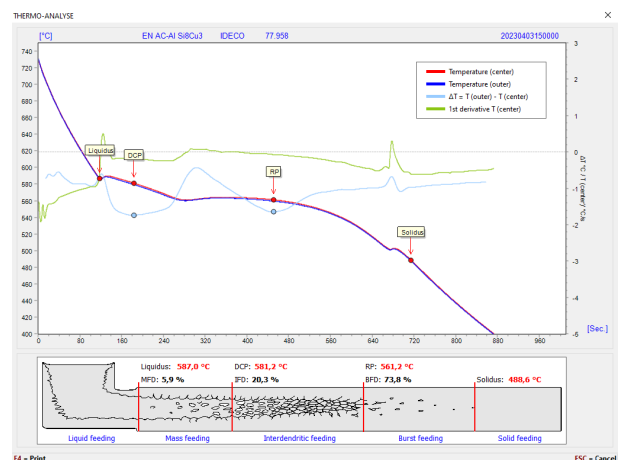


# FEEDING-ANALYSIS

System for determining and documenting the feeding capacity of aluminum alloys



The device combines Thermo-Analysis and Feeding-Analysis



Results graph of the feed analysis measurement

Type: **SA800SN**

Compared to the measuring devices already available on the market, **the new "Interdendritic Feeding Measurement"** provides additional information about the feed capacity of a melt and **prevents casting defects such as blowholes, sink marks and hot cracks.**

The **SA800SN** divides the feeding types into 5 phases and calculates the percentage feeding degrees in the transition phase.

The volume contraction in the transition region from the liquid to the solid phase occurs abruptly in most casting alloys and can lead to various casting defects.

These influencing factors are reflected in different types of feeding and can be divided into: Liquid feeding, Mass feeding, Interdendritic feeding, Burst feeding and Solid feeding.

With the device **SA800SN**, both a feed analysis and a "classical" thermal analysis (for the determination of grain refinement and modification) can be carried out..

Reusable sample ingots and NiCrNi temperature sensors.

Menu-driven program guidance, user-specific identification input, recording of cooling curves, automatic analysis, storage in database, input of additional data (e.g. spectral data, VAC test, temperatures, etc.), search function, network-compatible, further functionalities in connection with optional office software "QS-Master" (e.g. master data, target values, ...).

Industrial PC, 15" Monitor, Full-size keyboard (108 keys) with dust protection foil, Windows 10 IoT with secured user interface.

Dimensions: W550 x D630 x H1460 mm  
Weight: approx. 100 kg  
Energy: 230V~/50Hz or 115V~/60Hz

# FEEDING-ANALYSIS

System for determining and documenting the feeding capacity of aluminum alloys

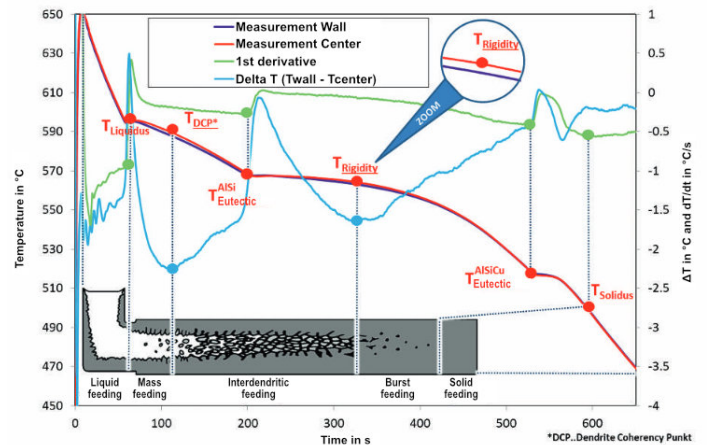
## Feeding Analysis, theoretical background

The feeding capacity is determined by the change in volume of a molten metal during solidification. Three phases of volume contraction are distinguished. In the range above the liquidus temperature, the "volume contraction of the melt"  $\Delta V_{liq}$  takes place, in the transition range between the liquidus and solidus temperature the "solidification shrinkage"  $\Delta V_{Erst}$  and in the range below the solidus temperature the "shrinkage in the solid state"  $\Delta V_{sol}$ .

The volume contraction in the transition region from the liquid to the solid phase occurs abruptly in most casting alloys and can lead to various casting defects. These include shrinkage cavities, sink marks and hot cracks. The type and location of casting defects and their severity depend on the component geometry, the alloy composition or the solidification morphology and the solidification conditions. These influencing factors are reflected in different types of feeding and can be divided into: Liquid feeding, Mass feeding, Interdendritic feeding, Burst feeding and Solid feeding (cf. Figure 1).

While the melt can move unhindered in the case of liquid feeding, there are already solid crystals in the melt in the case of mass feeding, which hinder the movement of the melt. When the melt cools down further, the growing crystals touch each other and a coherent network of dendrites is formed. This point in time is defined by a certain temperature of the melt, the so-called "dendrite coherency temperature", from which the movement of the melt is strongly restricted and describes the so-called "coherency point". From this point onwards, only the interdendritic feeding takes place, which acts via the interstices of the solid parts. As solidification progresses, the dendrites enlarge to such an extent that the liquid areas in the dendrite network lose cohesion. The temperature at which the movement of the melt is completely hindered is called the "rigidity temperature" and describes the so-called "pour point" or "rigidity point" of the solidifying melt. [4]

With the SA 800SN Feeding Analysis, the dendrite coherency temperature point as well as the rigidity point are measured using the thermal analysis, which allows companies to compare the values with the material database from the simulation programmes, for example, and adjust them if necessary. To determine the coherency point and the rigidity point, two thermocouples are required in the Thermal Analysis, which record the temperature in the centre and on the mould wall. The coherency point is located in the cooling curve at the first minimum of  $\Delta T = T_{Wall} - T_{Center}$ , the rigidity point at the second (see Figure 1). These temperature difference minima can be explained by the fact that heat is dissipated faster in a solid than in the liquid phase. In relation to the dendrite network, the heat conduction is higher in this than in the liquid melt.



