Comparison between a conventional and vacuum moulding sand preparation

Cornelis Grefhorst and Marcus Müller

Tests have been carried out in order to compare the conventional preparation of a synthetic bentonite bonded unit sand in the intensive mixer **(Figure 1)** with a vacuum preparation of the same moulding sand in the plant shown in **Figure 2.** The best facilities for the tests were to be found in the Technical Centre of the plant manufacturer because of the availability of mixers with the same capacity (75 l), the same equipment and the same mixer speed. The analyses of the circulating and finished sand were carried out in the Technical Centre of the plant manufacturer by the project partner (IKO-Erbslöh) in accordance with VDG Data Sheets.

The aim of the tests was to establish the effects of the vacuum preparation on the quality of preparation as well as on the bentonite and the additives respectively.

The unit sand was obtained from the original circulating sand in a large German automobile foundry working with cast iron materials. The initial material (a synthetic unit sand) had the following composition and physical properties:

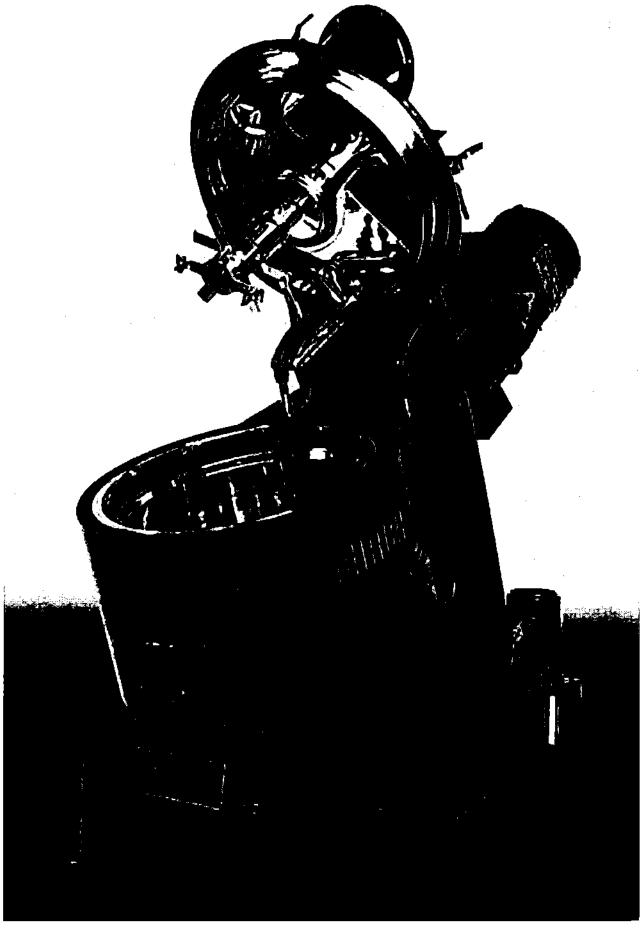


Figure 1. Intensive mixer for the conventional preparation *(Eirich Type R 08 W)*

- average grain size: 0.218 mm
- AFS No. 66
- moisture: 2.9%
- fines content: 13.7%
- bulk density: 1 370 g/l
- active clay content: 9.5%
- loss on ignition 6.9%

C. Grefhorst, Manager of Foundry/Refractory Research and Development, IKO-Erbslöh Industriemineralien u. Kohlenstoffe GmbH & Co. KG; *M. Müller,* Process Technology Department, Maschinenfabrik Gustav Eirich GmbH & Co. KG.

