DIS | Ductile Iron Society

Request for Proposal

The Ductile Iron Society (DIS) Research Committee is soliciting universities and research organizations to participate in a DIS research initiative. The DIS mission is to promote the production and application of ductile and compacted graphite iron. Completed projects may be published by DIS on their website and by the International Journal of Metalcasting (IJMC), by request.

The following describes a research need identified by the members of the DIS research committee. Attached to this document is the DIS proposal template. Interested universities and research organizations can complete the proposal, modifying the scope as they deem appropriate. Finished proposals should be sent to the Michelle Ring (michelle@ductile.org) and will be evaluated for funding based on the quality of the proposal, thoroughness of research methodology, available facilities and capabilities, student participation (if applicable), and projected timeline and cost. Questions regarding DIS or the research proposal can be addressed to the DIS Technical Director.

Topic: Effect of Cold Temperature on Green Sand Molding

Steering Committee Members: Michelle Ring (DIS), Liam Miller (American Colloid Co), Kiel Krause (American Colloid Co), Jay Morrison (Carpenter Brothers), Eric Nelson (EN Consulting), Carola Basaj (CWC Textron), Tom Arenholz (Simpson Technologies), Kohler

Project Goal: Figure out what is the cause and effects of the dreaded “Monday morning startup sand”. There has been a plethora of research on the effects of hot sand on green sand molding. However, the research and publications on the effect of cold sand on green sand molding has limited data. Research uncovered one publication from 1964 on the impact of cold sand (Cold Sands, Sanders from Foundry Magazine), however this publication was focused on using cold raw silica sand that had been sitting in inclement weather and while it gave some guidance on controlling the moisture of the sand and using sand warmers the data on the impact to sand properties was limited. An initial laboratory trial was completed by American Colloid to look at any effects on green sand properties in a laboratory setting. The results of this series of experiments did not show any major change in mechanical green sand properties as a function of temperature. The initial report is attached.

The industry would like to see a research project that further investigates what could be causing the “poor molding conditions” of what many consider “Monday morning startup” sand, and what properties are affected and how detrimental effects can be mitigated.

The selected university or research organization will be responsible for the following tasks:

1. Literature review on temperature effect on Green Sand
2. Proof of concept experiments measuring the effects of temperature on molding parameters and sand properties
3. Presentations and reporting
    - o Monthly reports to Steering Committee members
    - o In-person or virtual progress reports at triannual DIS Research Committee meetings
    - o Final written report submitted to DIS for dissemination to its membership
    - o Oral in-person presentation of the final written report at a DIS Annual Meeting

Project Report provided by American Colloid Co – Liam Miller

Project: **P24-047 Cold Sand Evaluation – Ductile Iron Society (DIS)**
Date: **09/19/24**
Customer: **Michelle Ring- Ductile Iron Society**
Completed By: Minerals Technologies Inc. Research and Development, Hoffman Estates

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Background:

There has been a plethora of research on the effects of hot sand on green sand molding. However, the research and publications on the effect of cold sand on green sand molding has limited data. Research uncovered one publication from 1964 on the impact of cold sand (Cold Sands, Sanders from Foundry Magazine), however this publication was focused on using cold raw silica sand that had been sitting in inclement weather and while it gave some guidance on controlling the moisture of the sand and using sand warmers the data on the impact to sand properties was limited. The purpose of this study is to see if any effects on green sand properties can be determined in the laboratory.

The present study looks to compare molding sands prepared in the laboratory with cold sand and water vs. room temperature sand and water. The testing was divided into a series of comparisons between molding sand prepared with the same amounts of clay, additives, sand, and water with the only variable being the initial temperature of the sand and water. The testing was performed with both lab prepared molding sand as well as return sand from a midwestern iron foundry. The first series of experiments looks to evaluate any differences in the properties of the sand after dwelling in the cold for a period of 72 hours , while the second series of experiment looks to determine if the there is a difference in the development of the clay when mixed with cold sand vs. room temperature sand.

