corrugated board base paper in 2005/2006, the paper mill installed a second combined heating and power plant based on the Hutter system (the CH65 model), which came into operation in 2002.

Economic basis

The electricity market was liberalised in 1998, which promised initially to reduce companies' costs. It was therefore necessary to reassess the mill's own electricity generation facilities and to compare them with possible alternatives.

An energy engineering study was commissioned for this purpose. Various energy conversion strategies for supplying Papier- und Kartonfabrik Varel with electricity and heat in future were investigated and evaluated by a dynamic capital value method. Four different kinds of system that are in widespread use today were covered in this investigation:

1. Light-gas turbine with a low-pressure waste heat boiler
2. Light-gas turbine with a low-pressure waste heat boiler and additional firing facilities
3. Steam turbine heating and power plant
4. Heating and power plant with a combined gas and steam circuit

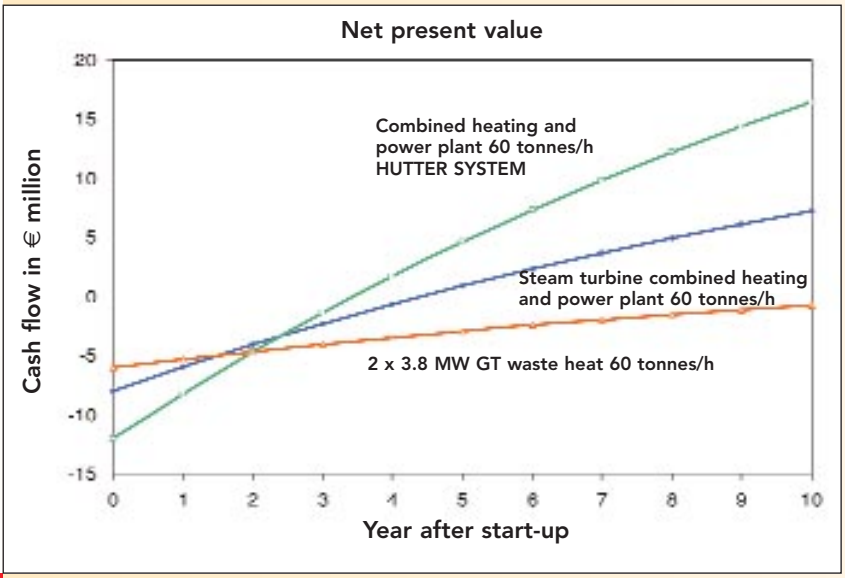
Each of the comparable plants generates 60 tonnes of steam per hour and supplies 7.2 MW of electricity (with the exception of the combined heating and power plant in 4. above). The latter has a higher electricity factor and a total electricity capacity of 16 MW.

It soon became clear that a combined heating and power plant of high thermodynamic quality at the mill is still superior to a supply system based on external electricity sourcing and simple steam generation in saturated steam boilers.

