Energy Reduction for Kilns Used in the Sanitaryware Production

Increasing energy costs and environmental obligations force manufacturers of industrial kiln plant and the ceramic industry in general to explore all available potential energy saving methods. One of our customers' main selection criteria by *SACMI*/IT when considering investment in new plant is energy efficiency and *Riedhammer GmbH*/DE offers cutting-edge innovation and specific technical solutions to meet current challenges in this regard.

The principal measures for enhanced energy efficiency in new plant as already presented in detail in various publications by Riedhammer GmbH comprise of the following:
- energy-efficient engineering (EEE)
- energy-management-system (EMS) and Reko burner system
- integrated process control
- internal heat re-use
- combined re-use of thermal energy.

Using the examples of a tunnel kiln and a shuttle kiln for firing sanitary ceramics the following sections will describe possible technical alterations to existing kiln plant which can be realized with varying investment costs and effort to achieve higher energy efficiency.

Technical options for continuous kilns

When using tunnel kilns the customer can achieve very good energy efficiency without any alterations to the kilns themselves by ensuring that a high product setting density is achieved, the kiln cars are uniformly loaded and an optimal use of the available cross section as well as short cycle times are realized.

As a first additional step which requires some alterations to be made to the kiln the waste heat from the cooling zone of the kiln can be directly re-used, which for this step has an efficiency of 100 % despite low investment costs and simple technology which can easily be installed on existing kiln plants.

As a second additional step heat exchangers can be fitted to use waste air from the cooling zone or waste gases from the kiln exhaust for the generation of hot water.

If hot air is required it is possible to use clean hot air directly from the cooling zone of the kiln without any heat exchanger, if the exhaust gases are to be used for producing hot air then a heat exchanger would be needed to be able to provide clean hot air. These steps are relatively easy to carry out and have a short term return on investment. The use of the energy contained in the flue gases is very much dependent on the actual flue gas temperature that is available; the level of feasibility can be described as follows:
- temperature > 180 °C a good feasibility
- temperature < 180 °C a reduced feasibility.

The retro-fitting of equipment for the use of flue gas energy on existing tunnel kilns can in most cases be relatively simple.

The 3rd step that is possible is the implementation of the use of pre-heated combustion air in the burner system. This can be realised via the direct use of waste hot air from the cooling zone combined with a regulated air gas ratio. This type of waste heat usage is characterised by:
- high investment costs
- medium reduction of energy consumption.

The direct use of waste hot air can however also be used as combustion air for burner systems that have a fixed combustion air (EMS 250). This method of waste heat usage is characterised by:
- cost efficient investment
- medium reduction of energy consumption.

A further step forward is the use of additional heating of the waste air by using an indirect cooling heat exchanger (EMS 400/600). This method of waste heat usage is characterised by:
- high end solution with high energy savings
- high quality gas-air ratio control system.

Technical options for intermittent kilns

As with the continuous kilns that have been described above there are also certain measures that can be taken to increase an intermittent kiln's efficiency without making alterations to the kiln itself. Some of these actions are to increase the setting density in the kiln to the maximum that is feasible, optimise the use of the loading space in the kiln, take out the most complicated products so that they can be fired separately with their own firing program. This will avoid having to fire the simpler products on longer cycles which would increase the energy usage unnecessarily, which in turn will enable shorter firing cycles.

Regarding energy saving methods that require some alterations to be made to the kiln, one of the first things that can be done is to carry out an evaluation of the practicality of using exhaust gases directly in the kiln as diffusion or secondary 'air'.

Additionally the use of waste gases can be considered via a heat exchanger that is fitted into the exhaust system. This is characterised by the following:
- technical feasibility
- large difference in volumes and temperature
- discontinuous supply
- technically advanced system.

A heat exchanger that can be fitted directly into the exhaust system so that the combustion air can be heated to a suitable temperature has the following characteristics:
- works well only for high temperature applications.
- technically advanced system.

Further to the use of waste heat new firing systems can be fitted to the kiln which increase efficiency and improve temperature distribution within the kiln.

