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Computer-based technology system for bar mills

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Off-gas cleaning by regenerative condensation proves suitability for long-time operation in a cold rolling mill

For four years, Vacuumschmelze GmbH & Co. KG (VAC), Germany, has been using a regenerative condensation process for cleaning the off-gas at a 20-roll cold rolling mill. Considered worldwide as an environmental pioneering step in 2007, today, the investment has proved to be very profitable. And not only that: after four years of operation, the cold rolling stand and the off-gas cleaning system have also demonstrated constantly high availability and contributed to sustainable energy efficiency.

Figure 1. **Coils of magnetic materials**

Introduction

Vacuumschmelze Hanau is one of the world's leading and most innovative producers of magnetic materials and products. 4,800 employees generate a yearly turnover of 350 million euros in more than 50 countries throughout the world. The manufacturing sequence always begins with a vacuum melting process, independently of whether the material is subsequently to be hot or cold rolled, converted into powder or cast to rapidly solidified ribbons. The alloy range covers soft magnetic materials, magnetic, semi-hard materials and alloys with special physical properties **(figure 1)**. These materials are the basis of the wide product range of Vacuumschmelze Hanau.

The majority of the melted alloys are, for example, subsequently rolled into strips of between 1.8 and 0.025 mm thick and up to 420 mm wide in an Andritz Sundwig 20-high cold rolling mill. A Schuh Anlagentechnik made regenerative condensation system employed in this process cleans the exhaust air during the rolling process and reduces the emissions of rolling oil vapour to a minimum. The collected rolling oil can then be processed and reused in the rolling or other processes.

Plant supplier Schuh Anlagentechnik has established itself as a competent partner in the solution of complex problems in the areas of ventilation, separation and filter technology quickly after its founding in 2001 and the subsequent acquisition of the engineering personnel and know-how from the traditional air handling technology company H. Spelleken, Wuppertal. The core competence spectrum of Schuh Anlagentechnik comprises basic and detail engineering, manufacturing, installation and commissioning as well as servicing of air handling processes. The company operates in a wide range of industries, e.g. in the manufacture and processing of aluminium, foil, cardboard, paper, food industries and, mostly, in the iron and steel industries. Their tailor-made solutions range from vacuum generating systems to conveyor systems for trims, suction plants for emulsion and oil mist, rupture, cutting and dust removal units to waste heat recovery systems. Since the foundation of Schuh Anlagentechnik in 2001, the company

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has successfully installed and commissioned over 450 air handling facilities worldwide.

Sophisticated off-gas cleaning technology

Under consideration of aspects such as quality and operational safety, efficiency and long term effectiveness, Vacuumschmelze Hanau specified stringent requirements for the 20-high cold rolling plant. These requirements also applied to the air handling system. Based on these specifications, Schuh Anlagentechnik developed a completely new exhaust air system. Here, the rolling oil vapours are optimally collected from the housing of the rolling mill unit via swirl tubes **(figure 2)**, so that the suction air rate is reduced by up to 60% compared with the more usual enclosure-type solution (hood).

In a first step, the rolling oil vapour is conducted into the condenser, which functions as a regenerative heat exchanger using cold air as cooling medium. Here, the exhaust air is cooled down to the point where most of the oil vapour converts to the liquid droplet state. These droplets then coalesce in stage 1 of the mist separator into larger drops, a large proportion of which is then separated out in the following drop separator. The cleaned air can then be exhausted directly to atmosphere via the exhaust air stack **(figure 3)**. The fresh outside air used for cooling in the condenser is warmed by the out-flowing exhaust air from the rolling process. This warm air is used for heating purposes, thus creating substantial heating energy savings.

The basic idea of the process was to develop an effective alternative to the more usual, but complicated and cost intensive gas scrubbing systems. Considering the annual average ambient temperature of 11°C in Hanau, it was also important to develop a process which could exploit this natural resource. Based on these requirements, a system was developed in which the exhaust air from the rolling unit was cooled before entering the separator, thus causing most of the oil vapour to condense before separation. The regained condensate can then be separated in the separator to a very high percentage by a combination of individual processes of inertia, barrier effect and diffusion. The regained rolling oil is then fed into a processing unit. With this system, a considerably higher percentage of the oil can be reused in comparison to other systems.

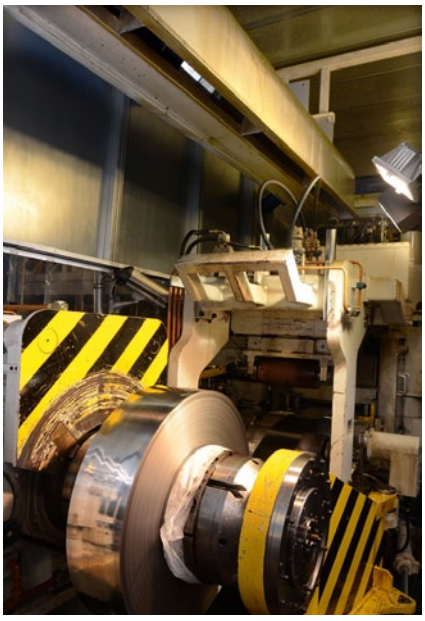

Figure 2. **Swirl tubes**

Figure 3. **External side of the air filtration plant**

Figure 4. **The rolling plant is completely enclosed**

Contribution to the environment

Considering the ever increasing requirements on quality and environmental compatibility of industrial processes, operation of the air handling system at Vacuumschmelze Hanau has numerous environmental advantages.