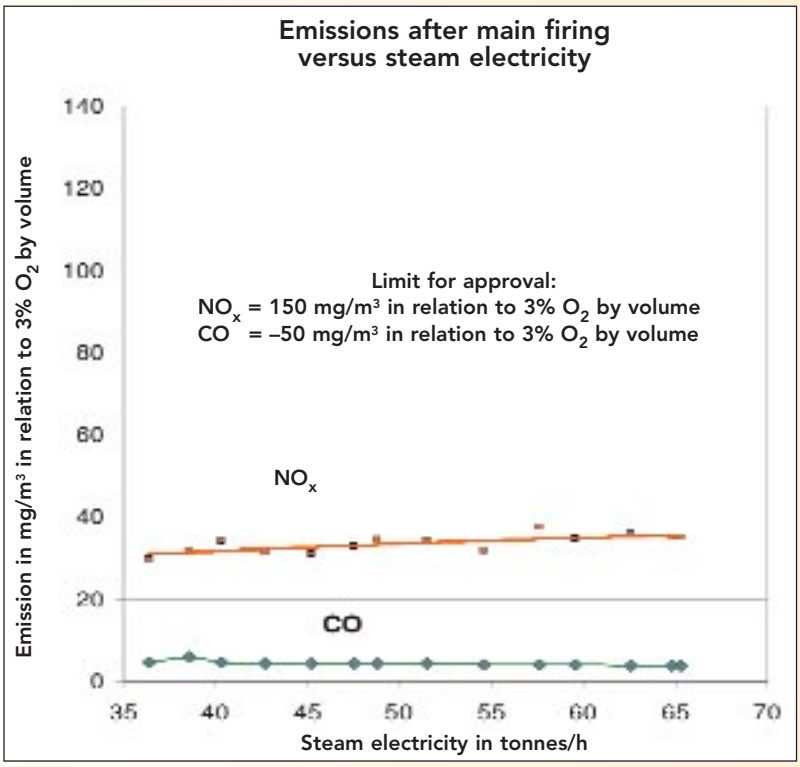
The CH65 system

Proven reliability, a fast response time and economic stability with respect to energy price fluctuations were the reasons why the paper and board mill decided to install

The dynamic capital value calculation shows that the internal rate of return for the combined heating and power plant is 24 %.



* Friedrich Hutter is the owner of Friedrich Hutter GmbH; Horst Büsing is a director of PK Varel.



Thanks to its low emission level, the paper mill is not required to carry out continuous measurement.

another heating and power plant supplied by Friedrich Hutter GmbH with a nominal electricity capacity of 16 MW.

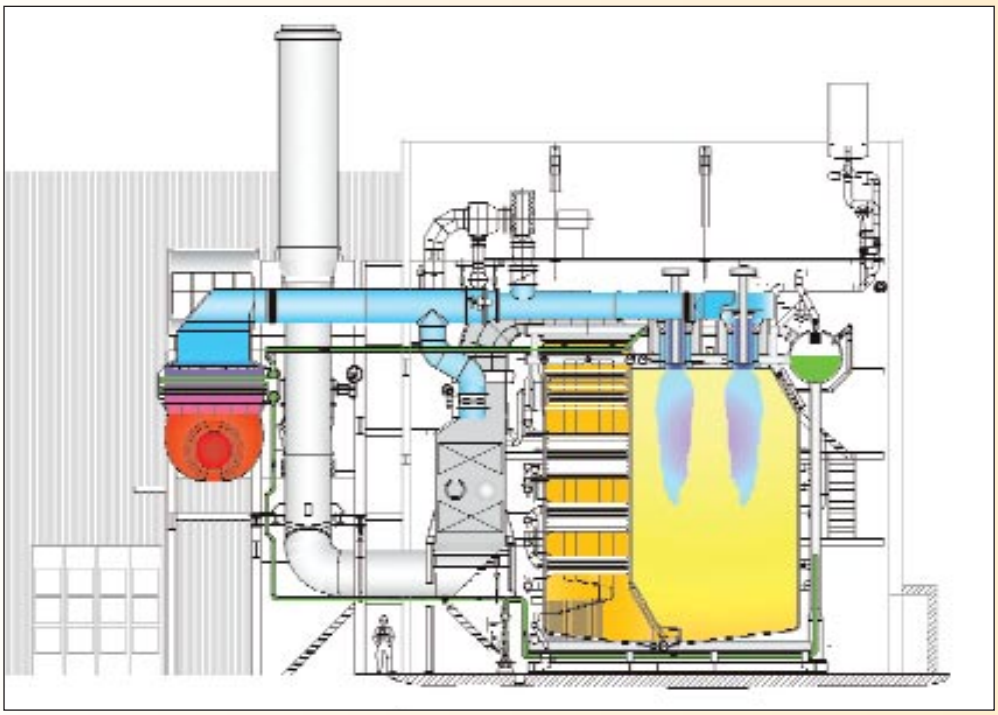
Construction work on the CH65 plant began in two stages. The steam generation equipment was set up first of all and was operated initially with a fresh air supply system. The 9.0 MW steam turbo facilities, the 7.6 MW gas turbine and the flue duct system were ordered in 2002. The entire system was started up the same year.

After what is now one year in operation, the plant is producing a surprisingly good fail-safe performance combined with unusually low

Varel 2 combined heating and power plant

pollutant levels (carbon monoxide below 5 ppm and nitrogen oxide 35 ppm). The low pollutant levels have a cost advantage too. The factory inspection authorities decided that the work and expense involved in carrying out monitoring in the form of the continuous measurement specified by the regulations is no longer appropriate. The mill is not required to comply with the continuous measurement rule introduced by the authorities. The fuel efficiency level of the combined heating and power generation process (more than 90%) in all load ranges also helps to reduce national CO_2 output.

