Saving energy by modernizing the heating system, using modern self recuperative burners

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When modernizing existing thermo-processing equipment, using self recuperative burners means that, for a moderate expense, the necessary increase in productivity can be combined with rewarding energy savings. Two practical examples demonstrate the possibilities of direct open heating and indirect heating with radiant tubes, as well as the fuel savings achieved.

Thermo-processing equipment, such as industrial furnaces, takes up a large share of industrial energy consumption. They have thus moved into the public and political limelight in recent times. The political but, in particular, the economic pressure to save energy is growing and energy efficiency is one of the main aspects when modernizing.

Self recuperative burners for combustion air preheating

Modern self recuperative burners, such as the ECOMAX® (**Fig. 1**), are a simple and effective option for enhancing energy utilization on thermo-processing installations and for saving fuel. With these burners, the combustion air is preheated by the exhaust heat via a heat exchanger integrated in the burner.

Historically, self recuperative burners originate from the sector of indirect heating with single-ended radiant heating tubes (**Fig. 2a**). In this application, the exhaust gases are generally routed past the heat exchanger inside the burner. The exhaust gas temperature drops, owing to use of the exhaust gas heat to preheat the combustion air and the exhaust gas losses are thus reduced which means that firing efficiency is increased.

Direct or open heating with ECOMAX® self recuperative burners (unlike radiant tube heating), involves extraction of the exhaust gases from the furnace chamber (**Fig. 2b**). For this purpose, the burners are equipped with specially designed ejectors which generate a negative pressure with the aid of a stream of motive air. Frequently only 80-90% of the entire exhaust gas quantity is extracted via the self recuperative burner for maintaining the pressure in the furnace and avoiding ingress of co-inducted infiltrated air into the furnace. The remaining, small quantity of exhaust air (10-20%) directly exits the furnace at a central point via a flue system and also via inevitable leaks. Admittedly, this causes a slight reduction in efficiency but ensures far better furnace operation.

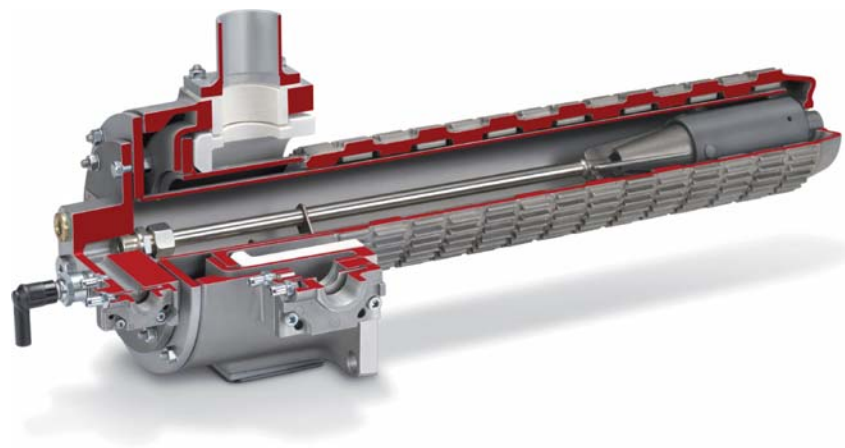

Fig. 1: ECOMAX® self recuperative burner

One special advantage of direct heating with self recuperative burners is that, unlike the central recuperator, large amounts of hot air ducting are no longer required. This avoids a reduction in firing efficiency by heat losses from the hot air duct work.

Possible air preheating is essentially dependent on the exhaust gas temperature at the recuperator inlet. With direct heating, the exhaust gas temperature is equal to the furnace chamber temperature and, in the case of indirect heating with radiant tubes, it is approximately 100-150°C above the furnace chamber temperature, depending on the application. If we consider the air pre-heating temperature in relation to the exhaust gas temperature upstream of the recuperator, we obtain the relative air preheating. On self recuperative burners, this reaches values of approximately $\varepsilon = 0.6$. The associated fuel savings are shown in **Fig. 3** as a function of the exhaust gas temperature upstream of the recuperator. For example, you can see that around 33% fuel savings can

