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The next step to the climate-neutral foundry of the future

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5

The next step to the climate-neutral foundry of the future

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Energy efficiency is crucial for the competitiveness of foundries. New solutions for heat recovery and exhaust air purification at melting furnaces offer great potential for energy savings. As an expert in energy-efficient exhaust air management and heat recovery in foundries, KMA Umwelttechnik in Königswinter, Germany, presents its current development activities in this article.

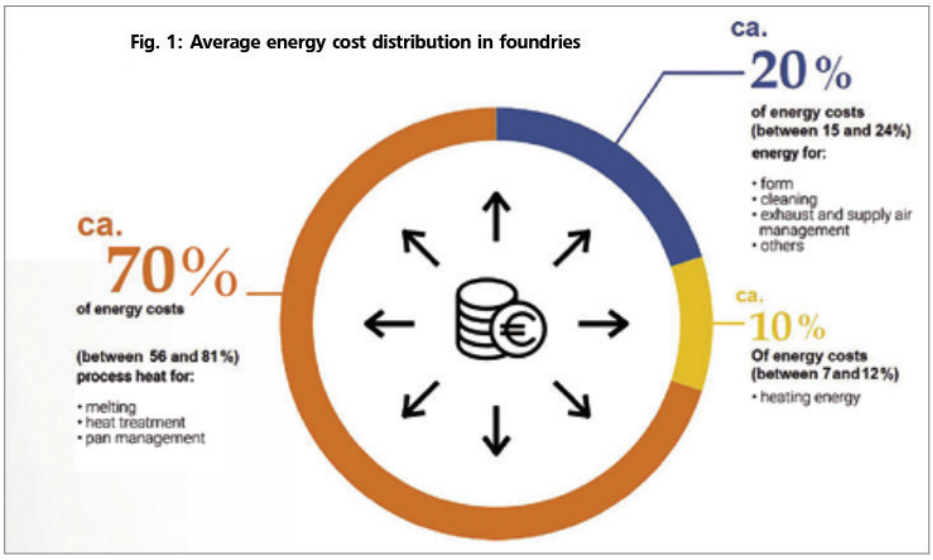


Fig. 1: Average energy cost distribution in foundries

Melting and casting of metal the main energy consumer in foundries

The German Energy Agency's guide *Systematically increasing energy efficiency and reducing CO_2 emissions in the foundry industry* brings it right to the point: energy efficiency is the foundation of climate neutrality [1]. One can take this statement even further: energy efficiency is the foundation for foundries' competitiveness. After all, in addition to reducing CO_2 emissions, energy efficiency enables significant cost savings as well as decoupling from rising energy prices and impending supply shortages.

It is therefore not surprising that the industry is working hard to find innovative solutions to optimize the energy efficiency of foundries. The relevant parameters are known (see Fig. 1) [2]. While many foundries have already introduced first measures to reduce their energy consumption, industry experts and machine manufacturers are working intensively on the development of forward-looking concepts and energy-efficient technologies.

The use of process heat, efficient exhaust and supply air management and the reduction of heating energy consumption are central starting points for measures to increase energy efficiency. The combination of exhaust air management systems and the conservation or recovery of waste heat offers great potential – not only, as already practiced in many places, in connection with the emission-laden exhaust air from the casting process – but also at the energy-intensive melting furnaces [3]. Studies show that not even half of the existing waste heat potential in foundries is currently being utilized, and that around 40% of the energy required by foundries could be covered by heat recovery if suitable solutions were found [4].

As an expert in energy-efficient exhaust air management and heat recovery in foundries, KMA Umwelttechnik presents its latest development activities in this article. The company is currently implementing new solutions for exhaust air purification and heat recovery at melting furnaces for several confidential companies.

