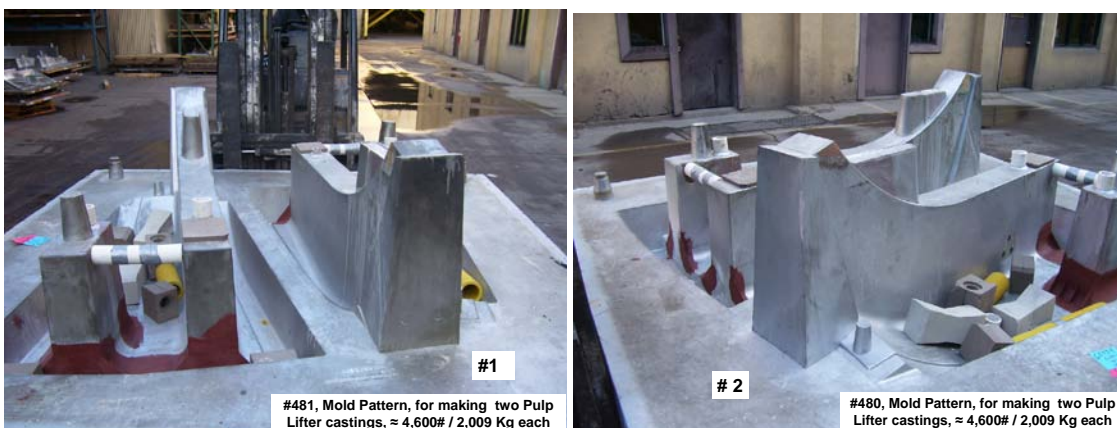


EVALUATING A NEW AND UNIQUE CHROMITE SAND
M.E. GLOBAL FOUNDRY
TEMPE, ARIZONA

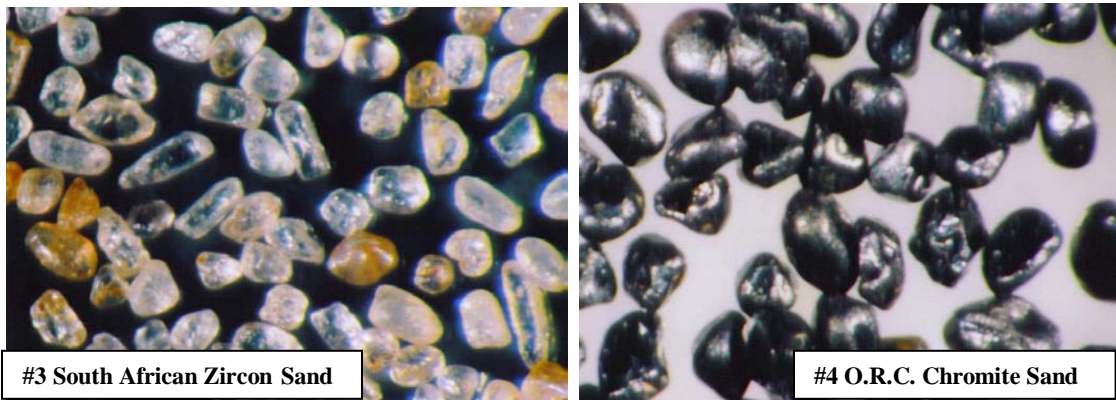
M.E. Global Foundry, a Division of Elecmetal, is an excellent steel casting foundry, which is highly successful in producing heavy section steel castings, which are too difficult or impossible for other competitive foundries to produce. During October 2009 we received an order for a quantity of “Pulp Lifter Castings” (see insert #1 and #2), which had been our second highest cause for rework and scrap castings in the previous year.



Since we were familiar with this casting, and the thermal stresses which are applied to the internal cores, we began a study to evaluate the performance of specialty sands which could overcome these thermal stresses. This study was initially restricted to two Zircon sand sources, to determine which sand would produce the highest quality casting, at the lowest cost. Our foundry typically utilizes Zircon sand for these cores, but we had encountered significant burnin, cracked cores and sand sintering to the casting’s surface, dramatically increasing the cleaning costs and periodically producing scrap castings.

The first Zircon sand evaluated was mined in South Africa. This sand had been used in our foundry for several years, but the quality of the sand had been deteriorating, with shipments containing foreign material and high quantities of dust, observed as the railcars were being unloaded. The second Zircon sand, mined in the U.S.A., was much cleaner, and the quality of the cores appeared to be improving, however the castings still possessed a significant amount of sand sintering to the metal’s surface and difficulty in shaking out the cores. The difficulty in removing the cores, from the casting, was partially due to cracks in the cores, which produced fins, impeding the removal of the cores from the casting’s cavities.

