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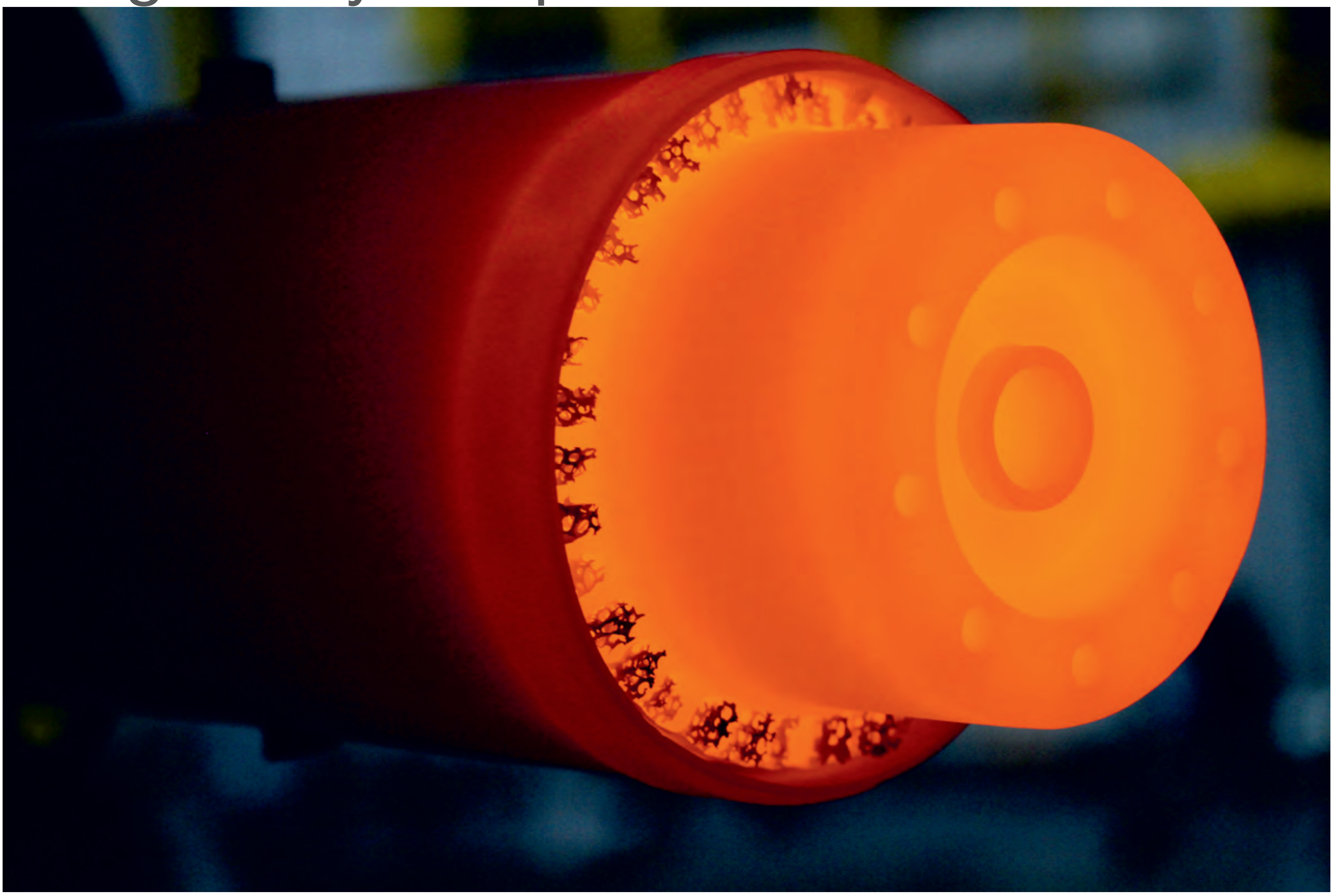

Retrofits for chamber furnaces with advanced Plug & Play recuperator burners

by **Dirk Mäder, Dirk Clever, Rolf Peekel, Reinhold Heizmann**

Retrofit measures on thermal processing plants to increase their efficiency have been quite popular recently. Depending on the age and condition of the plant, they are often also simply necessary. Besides reducing natural gas consumption, the raised quality standards must be fulfilled, and the safety issues of the relevant standards and regulations must be observed. As cost and time frames are usually tight in such projects, the retrofit measures often have very clear limits. The following paper lists successful retrofit measures on protective gas chamber furnaces with indirect heating, where the heating technology has been completely replaced and the furnaces' efficiency considerably increased in very little time.