Firstly, the rolling unit is completely encased as shown in **figure 4**, so that both exhaust air and noise emissions are eliminated. The special design of the housing, i.e. removable roof and safety gate, ensures maximum accessibility to the unit. At the same time, the use of swirl tubes reduces the necessary air rate up to some 40% compared with suction device via hoods, without loss of evacuation efficiency.

Secondly, the regenerative condensation process enables the recovery of a large portion of the evacuated rolling oil vapour. The compact system offers a high level of security and reliability in continuous operation and fulfils all aspects of the strict requirements of the

clean air specifications (TA Luft). Specifically, not only carbon emissions according to the specified standards are fulfilled. In addition, the requirements for cold lubricating media according to Class 1, Para. 5.2.5 of the clean air specifications for organic media mass are also fulfilled. Figure 5 illustrates the CO_2 emission reductions achieved by the technology. In addition to the heat of the warm exhaust air leaving the unit. Hereby a substantial portion of the energy which would otherwise be required to heat the facility can be saved. Economic savings calculations according to VDI 2071, as well as the actual measured results, show that in one year the heat exchanger can regain in excess of 1,160 MWh of heat energy. In addition to this, the reduced process air quantity achieved by the use of the swirl tube technology results in a further 825 MWh of heat energy.

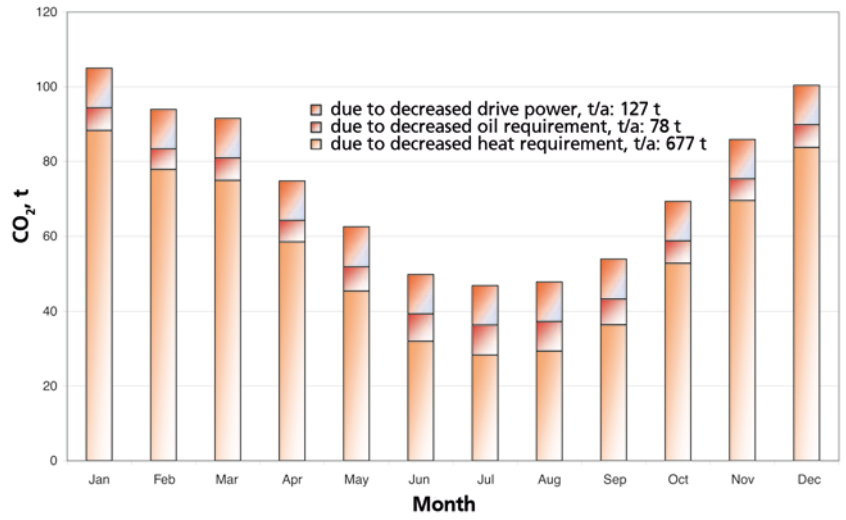

Figure 5. Carbon dioxide balance of the cold rolling mill with swirl tubes and regeneration condenser (Courtesy: Schuh Anlagentechnik)

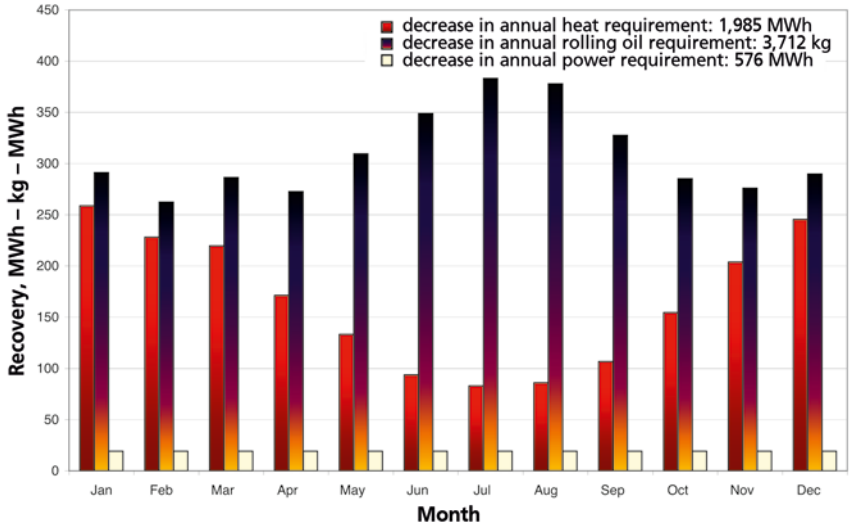

Figure 6. Savings in heat, power and rolling oil over a one-year period (Courtesy: Schuh Anlagentechnik)

energy savings these also include reductions due to lower drive power and lower hydrocarbon emissions.