During the foundry's search for alternative "specialty sands", we received information regarding a new source of Chromite sand, mined in the U.S.A. This Chromite sand is unique, with a rounded grain structure, a very smooth surface on the sand grains and a narrow two sieve particle size distribution, with $\approx 35\%$ retained on the 100 sieve and $\approx 63\%$ retained on the 140 sieve. This Chromite sand has an AFS GFN of ≈ 89 and contains a very low level of "ultra fine sand", with only 1.4% retained on the 200 sieve 0.0% retained on the 270 sieve and 0.0% retained on the pan. Our current Zircon sands have an AFS GFN of ≈ 113 , with $\approx 8\%$ retained on the 100 sieve, $\approx 55\%$ retained on the 140 sieve, $\approx 34\%$ retained on the 200 sieve, $\approx 2\%$ retained on the 270 sieve and $\approx 0\%$ retained on the pan (see inserts #3, South African Zircon sand and #4, Oregon Resources Chromite sand).



Due to the rounded grain structure, and lack of fines of in the ORC Chromite sand, the Chromite producer stated that tensile strengths, evaluated at the University of Northern Iowa, showed that the core tensile strengths of the Chromite sand were typically 30 to 40% higher, than those obtained when compared with the same South African Zircon sand we were using. Our sand laboratory obtained similar tensile strength increases; however we decided to maintain the binder additions at the same level for all three core sands, throughout these casting trials. We will attempt to reduce the binder additions in later tests, but we are very aware that production mixers often do not provide the same mixing energy that a laboratory mixer can achieve, and that the laboratory temperature and humidity conditions are typically far superior to those encountered on the foundry floor, especially in Arizona.

Our production trials began in October 2009, and are currently continuing, with the Chromite sand providing superior cores and castings. The binder used in these evaluations was an "Ashland Pepset", phenolic urethane, nobake binder system. The initial cores contained 0.9% total binder addition, however the Zircon cores were having problems with the cores cracking when the mold was closed; thereby requiring the foundry to increase the amount of binder added, as well as additional rebar to adequately support the cores. Subsequently the total binder additions were increased to 1.1% for the casting trials. The binder additions consisted of 55% part #1 (phenolic binder), 45% part #2 (polyisocyanate co-reactant) with the activator, part #3 (tertiary amine), ranging from 3% to 5%, based on the part #1 addition. These changes in the catalyst addition were to

compensate for variations in the temperature of the sand and the ambient temperature in the mixing area.

100# batches of the sand were mixed in an OMCO batch mixer, with a retention time of 25 seconds. The sand mixtures provided 3 to 3.5 minutes of work time, with strip times ranging from 30 to 45 minutes. Although the tensile strengths were not monitored during the production testing, we did monitor the scratch hardness values for the test cores. Typically the scratch hardness values, for the cores, one hour after stripping were 55, with the scratch hardness increasing to 75, 24 hours after the core was produced. We did not observe any significant variations in the scratch hardness values during the evaluations of these three sands.

When using the South African Zircon sand, the casting scrap, rework and scrap from rework, was $\approx 50\%$. When we changed to the U.S. Zircon sand we saw a minimal improvement, but there was no significant improvement in the core or the casting's quality. When we replaced the Zircon sands with the O.R.C. Chromite sand, the strength of the cores and the quality of the castings were significantly improved. The Chromite sand was the only sand which provided 100% high quality cores and castings, with no scrap castings.



The core sections shown above are ≈ 5 to 6 inches (≈ 12 to 15 cm) in diameter, narrowing to ≈ 2.5 inches (≈ 6.4 cm) in diameter at the junction of the core with the core print area (see insert #5 and insert #6). The metal section surrounding this core is ≈ 6 inches (≈ 15 cm) thick and ≈ 21 inches (≈ 53 cm.) long. The narrowing, of the core's diameter, at the junction of the core with the core print area, creates a significant stress on the core section when the cope is closed on the drag section of the mold.

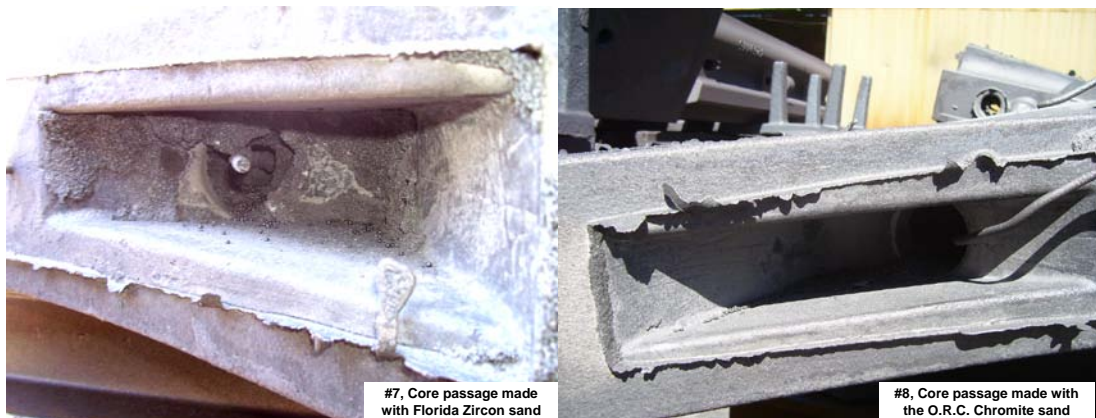
After the cores are stripped from the pattern, and allowed to complete their curing cycle, the cores are dipped in a water based Zircon coating and dried with a gas fired heater. After the coated cores are dried, the cores were sprayed with a Zircon coating and

allowed to air-dry. This secondary coating with the Zircon spray is repeated twice, resulting in the core having three layers of refractory coating on the cores.