Energy-efficient exhaust air treatment on die casting machines is best practice

Regarding the emission-laden exhaust air

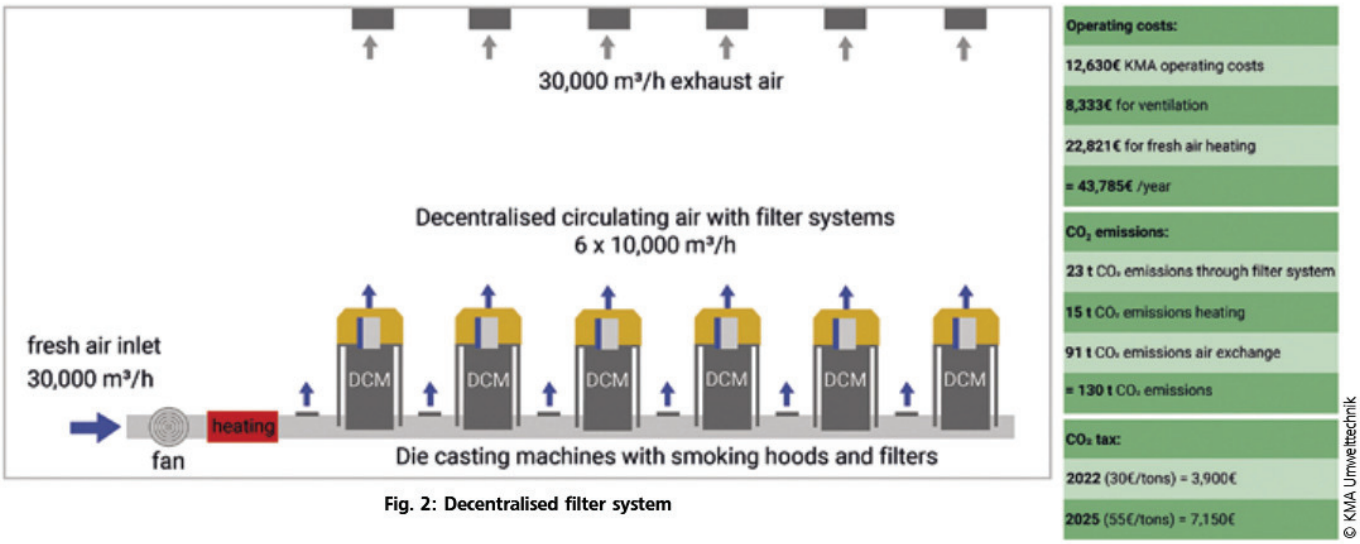


Fig. 2: Decentralised filter system

from the casting process, the potential energy savings through energy-efficient exhaust air filter systems combined with heat recovery are well known within the industry and already established for many foundries of all sizes. Taking the die casting process as an example, the polluted production exhaust air is ideally recorded directly at the emission source, for example with the aid of smoke extraction hoods above the die casting machine. After highly efficient exhaust air purification with proven electrostatic filter units, the exhaust air can be returned directly to the production hall in recirculation mode (Fig. 2). Thanks to the realized clean air quality, only a significantly lower exchange with fresh air is required. This significantly reduces the energy required for supply and exhaust air systems. At the same time, the energy costs for heating at low outside temperatures are minimized.

In alternative central exhaust air purification processes, the production exhaust air is extracted via a smoke collection system on the hall ceiling and fed to a central filter system. Integrated heat recovery systems extract the thermal energy from the production exhaust air and can thus heat the cold fresh air supplied from outside in an energy-efficient manner by means of heat exchangers. In this way, Stihl's magnesium foundry (Fig. 3) heats the fresh air to a constant 18 degrees even in the winter months, saving the costs of conventional energy sources such as electricity and gas and 85% of the CO_2 emissions compared with conventional hall heating.