Materials:

- Silica Sand (AFS GFN 60)
- Hoffman Estates IL Municipal Tap Water
- MTI/ ACC Sodium Bentonite
- MTI/ACC Calcium Bentonite
- Bituminous Seacoal
- Causticized Lignite (FloCarb)
- Return Sand from Midwestern Iron Foundry (Grede New Castle)

Executive Summary:

The results of this series of experiments did not show any major change in mechanical green sand properties as a function of temperature. It should be noted that the use of the Eirich high intensity mixer and the batch size resulted in an increase in temperature of the final mixture that was close to the same temperature as the ambient mixtures. In the testing design the mixing time was set to 90 seconds for Experiment 3 which may have been too aggressive to decipher any changes related to the clay development on cold sand, a future consideration may be shorter mixing times.

Sand Preparation and Test Methods:
Experiment 1:

For the initial experiment (Experiment 1) molding sand was prepared in the laboratory using an Eirich EL-05 high intensity mixer (mixed for 90 seconds at 2,222 rpm equating to a 16 m/s^{-1} tip speed). A control batch was prepared on a 3kg basis with 9% bentonite by weight using a blend of 56% Sodium Bentonite, 19% Calcium Bentonite, 18% Bituminous seacoal and 7% causticized lignite. The overall concentration of bentonite and additives was 12% (75% of which is bentonite resulting in the 9% clay by weight target). This recipe was used as it represents a common MTI/ACC Additrol (clay and additive pre-blend) recipe for customers producing iron castings. It was determined through trial and error that this mixture required the addition of 1.85% additional temper water to achieve a compactability of 40%. For this process the 2,640 grams of silica sand was added to the mixer with 56.5 grams of water and mixed for 15 seconds to premix the sand and water, then the 360 grams of clay and additives were added and mixed for an additional 90 seconds before removing the sand and placing in sealed plastic to await testing. Based on this recipe a second batch of molding sand was prepared and placed in a sealed plastic bag and placed in refrigerator at approximately 34°F. One sample was left sealed in the at approximately 72°F and the other in the 34°F refrigerator for 72 hours and were evaluated one right after the other.

Testing on the samples included compactability, green compression strength, dry compression strength, moisture, wet tensile strength (320°C with 6 seconds of contact time between the sample and heated plate), permeability, friability, and cone jolt toughness. Initial temperature and final temperature after mixing or testing was recorded for each test.

Experiment 2:

In Experiment 2 return sand was received from Grede New Castle foundry. The sand upon receipt was evaluated for compactability (approximately 40-41%) and then split into several 3 kg batch sizes using a sample reducer. One 3kg sample was sealed in a plastic bag and left in the lab at 72°F while a second 3kg sample was placed in the 34°F refrigerator, both were allowed to sit approximately 72 hours before testing.

Experiment 3:

In the third experiment the impact on clay development as a function of cold sand was investigated. Based on the recipe for the batch in experiment 1 the sand and water were mixed in the Eirich mixer, and the clay and additives were weighed out separately. One mixture of 2640 grams sand and 56.5 grams water was placed in a sealed plastic bag and left in the lab at 72°F while another mixture was prepared and placed in the 34°F refrigerator for 72 hours. After 72 hours each mixture was placed back in the Eirich, and the clay and additives were added and mixed for 90 seconds followed by testing.

Experiment 4:

For the 4th experiment we wanted to also investigate the ability of new clay additives to develop with the Grede New Castle return sand. For this experiment one of the 3kg splits of the return sand was left in the lab in a sealed plastic bag at 72°F for 72 hours while another was placed in the 34°F refrigerator for the same amount of time. Before evaluating 10% of the return sand was removed and replaced with 10% new sand, clay, and additives . The new target addition was based on 8% clay and 12.4% total clay + Additives (300 grams new sand, 31.6 grams clay and additives). One addition of sand was placed in sealed jar in the lab while the other was placed in the refrigerator along with a container of water to be used for the addition. For the testing, the mixing time in the Eirich mixer was reduced to 60 seconds and 4.5 grams of water (either room temperature or cold) was used for the respective batches in this experiment.