New dimensions in energy efficiency and cost reduction

The installed heat exchanger warms up the incoming cool air using the heat

Although the heat exchanger causes an additional pressure loss, overall savings of approximately 576 MWh of electrical energy are achieved thanks to the reduction in the process air flow. In total, the heat energy savings are in excess of 1,985 MWh with an additional saving of 576 MWh of electrical energy. The production of the energy saved would result in the generation of some 700 t of CO_2.

Figure 6 illustrates the savings in energy and oil over the course of one year. In addition to the expected savings in heat energy during winter the exponential character of the steam pressure curve leads to a significant decrease in rolling oil use at exhaust gas temperatures above 30°C. The exhaust air cooling results in a significant cost reduction. The additional initial investment for this system compared to conventional extraction systems amortises in less than one year.

Regenerative condensation replaces complex gas washing systems and saves operational costs, because:

- The required evacuation air rate is lower.
- The size of the condenser is smaller.
- The additional annual heat energy requirement is minimal.

Compared with alternative gas cleaning processes, the Schuh Anlagentechnik system is characterized by a more compact and, therefore, space saving design, while, at the same time, offering higher efficiency despite lower power requirements. The investment costs amount to less than one third of the costs for the gas filtration. Figure 7 illustrates cost reductions due to energy savings and recuperation of rolling oil. The specific values for heat and electricity are representative and not specific values.

Availability balance

The integrative system of regenerative condensation employs the principles of swirl tube technology in order to collect and clean the maximum volume of exhaust air. With this design from Schuh Anlagentechnik it is possible to reduce the number of individual components in the system and also make use of energy saving technology. Most of the components employed, e.g. the heat exchanger, require practically no service.

Following initial detail observation of the new exhaust air filter system by the operator it was decided to dismantle the heat exchanger after a two year period of operation in order to check for damage or blockage. All components were found to be in perfect condition and were able to be reinstalled.

Based on this result, the service interval for the heat exchanger elements was extended. The filter element is supervised by a pressure differential indicator. During four years of operation, it has never been necessary to replace or clean the filter outside usual maintenance cycles. This demonstrates that, apart from the daily visual check and the on-line pressure differential supervision, the operator activities can be restricted to the specified service and intervals for filter cleaning and replace.

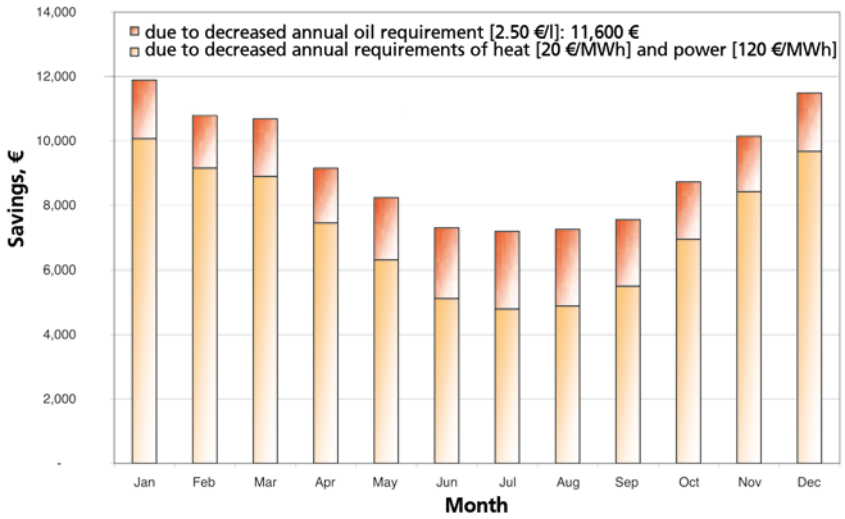

Figure 7. **Annual cost reduction compared with conventional evacuation units with enclosures (Courtesy: Schuh Anlagentechnik)**

Conclusion

The regenerative condensation system is suitable not only for new installations but also for revamping and modernization of existing rolling plants. These compact units are simple to install and, for example, where space is at a premium, can be mounted on the roof of the building. The capital investment for such a plant amortises in the shortest period of time by the recovery of most of the valuable rolling oil, recuperation and use of heat energy within the process as well as an operational mode which in itself is environmentally compatible.

With the installation of the regenerative condensation system, a reliable and almost service-free system was put into operation. Heinrich Bauer, production manager at Vacuumschmelze Hanau, stated: “As far as operation and service aspects are concerned, it can be said that after four years of operation no major unforeseen costs or replacements have been necessary. In addition to higher efficiency thanks to the swirl tube technology and the recuperation of rolling oil from the exhaust air, heat recuperation and preheating of the fresh air supply is a further major contribution to a substantially better energy balance. If there will be any such requirements in our company in future, we’ll certainly choose the regenerative condensation technology again.”

The regenerative condensation system installed in Hanau is suitable for all cooling processes using cooling media that condense within the range of normal atmospheric temperatures. The process parameters are always set up individually and, with the modular design, future extensions are possible at any time. ■

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