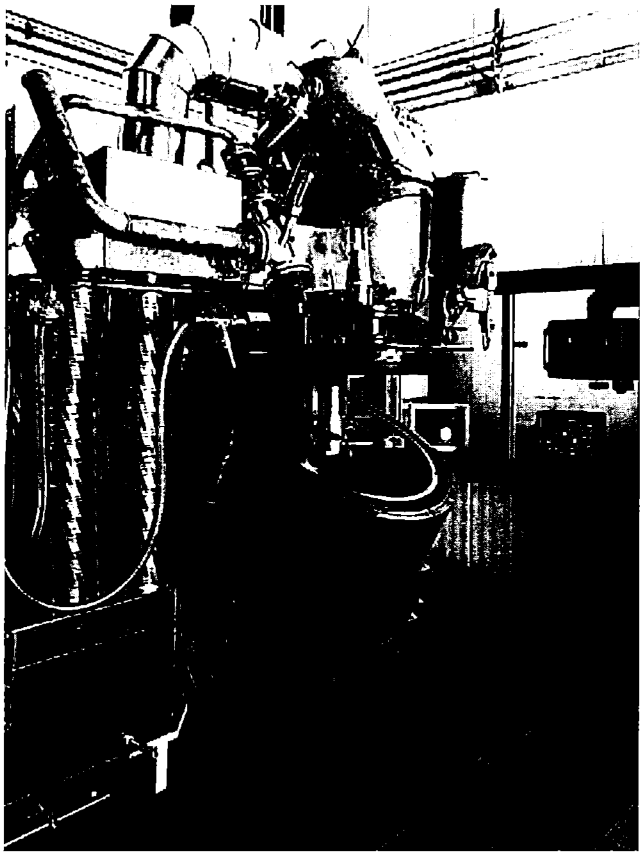


Figure 2. Technical Centre plant *(Eirich EVACTHERM R 08 W VAC)*

Tests

Before commencement of actual tests approx. 1200 kg of original circulating sand was homogenized in a slowly running mixer. A 20 kg sample of this was sent to the project partner who determined the necessary additives and carried out an exact circulating sand analysis. On the day of the test the remaining circulating sand was heated to 190 °C with the integrated gas heating in order to simulate the thermal sand loading. 60 kg charges were taken from this circulating sand for the purpose of the individual tests.

In the conventional tests the circulating sand was not only cooled to 45 °C through the spraying of water into the cooling mixer but also in separate tests through cooling in the ambient air followed by preparation in the intensive mixer. A hot moulding sand (approx. 115 °C) was used for the tests with the vacuum preparation. Cooling from 190 °C to 115 °C occurred on its own during charging.

QUICKBOND-D (lustrous carbon former), Antrapur (special bentonite) and G 634 quartz sand were added to the tempered sand for each test.

When comparing the two types of preparation it was strictly observed that almost the same test conditions were maintained in both cases. Preparation was as follows:

In the intensive mixer **(Table 1)**

- introduction of 60 kg of used sand (45 °C) into the mixer
- addition of QuickBond-D, Antrapur and G 634 quartz sand
- 10 s dry mixing
- addition of water
- 80 s wet mixing
- emptying of mixer
- packing of the sand in plastic bags.

With the vacuum preparation **(Table 1)**

- introduction of 60 kg of hot used sand into the mixer
- addition of QuickBond-D, Antrapur and G 634 quartz sand
- 10 s dry mixing
- determination of moisture and sand temperature
- calculation of amount of water for vacuum cooling and moistening
- addition of calculated amount of water
- 80 s vacuum cooling and preparation
- 10 s vacuum breaking
- emptying of mixer
- packing of sand in plastic bags.

Compaction of the sand was adjusted to 38% via the addition of water.

The sand was firstly tested directly after preparation and then after 60 min. A 5 kg sample was additionally prepared for 5 min in the 5 l laboratory mixer (R 02) in order to be able to completely assess the degree of preparation.

Test results

Sample weight **(Figure 3a).** The sample prepared with the vacuum process is approx. 2 g lighter than that of the conventionally prepared sample.