The main advantages of the Hutter heating and power plant



The thermal stress relief provided by the superheaters guarantees the steam generation equipment a long useful life.

include not only the independent adaptability to steam and electricity requirements that has already been mentioned but also the availability of the plant in continuous operation for 8 400 hours per year. In the first year of operation, the new steam generation facilities only had six hours of unplanned stoppages. This performance is attributable not only to the thermodynamic design of the steam generation system but also to the careful selection of the components.

The steam circuit

The Hutter system is based on the classic steam turbine process with a radiation boiler, which has high efficiency levels. The steam process has merely been extended to include a gas process that intervenes in the air – smoke – gas system. In the patented process, the gas discharged from the gas turbine, which still contains enough oxygen to fire the steam generator, is cooled down from 540 °C to about 360 °C in an external evaporator heating unit before it flows into the firing equipment. This measure reduces the flame temperature in the combustion chamber of the radiation boiler by about 200 °C compared with the normal level of 1 200 °C.

This eliminates a critical amount of strain on the superheating surfaces and at the same time reduces the susceptibility of the flame to form NO_x.

Experience with the combined heating and power plant installed in 1988 that uses the same process has shown that the heating surfaces have not needed to be repaired at all so far. The new steam generator is a classic radiation boiler with a corner tube structure supplied by Messrs Baumgarte Kessel- und Apparatebau, Bielefeld, with tightly welded, cooled combustion chamber walls. Water circulates naturally. The boiler has top firing, consisting of two burners with a firing capacity of 2 x 28 MW.

The steam generator feeds a steam turbine with an installed capacity of 12 MW, which cannot yet be exploited in full, however. With a steam flow of 65 tonnes/h and 64 bar, the steam turbine reaches 8.5 MW with back pressure of 6.5 bar. The turbine was supplied by Siemens, Görlitz. In addition to standard back pressure regulation, the turbine system also has steam flow limitation regulation facilities, which prevent undershooting of the permissible turbine parameters and a shutdown for safety reasons as a result when the paper web tears.

The gas circuit

In the Varel 2 combined heating and power plant, a gas turbine generator unit (Tempest model) with an electricity capacity of 7.6 MW supplies the oxygen for the natural gas-fired burner of the radiation steam generator. The gas discharged has a temperature of about 540 °C and leaves the gas turbine via a downstream silencer and flows to the burner system of the steam generator via a main exhaust gas duct. The flow of exhaust gas is divided up geometrically to the two burners after the flow speed has been reduced in a special diffusor. A flap system makes sure that exactly the right amount of oxygen is metered into the firing equipment. Fuel – oxygen regulation facilities, which operate in accordance with a specified model that is stored in the control system, guarantees almost completely CO-free combustion.

The compressor blades of a gas turbine are generally contaminated by hydrocarbons in the atmosphere in the course of operation. The compressor therefore needs to be washed with water and a cleaning agent at certain intervals, after about 2 000 hours. In order to reduce this maintenance work, a multi-stage filter which filters some of the hydrocarbons and the dust particles that attract water out of the combustion air was installed in the Varel 2 combined heating and power plant. After one year in operation, the pressure loss of the filter increased from 4 hPa when the filter bags were new to 8 hPa in the course of the year. The compressor of the gas turbine did not need to be washed over a period of 8 000 hours.

Technical data about the Varel 1 and Varel 2 heating and power plants

		CH45-4	CH65-8
Start-up	year	1989	2002
Annual operating time	h/a	8 600	8 600
Capacity of the gas turbine equipment	MW	4.0	7.6
Capacity of the steam turbo equipment	MW	6.5	9.0
Steam capacity	t/h	45	65
Superheater outlet	bar	64	70
	°C	450	470
Back pressure	bar	3.6	6.7
Fuel		Natural gas/biogas	Natural gas
Firing capacity in combined operation	MW	2 x 17	2 x 22
Fuel efficiency level	%	93	93
Emissions NO_x in relation CO to 3% O_2 by volume	ppm	75	35
	ppm	< 5	< 5

Summary

Following the start-up of the new combined heating and power plant based on the Hutter CH65-8 system, Papier- und Kartonfabrik Varel has another environmentally sound energy conversion system for the internal generation of electricity and heat that is sparing in its use of resources. It therefore helps to reduce national CO_2 emissions to the maximum possible extent and generates electricity at particularly low cost. The technology of the system leads to extremely low emission of CO and NO_x pollutants and high plant availability.