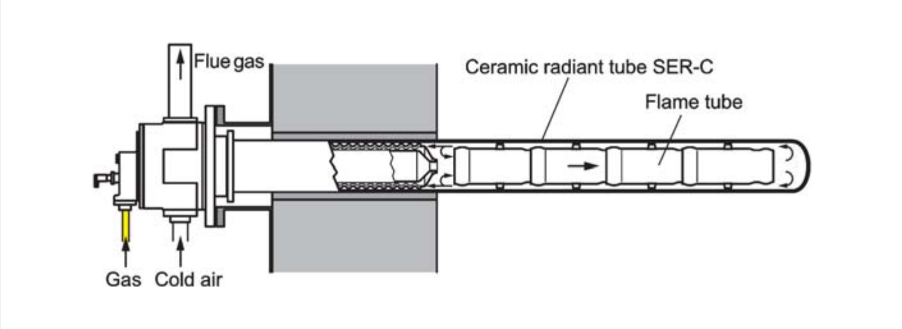

Fig. 2a: Indirect heating with self recuperative burners

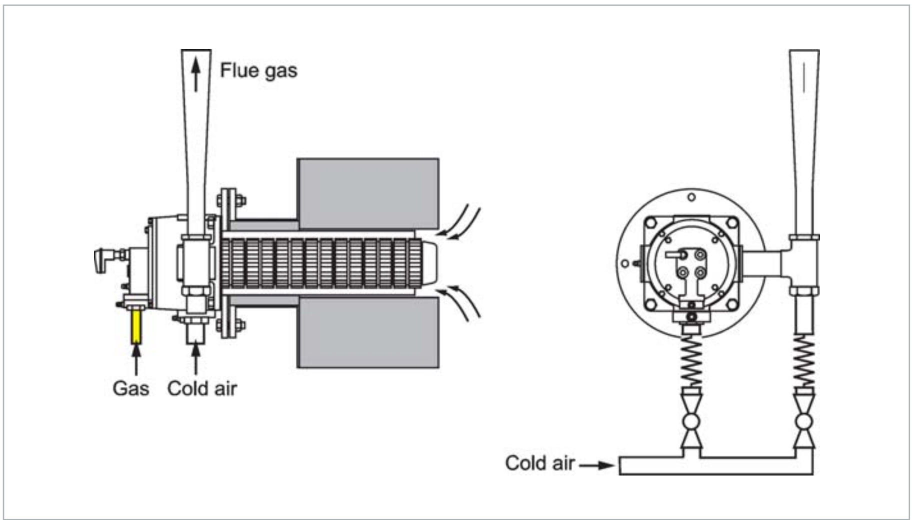

Fig. 2b: Direct heating with self recuperative burners

be achieved with a self recuperative burner by comparison with a cold air burner at 1,000°C furnace chamber temperature and a relative air preheating of 0.6. The achievable fuel savings increase with rising furnace chamber temperature. Two specific examples of modernization measures using ECOMAX® self recuperative burners are presented and explained below.

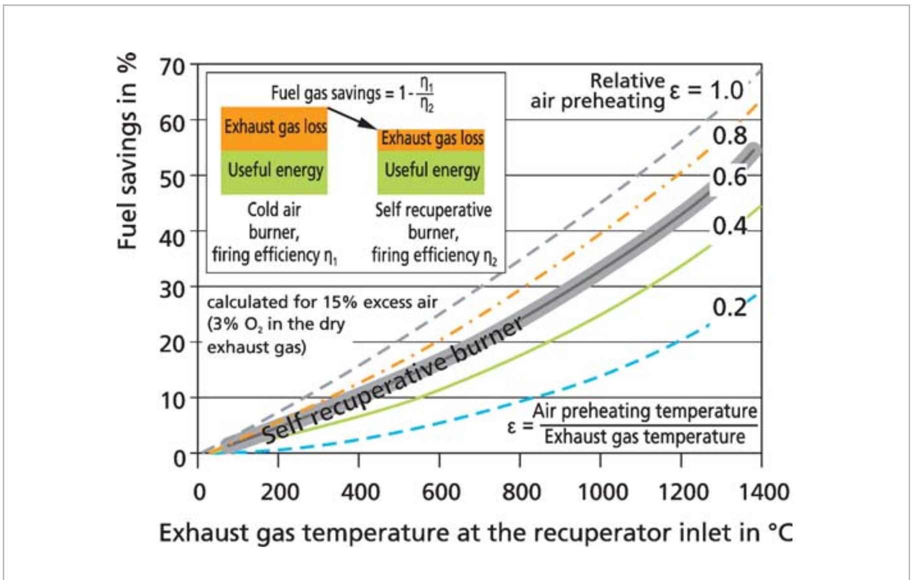

Fig. 3: Fuel savings with self recuperative burners compared to cold air burners

Example of continuous furnace for heating slabs

The task was to modernize a directly heated pusher-type furnace for brass and copper slabs at a rolling mill in Kirov, Russia. The revamping was performed by Volgaterm Ltd. and UralThermoKomplex Ltd. On this type of furnace, the slabs are "pushed" through the furnace on insulated, water-cooled slide rails. The furnace was equipped with oil and gas hot air burners beneath and above the slab level, and these were supplied with hot air via a central recuperator.

