Tradition gets a boost

HEAT TECHNOLOGY | Since May 2014, a compact cogeneration unit produces, in addition to power and heat, also steam for production of about 370 000 hl/annum of Kölsch beer at Cölner Hofbräu P. Josef Früh KG, Cologne. The cogeneration unit supplied by Sokratherm GmbH, Hiddenhausen, including exhaust steam boiler and housing, achieves an overall efficiency of up to 94.1 percent.

TRUE TO THE MOTTO "Kein Bisschen Alt" (literally "Not in the least bit old" and a pun on another German top-fermented beer – Altbier), Cölner Hofbräu P. Josef Früh KG introduces the 111-year old company history in the same style as its advertising campaign. It started back in 1904 when Peter Josef Früh opened a top-fermenting brewhouse including a public house in the immediate vicinity of Cologne Cathedral. Demand rose as time went on to such an extent that, in 1976, the benchmark output of 100 000 hl was exceeded for the first time. Between 1985 and 1987, a modern brewery was built on the northern outskirts of Cologne. With a staff of some 400, about 370 000 hl per year of the top-fermented pale beer are currently produced in the Kölsch brewery which has been continuously extended.

In 2014, the family-owned company, currently managed by the fifth generation, made an innovative switchover to generate the energy required for brewing. Instead of generating the media needed – steam, hot water and power – solely in separate boilers or drawing it from the mains, the company decided to generate the utilities also in-house using the highly efficient principle of combined heat and power generation, or short: cogeneration (CHP).

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Cogeneration

The core idea of cogeneration is to not to get rid of the heat which always comes along with power generation (as large power stations do with cooling towers), but to make use of it. In the most common application of cogeneration, a motor-driven CHP unit implements this principle with heat exchangers: a gas motor drives a generator that generates power for on-site use or for feeding into the mains. Almost all thermal energy arising, i.e. the heat from the motor cooling water (about 90 °C) as well as that from the exhaust gas (about 500 °C) is recovered via heat exchangers and generally combined into a hot water circuit 90/70 °C (flow/return). By using this cogenerated heat, the overall efficiency rises from ca. 40 % in central power plants to 90 % in decentral CHP units.

Tailor-made BTTP project

In order to customise this arrangement to meet the brewer's requirements, the operating technology department of Früh, together with Sokratherm GmbH Energie- und Wärmetechnik, developed a tailor-made concept in the summer of 2013. A natural gas CHP unit that heats the required process water and simultaneously generates steam all year round, in addition to generating power, was the ultimate objective.

The mid-sized company established in 1977 and meantime managed by the second generation has built and commissioned some 1500 cogeneration units and could draw on the experience gathered from previous CHP projects with steam generation. *Joachim Voigt*, Sales Manager at Sokratherm, explains: "With our compact CHP units, exhaust gas heat can also be recovered separately and supplied to an external steam generator." But making good use also of the 90 °C heat is a basic prerequisite for steam generation in a CHP.

Two natural gas-fired steam boilers with a capacity of 10 t/h and 14 t/h steam are the main components of the energy centre. They supply the saturated steam requirements of the brewery, the majority of which is used for boiling beer wort in the brew vessels. The two boilers also generate steam for sterilisation of pipework and filling plants as well as for ambient heating.

CHP with an efficiency of up to 94.1 percent

The compact CHP unit type GG 198 D with turbo-charged engine was added to the energy centre. It generates a total of 506 kW of utilisable energy from 538 kW of natural gas: 200 kW of electric power (gross) from the generator, 121 kW of heat recovered in the form of saturated steam from the exhaust heat boiler, 120 kW of heat from motor cooling and the first stage of mixture cooling, 20 kW from the second stage of mixture cooling and 45 kW from the downstream condensing heat exchanger. In total, it achieves an overall efficiency of up to 94.1 percent.

Utilisation of power and heat

The power generated by the compact CHP unit is used for supplying the brewery's power. Feeding into the mains – not very attractive under current conditions – can be avoided as it is operated in accordance with heat demand in the brewing process.

On the heat side, the CHP is primarily used to heat the brewing liquor from about 15 to 85 °C in the feed to the brewhouse. *Axel Spelzhaus*, Head of Operational Technology at Früh, explains: “The motor cooling water of the cogeneration unit as well as the first stage – the high-temperature loop – of the two-stage mixture cooling are mainly used.” The thermal capacity of the cogeneration unit was designed to be sufficiently large in order to heat the brewing liquor independently the whole year round. Regarding this task, the steam boilers only serve as a backup for the CHP unit. It is inherent in the concept that both energy generators will never be used simultaneously for this task”, Spelzhaus continues.

