Less is more – release agents in die casting

Aluminium die casting is the standard process for the manufacture of components with complex geometries, especially in the automobile industry. It is suited to the serial production of large engine blocks just as well as for the production of small parts. However, the emissions and waste waters from this process pollute the environment through the thermal decomposition of the release agents which the process requires in the casting forms. On the basis of fundamental investigations into the composition and application of release agent suspensions, the required amounts could be substantially reduced. A newly developed computer-controlled spray head greatly improves the environmental balance of this manufacturing process.

Aluminium die casting is a casting process which produces relatively little waste products, with reusable steel casting forms. The casting forms are subjected to high thermal loading when the molten aluminium is pressed into these forms at a temperature of more than 600 degrees Celsius. The steel forms, which are tempered to about 120 degrees Celsius before they are filled with the molten metal, take up the heat given off by the cooling of the aluminium. Following the removal of the cast parts, the excess heat must be dissipated from the forms before these can be filled again. For this purpose, until now foundries have used a mixture of water, release agent and additives. This emulsion simultaneously serves two functions. The water fraction in the emulsion evaporates and thus cools the casting forms. The release agent, as a rule a mixture of organic materials, remains on the cooled forms and prevents aluminium from sticking to the form during the next filling.

In the casting form the release agents are thermally decomposed by the heated aluminium, until now without the possibility of their recovery. Together with the gaseous emissions produced by the decomposition, other emissions can result from imprecise application. The release agent emulsion dripping from the casting form pollutes the waste water with chemical substances. In Germany alone, it is estimated that foundries use around 12,000 tons of release agents every year. Consequently, for the foundry industry, measures in the interest of minimising the use of release agents represent an important step towards the conservation of natural resources and reduction of emissions.

In this research project, sponsored by the BMBF, the Technical University Braunschweig pursued the goal of optimising the usage of the release agent. The project called upon the combined expert knowledge of the university’s own Department of Joint and Welding Engineering and Department of Ecological Chemistry and Waste Product Analysis. The engineers developed the computer-controlled prototype of a new spray head for release agent application and carried out numerous investigations on their pilot plant. The chemists researched the environmental relevance of different release agent combinations and derived suitable environmentally compatible formulas for the new application device. During the tests on the pilot plant, the emissions were controlled in the air and waste water paths resulting from the usage of the usual release agent combination. The close collaboration with the Association of the German Foundry Profession, the committee accompanying the project, ensured the fast transfer of the results to industrial application. At the Department of Joint and Welding Engineering, investigations were first performed on the usage of release agents applied with the usual spray head. Common spray
heads are equipped with two program-controlled rows of nozzles, one of which sprays the release agent-water emulsion to cool the casting form and wet the form with release agent. The other row of nozzles serves to subsequently dry the casting form with pressurised air. What was not visible to the human eye was revealed by thermographic recording using a special camera. With these measurements, the researchers analysed the temperature behaviour on the surface of the casting form. This demonstrated the weaknesses of the conventional method of release agent application. Even with an optimally adjusted spray program, with this spray head no convincing result could be achieved. Either the forms were not optimally cooled or release agent suspension was wasted. For complicated forms with a high release agent requirement, some areas of the casting forms cooled down excessively due to the evaporation of the emulsion, so that a considerable amount of energy had to be supplied to heat them to the operating temperature again before the next filling.

To improve the process, the researchers decided upon an innovative concept, with which the cooling of the forms and the application of the release agent take place in separate steps. With the help of a specially developed standard spray head with a separately controlled additional row of nozzles for cooling water, this idea was implemented. A great advantage of this functional separation is in the optimised control of both separate steps. Since the cooling function of the release agent is eliminated, the spray program can be very flexibly adapted. Thermographic investigations show the superiority of this system concept. Even complicated casting forms can be optimally tempered using the adjustable nozzle configuration, and the release agent precisely targets even largely inaccessible places. The savings resulting from the use of this innovative concept are indeed impressive. The new process offers sustainable production methods in the foundry industry and conserves natural resources. For the same production output, the process uses one quarter less release agent and in addition, due to the optimised program-controlled application, also reduces the water requirement by one seventh.

Other environmental advantages of the process are the reduced energy consumption for heating the casting forms and the prevention of the polluted waste water arising in the conventional process due to the dripping of excess release agent.

The Department of Ecological Chemistry was able to show for the selected release agent that the modification of release agent application reduces emissions, while still conforming with the standards for occupational safety. In laboratory experiments into release agent optimisation, it was also possible to identify a component in conventional release agent mixtures which in higher concentrations can undergo conversion to a toxic substance. The manufacturer of this release agent mixture was informed of the research results and in consequence of these removed the component from the formula. Accompanying investigations using test specimens cast in accordance with the optimised process show a uniform high quality and good weldability.

Due to its savings of energy and release agents the new spray head prototype, offering cost-saving advantages as well, is currently undergoing development for serial production.