Molding Sand – Particle sizing in the foundry industry

Instrument: CAMSIZER P4

Introduction

Sand is the ideal medium to cast liquid metal into a desired form. First, a suitable sand is mixed with a binder (e. g. resins) and pressed into the desired shape by a machine. This sand core defines the structure of the future workpiece (Fig. 2). The liquid metal is cast into the mold and after the after the workpiece is completely hardened, it is released from the sand. The sand can be recycled and used for new molds by removing the remainders of the binder. For this application, it is necessary to use a high-quality sand, which is almost pure quartz (SiO_2) to prevent reactions between the mold and the liquid metal. Furthermore, the sand must have a good gas permeability and low compressibility. The grain size is carefully monitored since it has an impact on the surface structure of the cast piece, which will be too rough if the particle size is too large.

Foundry sands usually have a size distribution from 0,1 mm – 0,8 mm with a mean size between 0,2 mm and 0,45 mm. A standard parameter to express the size of molding sands is the AFS fineness number (AFS = American Foundry Society). This number is calculated from the size distribution, which is determined by standard ASTM sieves. Each fraction is multiplied with a weighting factor, the results are added together and divided by 100. Note that the resulting AFS number gets bigger as the average size decreases. The AFS number is considered proportional to the number of grains per unit weight.

Example 1 AFS (ISO):

After measurement, the following result is determined:

Size class [mm] from	to	ASTM mesh	Fraction p_3 [%]	Weighting factor M_3	p_3M_3
> 1.000		18	–	–	–
0.710	1.000	25	0	18	0
0.500	0.710	35	0.75	25	18.75
0.355	0.500	45	13.70	35	479.50
0.250	0.355	60	28.60	45	1 287
0.180	0.250	80	30.05	60	1 803
0.125	0.180	120	15.90	80	1 272
0.090	0.125	170	6.00	120	720
0.063	0.090	230	2.30	170	391
0.020	0.063	635	0.70	230	161
Collecting pan		–	2.00	635	1 270
Sum			**100**		**7 402.25**

This results in:

$$AFS = \frac{7402.25}{100} = 74.02$$

Example 2 AFS (ASTM):

After measurement, the following result is determined:

Size class [mm] from	to	ASTM mesh	Fraction p_3 [%]	Weighting factor M_3	p_3M_3
> 1,7		6	-	3	
0.85	1.7	20	0	10	0
0.6	0.85	30	0.5	20	10
0.425	0.6	40	6.7	30	201
0.3	0.425	50	20.5	40	820
0.212	0.3	70	31.8	50	1590
0.15	0.212	100	22.4	70	1568
0.106	0.15	140	11.3	10	1130
0.075	0.106	200	4.2	140	588
0.053	0.075	270	0.6	200	120
Collecting pan		–	2	300	600
Sum			**100**		**6627**

This results in:

$$AFS = \frac{6627}{100} = 66.27$$

***Fig. 1**: Calculation of the AFS number. Note that the AFS number can only be calculated, if the correct size classes have been used. The selected sieves must be a contiguous subset of the ASTM mesh sieve series.*

***Fig. 2**: Molding sand, sand core and cast piece.*

Dynamic Image Analysis with CAMSIZER P4

The CAMSIZER P4 dynamic digital image analyzer determines particle size and shape in a range from 20 µm to 30 mm and is therefore ideally suited for the routine analysis of foundry sand. The particles under investigation are conveyed by a vibratory chute into the measurement zone where they are passing a planar light source in free fall. The resulting shadow projections are captured by a camera system and evaluated in real time. This allows the simultaneous measurement of several size and shape parameters like width, length, equal area diameter, aspect ratio, roundness, compactness and many more. The huge advantage of this arrangement is the vast amount of sample that can be processed in a very short analysis time of only a few minutes. The CASMIZER P4 can evaluate up to 60 images per second and the total analysis time is usually less than three minutes. Since the CAMSIZER P4 is maintenance-free, it is a faster and more reliable alternative to traditional sieve analysis. The CAMSIZER P4 has a robust design and is unsusceptible to vibration and dust. The instrument can therefore operate in an industrial plant as well as in a laboratory environment.