Retrofits on chamber furnaces by means of advanced plug & play recuperator burners

Retrofit actions on thermal processing plants for subsequent increase of efficiency are becoming ever more popular and are also mandatory depending on the age and condition of relevant line. Further to the reduced consumption of natural gas, it is of importance to respect the ambitious requirements regarding quality assurance as well as the safety aspects of relevant standards and regulations. Due to the often very short cost and time frames such an action is mostly restricted by narrow limits. The following article describes successful retrofit actions taken by the example of inert-gas chamber furnaces with indirect heating where the heating equipment was in part completely renewed within the shortest time possible and the efficiency of furnace lines could be significantly increased.

The one and only party responsible for keeping their plants up to date, or to get them up to date after, for instance, legislative changes, is the operator, often without being aware of that fact. The often quoted "grandfathering", i.e. the protection of existing inventory and the operation of old machines even after new legal regulations have been introduced is non-existent from a legal point of view. The Occupational Safety Act and the Industrial Safety Regulation must be observed [1].

However, quite often, thermal processing plants, which naturally bear considerable risk potential, are being operated without any noteworthy optimization measures, up until the point where they are no longer profitable and efficient and must be scrapped. At which point they are often 20 years old, sometimes even much older. If requirements regarding safety and technology have improved in the meantime, they are likely no longer fulfilled.

Retrofit

Retrofits, meaning the modernization or expansion of existing older plants or pieces of equipment, usually have one or more of the following objectives:

- Improving plant safety
- Increasing production by reducing plant downtimes
- Minimizing power consumption of the supply facilities

- Improving furnace classification
- Minimizing maintenance costs
- Guaranteeing spare-parts supply
- Enhancing levels of automation
- Improving handling and batch traceability
- Lifetime extension of the plant.

Regarding the first six points, both burner and heating technology play an important role. Depending on the complexity of the heat treatment process, the malfunction of a single burner can lead to inadmissible temperature deviations inside the chamber, thus considerably compromising the quality of the batch.

The problems arising in existing plants with regard to burner technology are often the following:

- Safety flaws regarding DIN EN 746-2
- Poor cold start behavior with deflagrations when starting the burner
- Susceptible to malfunctions
- Low energy efficiency
- High wear / expensive and complex maintenance
- Complicated maintenance and adjustments
- Guaranteed spare-parts supply.

Many operators accept these negative circumstances as mere facts of life (often out of habit) and just live with them.

Innovative companies, on the other hand, who are interested in new and environmentally friendly technologies, are eager to enhance and improve their facilities to ensure optimal quality, safety, and energy efficiency. **Image 1** gives an insight into a modern hardening shop in Southern Germany with numerous chamber furnace plants customary for the industry.

Retrofit measures are usually expected to yield a very short ROI (2 years maximum), so that they can actually be implemented. That way, many very sensible measures do not stand a chance from the beginning.

Saving on combustion gas alone by using modern burner technology only rarely makes the costs of such retrofit measures financially worthwhile. More or less hidden costs, such as the increased amount of maintenance and the required spare parts for older burners are often not considered, as such data simply cannot be recorded. Even though it may actually be essential.

Ceramic burners have longer service life than metallic ones at high-temperature heating processes, which are common in the heat treatment industry. What is essential for thermal loading with indirect heating is not only the furnace temperature, but also the installed burner capacity in combination with the free area of heat radiation of the jacket tubes. In general, the thermal loading at lower burner capacity and larger jacket tube surface is reduced. At a furnace chamber temperature of 950°C, a jacket radiant tube with a diameter of 130 mm, and a free length of heat radiation amounting to 1,200 mm, a recuperator burner with an installed load of 25 kW will make for a jacket tube internal temperature of approx. 1,170°C. A metallic recuperator burner would overload at that combination, meaning that this mode of operation causes considerably higher wear of costly parts such as recuperator, combustion tube etc. A ceramic recuperator, on the other hand, can easily operate at a constant application temperature of 1,300°C, hence it is much better suited for this particular case.

Advancement of burner technology

When refurbishing for modern burner technology, complex adjustments to the following components were often necessary:

- Furnace housing (burner/jacket pipe flange)
- Furnace duct (fire-proof insulation)
- Connectors for supply media (gas and air supply)
- Waste gas connector
- Burner position relative to the jacket/flame tube (flame exit out of the burner)
- Adaptation of furnace control.