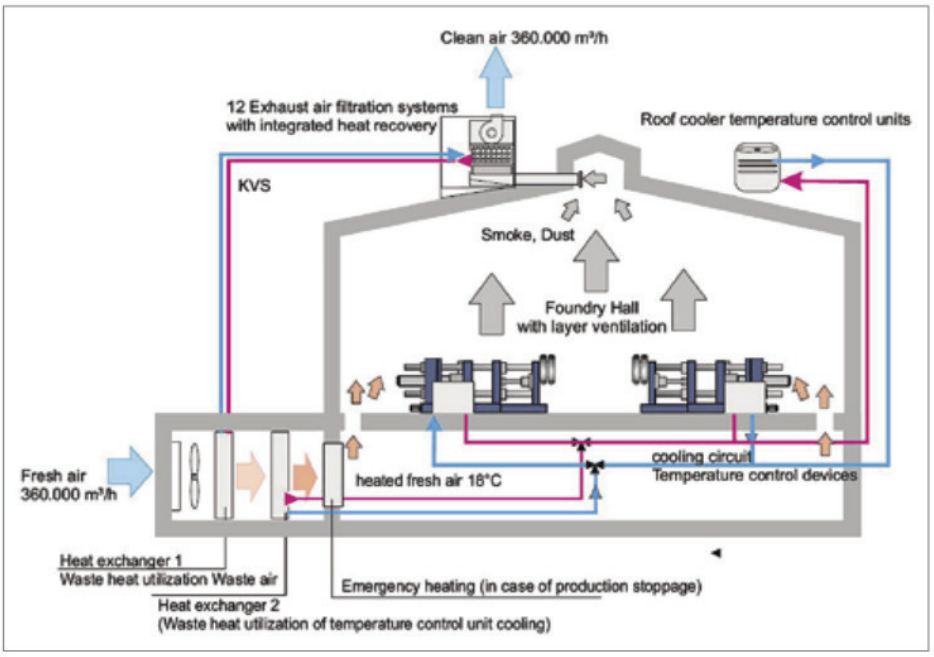


Fig. 3: Stihl's magnesium foundry heats the fresh air to a constant 18 °C, thus saving energy costs and reducing CO_2 emissions compared with conventional hall heating

Rising gas prices intensify focus on energy efficiency of melting furnaces

The situation is currently still different with regard to the melting furnaces. Foundries in aluminium die casting predominantly use gas-fired melting furnaces to melt the aluminium. In the past, central melting furnaces were usually used to then distribute the melt from there to the holding furnaces and feeders on the individual die casting machines. With the new trend toward casting very large components or multi-mould casting (so-called giga- or mega-casting) and the associated high consumption of melt, decentralized melting furnaces are also increasingly being used. From the modern shaft melting furnace to the dosing furnace, our own continuous supply lines are realized for individual or several die casting machines in order to realize castings with a dosing weight of up to 160 kg. The expansion of the casting capacity is accompanied by an expansion of the melting capacity and, in turn, the energy requirement.

The energy efficiency potential of natural gas-fired melting furnaces is now coming into focus, both for existing plants and for planned new investments. With a share of approx. 80%, natural gas is the main energy source for the operation of melting furnaces. Due to the average annual consumption of 19.5 GWh, non-ferrous metal foundries are particularly at risk from energy price increases in 2022 to three times or more compared to 2021, as well as additional threats of supply shortages [5]. The urgency for energy-efficient operation of melting furnaces is reflected in the lively international interest in new sustainable solutions in the industry. "We are seeing strong interest in sustainable heat recovery measures for melting furnaces. Our customers demand a green footprint, i.e., not only sustainability in terms of energy efficiency, but also through reduced CO_2 emissions. In current customer projects, the sustainable operation of melting furnaces is the focus of our project planning," confirms Hans Henrik Würtz, CEO of Støtek A/S.

Impressive potential for heat recovery

Many foundries are currently becoming aware of the process heat contained in the exhaust air of the melting furnaces. Modern shaft melting furnaces for aluminium die casting, for example, have an exhaust air volume of up to 20,000 m³/h with a melting capacity of 3.5 tonnes. This exhaust air has different temperatures depending on the filling and operating state of the furnace. They generally range from 180-300 °C. On average, a temperature of around 240 °C can be assumed.

The process energy that can be recovered from the exhaust air in this way is impressive. It depends on various factors: on the one hand, these are exhaust air volume and exhaust air temperature, i.e., the available process energy; on the other hand, it is especially the process of heat recovery and the flow temperature of the medium used for heat absorption, such as water or solar fluid.

The potential can be shown by means of exemplary design calculations for multistage finned heat exchangers with solar fluid at an exhaust air volume of 20,000 m³/h (see Table 1, next page): an average energy recovery of 2.7 MWh per year according to the exemplary design calculations corresponds roughly to a consumption of 270,000 m³ of natural gas or, at a gas price of 9 Ct/kWh, to a value of €243,000 per year. In the case of higher melting capacities and a correspondingly higher exhaust air volume, the potential for energy recovery also increases. If it is possible to reduce the consumption of natural gas by means of heat recovery, then in many places – in addition to the contribution to the implementation of the sustainability goals – additional cost reduction potentials for CO_2 taxes can be expected. Even if alternative energy sources such as electricity or hydrogen are used to operate the melting furnace instead of natural gas, it is difficult to imagine the process heat being emitted unused with the exhaust air in the long term in the current climate. →

