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Expansion Control Method for Sand Cores

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ABSTRACT

It's a fact that lake sands exhibit less thermal expansion than silica sands. Lake sands contain a variety of impurities in the form of various oxides that thermally expand at a different rate than SiO_2 or may soften or flux at elevated temperatures. A lake sand may be 92% SiO_2 where a silica sand 99% SiO_2. The challenges of getting silica sand to perform as well as lake sand in expansion is what drove the authors to their discovery. It was evident from the beginning that throwing larger quantities of anti-vein agent in the sand was not a cost effective method. Through much testing and experimentation a cost effective method was discovered that not only allowed good expansion control in silica sand, but allowed for improvement in lake sand expansion control.

INTRODUCTION

The expansion of silica, in sand cores, has been a problem plaguing foundries for many years. The phenomenon is caused by the rapid thermal expansion of the sand during the casting process resulting in core cracking. The molten metal then enters these cracks, creating a thin fin of metal, which is referred to as a veining defect in the casting. There are many methods used to offset this problem. Some are more successful than others. The intent of this paper is to present a method that improves on one of the more successful methods used today, while at the same time reduces cost.

BACKGROUND INFORMATION

Sand cores are produced in the Foundry Industry to primarily make internal cavities of a finished casting. When the sand cores are placed in a mold and molten metal is introduced, a rapid thermal expansion of the sand in the sand core takes place. This rapid expansion results in core failure in that the core cracks. If the metal is still liquid, the metal runs into the cracks in the core creating a fin, or in foundry terms, a vein as the metal solidifies. See figure 1. A severe case of these phenomena results in a sponge iron defect that resembles metal penetration or burn-in. See figure 2.

Figure 1. This is an example of the veining defect.

Figure 2. Sponge Iron defect. (Note the veining close to defect.)

In this case, the integrity of the coating and the core skin has been compromised allowing migration of metal back into the core. This chunk of sponge iron is often misidentified, as burn-in. Close examination will reveal that there is a vein going through or under the chunk of sponge iron. The expansion vein came first and then the more severe failure of the core next. This is noticed most often in an area of heavy metal sections or hot spots. The solution to this problem is solving the core expansion problem and the sponge iron will not occur. This is of special concern in water jacket or oil passageways in motor blocks and heads. A vein in these key areas may lead to failure of the part due to blockage of water or oil flow.

This veining defect, caused by core sand expansion, is most often controlled by the addition of an anti-vein or expansion control agent (synonymous terms). This additive is added directly to the sand in the mixing process to produce cores. The addition of an anti-vein agent changes the thermal coefficient of expansion of the core sand to allow the veining defect to improve or not exist. Selecting the right expansion control agent is important, as there are often trade-offs when adding another material to the sand. Most of the additives available today are finer than the sand; therefore the surface area of the core aggregate is increased resulting in the need for more resin to maintain the desired core strength. Many of these additives are combustible and may add significantly to the amount of gas generated from the core.

EXPANSION EVALUATION TESTING METHOD

The testing method used to evaluate core expansion was to use 2”X2” test cores set in a green sand mold. See figure 3. The 2”X2” cores are made using a standard laboratory compactability rammer. The cores are rammed to the same density as blown cores made by a standard core machine. 2”X2” cores were made with various sands, both lake and silica, using a Phenolic Urethane Cold Box Binder. This method allows the addition of various expansion control agents for evaluation to the current foundry process. The foundry core process uses 50 G.F.N. lake sand with 5% of a commercially available expansion control agent. After a series of six cores were made (one of which is always the standard) a test casting was then poured, allowed to cool and then the core sand shaken out. See figure 4. This is a severe test that allows good evaluation of expansion veining. The veining is evaluated, by measuring the length and height of the veins and calculating the total surface area of the veining that occurs. See example in table 1. The results in the table relate directly to the figures to follow. Those results that offered some improvement were then verified on subsequent test castings.

Figure 3
Green sand test mold with test cores in place.

Figure 4
Test casting used for veining evaluation.

Table 1. Veining measurement results

Recipe	Figure	Surface Area in^2
Lake 1.2%+ CW	5	2.60
Lake 1.35%+ 5% AV+CW	6	0
Lake 1.4% + 1.5% AV + 1% Fe2O3 + CW	7	0
IL Silica 50 1.1% + CW	8	3.75
IL Silica 50 1.25% + 5% AV + CW	9	0.6
IL Silica 50 1.20% +4% AV+ 1% Fe2O3+CW	10	0
IL Silica 50 1.10% +3% AV+ 1% Fe2O3+CW	11	0
WI Silica 55 1.0% +CW	12	2.33
WI Silica 55 1.15%+5% AV+CW	13	0
WI Silica 55 1.10% +4% AV+CW	14	0.1
WI Silica 55 1.3%+4% AV+1% Fe2O3+CW	15	0
WI Silica 55 1.2%+3% AV+1% Fe2O3+CW	16	0
WI Silica 55 1.2%+2.5% AV+1% Fe2O3+CW	17	0

The results from the test castings have been compared to results from foundry production castings, such as motor blocks and heads, and shows strong correlation. The test casting allows for quick and easy analysis of many variables and decreases the interruption to the production floor.