**Figure 1:** Cooling curves (red and violet) and the corresponding  $\Delta T$  curve (light blue) determine the dendrite coherency point (1st minimum of  $\Delta T$ ) and the rigidity point (2nd minimum of the  $\Delta T$  curve). By means of projection onto the temperature curve, these two characteristic temperatures ( $T_{DCP}$  and  $T_{Rigidity}$ ) are obtained. Entered with the feeding mechanisms. [1, 4]

The SA 800SN Feeding Analysis determines the total feed percentage at 100% for each of the 3 transition phases.

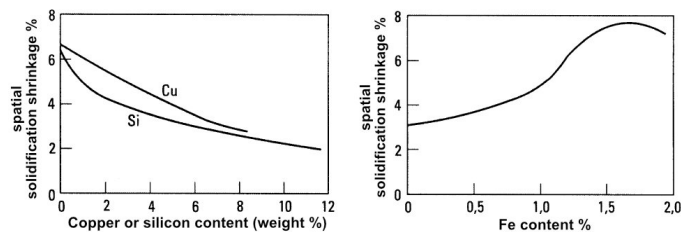
Furthermore, it should be mentioned that the refinement with strontium has an influence on the rigidity point. Thus, the rigidity temperature drops by approx. 6°C at 150ppm strontium. Directly after the stock point, feeding is only possible by disrupting the dendrite network and is called Burst feeding. This can only be done via pressures such as the hydrostatic pressure of the melt (e.g. feeder height), a negative pressure within the casting (e.g. capillary forces) or a pressure acting from outside (e.g. die casting). [1]

The knowledge of the solidification shrinkage is of great importance for the casting-friendly design of components in the development phase, because these volume deficits must be compensated for by controlled solidification and feeding in order to avoid defects such as solidification-related volume deficits or hot cracks. A distinction is made between internal and external deficits, whereby internal deficits are referred to as internal cavities and are further subdivided by their size into micro and macro cavities. External deficits are open blowholes or external blowholes or sink marks.

# FEEDING-ANALYSIS

System for determining and documenting the feeding capacity of aluminum alloys

The extent of volume deficits is determined by the temperature field and the solidification process, which depends on the casting method and casting alloy (solidification morphology). It should be noted that the sum of all volume deficits remains constant and results from the volume contraction between the liquid and solid phases. Thus, the repression of one (undesirable) volume defect is associated with the formation of another (preferential) volume defect. In aluminium alloys, the solidification shrinkage varies depending on the alloy content. Thus, the total shrinkage volume decreases with increasing addition of copper, magnesium and silicon compared to pure aluminium. In the presence of impurities, such as iron, the total shrinkage volume increases. These changes are shown in Figure 2.



**Figure 2:** Left: Cavity formation (spatial solidification shrinkage) as a function of Cu and Si content; right: Cavity formation in AlCu7 with increasing iron content. [2]

The ratio between external shrinkage volume and internal shrinkage volume as well as sink mark volume depends, among other things, on the temperature interval of the solidification, the casting process and the refinement by sodium or strontium. For clarification, Figure 3 shows the influence of the sand casting process compared to the gravity die casting process for different aluminium alloys.

Volume defects in %	Material									
	AlCu4		AlCu4TiMg		AlSi7		AlSi7Cu3		AlZn5Mg	
	S	G	S	G	S	G	S	G	S	G
Macro external shrinkage	18	54	41	48	11	30	25	51	36	56
Shrinkage	38	41	25	38	37	35	18	37	33	37
Microporosity	10	1	13	4	10	6	28	11	10	1
Sink marks	34	4	31	10	42	25	29	1	21	6
S Sand casting G Gravity die casting										

**Figure 3**

## Feeding-Analysis, Summary & Outlook

We have initiated the development in order to extend the classical thermal analysis by insights and data on the feeding dimension of the individual phases and thus to provide you with valuable information already during the casting design! The actual measured values obtained are made available in the software QS-Master for further analysis and can, for example, be compared with the material databases of the simulation.

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- [2] L. Henrichs, Gießereigenschaften der Gußlegierungen am Beispiel der Aluminiumlegierungen, Giesserei, 77, 1990, Heft 23, S. 745 – 748
- [3] G. Drossel, R. Mai, Bedeutung und Probleme bei der Anwendung der thermischen Analyse für die Einschätzung der Schmelzenqualität von AlSi-Legierungen, 3. Duisburger Industrieofentage, Agst Verlag, Moers, 1995, S. 145-182
- [4] Gerhard Huber, Mile Djurdjevic, Die erweiterte Thermische Analyse mit Dendrite Coherence und Rigidity Punkt und deren mögliche Anwendungsgebiete, Giesserei Rundschau heft 5/6 61-2014 Seite 223ff.