Indicators, structures and sales statistics for the German foundry industry were the subject of an article in Volume 53 in January 2019. In particular, the sections on “Outlook” and “Cast iron initiative” triggered an unexpectedly intensive discussion process which went considerably beyond manufacturers and customers in the cast iron pipe system sector. But first, let us have a look at the economic situation of German iron and steel foundries as a whole.

The business status of the foundry industry

For almost all indicators, business performance for the year 2019 in no way corresponds to the successful progress in 2018. By July 2019, the casting production of German iron and steel foundries had already fallen by nearly 9 %. However, progress with incoming orders was considerably more critical, being 17 % below the values for the period in the previous year. This of course meant that the cushion of orders melted away like the proverbial “butter in the sun”.

When we take account of the client structure, we get the following picture as regards the production level of German iron and steel foundries [1]:

- Vehicle construction:  – 18.9 %
- Machine construction:  – 13.4 %
- Other applications (including cast products for the building trade):  – 1.0 %
- Total:  – 8.6 %

Unfortunately, this confirms the market forecast for 2017 already stated on page 18 of Volume 53 much more clearly than anticipated. The integration of the projected iron and steel production figures into developments since 2003 thus firmly brings the foundries firmly back down to earth.

1 million tonnes of the estimated foundry capacity of 4.8 million projected for iron and steel castings will not be needed in 2019. This amounts to a foundry utilisation rate of approx. 80 %. In the end, even at this early stage, all this points to a difficult first half-year for 2020. Because of the extraordinarily poor level of orders received during the course of 2019, from the current viewpoint this is the only prognosis which can be given for 2020.

Causes and categorisation

The causes are many and varied and they are specific to the respective client categories. Matters which affect all sectors are the international trade disputes which, above all, hinder the export-oriented vehicle and machine construction trade as well as the increasing uncertainties of the BREXIT process’. Specific factors are, for example, the E-mobility hype which, for German founders for vehicle components, means not merely an economic downturn but, by now, a structural crisis.

And, in particular, operations which have cast iron pipe systems as their key production area are suffering even more from the reprehensible economic sanctions against Russia, which is one of the most interesting future markets for water supply. By contrast, Chinese suppliers are winning Russian markets to the same extent as they are being lost by Central European manufacturers.

Finally, client sectors are having an effect on the increasing deterioration of the economic environment in Germany overall. To describe this in detail would go beyond the scope of this article, so we will only mention the increase in energy costs. It is not only the level of electricity prices in themselves, both in Europe and across the world, that is unparalleled. Much more emphasis should be placed on uncertainties.
in baseload generation and in energy transmission, including the future costs associated with this which, to date, are entirely unclear but are in the focus of industrial and private consumers.

And, as is already the case in the chemical industry, foundries are also clear about the fact that the investments which will doubtless be necessary for the further reduction of greenhouse gas emissions will increase the electricity requirement, and hence electricity costs, massively [2].

To summarise, it must therefore be stated that almost all client sectors will meanwhile find themselves in situations of structural upheaval as a result of change in the widest range of sector-specific framework conditions.

For manufacturers of cast iron pipe systems, however, this situation is not entirely new. Competition as regards materials has dominated in this sector for decades, particularly focussed on cast iron versus plastics.

This debate is subject to entirely new impetuses, on the one hand because of ever-increasing knowledge about the effects of plastics on the environment and humans [3]. On the other hand, there is the fact that the foundry industry in general and the manufacturers of cast iron pipe systems in particular have long since been looking at the subject of circular economy and hence the efficient handling of resources.

The production of cast iron pipe systems – initial situation and prospects

The changeover in the production process to the efficient handling of resources has, in the opinion of the author, been underway more emphatically than ever since the beginning of the 21st century and, despite the very considerable success achieved so far, is still a long way from being completed (if there can be said to be completion at all!). The three significant examples below give a striking illustration of the level of work achieved and the tasks yet to be completed.

Firstly, the melting process

For the last time, the July 2011 issue of the “Ductile iron pipe systems” handbook contained its own section on the blast furnace process on page 3/2. According to this, iron for the production of pipes and fittings can be produced either as pig iron from the first melting or as a recycling material from steel scrap, cast iron scrap and foundry pig iron. That was the text at the time, supplemented by the illustration of a blast furnace tapping [4].

The so-called liquid compound process as the direct charging of molten pig iron from the blast furnace into the channel-type induction furnaces downstream in pipe foundries was, for decades, the characteristic method of producing cast iron pipes and, in some cases, cast iron fittings as well. Molten pig iron and ultimately the pipe bodies were produced almost exclusively by reducing the limited resource of iron ore available worldwide with the help of coke and limestone in the blast furnace process.

The fundamental change was documented in the October 2015 issue of the same handbook in the introductory sentence on page 3/4. Usually, foundries now melt their iron in cupola or electric furnaces from recycling material and pig iron [5]. Particularly with the cupola furnace process, up to 100 % scrap with differing classifications is used today. In turn, the cast pipe bodies are accordingly produced exclusively from recycled materials. The melting of iron ore has been completely dispensed with.

Cross-section of a cupola furnace and its operation.
So far, so good – if it was not for the increasing CO₂ debate. Taking account of the fact that the burning of one kilogramme of carbon releases 1.87 m³ CO₂ and our coke contains around 91 % carbon, this results in 1.7 m³ or 3.36 kg CO₂ being released in the burning of one kilogramme of melting coke. The assumption that, with a 130 kg volume of coke used, the CO₂ emission is 437 kg per tonne of molten iron is not correct. With the cupola furnace method and as a result of some very complex reactions, a major part of the carbon contained in the coke concentrates the C-content of the molten mass to the desired value. Regardless of this, however, CO₂ occurs depending on the type of construction and operation of the cupola furnace melting plant.