Image 1: Modern hardening shop with numerous chamber furnace plants (modern plants in the foreground)

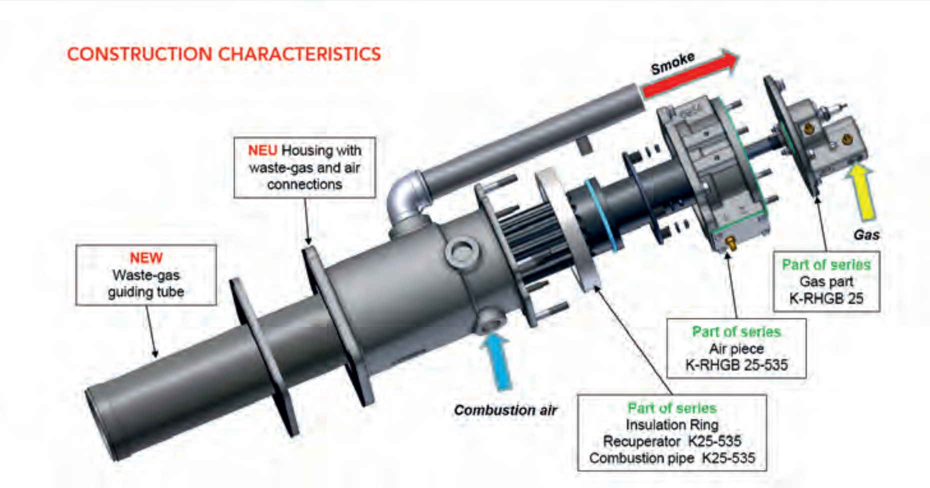

Image 2: Ceramic retrofit burner K-RHGB25 RN, in short

With such measures, the costs for a new burner would be relatively low. The often considerable effort to refurbish the components mentioned above is usually significantly higher than the cost of the burner, thus rendering the measures inefficient. The experience of recent years has clearly confirmed this, especially for burners on indirectly heated chamber furnace plants and with the following parameters:

- Furnace chamber temperature up to 980°C
- Burner capacity between 15 and 25 kW
- Outer diameter of the jacket tube: 130 mm (centrifugal casting) or 127 mm (ceramic)
- Connection pressures of 70 mbar (gas) and 100 mbar (air)
- Recuperator lengths (insertion depth) between 377 and 557 mm.

This, in turn, meant that the logical objective had to be to adapt the burner to the furnace and not the other way around. This would considerably decrease costs for retrofit measures and make it affordable for the operator. For this reason, an especially cost-efficient retrofit model for a burner was developed, only through adapting two components. The measure was based on a ceramic recuperator high-velocity burner with a rated capacity of 25 kW which had proven its worth over many years and was sold in high quantities (**Image 2**).

Due to its similar design, this model enables the exchange of a single burner or of all installed burners in very little time. The refurbishment of an entire furnace with 12 burners and more can thus be completed in a single day.

Operators benefit, among other things, from an extremely short downtime (minimal production downtime), and from state-of-the-art burner technology. If this measure is implemented as part of regular maintenance and the costly spare and wear parts for the old burners are no longer needed, the real cost is reduced to a minimum.

If still usable, the jacket and flame tubes of the existing burner are reused. The newly developed housing with a waste gas and air connection and a waste gas routing tube enables quick "replugging" to the existing mounts. The burner connections as well as the gas and air supply can also remain - which saves additional installation time.

Variable retrofit measures are possible

The following retrofit measures have been implemented for a renowned operator in Southern Germany. They were applied to indirectly heated protective gas chamber furnaces with varying versions of recuperator burners the way they are commonly found in heat treatment facilities. These measures show how refurbishment efforts can be reduced with the advanced ceramic recuperator burner, and that such measures become economically worthwhile in no time.

The operator here is a manufacturer active in the fields of gear wheel and transmission technology and has its own center for research and development. A particular challenge in this case was the very high and often very individual requirements of the operator's customers. The heat treatment processes are very variable and tailored perfectly to the products. The expectation is usually that especially during the heating process, a particularly high burner performance is desired. However, in this case, the operator wanted a very reduced burner performance to enable a very nuanced heating, which guarantees maximum quality of his very sensitive work pieces.