The first of these systems that are available is the pulse firing system which as the name implies uses burners that are either switched on and off according to the energy requirement of the kiln or burners

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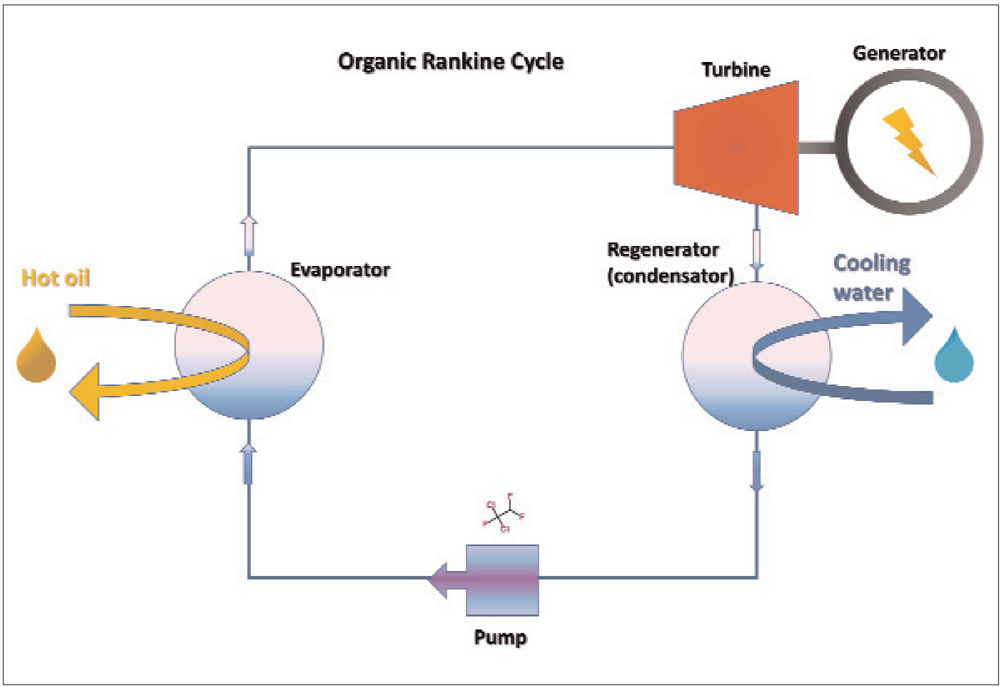

Fig. 1 Functional diagram of the ORC process

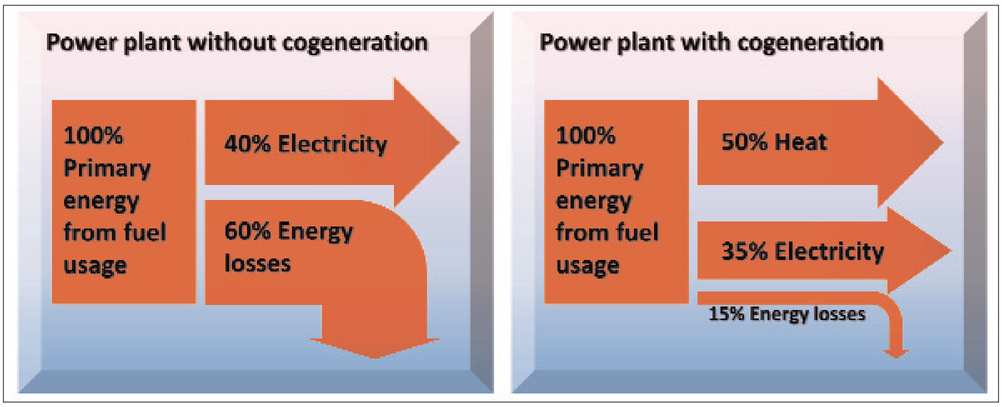

Fig. 2 Power plant without cogeneration vs. power plant with cogeneration

that are fired in a high – low mode. The characteristics of this type of firing system are:

- reduction in energy consumption by elimination of secondary air
- increased temperature uniformity due to an impulse in the kiln
- wide range of energy supply via the burners.

A second firing system that is highly effective is the use of recuperative burners which use the exhaust gases of the kiln to directly heat the combustion air within the burner itself, this being realised by exhausting the kiln through secondary external burner tubes that are fitted around the actual burner nozzle. The Reko firing system's characteristics are:

- technically the most efficient solution
- high reduction of energy consumption
- heat exchange takes place in the burner – cold combustion air piping
- uniform flue gas extraction – very good temperature uniformity
- shorter firing cycles due to large cooling volumes for final cooling.

The technical measures that are presented under point 1 and 2 have to be investigated for technical and economic feasibility in each individual case.

Riedhammer GmbH's expertise also comprises new and alternative solutions for generating power from waste heat which can be used within the production system for sanitary ware and other products. These possibilities are defined under the term cogeneration.

One process that is described as follows is the use of kiln waste heat for power generation by means of the Organic Rankine Cycle (ORC).

