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Suggestions for Ductile Iron Production

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THE USE OF ADI AS PATTERN TOOLING MATERIAL

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The material(s) chosen for the production of medium to high volume patterns is of considerable interest. An informal survey of vertically parted, green sand iron foundries showed that pattern costs can vary between $10,000 and $100,000. Simple iron or aluminum pattern equipment is available in the range of $10,000 and more sophisticated, longer life patterns in stainless steel or tool steel can approach or exceed $100,000.

Two major concerns in the selection of pattern equipment material are dimensional reproducibility of the castings produced and wear resistance. Both of these factors inevitably affect the total cost of casting production, affecting profitability for the metalcaster. High quality tooling can produce castings with a much lower incidence of finning, reducing cleaning room time. High wear resistance minimizes pattern repair and reduces the incidence of sand erosion as cores are set into the molding cavity.

One US foundry was experiencing excessive pattern wear and increasing pattern repair costs to several high volume parts. One of these parts was a rail clip casting. The clips are used to anchor steel rails to concrete ties as in improved method over forged steel spikes driven into wooden ties. Many passenger light rail systems are equipped with millions of such rail clips. The geometry of the casting, as shown in Figure 1, is such that excessive wear was being observed after 60,000 molds.

The foundry management staff at the foundry was familiar with the economic growth of Austempered Ductile Iron (ADI) as well as the high wear resistance of ADI through its strain induced transformation to martensite (SITRAM). This led to a trial pattern plate produced with the casting inserts made of ADI. The conventional material for this particular pattern plate had been “Austenitic Stainless Steel 304”. Contributing to the wear of the pattern plate was the fact that this foundry used olivine sand versus the more commonly used silica. Olivine is a mineral containing approximately 50% MgO, 42% SiO_2, and 7.5%Fe_2O_3. Olivine exhibits more thermal stability than silica and is a much more angular aggregate. Both minerals have similar melting points and hardness values. The major difference is the particle shape. The angular nature of olivine also makes it an attractive aggregate for sand blasting operations. Its chemical basicity renders it desirable for casting Hadfield austenitic manganese steel castings.

The properties of ADI are due to its unique matrix of acicular ferrite and carbon stabilized austenite. This matrix is properly known as ausferrite. The matrix is produced through a thermal treatment known as austempering (Figure 2). Several grades are recognized by the International standards community and are partially depicted in Tables 1 and 2.

The original trials at the foundry were completed using continuously cast ductile iron bar, machined and austempered for the inserts. The first trials were run with ADI made to ASTM grade 200-155-02. Later, this was changed to grade ASTM 230-185-01 to maximize hardness and wear properties.

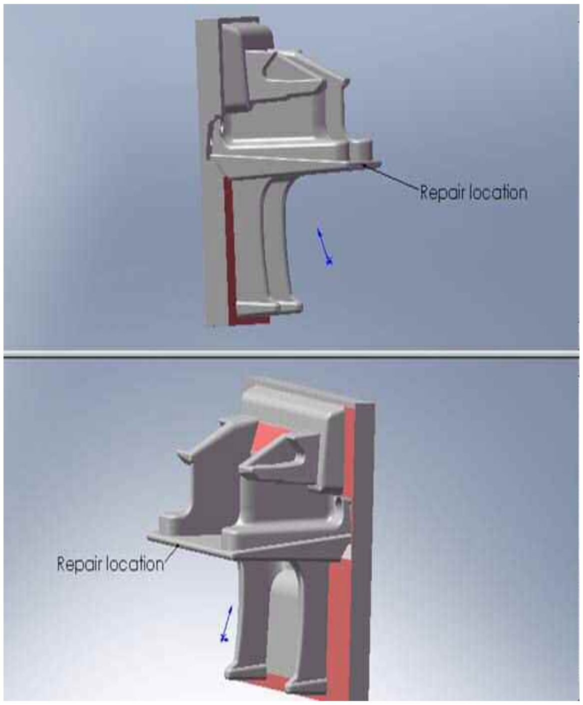

Figure 1. Areas of High Wear on Rail Clip Inserts.

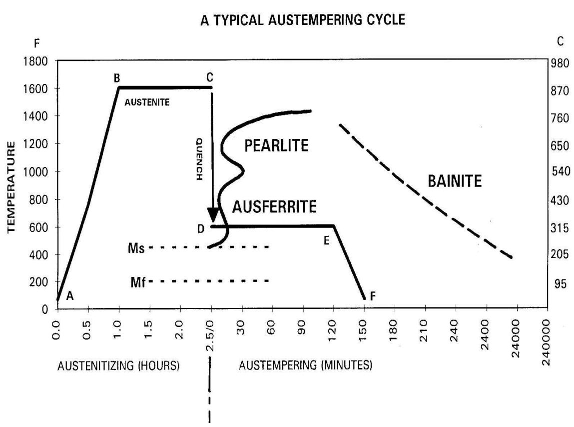

Figure 2. The Austempering Heat Treat Cycle for ADI.

The original "Austenitic Stainless Steel 304" tooling was done at a cost of approximately $26,000. As stated above, this tooling would require repair after roughly 60,000 cycles. The initial trials with ADI did not require repair until 160,000 cycles were made. The initial cost of ADI inserts, including heat treatment, is slightly more than 25% of the cost of the stainless tooling. Some design adjustments were necessary in order to take into account the predictable growth of ADI parts after heat treatment. The growth is predictable and repeatable.

As a result of the early trials, the foundry has now converted more than 500 patterns to ADI inserts. This is an excellent example of a ductile iron foundry utilizing the superior properties of ADI on an internal casting to save money and improve productivity.

TABLE 1

THE SIX ASTM A 897/A 897M - 06 GRADES OF ADI

Grade	TS ksi / MPa	YS ksi / MPa	EL %	Impact ft-lb/J	HBW
110-70-11	110 / 750	70 / 500	11	80 / 110	241-302
130-90-09	130 / 900	90 / 650	9	75 / 100	269-341
150-110-07	150 / 1050	110 / 750	7	60 / 80	302-375
175-125-04	175 / 1200	125 / 850	4	45 / 60	341-444
200-155-02	200 / 1400	155 / 1100	2	25 / 35	388-477
230-185-01	230 / 1600	185 / 1300	1	15 / 20	402-512

TABLE 2

THE ISO 17804:2005(E) GRADES OF ADI

Material Designation	TS N/mm^2	YS N/mm^2	EL %	Impact J	HBW
ISO 17804/JS/800-10	800	500	10	110	250-310
ISO 17804/JS/900-8	900	600	8	100	280-340
ISO 17804/JS/1050-6	1050	700	6	80	320-380
ISO 17804/JS/1200-3	1200	850	3	60	340-420
ISO 17804/JS/1400-1	1400	1100	1	35	380-480

Relevant wall thickness of the casting : $t \leq 30$

The R&D department of **Sorelmetal** has been active in the research and development of Austempered Ductile Iron for over 25 years. Rio Tinto (Research) has published a number of technical papers and has assisted numerous foundries as well as end users in the production and use of ADI. Do not hesitate to contact the **Sorelmetal** Technical Services directly, via your **Sorelmetal** agent or Rio Tinto Iron & Titanium regional offices to help with your ADI questions as well as any other ductile iron issues.

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