Any furnace plants and batches may be controlled via a cutting-edge control station and everything can be monitored at a glance (**Image 3**).

An extensive data collection system enables, among other things, the metering of each individual batch, which provides reliable figures about the state of the furnace plant and about the energy savings resulting from each implemented measure.

Image 4 on the left shows the new burners in a chamber furnace, where only the basic burner was exchanged. Other measures were not necessary at this plant, so that refurbishing was completed very quickly.

Depending on the state of the old burners, more refurbishing measures may be necessary. If, for instance, they still operate with an integrated pilot burner, it is advisable to make use of the safe ignition and stable mode of operation of modern burners, so that pilot burners as an additional source of potential malfunction can be ruled out. It is also advisable to operate the new burners with an all-round cycle control. This has advantages regarding the burner settings and the emission levels. If the components of the gas and air supply have reached a certain age, it is advisable to exchange them anyway during retrofit measures, which will rule out additional sources of malfunctions and safety hazards in the future. Manufacturers of magnetic gas valves, which have a high safety significance anyway, specify a maximum service life of 10 years and a maximum number of switching cycles of 10,000,000. Once these numbers are exceeded, manufacturers warn of safety risk if the plant continues to operate. Image 4 shows a completely renewed chamber furnace, where not only the burners, but also the supply lines and the parts for supply media were renewed.

A widely used recipe for a constant and consistent load was implemented and documented at this plant, with 18 different measuring ranges before refurbishing with the old burners, and after refurbishing with the new burners. This led to energy savings of 20% and a proven reduction of the heat treatment process of 4%.

Image 5 shows the total gas consumption per batch. The mean energy savings amount to 20%. **Image 6** shows the achieved total duration of the heat treatment processes before and after the retrofit measure. The mean duration is reduced by approx. 12 minutes.

Image 3: Modern control station with a visualization of the entire hardening shop

Step-by-Step Retrofit

The possible combinations between burners and jacket tubes either made of ceramic or of steel are manifold; and they should all be taken into consideration when designing new plants. When refurbishing an existing plant, the operators often want to change as little as possible. The simplest way to achieving this is to not exchange jacket and flame tubes for new ones, but to continue to use the existing components. The same applies to the components used for gas and air supply.

Especially due to the lower minimum connection pressures of the supply media in the REMAT burner, an exchange of individual burners within a furnace plant becomes possible. And that, in turn, also enables the implementation of a step-by-step retrofit. The new burner must only be adapted to the existing pressure conditions

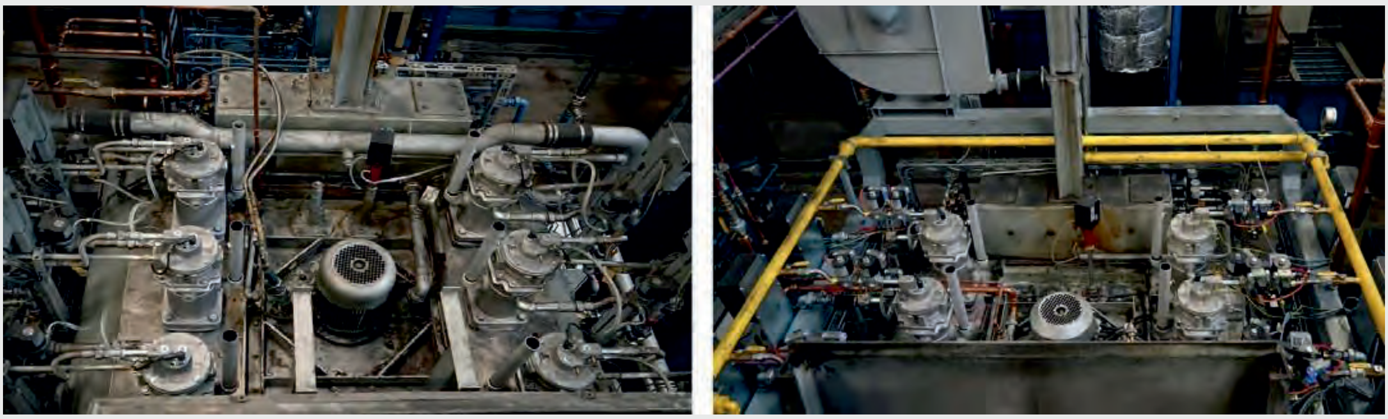

Image 4: View of two chamber furnaces after retrofitting –left: exchange of the burner only; right: exchange of the burner plus gas and air supply and burner control

