Understanding the basics of green sand testing.

By Granlund, Matt J.
Publication: Modern Casting
Date: Monday, March 1 1999

Familiarize yourself with the sand testing methods used in your operation to understand how those readings reflect both the consistency of your molding sand and the quality of your castings.

The quality of a foundry's green sand has a definite impact on the quality of the castings.

Maintenance and control of the system sand is not only an important job but also a demanding one, requiring a battery of tests aimed at improving consistency. Knowing why and how sand testing is performed, therefore, can offer important clues to improving quality in your foundry.

Sand testing falls into two categories: checking consistency and evaluating physical and chemical properties of a sand mix. Tests such as moisture, permeability, green compression and compactibility are used to check consistency of the sand. Such tests, along with actual mold testing and physical tests like loss on ignition (LOI), AFS clay, 25 micron clay, methylene blue (MB) clay and screen analysis can explain casting quality.

To obtain comparable results, each test must be run according to AFS standard methods. Testing equipment must be checked and calibrated. Samples, usually a quart or larger, should be taken nearest the point of use, and casting quality should be correlated to sand test results. It's important to follow statistical process control procedures, and graphing results makes them easier to track.

CONSISTENCY TESTS

Moisture

Moisture in molding sand develops the plasticity of the clay bond, and different types and amounts of clay require different amounts of water to achieve the best properties. The water consumption in the sand system is directly related to the tons of metal poured. Water also acts as the main coolant and heat extractor in the system.

Procedure - The percent moisture is determined by completely drying a given amount of green sand (50 g). The sand and the drying container are weighed before and after drying, and the weight loss is doubled to arrive at the percent moisture.

Significance - The water content affects every property of green sand, with the exception of grain fineness number of the base sand. Excess water produces an oxidizing atmosphere in the mold, excess gas evolution, lower permeability, high dry and hot strength, low mold hardness and poor flowability. Moisture content of a green sand is not an arbitrary figure; it must be maintained within a narrow range. Two factors that affect the moisture requirement are the type and amount of clay and the type and amount of additives in the sand mix.

Compactibility

Compactibility is directly related to the performance of the sand in the molding operation and reflects the degree of temper of the sand mix.

Procedure - The test is run by filling a standard specimen tube (4.75 in. high, 2 in. around) with riddled sand through a 0.375-in. screen mounted at a constant height above the tube. The excess sand is struck off the top of the tube, and the sand is rammed three times. The distance from the top of the tube to the surface of the sand is read as percent compactibility [ILLUSTRATION FOR FIGURE 1 OMITTED].

Significance - Because the test is independent of the specific gravity of the sand, it is superior to the bulk density test for measuring the water requirement of the sand mix. The presence of water in excess of what is required to establish the minimum density point of the molding sand results in free water within the sand mass. As the moisture decreases, the water-clay coating thickness decreases, and more sand can be riddled into the specimen tube.

Compactibility duplicates how a fixed volume of sand will react to a fixed input of energy and is useful in controlling the clay-to-water ratio. This test, in conjunction with green compression, can be used to determine the working bond or effective clay present in a sand mix.

Green Compression

Green compression has been the most widely used control tool to measure the rate of clay addition to a sand molding system.

Procedure - The green compressive strength of green sand is the maximum compressive stress that a mixture is capable of sustaining when prepared, rammed and broken under standard conditions. The rammed cylindrical specimen (2 in. diameter and 2 in. long) is formed by placing a weighed amount of sand in a tube and ramming the sand three times. The instrument used for breaking the specimen must continuously register the increasing load until the specimen fractures.

Significance - The degree of mulling, sand-to-metal ratio, clay content, compactibility range and type of additives have a significant effect on green compression. The compression reading should be read at comparable compactibility ranges. Molding sand at higher or lower compactibility will produce varying green strengths. Green compression in conjunction with moisture can be used to determine the available bond.

Permeability

Permeability is a test of the venting characteristics of a rammed sand.

Procedure - The permeability number, which has no units, is determined by the rate of flow of air, under standard pressure, through a 2 x 2-in. rammed AFS cylindrical specimen.

Significance - The grain size, shape and distribution of the foundry sand, the type and quantity of bonding materials, the density to which the sand is rammed and the percentage of moisture used for tempering the sand are important factors in regulating the degree of permeability. An increase in permeability usually indicates a more open structure in the rammed sand, and if the increase continues, it will lead to penetration-type defects and rough castings. A decrease in permeability indicates tighter packing and could lead to blows and pinholes.

2 x 2-in. Specimen Weight

Variation in specimen weight indicates variation in the density of the rammed sand and changes in the system.

Procedure - The weight of sand required to make a standard three-ram specimen should be recorded every time a test is run. The specimen weight should be recorded at or near a predetermined compactibility.

Significance - When the specimen weight drops appreciably, it indicates a buildup of dead or oolitic material. This buildup can lead to burn-in, burn-on and penetration defects. A trend to lower weight indicates not enough new sand is entering the system.

Dry Compression

Dry compression indicates the resistance of the mold to stresses during pouring and cooling of a casting and the ease of shakeout.

Procedure - Dry compressive strength is the maximum load a dry specimen can sustain before fracturing. A standard 2 x 2-in. specimen is made and dried in a ventilated oven at 230F (110C) for 2 hr. After cooling, it is broken, and the strength is recorded.

