IN FORM

Dear Friends of the Company, Dear Customers,

the last year was quite busy for our organization. Every week we ramped up one to two new articles into series production, not counting several prototypes and one-time demands. With pride and gratefulness I see the trust that our (former and new) customers place in us. Our organisation had to undertake a great deal of internal and external coordination in order to provide samples of every single article on time and in the right quality. This year it has been our task to transfer these parts from 0-series into series production, which, at least from a customers' perspective, went smoothly in most cases.

It is with surprise that I realised that in the meantime we have missed at least one edition of **IN FORM**! Nevertheless, a lot has been happened at Dietermann. In the last edition of **IN FORM** we wrote that "*Dietermann is also a foundry*". Today we can say that we have expanded machining to become a real, additional core competence of the company. In doing so, we are responding to the growing number of customers who want to purchase casting and machining from one source. If that is what customers want, then it is my business understanding that we have to be able to provide this in-house and must therefore expand capabilities. You will read about the last round of completed investments on the following pages, the next round of investments is already in planning and implementation stage.

In order to match the increase of volume and complexity of our business we have also increased the head-counts in the "non-productive" departments of our organisation including: production engineering, order processing and quality assurance. By doing so I hope that in what you see of us we will become even more productive.

As we are glad to be your sparring partner in engineering and development, we have put together some general guidelines on casting design in this newsletter, which is the first of a small series of two articles on this subject.

I hope this makes interesting reading!

Yours

Investments:

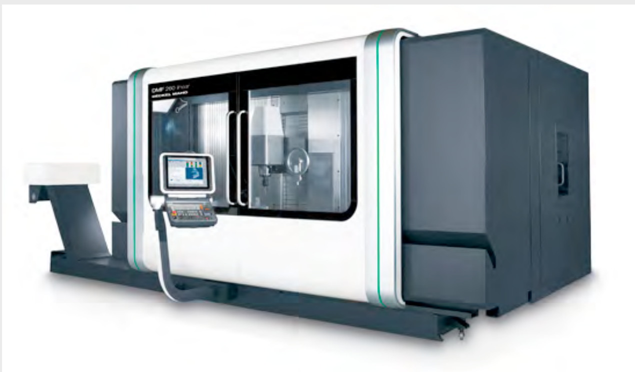
Substantial expansion of our machining capacity

In 2012, 2013 and also in January 2014 we have substantially expanded the capabilities and capacity of our machining workshop. This has also included increasing the number of employees and led to a doubling of the headcount in this department over the last 18 months.

DMF 260 / 1100 FD:

This machine will probably be our largest machine for some time. It represented our entry into today's world of 5-axis machining. On this piece of equipment we are able to process nearly all the dimensions that we are able to cast. The machine does not only work in five axes, but also has an integrated rotary table (600 rpm), so that we can carry out combined turning and milling work in one operation.

- X-axis 2600 mm
- Y-axis 1100 mm
- Z-axis 900 mm
- Interference circle 1400 mm



DMU 60eVo PW:

Our new DMU 60eVo milling center is the ideal choice for economical high-speed machining of medium-sized geometries. With a spindle speed of up to 18,000 rpm, pallet changer and 60-places tool magazine, this is our machine for efficient series production in 5 axes:

- X-axis 600mm
- Y-axis 500mm
- Z-axis 500mm

MAFAC Palma

We respond to increasing requirements of engine manufacturers for technical component cleanliness, particularly after machining, by setting up a cleaning plant. Here components are simultaneously cleaned inside and outside by rotating in a pulsating water bath. Subsequent and alternating spray and flood cleaning and drying can be freely programmed. Three separate water chambers with powerful pumps are available for component sizes of approximately 660mm x 480mm x 338mm. With this machine we can achieve cleanliness grades below 600µm of particle size and 1mg/1000 cm² on the inside of parts even for complex geometries.

Background:

Design for moulding and casting (Part I)

1. General

"What can be designed can also be cast." Casting offers the shortest path from raw material to the finished product, the quickest realisation of the design idea and usually the only possibility of integrating several components into one. These advantages of casting as a production process are as obvious as persuasive. However, there are certain design rules whose adherence make life easier for the foundryman. He can then pass the more stable process on to his customer in form of better prices or quality.

In a small series of two editions we want to refresh a few general design principles with you.