DISCUSSION

In Experiment 1 where lab prepared molding sands that were previously mixed and then placed in either an ambient or cold environment showed a small decrease in green compression strength from 24 psi to 21.8 psi however this drop was not observed with the return sands. In general, the standard deviation between the 5 replicates conducted green compression strength in each batch ranged from 0.45 to 0.85 psi.

There does appear to be a general trend of lower friability and higher cone jolt toughness when cold sand and water mixtures were used suggesting that the cold sand preparations may be stiffer but the standard deviation in the cone jolt testing is as high as 6 jolts for some batches so it is unclear how significant these differences are at this time.

Future considerations should be made in the experimental design to try to minimize the temperature increase when mixing , using a Simpson vertical wheel muller at a reduced mixing time (2-4 minutes) may help.

LABORATORY RESULTS

Table 1: Experiment 1 & 2 Data

Sample ID	Initial Temp (°F)	Final Temp (°F)	Comp (%)	Moisture (%)	Green Compression Strength (psi)	Green Shear Strength (psi)	Dry Compression Strength (psi)	Wet Tensile strength (N/cm2)	Permeab ility	Cone Jolt Toughness (#)	Friability (%)
Lab Prepared-Ambient	66.5	66.5	42	3.24	24.0	7.7	59.2	0.440	90	35	7.0
Lab Prepared-Cold Sand	39.0	67.0	42	3.26	21.8	7.4	53.4	0.450	90	43	5.3
Return Sand-Ambient	67.5	67.5	41	3.35	22.7	7.8	71.2	0.445	151	68	4.2
Return Sand-Cold Sand	38.0	57.0	42	3.41	22.5	7.8	65.5	0.423	167	72	2.7

Note : For Experiment 1 lab prepared samples were mixed in Eirich mixer and then set in lab or refrigerator. For Experiment 2 Return sands were split and placed in lab or refrigerator with no additional mixing.

Table 2: Experiment 3 Data

Sample ID	Initial Temp (°F)	Final Temp (°F)	Comp (%)	Moisture (%)	Green Compression Strength (psi)	Green Shear Strength (psi)	Dry Compression Strength (psi)	Wet Tensile strength (N/cm2)	Permeab ility	Cone Jolt Toughness (#)	Friability (%)
Lab Prepared-Ambient	66.5	75.0	38	2.96	22.5	6.0	37.4	0.364	83	27	12.7
Lab Prepared-Cold Sand	37.0	67.5	40	3.10	21.3	6.3	37.7	0.357	85	30	8.6

Note : For Experiment 3 lab prepared samples were prepared by mixing clay and additives with either ambient sand and water mixture or with prepared sand and water mixture that had been placed in refrigerator. Note for the cold sand batch the initial temperature of the sand and water mixture was 37°F but after 90 seconds of mixing the temperature increased to 67.5°F.

Table 3: Experiment 4 Data

Sample ID	Initial Temp (°F)	Final Temp (°F)	Comp (%)	Moisture (%)	Green Compression Strength (psi)	Green Shear Strength (psi)	Dry Compression Strength (psi)	Wet Tensile strength (N/cm2)	Permeability	Cone Jolt Toughness (#)	Friability (%)
Return Sand – Ambient with Ambient Addition	66.5	76.0	42	3.20	24.8	8.2	51.5	0.464	162	72	5.1
Return Sand – Cold with Cold Sand Addition	37.0	76	44	3.27	25.5	8.5	51.4	0.472	157	82	3.4

Note : For Experiment 4 return sands either ambient or cold were prepared by mixing new clay and additives with either ambient sand and water mixture or with prepared sand and water mixture that had been placed in refrigerator. Mixing times for this experiment were reduced to 60 seconds . Note for the cold sand batch the initial temperature of the sand and water mixture was 37°F but after 60 seconds of mixing the temperature increased to 76°F.