Table 1	Scenario 1	Scenario 2	Scenario 3
Exhaust air temperature	180 °C	240 °C	300 °C
Exhaust air volume	20,000 m³/h	20,000 m³/h	20,000 m³/h
Flow temperature of the solar fluid	40 °C	40 °C	40 °C
Exhaust air volume after heat recovery; approx.	15,140 m³/h	13,500 m³/h	11,800 m³/h
Exhaust air temperature after heat recovery	70 °C	75 °C	65 °C
Return temperature of the solar fluid	128 °C	140 °C	145 °C
Volume flow of the solar fluid: approximately	5 m³/h	3 m³/h	8.5 m³/h
Recovered energy; approx.	492 kW	675 kW	961.4 kW
Annual energy recovered at 4,000 operating hours; approximately	1.97 MWh	2.7 MWh	3.85 MWh
Possible annual cost savings for natural gas at 9 Ct/kWh	€177,300	€243,000	€346,500

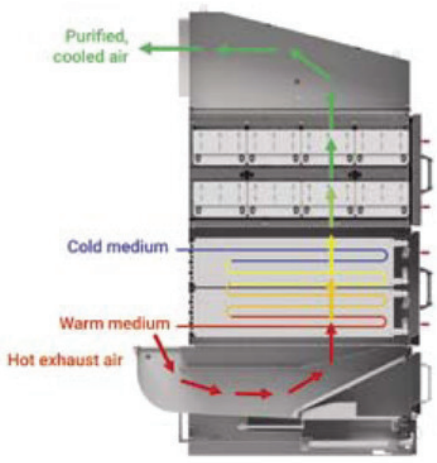
Source: KMA Umwelttechnik, for four-stage finned heat exchangers made of stainless steel.

Heat recovery and exhaust air cleaning requires integrated solution approach

In order to be able to exploit this heat recovery potential in the long term, suitable process technology and exhaust air purification are required, as the exhaust air from the melting furnaces is contaminated with emissions. It contains a dust load, which in turn can range from 5 mg/h to a multiple of this, depending on the operating condition and, for example, the addition of salts to prepare the melt. The dust load settles in the heat exchanger during operation. The fouling initially reduces the heat conductivity and thus the efficiency of the heat exchangers. Finally, it causes areas of the heat exchanger to become clogged, blocking the system. The heat exchanger must therefore be cleaned regularly. To avoid high dust emissions into the environment, effective cleaning of the exhaust air is also required.

Since exhaust air filters generally cannot be operated at very high temperatures, they must be arranged after the heat recovery unit in the process sequence. The exhaust air filter must also be regularly freed or cleaned of the separated dust load. Another challenge is that acidic substances can form, particularly as a result of the combustion process and the added salts, which can have a corrosive effect on the heat exchanger and the exhaust air filter. During heat recovery, care should therefore be taken not to cool the exhaust air below the dew point and thus avoid condensation. Furthermore, attention must be paid to a suitable selection of durable materials. Finally, the high temperatures of the exhaust air as well as the possible fluctuations of the exhaust air temperatures depending on the operating condition require a suitable planning of the exhaust air piping, especially to consider the temperature-dependent expansion of the material.

Fig. 4: The KMA Ultravent system



Thus, there are various challenges to be solved when selecting a suitable technical solution. The main problem for foundries, however, is probably the fact that technology providers have so far hardly offered any holistic solutions for heat recovery and exhaust air purification for exhaust air with emissions at high temperatures.

This is where the solution from KMA Umwelttechnik comes in. With the proven **Ultravent system** (Fig. 4), functional modules are combined in a modular way. In this way, high-performance heat exchangers and highly efficient electrostatic precipitators can be installed in a space-saving manner in one system. This integrated approach is already successfully applied worldwide in various industries with demanding operating conditions. The Ultravent system is flown through vertically from bottom to top. The hot exhaust air is first passed through multi-stage finned heat exchangers made of stainless steel. There, the process heat is transferred to a liquid medium. For example, water can be heated to up to 95 °C or solar fluid to up to 145 °C. At the same time, the temperature of the exhaust air is lowered close to above the dew point. The number of heat exchanger stages is designed according to demand and can vary accordingly.

In the next section of the Ultravent system, the exhaust air is passed through a multi-stage electrostatic filter made of stainless steel. The particles contained in the exhaust air are s eparated there with high efficiency. The very low air resistance of the electrostatic filter contributes significantly to the high energy efficiency of the solution. The number of stages allows flexible design of the separation performance to meet requirements. With a four-stage electrostatic filter, for example, even high emission loads of 150 mg/m³ can be reduced to less than 2 mg/m³. At the same time, the pressure drop of four filter stages is only about 130 Pa in total. The energy input required for conveying the exhaust air is thus considerably lower than with comparable mechanical exhaust air filters.

