

Improving Sand Control with Wet Tensile Testing

By Scott Strobl, Vice President of Technology, Simpson, Aurora, Illinois, USA

The wet tensile test, which determines the tensile strength of green sand's condensation zone, is profiled. Through wet tensile testing foundries struggling with several common sand related defects could monitor the strength of the sand's wet layer to help control sand composition. This article examines the wet tensile test, describing for foundries an alternate method for testing the strength of their molding sand. It will also describe how the addition of wet tensile testing to a program of more common green sand testing can improve sand control, reduce casting scrap and improve foundry profitability.

How Wet Tensile Fits In

In current practice, the sand control program of many green sand foundries relies completely on statistics generated from several traditional, basic sand tests. Typical control efforts focus on data generated from standard compactability, moisture, green compression strength, permeability, methylene blue clay, AFS clay, grain fineness and loss on ignition tests. While important, and an essential part of any quality control program, these standard tests may not reveal all the important sand characteristics that affect casting scrap rates or that could improve casting quality and foundry profitability. These principal green sand test procedures focus on the physical properties of sand measured in ambient temperature conditions.

Understanding these properties is extremely important as they can be directly related to the performance of the sand in the molding department. They also yield important information regarding the sand processing and preparation efficiency. These tests are also useful in controlling raw material quality and addition rates to the sand system. Unfortunately, these same tests do not clearly indicate how sand will perform at the elevated temperatures encountered during metal pouring, solidification and casting shakeout.

The casting process changes the physical properties of molding sand due to a rapid temperature rise of the mold – particularly at the mold/metal interface. This dramatic increase in temperature affects the bonding strength of the clays. The compression and tensile strengths of molding sand tested at elevated temperatures are not comparable to strength data generated at ambient temperatures. Because of this difference in bonding performance across a range of



mold temperatures, many foundries develop casting problems that cannot be correlated to conventional green sand tests.

Important technical information can be measured and monitored by incorporating test procedures that measure the characteristics of molding sands at elevated temperatures. The wet tensile test was developed specifically for the purpose of determining the effect on bonding strength within the mold from pouring molten metal into a sand mold at ambient temperatures. Due to its ability to quantify the performance of green sand at elevated temperatures, the addition of wet tensile testing with standard green sand tests can improve sand control and reduce sand related scrap.

The Problem

As molten metal enters a mold cavity, the sand develops several distinctive strength zones. A temperature gradient is generated in the mold as heat transfers from the metal into the sand. This temperature gradient develops regions within the mold that have varying temperatures and moisture contents. These changes in temperature and moisture have significant effects on sand strength.

During the pouring process, sand at the mold/metal interface is heated dramatically. The water within this hot layer is vaporized and migrates between the sand grains to a cooler region of the mold away from the casting and condenses. This condensation results in a thin layer of sand that is saturated with water. This condensation zone is known as the wet layer. Behind this region is a layer of warm sand that contains a normal water percentage. Following this region is the remainder of the mold that has not been influenced by the casting process.

Assuming good sand preparation and molding technique, the sand in the mold prior to the introduction of molten metal was relatively uniform. After pouring, the layering effect of various temperatures and moisture contents within the mold results in a green sand mold of varying strength. At the mold metal interface the sand surface layer is dry, hot and strong. Behind this hot zone is the condensation layer that is wet and weak. Following the condensation zone is a warm layer that is slightly stronger when compared to the condensation zone but weaker than the remainder of the mold, which is still at ambient temperature.

The condensation zone is the lowest strength layer in the cross section of the mold and the source of casting defects. Sand expansion defects are a result of a bonding failure between the hot surface layer and weak condensation zone. The thermal expansion of silica sand in the hot zone and weakness of the wet layer can cause a rupture between the two layers, resulting in expansion rattail, buckle and scab defects.

How the Test Works

The wet tensile tester is designed to accurately determine the tensile strength of the condensation zone. The instrument recreates the mold environment at the mold/metal interface by utilizing a heater to generate a condensation zone in a sand specimen. The wet tensile strength is determined by pulling a detachable ring from a special tube. The specimen tube with its detachable ring in position is loaded with molding sand and compacted to a proper specimen height using a sand rammer.

The sand specimen and specimen tube are loaded into the wet tensile tester. In more advanced testers, after a start button is pressed the specimen is raised against a heating plate. Once in contact with the heating plate,

the temperature at the surface of the sand specimen increases. Steam is generated at the heater interface and a temperature/moisture gradient is developed through the sand specimen. The steam is driven away from the heating plate through the porosity of the sand specimen. The moisture vapor migrates back into the sand specimen to a low temperature zone where it condenses. After a user-selected time has elapsed, the elevation table lowers away from the heating plate and begins to apply a tensile load to the sand specimen. Since the wet layer is the weakest strength zone, when a load is applied to the specimen it will always fail this layer. The load required to break the wet layer is the wet tensile strength. The instrument is fully automatic and displays the wet tensile results in an easy to read digital display.

Interpreting the Results

The wet tensile test is excellent at measuring the characteristics of bentonite within a sand system as the test is very sensitive to slight changes in bentonite performance. It is capable of measuring deterioration in clay performance influenced by changes in the sand composition that are not detected by other standard test procedures. Foundries can use the methylene blue clay test in conjunction with the wet tensile test to control the amount of clay and to monitor and control clay ratios.

Sodium bentonite results in higher wet tensile strengths when compared to calcium bentonite. Foundries can utilize this information to reduce their total clay addition and to control clay ratios to optimize the shakeout characteristics of the sand without encountering expansion type defects.

Foundries that are facing difficulties with expansion defects would benefit greatly by including wet tensile results in their sand control efforts. Expansion defects are a direct result of a mechanical failure between the hot sand surface layer and weak condensation zone. Measuring and monitoring the strength of the wet layer can help control or assist in changing sand composition to completely eliminate the defect. For instance, the amount of cereal or soda ash additives can have a substantial impact on wet tensile strength. The test can be utilized to monitor the condition of the sand and indicate when an expansion defect will appear.

As foundries try to reduce carbon additives to lessen emissions, they also reduce the expansion fighting benefit of the carbon additive. By monitoring the wet tensile strength, carbon levels can be maintained at lower levels without encountering expansion problems. Castings that are more prone to expansion defects can be scheduled for production only when minimum wet tensile strengths are achieved.

Foundries around the world have found that the addition of wet tensile testing to a program of molding sand control have allowed the foundries to reduce casting scrap and improve overall casting quality. The end result is that for a low cost investment in laboratory testing equipment foundries will have better data available to significantly improve their ability to troubleshoot, control and document the metal casting processes for optimal quality and profitability. An essential quality control tool, the investment in molding sand testing equipment is easily justified in every foundry operation.