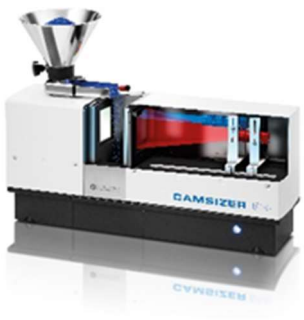

***Fig. 3**: The CAMSIZER P4 dynamic digital image analyser.*

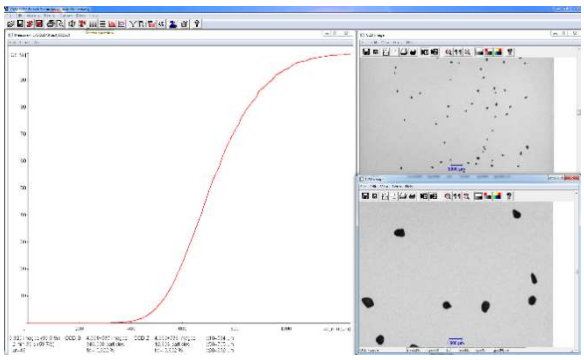

***Fig. 4**: CAMSIZER software during a measurement of a sand sample. Particle images are evaluated in real time as shadow projections.*

Measurement Example: Molding Sands

In this example we present the results of the particle size analysis with the CAMSIZER P4 of new molding sand as well as recycled sand. Fig. 5 shows the q_3 distribution (frequency distribution) of the samples. The three different types of "new sand" all show very narrow distributions, i. e. all particles are very similar in size. The used sand shows a wide distribution with a significant percentage of fines, which are combustion residues of the binder. This material cannot be used again as it is since the fine particles reduce the porosity so that the flue gas cannot properly escape during the next casting process. Therefore, the used sand is recycled, conditioned and mixed with new sand. This keeps the consumption of new sand as low as possible.

Sieving is the traditional method to determine the particle size distribution of molding sand. It is a cheap and easy method, however it has a limited resolution, is time-consuming, labor intensive and prone to human error. The CAMSIZER P4 provides fast, fully automated measurements and a perfect match with the result of traditional sieve analysis can be achieved (Fig. 6). Naturally, the software will calculate the AFS number according to Fig. 1.

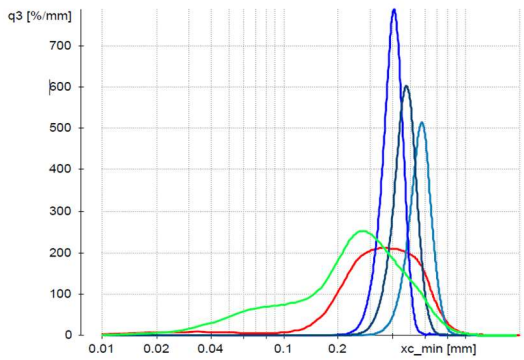

***Fig. 5**: CAMSIZER P4 analysis result of three different samples of new sand (**blue**), used sand (**green**) and recycled sand (**red**).*

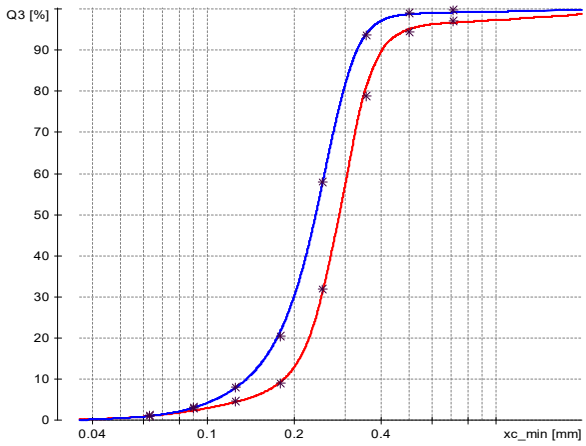

***Fig. 6**: CAMSIZER P4 result of two sand samples (**red** / **blue**) as cumulative distribution (Q_3). The black asterisks represent the corresponding sieve analysis.*

Summary

The CAMSIZER P4 is ideal for the measurement of moulding sand. New sand and recycled sand can be characterized with highest accuracy and within a few minutes. This guarantees a high sample throughput, reduced workload and faster response time. The agreement of the results with traditional sieve analysis can easily be established so that all product specifications can remain unchanged. The CAMSIZER P4 can also be equipped with an AutoSampler (Fig. 7) which will allow the consecutive analysis of up to 12 samples. The AutoSampler can also operate in a stand-by mode and start a measurement automatically as soon as a new sample is introduced.

CAMSIZER P4 – Benefits at a glance

- Analysis time 2-3 minutes
- Measuring range 20 µm – 30mm
- Automated analysis
- Results comparable to sieve analysis
- Autosampler available for further automation
- high sample throughput
- excellent reproducibility
- objective, independent of operator
- shape analysis: length and diameter of particles
- low maintenance, robust design

Fig. 7: *CAMSIZER P4 with AutoSampler*

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