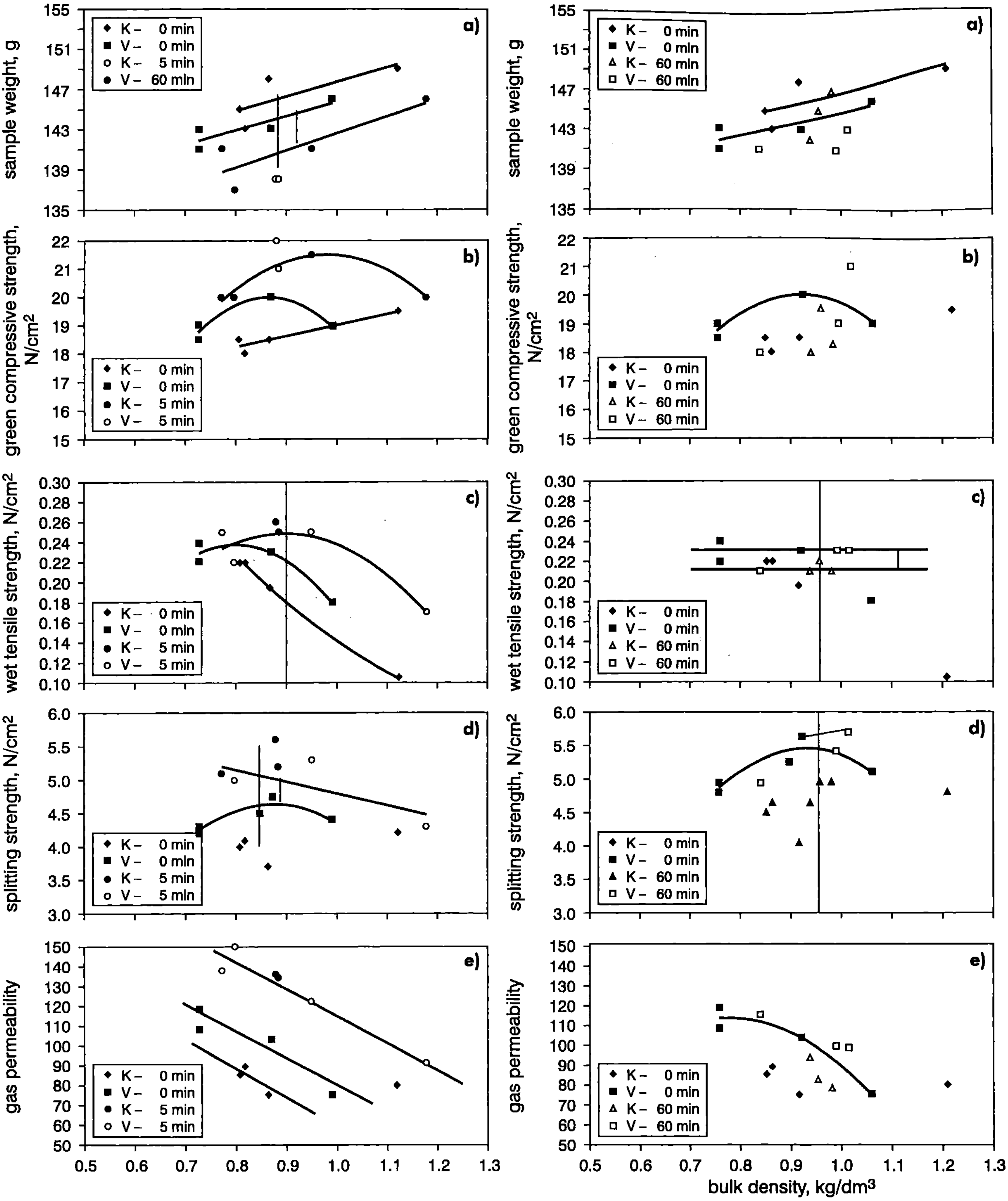
Green compressive strength **(Figure 3b).** With a specific density of 0.9 kg/dm^3 the sand prepared by the new process has a 1.2 N/cm^2 greater green compressive strength. A 60 min maturing time does not result in any increase in the compressive strength.

Wet tensile strength **(Figure 3c).** The vacuum preparation results in higher wet tensile strengths.

Green splitting strength **(Figure 3d).** This is considerably greater with the vacuum sand preparation. A maturing time of 60 min results in an increase with conventional preparation but with the vacuum preparation it remains constant.

Table 1. Tests according to the two types of Preparation

Test	Preparation in intensive mixer	Vacuum preparation
Circulating sand into the mixer	45 °C	115 °C
Introduction of additives	QuickBond-D, Antrapur, G 634 quartz sand	
Dry mixing	10 s	10 s
Water addition	Moistening	Moistening + cooling
Preparation (80 s)	Wet mixing under normal pressure	Wet mixing with simultaneous vacuum cooling



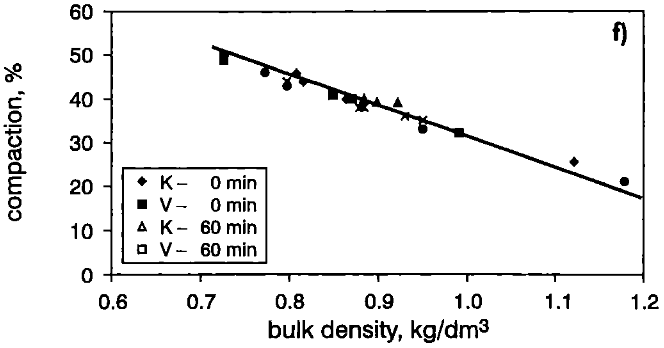


Figure 3. Test results from the two types of preparation in relationship to the bulk density (K = conventional, V = vacuum): a) sample weight; b) green compressive strength; c) wet tensile strength; d) splitting strength; e) gas permeability; f) compaction

Table 2. Comparison of test results with the two types of preparation (compactibility 38%; bulk density 0.9 kg/dm^3