2.1 Wall thickness guidelines

Wall thickness usually is determined by their function. On top of that, it has to be understood that from the foundryman's point of view, walls serve other functions: to fill the part when pouring metal into the mould and to support the feeding process during cooling and solidification. Therefore, while walls have to be kept as thin as possible to prevent material accumulation, they should be as thick as necessary to ensure a stable filling process of the component.

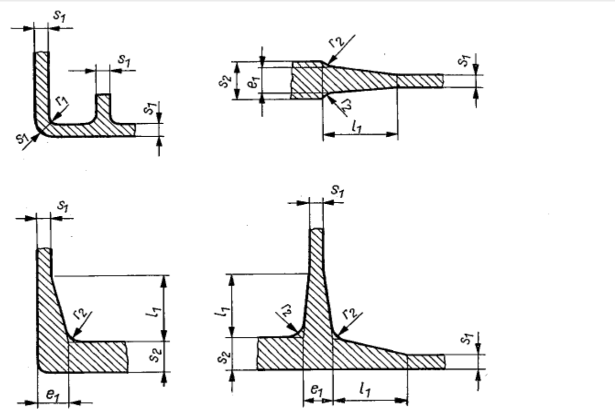
As a general recommendation for aluminium sand casting, a **minimum wall thickness of 4mm – 6mm** can be specified, whereby it should be noted that it is possible to safely cast small components with steady cross section below 4mm, while for other components 6mm may not be sufficient.

Failure to observe the minimum wall thicknesses specified by the foundry runs the risk of cold runs and cold laps in the casting. This can be counteracted only to a very limited extent by a higher casting temperature. In aluminum castings, this measure then will come with increased risk of other casting faults such as gas porosity, oxide inclusions or sand penetration.

Equally decisive for minimal wall thickness are:

2.2 Wall thickness transitions and radii

Castings must be designed in such a way that design-related differences in wall thicknesses must be kept as small as possible. If that is not possible, transitions have to be smooth. The construction of smooth transitions is the prerequisite for achieving thinner wall thicknesses, and they also prevent local hot spots and thus porosity or sand erosion.



Transition ratios for changing wall thicknesses:
e1 = (s1 + s2) / 2   l1 = 2 (s1 + s2)   r2 = s1 + s2/2

Transition ratios for equal wall thicknesses: r1 ≥ s1

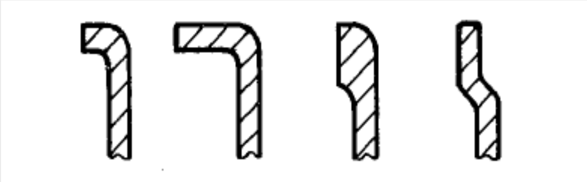
The above-mentioned rules for the design of wall thickness transitions have proved valuable in the process of aluminium sand casting.

3. Design for little internal stress

Internal stress in the cast piece appears during the cooling phase as a consequence of differing shrinkage restraints within the mould. This internal stress can lead to cracks in the raw casting. Moreover, when breaking the cast surface during machining, stress relaxation can lead to deformations which surpass tight machining tolerances. A symmetrical casting design is therefore desirable, similar workpiece cross-sections and similar cross-sectional shapes are preferable.

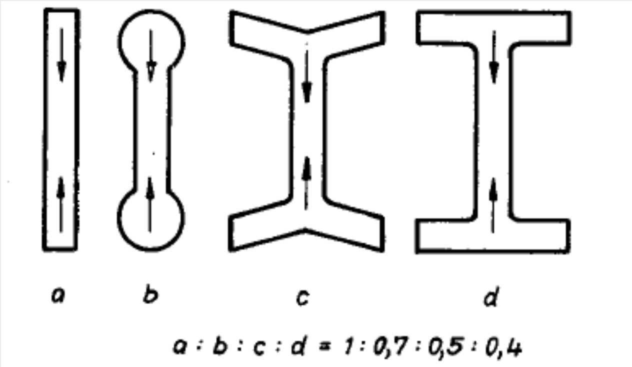
3.1. Increasing form strength

Designing edge profiles on the walls of the casting will increase the walls' mechanical strength. However, they should not lead to material accumulations, undercuts, sharp edges or offset mould parting lines. Some examples:



3.2. Shrinkage prevention

The shrinkage of a component is not always identical in all directions. Edges and profiles restrain the shrinkage onto more stable parts of the mould (e.g. cores). To avoid high internal stresses and geometrical defects through shrinkage prevention, it is preferable to use obtuse angles in the direction of shrinkage.



