Stream treatment for processing nodular iron

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Dust, smoke and fume have long been a part of the iron foundry environment, and despite many technological advances, atmospheric pollution continues to be a problem. Legislation aimed at cleaning up the environment poses a number of serious problems for the foundry in that the capital cost of installing fume equipment, running and maintaining it does not contribute at all to profitability or casting quality. There is however no doubt that an improved environment within the foundry does reduce fatigue and improve morale within the work force.

Fume (Fig. 1) from the manufacture of the nodular iron is only one of the aspects of atmospheric pollution in a foundry and the simplest answer to this particular problem is a technique that does not create the offending fume.

The problem of spheroidal graphite (SG) iron fume has been studied by many investigators and many remarkable advances have been made not least the very successful Inmold process. Very soon after the adoption of the Inmold Process in production foundries, development work started to utilise some of the inherent principles for a batch system capable of producing a ladle of SG without the pyrotechnics then associated with most batch methods.

The technique became known as the ‘FLOTRET PROCESS’: — as metal was directed to ‘flow’ over the alloy in a controlled relationship.

In 1974 a report was presented to the American Foundrymen Society entitled “Mould nodularising and stream treatment technique for the manufacture of nodular iron”. This report described development work and production with the FLOTRET PROCESS up to that time.

Some of the basic requirements which emerged from this initial work was:

1. Nodularising alloy solution had to be controlled to ensure that layering in the receiving ladle did not occur. This phenomenon has been reported even when sub-surface ladle treatments have been used with a reduced but still apparent boil. In the case of this process there was no ladle activity at all so early alloy solution had to be avoided.

2. To eliminate fume and fume reactions must be contained within the unit.

3. The treatment unit was to be reusable therefore a degree of self cleaning was required. This requirement of self cleaning had to fit in with the factors involved in avoiding layering. It was established and later adopted that alloy should be dissolved during 80% of the treatment cycle.

4. The unit must be capable of processing a reasonable range of metal weights. This was generally achieved without undue difficulty as the critical factors of cleaning and layering are associated with pouring rate rather than pouring weight. The limiting factor for treatment weights is the maximum amount of alloy which can be contained within the chamber.

Basic designs
The design of the unit at the time of the A.F.S. report is shown in Figs 2 and 3.

Most of the requirements of fume and flare eradication were achieved but the chamber did exhibit a tendency to deteriorate as drosses were accumulated.

It was established that the inlet to outlet area ratios must induce a heavy choke. The position 1 to position 2 established as a minimum for this unit.

Solution control was satisfactorily achieved using the relationship.

Flow processing rate (lb/sec)  
Cross sectional area of chamber (sq. in)  
= 0.75 factor

The unit was designed to process metal weights between 250–500 kgs. In the particular foundry involved in the development work a single treatment weight of 320 kgs was the requirement, treatment time in 40 seconds. The resulting treatment of 8-0 kgs/sec was considered satisfactory in overcoming the possibility of back reaction which can occur if the rate of flow falls below 6.5 kgs/sec, the figure established with the alloy selected for this work.

A number of units were constructed for a variety of conditions and generally resulted were as forecast from the chamber area/flow rate relationship and the use of the well known formula:

\[
\text{Area of outlet} = \frac{\text{K x treatment weight}}{\text{Treatment time x Effective head height}}
\]

K for this purpose was taken to be 0.39.
Nodulariser & Chamber Requirements
As in the case of the Inmold Process it was established that a granular alloy allowed reproducible solution rates and that the voids between lump alloy had a tendency to be penetrated quickly causing early solution.

Any fines in the alloy tended to oxidise quickly giving a poor yield of magnesium and also contributed excess dross and dirt.

As the alloy was consistent in grading it became a simple matter to establish chamber depth once the chamber area related to flow rate has been calculated:

\[
\text{Metal Flow Rate} = \text{factor}
\]

\[
\begin{align*}
8-0 \text{ kg/sec} & = 160 \text{ sq. cms.} = 10 \times 16 \text{ cms} \\
0-05 \text{ factor} & \\
1-2\% \text{ Prosloly alloy for 320 kgs} & = 3-84 \text{ kgs} \\
& = 2-03 \text{ (Bulk density) gms/cc}
\end{align*}
\]

\[
= 1891 \text{ cm}^3 \text{ (Total volume of alloy)}
\]

\[
\frac{1891 \text{ cm}^3}{160 \text{ sq. cms.}} = 11-8 \text{ cms height in chamber of L x B 160 cm}^2
\]

To this basic height of alloy, allowances must be made for metal inlet etc.