The main problems of the old furnace installation consisted of high exhaust gas and cooling water losses and a control system that was susceptible to malfunction. The high heat losses led to a poor (overall) heating efficiency of only 15%. The central recuperator achieved only a very low air preheating of 108°C, even allowing for the low furnace temperature level of around 880°C.

One essential element of modernization was to optimize heat recovery by converting from central heat recovery with a central recuperator and hot air burners to distributed heat recovery with metallic ECOMAX® 5M (rated capacity 250 kW) self recuperative burners. **Fig. 4** shows a view of the furnace after conversion. A new manifold was laid on the furnace for discharging the exhaust gases extracted at a decentral point via the self recuperative burner, but this manifold did not need to be lagged and it discharges into the existing exhaust gas system at the furnace inlet (at front right in Fig. 4).

Besides modification of the burners, modernization also involved repairing of the furnace-wall refractory lining, in addition to thermal insulation of the water-cooled slide rails for reducing cooling water losses. **Table 1** shows the most important data of the furnace with comparable goods feed before and after modernization.

What is very impressive is the increase in productivity of over 70%. In this case, it is primarily attributable to the fact that the slabs are no longer cooled to such an extent on the slide rails which are now insulated better, thus allowing the

Fig. 4: View of the pusher-type furnace after revamping with ECO-MAX® self recuperative burner

Table 1: Comparison of important furnace data before and after modernization

	Before	After
Furnace chamber temperature	880°C	
Productivity	5.56 metric tons/h	9.64 metric tons/h
Natural gas consumption	351 m^3/h	304 m^3/h
Specific consumption	2301 MJ/metricton	1056 MJ/metricton
Air preheating	108 °C	420 °C
Firing efficiency*	60.6 %	73.4 %
Energy balance		
Useful heat	15.0 %	45.0 %
Exhaust gas loss	39.4 %	26.6 %
Cooling water losses	29.4 %	19.2 %
Wall losses	11.0 %	6.5 %
Losses via pushing device, etc.	5.2 %	2.8 %
* For comparison: on cold air burners = 57.3 %		

target temperature to be reached faster. This and the reduced exhaust gas losses owing to intensive preheating to 420°C led to a tripling of the thermal efficiency from around 15 to 45%.

Despite the increase in product throughput, the optimized furnace achieves an absolute (!) fuel gas savings of 13%. The fuel savings achieved as the result of the reduced exhaust gas loss (increased firing efficiency) are theoretically 17.4%. The specific natural gas consumption per metric ton of goods has dropped to less than half.

Hardening furnace example

Hardening furnaces are operated in large numbers, in many, often small heat treatment shops or even large contract heat treatment shops. Here, the indirectly heated furnace belonging to a heat treatment service provider in England (a branch office of the TTI Group, Blackburn) has been modernized. In particular, the task was to increase the productivity and the operational safety, as during the relatively tough operation the old burners frequently caused faults.

Before being modernized, the furnace was heated with straight through fired radiant tubes. The burners were mounted underneath the furnace. The flue gas emerged from the open radiant tubes at the top of the furnace at a high temperature. **Fig. 5a** shows the outlet of the radiant tubes on the furnace roof. As a result of there being no air preheating, the system had an extremely high gas consumption. The maintenance costs were also high.

Fig. 5a/b: View of the roof of the hardening furnace before (left) and after (right) modernization with ECOMAX® self recuperative burners

A particular challenge for planning the modernization was the very small amount of space available between the interior furnace wall and the charge holders. After testing various alternatives, single-ended metal radiant tubes with ECOMAX® self recuperative burners in size 0 C, each with 25 kW, were installed in the furnace roof, whose design was adjusted accordingly (**Fig. 5b**). The burners were of course also provided with modern control lines and flame safeguards. The control setup was converted to ON/OFF cyclical control.

Through measurements during operation conducted internally, the customer recorded the fuel savings achieved between 45% and 60% depending on the amount of charge. A review of the diagram in Fig. 3 shows that such high fuel savings are not possible as a result of the improved heat recovery alone. Additional savings were achieved through optimum energy-efficient burner adjustment with a low amount of excess air. The results clearly show the urgent and rewarding need to address radiant tubes with no heat recovery that are still used today.

Since being modernized, the burners have regularly undergone annual maintenance checks and only the ignition electrodes and seals have been replaced. Overall, the operational safety and the reliability of the system have significantly improved. Based on these good results, additional furnaces have been modernized in the meantime.

The energy savings achieved in these two examples are above average and not representative, as out-of-date technology was replaced. But even for other systems in Germany and abroad, noteworthy savings and increases in productivity could be achieved by modernizing them using ECOMAX® self recuperative burners. ■

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