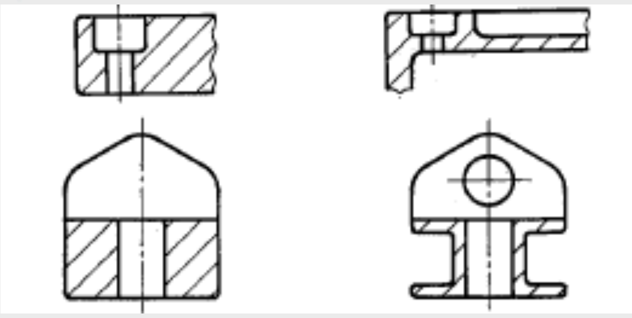
The examples above illustrate the different shrinkage restraints in the direction of the arrow for different geometries, showing the relative shrinkage ratios. The internal stress in the component increases with increasing shrinkage restraints.

4. Ensuring casting quality

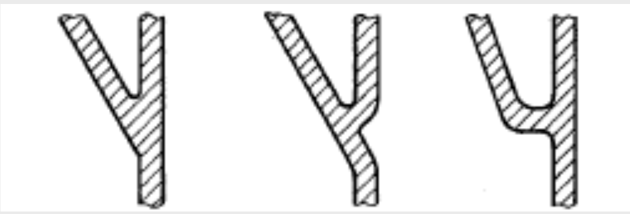
4.1. Preventing material accumulations

Material accumulations promote casting faults such as shrinkage cavities and shrink marks, particularly if these accumulations are connected to significantly thinner walls. This can be prevented by designing according to the above-mentioned rules for wall thickness, esp. thickness transitions (see 2), or by resolving the material accumulation by an alternative design.

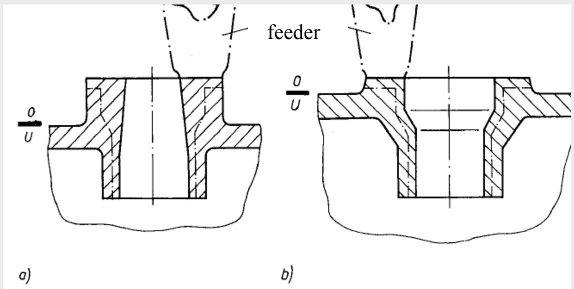
Here are some examples of design changes:



Unfavorable Favorable

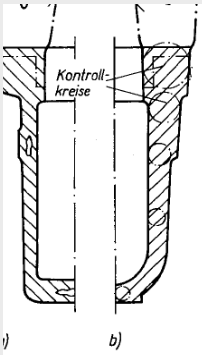


Material accumulation Possibilities of dissolution at joint connection



a) Favorable, but directional solidification comes at the expense of increased machining allowances

b) Favorable; design adapted to directional solidification



a) Cavity due to unfeedable material accumulation

b) Directional solidification; increase of cross-section indicated by control circles

4.2. Directional Solidification

Shrinkage cavities and porosities occur through the change (reduction) of the specific volume of the cast material during the cooling and solidification phase after casting. The volume change occurs continuously in both liquid and solid phase, and it occurs promptly in the transitional phase from liquid to solid (solidification). The contraction of the material during the cooling cycle leads to the formation of a volume deficit. This volume deficit is responsible for the formation of shrinkage cavities and porosities in the workpiece. The emergence of volume deficits can be limited by measures of the foundry such as well placed feeders. But also feeders are only effective if the part geometry allows feeding!

Therefore the designer has to ensure that a continuous flow of liquid material into the casting is maintained during solidification. Solidification has to start on the inside and move towards the outside of the part in question. Directional solidification is effectively assisted through a wedge-shaped cross-section that increases towards the feeder.

Here are some design examples:

More design guidelines will follow in Part II. Do you have any questions about the design of your products? Then please contact us!

by Thomas Zöbisch, Operations Manager

Outlook: The latest from Dietermann...

- **Core sand preparation:** while this was being written we have put into operation a completely new central core sand preparation plant! Process reliability and readiness for future needs have been our guidelines also on this investment.
- **Machining**: We need more floor space and are setting the course for further growth!

We will report on these issues soon.