As described, the heat exchanger and exhaust air filter must be regularly cleaned of the accumulated dust. This is where the proven wet cleaning system (Cleaning In Place, CIP) of the Ultravent system comes into play. A washing solution consisting of water with a small amount of cleaning agent is heated in a water tank. A circulation pump delivers it to various levels of the Ultravent system, where it is sprayed into all areas of the heat exchangers and electrostatic filters via motor-driven nozzle sticks. The water flows by gravity back to the water tank, taking contaminants from the system with it. To protect the cleaning system in the event of a high dust load, the returning water is passed over a belt filter. Dust is retained in the filter fleece of the belt filter and separated into a collection tank before the water is again conveyed into the Ultravent system via the circulation pump. The small footprint is another strength of the integrated approach to heat recovery and exhaust air purification.

Holistic energy consideration as a new task for foundries

In the current cooperation between the industry expert and well-known foundries, the focus is on other tasks in addition to plant engineering. For example, foundries generally have little information about the exhaust air from the melting furnaces they operate or plan to operate. Exhaust air volumes and exhaust air temperatures, but also the quantity and characteristics of the emissions contained in

the exhaust air, have often not been systematically investigated in the past. Therefore, appropriate measurements and analyses are now required for the correct design of heat recovery and exhaust air purification.

No less important is the task of making sensible use of the recovered energy in order to reduce the primary energy requirement, since the process heat from the exhaust air can be used to heat the fresh air required for the melting furnace or the supply air in general. However, this energy sink is only available at low outside temperatures. Further potential uses should therefore be identified and developed, the demand for which is as uniform as possible in relation to the operation of the melting furnace. Since the liquid medium in the heat exchangers can be heated to very high temperatures (in the above design calculation, for example, to 128-145 °C), a comparatively wide range of uses is possible.

In addition to feeding into district heating networks or generating electrical energy by means of organic rankine cycle (OCR) technology, applications that are in turn linked to the production processes appear particularly interesting. For example, the process heat from the exhaust air can be used to preheat the aluminium ingots before they are fed into the melting furnace. In this way, the energy requirement for the melting process itself can be reduced. As with the technology providers, a change to integrated solution thinking is also required here among foundries. The traditional separation of responsibility between building management, production technology and immission control often proves to be an obstacle and requires new forms of cross-divisional planning.

Energy weaknesses of traditional exhaust air filtration at melting furnace

In many foundries, the exhaust air from existing melting furnaces is still emitted without further measures for exhaust air purification. Otherwise, bag filters are mainly used to mechanically separate the dusts from the relatively dry exhaust air. For this, however, the temperature of the exhaust air must generally be lowered before it enters the filter. For this purpose, ambient air is usually drawn in via a draft interruption at the outlet of the melting furnace, thus generating a lower mixing temperature. The total volume of air to be filtered is thus increased.

This approach is well established, but has technical disadvantages: the process heat contained in the exhaust air is lost. On the contrary, the total volume of exhaust air is increased, so that piping, filters, and fans must be designed to be correspondingly larger and operating costs increase. The mechanical bag filters are an obstacle for the air flowing through and cause a relatively high pressure drop, which leads to a correspondingly high energy consumption for the fans. This also increases the space required for the installation of the bag filter systems – a typical bottleneck, especially at historically grown production sites.

Conclusion

For foundries, increasing their energy efficiency has become a strategic necessity. Analyses show that the use of waste heat is one of the central building blocks for energy efficiency in foundry processes [6]. In particular, the exhaust air from energy-intensive melting furnaces offers impressive potential in this respect. Industry experts from both technology suppliers and foundries are working hard to develop integrated solutions comprising heat recovery, exhaust air purification and heat utilization. To achieve improved energy efficiency, a holistic view of the various processes within the foundry is a forward-looking necessity.

References

[1] Deutsche Energie-Agentur (Hrsg.) (dena, 2021): Systematisch Energieeffizienz steigern und CO_2-Emissionen senken in der Gießerei-Industrie, p. 3.
[2] ibid., p. 8
[3] ibid., p.34
[4] ibid., p. 37
[5] ibid., p. 6
[6] ibid., p. 8

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