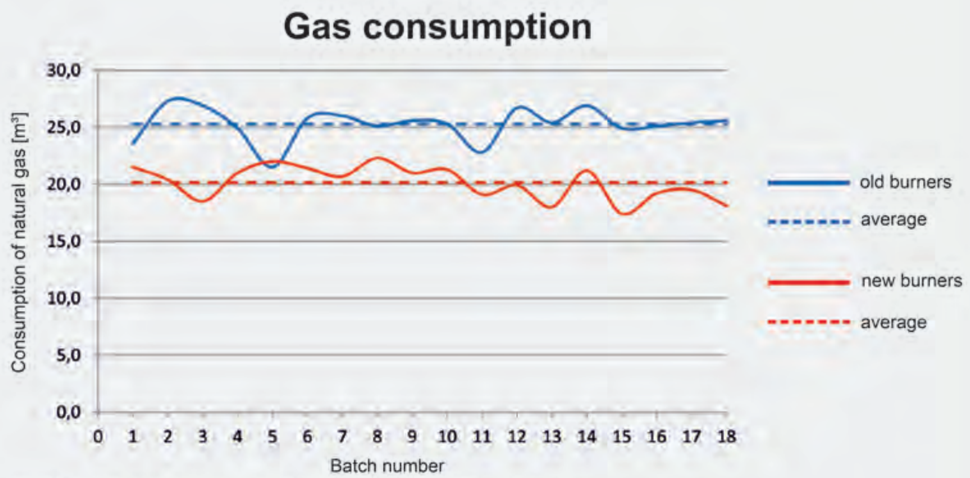

Image 5: Total gas consumption per batch before and after the retrofit

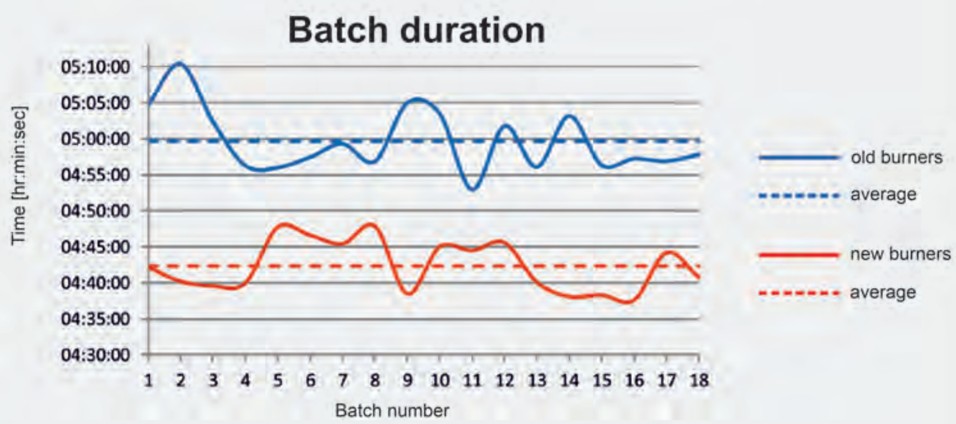

Image 6: Total duration of the heat treatment process before and after the retrofit

of the supply media, so that the same heat input into the furnace is guaranteed. This avoids inconsistencies in the area of the sensitive furnace batch. This is usually very straightforward, as there are usually enough mechanically operable positioning elements within the pipes of the supply media of an individual burner. If this is not the case, the new burner has an integrated gas nozzle that can be adapted accordingly, so that the desired burner capacity can be dosed precisely. **Image 7** shows such a new burner amongst the existing old ones. The connection pipes were maintained. The savings due to the new burners were confirmed directly through parallel measuring of all burners. Savings amounted to 8% in this particular case, at a furnace temperature of 940°C. Optimizing gas and air supply of the burners provides scope for further improvements.

Current safety matters must be observed

Usually, burners of old plants that were marketed before February 2011 lack the second magnetic gas valve per burner (point 5.2.2.3.3 DIN EN 746-2) as well as the control of a sufficient air volume flow in all modes of operation (point 5.2.2.5.1 DIN EN 746-2).