Accordingly, the ostensible objective of this melting process is the achievement of a more efficient combustion. A special process of oxygen injection will significantly reduce the consumption of melting coke in the future and so result in a considerably lower CO₂ emission.

A smelter which is increasingly being used in iron foundries is the crucible induction furnace. The diagram in the illustration shows the basic structure of an electric melting operation with three ABP type crucible induction furnaces [6].

The cylindrical vessels with fire-proof cladding are surrounded by coils through which an alternating current flows, thereby inducing a secondary current in the metallic insert. Under ideal molten iron production conditions, there is an energy consumption of 580 to 600 kWh per tonne of molten iron at approx. 1,480 °C tapping temperature. If the current needed for melting is taken from renewable energy sources, the result actually represents an excellent environmental balance and energy resource efficiency. The original limit of an average 18,000 t cast iron production and 27,000 t to 30,000 t molten iron which applied to medium-sized foundries is also history. ABP Dortmund meanwhile is building melting plants worldwide for more than 80,000 t molten iron.

Of course, there is also some homework to be done by electric melting operations, even though it differs from what is needed for cupola furnaces. The metallic insert for crucible induction furnaces not only contains steel scrap but, due to the absence of a carbon carrier and the altered nucleation state, it requires a certain proportion of pig iron. It fluctuates practically between 5 % and 30 % in the cold state, depending on the structure of the casting, the cast iron production process and the quality of the casting itself.

To summarise, according to current levels of knowledge, it remains to be said that a further reduction of pig iron proportions in the charge for crucible induction furnaces seems realistic as compared with a considerable reduction of the CO₂ emission of cupola furnaces. It can be inferred from this that, at the moment and from environmental view-points, an electric melting operation with mid-frequency crucible induction furnaces represents an interesting alternative, even for pipe foundries.

**Secondly, the blasting process**

The blasting process in foundries producing fittings and valves is rather unprepossessing and therefore often treated with disrespect. In so far as the foundries operate coating systems downstream of the main process, the blasting of unfinished castings commonly used in foundries to remove adhering sand and core residues is supplemented by a special surface treatment blasting process. The aim is to achieve the greatest possible degree of cleanness, also referred to as the surface preparation grade, of at least Sa 2 1/2, directly before the coating process. As a rule, the blasting machines contain round-grain cast steel blasting abrasive with a grain size of 1.0 mm to 1.6 mm. Special blasting processes require a proportional admixture of angular blasting agent.

Something which is less well known and therefore neglected is the high energy consumption due to uncontrolled blasting machine operation. The leading blasting agent manufacturer, Würth in Bad Friedrichshall, has now taken up this problem, regardless of type, and
for some time has been applying itself to corresponding energy efficiency programmes. The status of the work to date is shown in the “Blasting process monitoring” illustration [7].

Targeted sensor monitoring and simultaneous data recording of the widest range of blasting machine functions produces the highest possible level of process transparency. With the AP-Con – Abrasive Process Control project, energy savings potentials of > 20% become accessible.

Thirdly, the regeneration process for mixed used sand bonded with bentonite

Foundrymen initially distinguish two basic possibilities as regards the moulding process:

- permanent moulds, e.g. for the production of cast iron pipes in the centrifugal casting process with the help of metallic moulds and
- lost moulds, i.e. processes with single-use moulds.

Fittings as well as castings for hydrants and valves are almost exclusively produced with lost moulds and corresponding cores to form hollow spaces and/or contours. While castings for cast iron pipe systems of larger nominal sizes are hand-moulded in chemically bonded moulding materials, the production of smaller nominal sizes is done on moulding lines with bentonite-bonded green sand in the sand circuit. In particular because of the inflow of core sand, represented by the yellow line in the illustration, there is an accrual of overflow sand [8]. This mixture of bentonite-bonded moulding material and core residues, sometimes in fact from different types of core production processes, is referred to as mixed used sand or used foundry sand.

The regeneration of mixed used sand with the aim of reusing the quartz sand in the core shop, while at the same time reusing the bentonite and carbon components which get into the sand circuit, is proving not too feasible at the moment because of the absence of complex regeneration processes. The volumes of used sand produced annually are not inconsiderable. The Saxony iron and steel foundries alone dump around 220,000 t each year for a cast iron production of about 320,000 t.

The accrual of used foundry sand in the production of fittings as well as cast parts for hydrants and valves is particularly high. As a rule, low cast iron wall thicknesses surround large-volume cores and, depending on the configuration and the process, result in poor casting/sand ratios. Regardless of the critical materials balance itself, from the ever scarcer landfill space in Germany, it is clear that there is a further and dramatically increasing pressure to close the foundry sand circle.

But action will also be taken here. In consultation with the most seriously affected Saxony iron and steel foundries as well as the eastern region sector of the German foundry industry federation, the Gießerei Institut and the Institut for some time has been applying itself to corresponding energy efficiency programmes. The status of the work to date is shown in the “Blasting process monitoring” illustration [7].

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Summary

Today, manufacturers of cast iron pipe systems have already made enormous progress in reducing the CO₂ emissions in their melting processes and closing material cycles.

On the basis of three examples it has been strikingly shown that these processes are far from being complete but that promising solutions are to be expected from the sector in the coming decade. All of the steps introduced for the reduction of CO₂ emissions as well as for closing material cycles are aimed at proving that the European producers of ductile iron pipe systems who are united under the EADIPS FGR banner are global role models in the handling of resources and providing entirely new decision-making standards for the choice of pipe systems for network operators and other users.

Thanks

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