The exhaust heat from the CHP is then supplied to a compact exhaust heat boiler serving as steam generator. In order to reduce transmission losses as far as possible, it was installed directly next to the CHP in the new factory building. It generates 185 kg/h of saturated steam that also supplies to the particular points of usage in the brewery through the steam distribution in the boiler room. Spelzhaus emphasises: “Compared to the steam boilers, the CHP unit delivers a relatively low amount of steam. But that is sufficient to maintain a pressure of 4 bar in the steam loop outside production times.” The unit ensures that radiation losses from the pipework in the brewery’s steam loop are compensated.

The residual heat still present downstream of the steam generator is used for heating the feed to the brewhouse as well as low-temperature stage of mixture cooling. Voigt points out: “In many CHP projects, this heat is removed in an emergency cooler, due to the fact that its temperature of about 40-46 °C is relatively low and also due to the necessity of cooling the mixture in any case. In this project, however, it can be put to good use as the return temperature is consistently low.” Depending on heat quantities needed in the brewhouse, these two exhaust heat sources can be used as required or switched off while power and steam generation of the CHP remains at a constant level. “The project shows that the highly efficient principle of cogeneration can also be used for steam generation and achieve excellent efficiencies proven in industrial operation”, Voigt sums up.

Economics

Sokratherm installed the plant as a turn-key package on the Früh brewery site including the CHP unit, steam generator and their operation building. Integration of the plant into the operation and control of the points of usage was handled by the brewery. Due to the energy cost savings, the investment, including all ancillary trades and integration of the cogeneration unit, is paid off in some three years.

Inside the brewery

The main components of this system for saving energy costs include substitution of power drawn from the mains, lower utilisation of the conventional steam boiler as well as a subsidy in accordance with German CHP legislation.

After a year of base load operation, Spelzhaus concluded: “The CHP is operating as well as we had expected.” As forecasted by a profitability analysis, the cogeneration unit operated just short of 6000 hours, more than 98 percent of that in full load, during that period. According to what Spelzhaus has observed to-date, commercial objectives will be achieved. The environment also benefits from the project: due to highly efficient energy generation, CO_2 emissions from the brewery are reduced by 840 tons annually.

CHP types suitable for steam generation

High-capacity cogeneration units with turbo engines are generally more suitable for steam generation than smaller cogen-

Compact CHP unit GG 198

The exhaust heat boiler generates 185 kg/h of saturated steam from the exhaust heat of the cogeneration unit

eration units with aspirated engines. This arises from the fact that only exhaust heat can be used for steam generation and turbo engines offer a higher ratio of exhaust heat. The GG 198 (200 kWel, 287 kWth) with turbo engine generates e.g. more heat from the exhaust gas heat exchanger than a CHP with an aspirated engine of the 200 kW power class but having just about half the amount of heat using the cooling water heat exchanger.

Moreover, the CHP for steam generation should not be too small so that costs for installation and approval procedures for the steam generator pay off. In other projects involving steam generation, high-capacity CHP types with turbo engine and a capacity between 200 and 550 kWel were selected. They are also very suitable for similar special applications where exhaust heat is used e.g. for heating thermal oil.

Additional CHP applications in breweries

Cogeneration units with an aspirated engine can also be an interesting option for the beverage industry: if larger amounts of power and heat are required, a cogeneration unit, in standard design, with a lower capacity such as the GG 50 (50 kWel, 82 kWth) can be installed on site and can generate heat at 90/70 °C (flow/return) in addition to power. With careful planning, such projects can pay off within three to six years.

Should refrigeration be required in addition to power and heat, a combination of cogeneration unit and absorption chiller is an interesting option. Absorption chillers generate cold water in temperatures of about 6 - 12 °C from the heat of the cogeneration unit. As the motive heat has to be somewhat higher for this process, Sokratherm can supply all CHP types as "hot coolers", with a flow at 95 °C and return at up to 80 °C. The ratio between the thermal quantity inputted and the refrigeration energy generated by the absorption chiller is just under 4:3. Accordingly, an absorption chiller would provide about 55 kW refrigeration capacity from the GG 50 H compact module's 77 kW thermal input.

Cogeneration units can also be equipped with the accessory equipment for acting as an emergency power supply. In the event of a power failure, they automatically switch over supply to points of usage requiring power at all times (e.g. IT, sprinkler, lifts).

Conclusion

Cogeneration units are versatile, highly efficient and an important building block for decentralised power supply in a brewery. Not only can they generate power and heat but also, as in the Früh Brewery, provide steam flexibly and with high efficiency. Cogeneration units are also able to provide refrigeration and emergency power requirements in industrial operations in many instances. ■