It is still often wrongly assumed that the main gas valve of the gas pressure control, measuring, and safety line of the thermal processing plant fulfills the requirement of the standard mentioned above. It does apply to a single-burner system if both valves really close at the same time; however, it does not apply to a multiple-burner system, unless all burners are switched on and off at the same time. In case of a fault shutdown of one burner, both valves would have to close immediately. For a multiple-burner plant with cycle control, this means that in case of a malfunction of a single burner, not only the individual burner valve, but also the main gas valve must close, leading to the shutdown of the entire heating system of the plant.

To avoid this undesirable outcome, the common practice is to equip each individual burner with a double magnet gas valve.

Furnace control

Another focus when retrofitting includes the modernization of furnace control by renewing the switch- and control systems. The use of modern industrial PCs combined with programmable logic controllers (PLCs) of the most current generation lays the foundation for innovative process and documentation options. A special focus is placed on the documentation of heat treatment processes, which are an essential part of current customer requirements, due to the regulations of the CQI 9 (automotive industry) or the AMS 2750 D (aviation industry).

This goes hand in hand with a complete renewal of the electric installations, which becomes necessary due to
negative external impacts such as heat or high pollution levels in the surroundings.

The results of this measure are, among other things, production reliability, spare parts availability, considerably more convenient operation and programming, the implementation of real-time diagnosis, meaning remote maintenance via external log-in and engaging of the service company in the plant control systems. Both error analysis and even changes to the program can be made this way. Short downtimes in case of plant malfunctions are also guaranteed with this option.

The degree of automation of an existing plant can be improved as desired over the course of a retrofit measure, even achieving a fully automated plant with integrated third-party or new plants, magazines, and charging or feeding systems. The determining factor here is the requirements of the operator [2].

More retrofit measures

Besides renewing the heating system, there are, of course, also other retrofit measures, such as the optimization of furnace insulation and furnace sealing, which both reduce gas consumption significantly. The frequency of use of electric drives for pump engines, heating chamber atmosphere fans, oil circulators with flow control, and pressure-dependent combustion air supplies all reduce the electricity demands in the regulated state of the plant. Heat recovery for drying processes is another example of this option [2].

Conclusion

Retrofitting a furnace plant is a cost-efficient alternative to acquiring a new plant, with nearly the same result. Refurbishing for modern burner technology is made much easier with so-called plug&play solutions, making for the completion of such measures in a single day.

The results are top plant availability and
safety, as well as lower costs of operation. These manifest not only, but also quite considerably in gas consumption numbers.

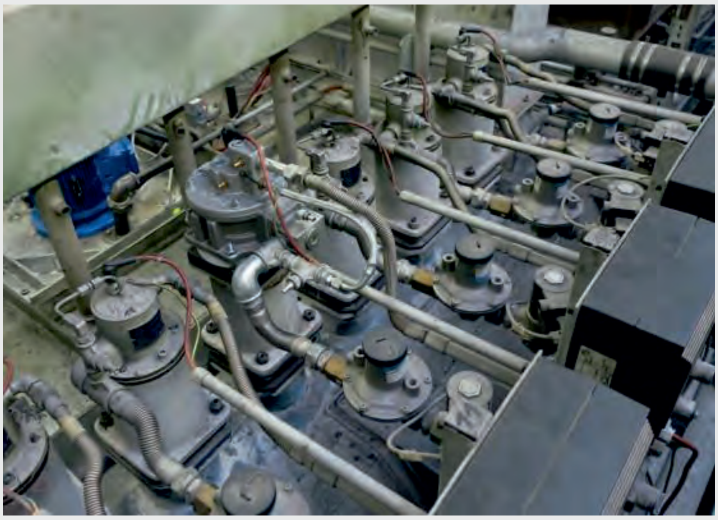

Image 7: Austausch eines einzelnen Brenners, z. B. zum

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AUTHORS

Dipl.-Ing. (FH) **Dirk Mäder**
NOXMAT GmbH
Hagen
02334 / 442358
maeder@noxmat.de

Dirk Clever
NOXMAT GmbH
Hagen
02334 / 441328
clever@noxmat.de

Rolf Peekel
HSH Härtetechnik GmbH
Kranenburg
02826 / 904011
r.peekel@hsh-gmbh.com

Reinhold Heizmann
IMS Gear SE & Co. KGaA
Donaueschingen
0771 / 8507538
reinhold.heizmann@imsgear.com

combustion technology

NOXMAT GmbH
Ringstraße 7, D-09569 Oederan
Phone: +49 37292 65 03 0
Fax: +49 37292 65 03 29
E-Mail: info@noxmat.de

www.noxmat.com

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