The metal required for this casting is a Chrome/Molybdenum Steel, poured at 2,770 to 2,800F (1,507 to 1,523C). Each mold has two casting cavities, with each casting weighing \approx 4,009 pounds (1,818 kg). Due to the design of the cores, with the narrowing of the core's diameter at the core print connection, our foundry felt we would always need a significant quantity of rebar to support the core and to eliminate the core breakage during the closing of the mold.

Although we have not totally eliminated the use of the rebar, we were able, with the O.R.C. Chromite sand, to reduce the rebar required to one short section at the junction of the core with the core print, providing an improved shakeout of the core. We feel we may be able to produce castings, using the O.R.C. Chromite sand, without the need for any rebar, however we did not confirm this during this trial period, due to the customers need to have the castings shipped as quickly as possible. When production requirements allow, we would like to try to eliminate all of the rebar, reduce the binder addition to produce the casting more economically, eliminate one or two of the coating operations and subsequently improve the efficiency of the shakeout and cleaning operations.

The following photographs show the difference in the casting's quality, related to the type of core sand used to form the cores. Based on these photographs, it's easy to see the impact of changing from the two Zircon sands to the O.R.C. Chromite sand.



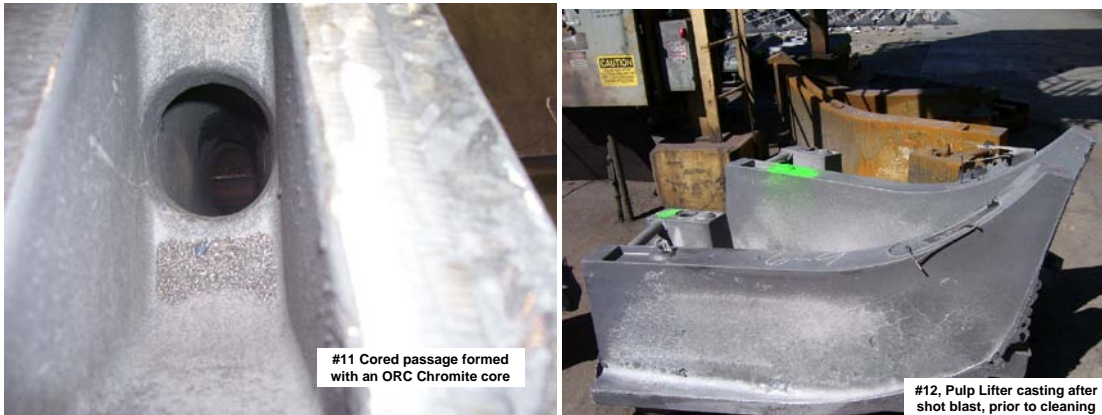
Insert #7 shows the core passage formed with a core, containing the Florida Zircon sand, with an identical core made with the O.R.C. Chromite sand. The difference in the casting's finish and excellent shakeout characteristics make the O.R.C. Chromite sand the obvious choice for difficult castings, similar to this "pulp lifter casting".



#9, Core passage made with Florida Zircon sand



#10, Pulp lifter casting, core passage was formed with O.R.C. Chromite sand



Insert #9 illustrates the difficulties we encountered, when trying to shake out the cores formed with either of the two Zircon sands. Insert #10 shows a very clean core passage, obtained when we used the O.R.C. Chromite sand. Insert #11 shows the cored section of a casting made with the O.R.C. Chromite sand, after shot blasting, but prior to any cleaning operations. Insert #12 shows the “pulp lifter casting” after shot blast, but prior to any grinding in the cleaning room.

Since our customer has received all of the castings they had ordered, we will begin evaluating the use of the O.R.C. Chromite sand on our Disco bolt blower, using a gas catalyzed coldbox binder system. The narrow particle size distribution of the O.R.C. Chromite sand, and its rounded grain structure, should allow us to blow a more dense core, with more grain to grain contact, increasing the tensile strength and allowing us to reduce the binder level require to obtain the core properties we desire. The lack of the ultra fine sand, on the 200, 270 and the pan, should also help in reducing the potential for plugging the vents in the core box, eliminating down time cleaning these vents.

M.E. Global is convinced that this unique sand will aid our foundry in the production of complex castings, and offer us a competitive advantage in today’s foundry market.