Property	Conventional	EVACTHERM	Change
Green compressive strength **(Figure 4a)**	18.7 N/cm^2	19.9 N/cm^2	+ 6%
Wet tensile strength **(Figure 4b)**	0.185 N/cm^2	0.205 N/cm^2	+10%
Splitting strength **(Figure 4c)**	4.0 N/cm^2	4.6 N/cm^2	+15%
Gas permeability **(Figure 4d)**	72	92	+27%

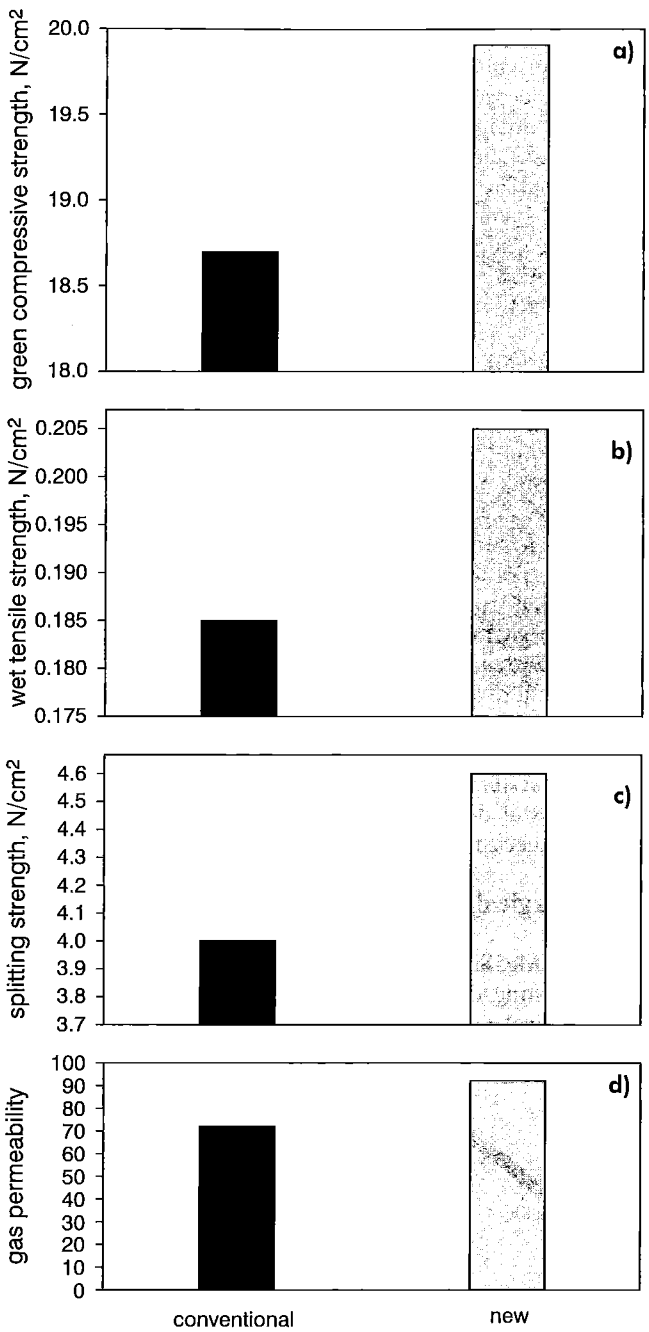


Figure 4. Test results from the two types of preparation with a compactibility of 38% and a bulk density of 0.9 kg/dm^3: a) green compressive strength; b) wet tensile strength; c) splitting strength; d) gas permeability

Gas permeability **(Figure 3e).** With the vacuum preparation this is around 20 units higher than with the conventional and still remains at the same level after 60 min.

In addition to these results there are also positive tendencies in the flowability according to Orlov, water content, compaction, bulk density.

The results of the tests with both types of preparation are summarized in **Table 2** and **Figure 4.**

Conclusion

Under the given production conditions, the vacuum preparation leads to better preparation results than the conventional preparation.

It is to be noted that the QUICKBOND bentonite (prepared with process carbon) used in the tests resulted in a higher compaction per percentage of water, so that the water content could therefore be minimized.

It is also to be noted:

1. In the tests it was not possible to investigate the cumulative changes of the sand parameters with preparation under production conditions, i.e. in a circulating sand system. Improvements in the moulding sand only normally develop after several circulations.

2. With the vacuum preparation the cooling water is fed back in the form of condensate. Salination of the sand is thus lower, through which the deactivation of the bentonite in the circulating sand is reduced.

According to the moulding sand system, i.e. according to the sand/iron ratio, water addition and water quality, new sand addition etc., it is to be expected that more favourable results would be achieved in practice than those carried out in the tests in the Technical Centre.