EXPANSION EVALUATION TESTING RESULTS

Fifteen silica sands were evaluated using the veining test casting. The best two performers (those that exhibited the least veining) were further evaluated and modified to achieve similar results, in expansion control, compared to the lake sand.

One of the best expansion control methods, and the one used in the foundry, uses a commercially available anti-vein agent that consists of a blend of Lithia containing materials, alpha spodumene, lithium carbonate, black iron oxide, and others.[1] The proven level, of the commercially available anti-vein agent, to achieve benefit in sand core expansion is 5% or more based on sand weight. The amount of commercially available anti-vein agent can be reduced without sacrificing expansion control by adding commercially available Red Iron Oxide Fe_2O_3 also known as Hematite. In fact testing shows that there is an improvement of the performance of the commercially available anti-vein agent with the red iron oxide present.

In figure 5, 6 and 7, Lake sand is evaluated with and without 5% of the commercial anti-vein agent and then commercial anti-vein agent and red iron oxide. The veining is eliminated with the commercial anti-vein agent and also with the blend of commercial anti-vein agent and the red iron oxide. Notice the 70% reduction in the expensive commercial anti-vein agent with the addition of red iron oxide.

Figure 5
Lake Sand with no anti-vein agent.

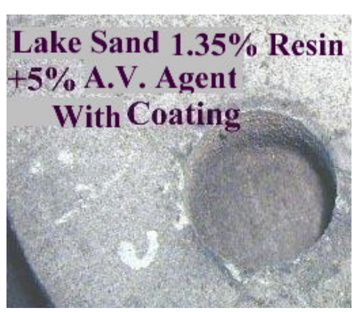

Figure 6
Lake Sand with 5% commercial anti-vein agent.

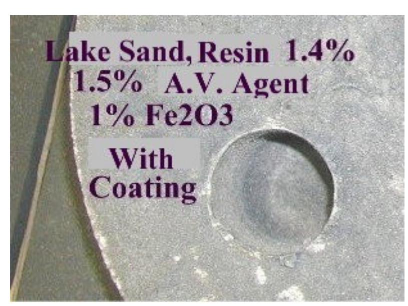

Figure 7
Lake Sand with 1.5% commercial anti-vein agent and Fe_2O_3.

In figure 8 and 9, Illinois silica sand is evaluated with and without 5% of the commercial anti-vein agent resulting in significant veining.

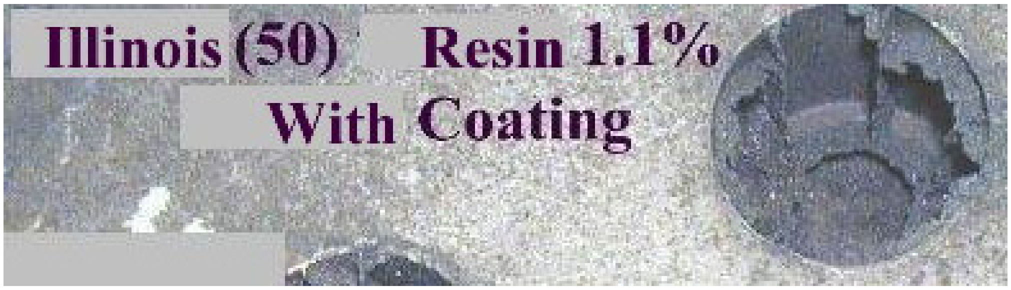

Figure 8
IL. Silica Sand without anti-vein agent.

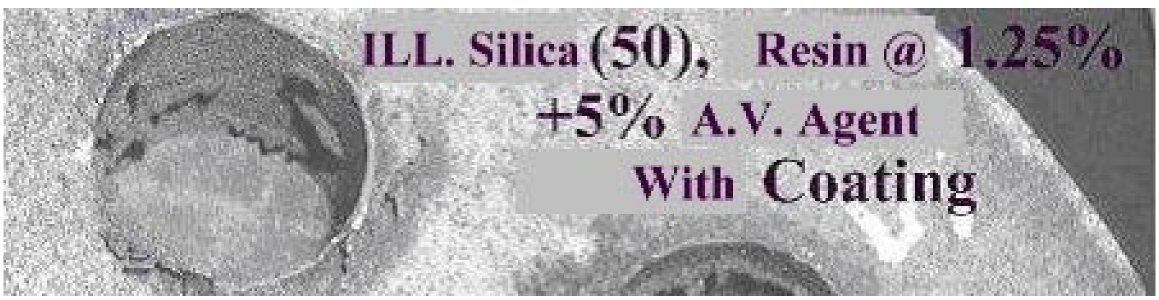

Figure 9
IL. Silica Sand with 5% commercial anti-vein agent.