Units of this type have operated for a number of years during which time some limitations were noted. Close control over sulphur levels was required and even in the best run foundry problems due to high or variable sulphurs could arise and as the units were moulded as slab cores it was a difficult job to alter chamber dimensions if problems arose. It was also apparent that sealing of the units after recharging could cause problems due to poor contact thus allowing leakage and operator discomfort.

Modifications to the original concept were tried during this period, most attractive amongst these were feeding the alloy on to the metal stream surface either by gravity of in a medium of nitrogen under pressure (Fig. 4 and 5). Both concepts were only partially successful and were subsequently replaced with a version which considered the question of alloy reactivity.

The current simplified design developed when the reaction chamber was moved directly under the pouring basin. In this case alloy could simply be charged directly down the pouring basin, this removed the earlier problems of airtight sealing (Fig. 6) of the alloy chamber.

The slab core design has been replaced with a simple steel box in which a variety of refractory linings have been used including a silicate sand moulded around the pattern.

The dimensions of the reaction chamber are calculated from the basic formula, however, the exit end of the chamber is formed from a graphite tile. The position of the tile establishes the workable volume of the chamber. There is a 25 mm gap below this first tile to allow draining and cleansing of the chamber. A second brick set at the top of the unit establishes an early choke and ensures that any initial reacting alloy carried through does not cause back pressure.
The first units constructed were designed to process 1,000 kgs in 50/60 seconds with iron containing 0.020/0.025 sulphur. Fig. 7 shows one of these units in use, Fig. 8 shows the most recent design for treatment weights between 250-500 kgs. Clamps are used for joining the box which facilitates easy opening, the single leg shown is a leveller for the cope half.

The unit has generally been used with a ladle pour through, in these cases final pouring temperatures are between 1390°C/1400°C from a pouring ladle temperature of 1470°C/1480°C.

In production conditions the unit produces good quality SG without any visible fume or flare.

Fig. 9 shows the treatment of 300 kgs of metal. Over a number of months, SG produced in this foundry has been characterised by excellent fluidity high nodule count and freedom from cementite.

Fig. 10 shows a range of castings produced using the process, and figure 11 typical pearlitic/ferritic nodular iron microstructures achieved in production.

Fig. 6 — Charging the unit.

Fig. 12 indicates a number of treatments during the preproduction trials at the foundry.

Later modifications were made to similar units to permit processing direct from electric furnaces. Pouring basin areas were increased to cover the tapping arc of the furnace. Solution factors were altered to bring the chamber areas in line with the greater variations in tapping rates experienced.

Conclusion

The FLOTRET PROCESS has now been developed to the extent that it can be used in most foundry situations for the production of good quality SG without fume or flare. The units are inexpensive and can be used with many types of refractory. The unit can be used in jobbing situations and because of its portability allows the metal to be processed near the mould thus limiting the likelihood of fade. The process has also been employed in mechanised foundries producing over fifteen ladles per hour of good quality SG irons.
Fig. 8 — A unit designed for 250-500 kgs treatments.

Fig. 9 — The treatment of 300 kgs metal.

Fig. 10 — A range of castings produced by the process.

Fig. 11 — Typical microstructures achieved in production.
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**Foundry A**

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<th>DATE &amp; WEIGHT</th>
<th>PS2 ALLOY%</th>
<th>TEMP FURNACE</th>
<th>POURING TIME</th>
<th>Te</th>
<th>Si</th>
<th>Ma</th>
<th>S</th>
<th>Mg</th>
<th>REC%</th>
<th>NOD%</th>
<th>NMM TENSILE</th>
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Fig. 12 — Preproduction trials data.

Capital investment is minimal with the FLOTRET unit and in many cases it has been found that cost savings over existing practices have been made.

Acknowledgements
The authors wish to thank the following foundries and organisations for photographs, information and assistance: Materials and Methods Limited (Reigate); Serck Audco Valves (Newport, Salop); S. Russell & Sons (Leicester); Swinburns (Wallsend); Brockmoor Foundry (Brierley Hill); Pickands Mather (U.S.A.) and International Mechanite Metal Co. Ltd. (Reigate).

FLOTRET is a reg. name

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Specialist castings service

Protocast Limited, of Risley, Warrington offers to industry a one-off and small batch production service for ferrous castings up to 60 kg (135 lb). The service is particularly suitable for prototype component manufacture and the replacement of machine parts.

The range of materials available extends from grey iron grades to high nickel alloys. Included in the range are austenitic and hardenable stainless steels, heat and wear resisting steels, low alloy/high strength steels, tool steels and the nickel and cobalt alloys.