The main features of the ORC process are:

- The conversion of heat, first into mechanical and then into electrical energy according to the functional diagram in Fig. 1.
- The working fluid of the ORC is an organic liquid.
- The heat exchanger uses diathermic oil.
- The cooling medium is water.

The main application for the ORC is generation of power from waste heat. There are factors that influence whether or not the ORC is a suitable technology for a specific application. The efficiency of the ORC is dependent on the volume and temperature of the waste heat flow that is available. ORC equipment is available for varying temperatures and volumes at varying efficiencies and as such each case must be looked at individually.

ORC equipment is moving towards being a standard type of equipment which will result in higher production levels that will in turn, as manufacturers produce more ORC equipment, help to reduce production costs and thus investment costs.

A second process is the generation of power and usable waste heat by means of a micro-gas turbine which entails following advantages (Fig. 2):

- production of electrical power for independence from the electrical grid
- production of electrical power for a reduction in the amount of purchased electricity
- production of electrical power for an increased efficiency by using the waste gases
- production of electrical power for the decentralization of the entire system.

The main features and the functional diagram of the micro-gas turbine are shown in Fig. 3. The use of a micro-gas turbine in cogeneration can result in an overall efficiency of up to 86 %. Higher efficiencies depend on the optimization of the heat exchanger and on the specific plant parameters.

Summary

The main objective of the developments presented under the terms EMS, Reko system and cogeneration consists of the following: significant energy savings combined with CO_2 emission reduction and improved glaze quality on continuously operated kiln plants for sanitaryware production thanks to the Energy Management System (EMS). Apart from the possibility of using the waste heat from the kiln plant for other purposes to improve the energy balance of the factory, the EMS presents the latest technology for optimizing the use of resources such as gas and electrical power which also contributes to an increase in product quality. Due to various hardware and software tools contained within the system which interact with the state-of-the-art kiln components, an extremely high performance level can be achieved to meet our customers' demand for ecological and economical production plants for firing sanitaryware. Reko is synonymous for enormous energy savings combined with CO_2 emission reduction on intermittently operated kiln plants.

The state-of-the-art combustion system with self-recuperating burners presents a new milestone in advanced firing systems for sanitaryware production plants. This burner system with preheated combustion air and preheated combustion gas installed in the kiln chamber ensures a high level of flexibility and economic efficiency combined with first-class product quality. Due to the higher consumption of resources in intermittently operated kiln plants compared to continuously operated kiln plants, the Reko burner system represents an important step forward for production plants in the sanitaryware industry.

Cogeneration stands for flexibility and high efficiency in the use of available energy sources and recovery of waste energy from the firing process.

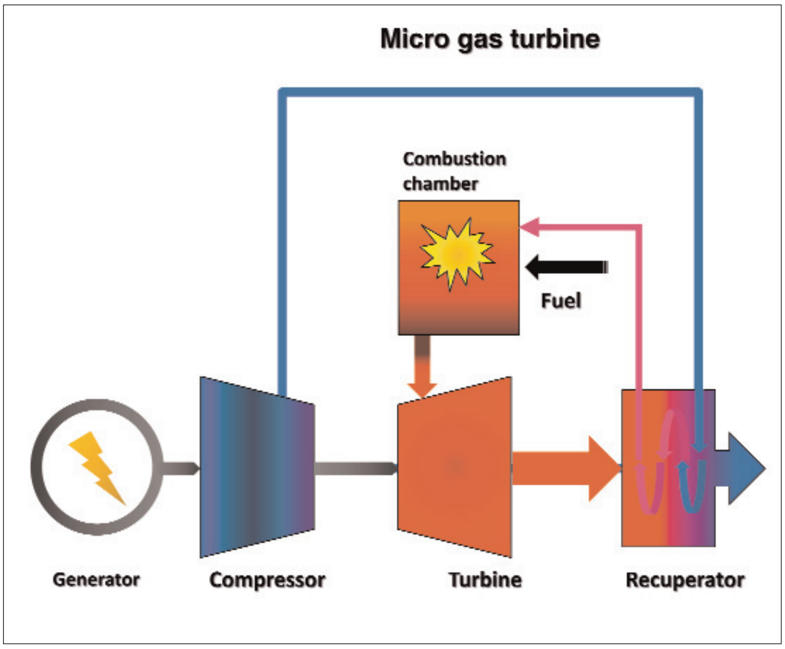

Fig. 3 Functional diagram of the micro-gas turbine