Significance - When sand exhibits high dry compression, a greater number of large, hard lumps are present at shakeout and more sand carryout will take place. An increase in moisture, the type and amount of clay and the rammed mold density will affect the dry strength. An excessive amount of moisture-absorbing materials will decrease the dry strength.

Table 1. Example of a Sieve Analysis

U.S. Sieve Number	Sand A	Sand B
20	0.0	0.0
30	1.0	0.0
40	24.0	1.0
50	22.0	24.0
70	16.0	41.0
100	17.0	24.0
140	14.0	7.0
200	4.0	2.0
270	1.7	0.0
Pan	0.3	1.0
Total	100.0	100.0
AFS Grain Fineness Number	60.0	60.0

AFS Clay

AFS Clay indicates the amount of fines and water-absorbing material in the sample.

Procedure - A known amount of dried molding sand mixed with a pyrophosphate solution is stirred with a high-speed mixer for 5 min. Water is added to the top level line, and the mixture is allowed to settle for 5 min. before the top 5 in. of the water is siphoned off. The procedure is repeated until the water above the sample is clear. The sand then is dried, and the weight loss is recorded as AFS Clay.

Significance - AFS Clay may contain active clay, dead clay, silt, seacoal, cellulose, cereal, ash, fines and all materials that float in water. Only the active clay gives active bonding capacity to the system.

Methylene Blue Clay

The MB clay test determines the amount of active clay, indicating the base exchange capability of bentonite.

Procedure - The amount of exchangeable ions present is determined by replacing these ions with MB dye.

Significance - Clay that still has the ability to exchange ions will contribute to green, dry and hot properties of molding sand mixes. MB clay values are not affected by the majority of other sand additives. The MB clay value varies depending on the purity and nature of bentonite and can be used to check incoming shipments of bentonite or pre-mixes.

Loss on Ignition

LOI determines the total amount of combustible material in the sand.

Procedure - The sand sample is fired at 1800F (982C) until it reaches constant weight. The time of firing is directly related to the size of the sample.

Significance - The quantity of gas-forming material in the sand will affect casting results. High LOI may produce gas defects such as pinholes and blows. Scabbing also can be caused by excess gas formation. In steel castings, high LOI can lead to carbon pickup on the casting surface.

Sand Temperature

Temperature readings from the hopper sand help to determine if more or less water is required for tempering.

Procedure - A thermometer is placed into the sand sample immediately after sampling, and the temperature is recorded for each test.

Significance - Variations in temperature indicate a need for varying the amount of water added to the muller. To assist muller operators, many foundries have installed thermocouples in the batch hopper above the muller.

Automatic controllers use the incoming sand temperature as one of the parameters to determine the correct water addition. The muller is not the place to cool hot sand - only warm sand can be cooled in the time allowed by the mulling cycle.

Screen Analysis and GFN

The fineness of the sand has a bearing on the physical properties that can be developed by the sand system.

Procedure - A dry sample of sand is screened through a "nest" of sieves (largest opening sieve on top and progressing down the nest). The sample is shaken for 15 min in the screen shakers, and the sand retained on each screen is weighed. The percentage retained in each screen is multiplied by a factor to give a product for each screen, and that sum is totaled to determine the AFS grain fineness number (GFN).

Significance - The fineness influences the bond required and the surface finish of the castings. The test should be run on the washed system sand and the dried system sand. The dried sand should be shaken for only 2.5 min - the time required to break up the lumps but not the agglomerates, which are the basis of the entire system. A comparison of the dried and the washed screen analyses shows how much agglomeration takes place in the sand system. Also, very different sand mixes with different casting properties still may average out to the same GFN (Table 1).

MOLD PROPERTY TESTS

Mold Hardness

The mold hardness test indicates the resistance of the mold-to-metal damage as the metal contacts the mold surface.

Procedure - Mold hardness is measured by the resistance offered by the mold surface to a spring-loaded plunger. Both "B" and "C" scale hardness testers are available, but the "C" scale tester is more accurate at the high end of the hardness scale.

Significance - Proper mold hardness will give castings a better finish, more accurate dimensions and reduced penetration, drops and swells. Excessive hardness, meanwhile, can cause cracks, scabs, blows, pinholes and penetration.

Mold Strength

This test measures uniformity of compaction on the mold face in production.

Procedure - A spring-loaded plunger is driven into the mold face to a pre-determined depth, and the sand's resistance is measured in psi.

Significance - This strength can be compared to the green compression on a three-ram specimen. Although they may not always agree, they should remain in a constant relationship.

Mold Permeability

The mold permeability test measures the degree of compaction to which the mold has been rammed.

Procedure - A rubber-faced contact head, connected with rubber tubing to the perimeter, allows the mold face permeability to be read.

Significance - This test shows changes in the venting ability of the molding sand, indicating system changes.

Mold Quality Indicator

The mold quality indicator (MQI) readings are an indirect density reading based on permeability.

Procedure - A robber-faced contact head, connected with tubing to the MQI unit, is placed on the mold face, and the back pressure to an airflow is read.

Significance - The tighter sand is compacted, the higher the MQI reading.