In figure 10, with the Illinois silica, the commercial anti-vein agent has been reduced to 4% with the addition of 1% red iron oxide. The veining has been eliminated. In figure 11, commercial anti-vein agent has been reduced to 3% with the addition of 1% red iron oxide. Again, the veining has been eliminated. This process allows comparable results to lake sand with a reduction of 40% of the commercial anti-vein agent normally used.

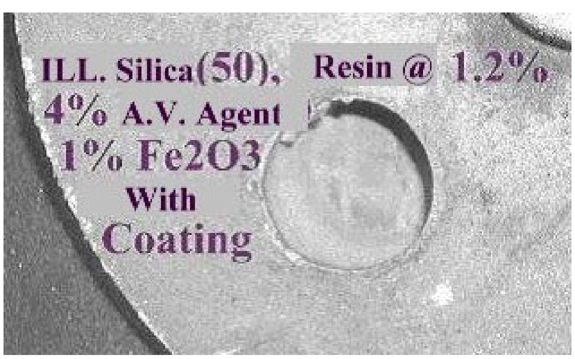

Figure 10
IL. Silica Sand with reduction in commercial a.v. agent + red iron oxide.

Figure 11
IL. Silica Sand with further reduction in commercial a.v. agent + red iron oxide.

In figure 12, Wisconsin silica is evaluated without an anti-vein agent resulting in considerable veining. In figure 13, a 5% addition of the commercial anti-vein agent eliminates most of the veining.

Figure 12
WI. Silica Sand without anti-vein agent.

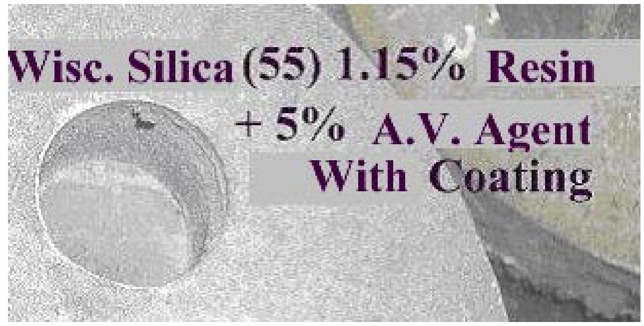

Figure 13
WI. Silica Sand with commercial anti-vein agent.

In figure 14, the anti-vein agent was reduced to 4% since not much veining was evident at 5%. The veining starts to appear. In figure 15, the commercial anti-vein agent was reduced to 4% with the addition of 1% red iron oxide. Veining has been eliminated.

Figure 14
WI. Silica Sand with reduction in commercial a.v. agent

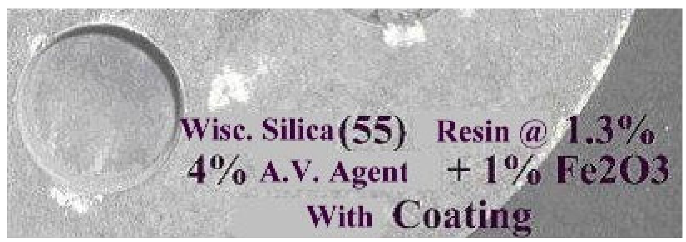

Figure 15
WI. Silica Sand with reduction in commercial a.v. agent + red iron oxide.

In figures 16 and 17, the commercial anti-vein agent has been reduced to 3% and then 2.5% with the addition of 1% red iron oxide. This results in a 50% reduction in the commercial anti-vein agent compared to the original formula of 5% addition.

Figure 16
WI. Silica Sand with further reduction in commercial a.v. agent + red iron oxide.

Figure 17
WI. Silica Sand with even further reduction of commercial a.v. agent + red iron oxide.

OVERALL RESULTS

Compared to the current foundry process, adding red iron oxide to the commercial anti-vein agent allows for a reduction of the commercial anti-vein agent material of up to 70% and a reduction in resin of up to 0.1%. The addition of the red iron oxide is an extra step in the process, but the performance obtained and the cost savings offset the inconvenience. The red iron oxide is one-third the cost of the commercial anti-vein agent. This method equates to about $15 per ton savings on prepared core sand cost.

Silica sands can be made to work as well as lake sand, in expansion control, by using the above-described cost effective method. Lake sand expansion can be better controlled using this method as well, resulting in considerable savings and improved performance.

The result may not be exact for all applications, but the fact remains that the addition of Red Iron Oxide allows for the reduction in the amount of expansion control agent used. The testing has been done using a Phenolic Urethane Cold Box Resin. This type of expansion control agent is used in many other resin systems and because the mechanism of veining prevention is the same from core to core the same result of expansion control agent reduction should be achieved using any resin system.

SUMMARY

The process of adding Red Iron Oxide to a commercially available expansion control agent results in significant material cost savings and improvement in casting quality. The process is currently used at a foundry producing motor blocks and heads with great success. This process has solved very severe core expansion problems in water jacket areas where the sand to metal ratios are extremely low.

REFERENCES

1. Brander, John J., Kotsci, Ronald M., U.S. Patent No. 5,911,269 (June 15, 1999), Veinseal 14000, Mfg. By Industrial Gypsum Co., Inc. (Milwaukee, WI.)