Seventh Australian Asian Pacific Conference

ALUMINIUM CAST HOUSE TECHNOLOGY

EDITED BY

P.R. Whiteley

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CAST HOUSE
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This International Conference was staged by the G.K. Williams Cooperative Research Centre for Extractive Metallurgy* and was held during 23 – 26 September 2001 at the Wrest Point Hotel, Hobart, Australia.

Edited by

Peter R. Whiteley

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PREFACE

This International Conference follows six previous very successful conferences in the series, which are held every two years in Australia. The continued provision of sponsorship from the aluminium industry and related companies continues to help attract well renowned speakers from this country and round the world, in all aspects of aluminium casthouse technology.

The high quality of the technical contributions has seen the conference grow progressively in reputation and size over the years.

At the conclusion of each Conference, delegates are required to complete response sheets aimed at providing information to the Steering Committee on topics, which would be of interest in subsequent conferences, as well as any suggestions as to how the conference may be improved. The papers presented here at the 7th Conference were selected in response to the needs identified by the delegates to the 6th Conference, and cover a wide range of issues, from management through to detailed metallurgy.

The Editor, the Conference Secretariat, and the Steering Committee would like to thank the authors for the considerable time and expertise put into their work in preparing papers for this conference. We also extend our appreciation to the TMS (The Minerals, Metals & Materials Society) for its continued support and for producing this publication. We are also indebted to the other companies and organizations for their participation in the trade show and the plant visits, which have become important adjuncts of the Conference.

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TABLE OF CONTENTS

MANAGEMENT

QUALITY

FURNACES

MELT TREATMENT

DC CASTING

CAST HOUSE SAFETY

CONTINUOUS CASTING

HEAT TREATMENT

MAGNESIUM CASTING

RECYCLING

REFRACTORY

PROCESS CONTROL

MANAGEMENT

PROSPECTS FOR THE WORLD ALUMINIUM MARKET

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ABSTRACT

The world aluminium market is currently in the grips of two opposing, yet equally significant factors that are likely to determine its future direction in the medium term. First, a decline in world consumption, initially triggered by a sharp downturn in United States growth, continues to affect important end-use sectors, namely construction and motor vehicle manufacturing, world-wide. Second, increasing electricity costs are an important influence on the supply side, with the scale of recent cuts in the US Pacific Northwest deepening and similar problems looming in Brazil and Russia.

In this uncertain market environment it is expected that world aluminium consumption growth will increase in 2002, before stabilising with assumed higher levels of world economic growth over the medium term. However, in a market characterised by growing demand for aluminium, price outcomes will largely depend on the rate of commissioning of additional smelting capacity (and capacity restarts in the United States and elsewhere), and the ability of producers to lower their operating costs.

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ALUMINIUM CASTHOUSE TECHNOLOGY OVERVIEW

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ABSTRACT

In the two and a half years between the 6th Casthouse Conference and this, the 7th Casthouse Conference, there have been some significant developments in technology. The purpose of this paper is to provide an overview of some of these advances – many of which will be covered in detail in subsequent papers.

By and large, the enhancements have been evolutionary rather than revolutionary, as the industry strives to make steady progress in productivity, safety, melt loss, quality, energy efficiency and reduced environmental impact.

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INTRODUCTION

The author has been fortunate enough to have been involved with a large number of casthouse expansions and rationalizations in the last couple of years in Europe, South Africa, the Middle East, North America and Australia. This work has been involved with primary smelters, remelts, and recycle facilities, and has provided the opportunity for exposure to a fair range of the latest aluminium casthouse technological developments. My focus in these projects has been primarily from an engineering and process perspective, and the following commentary will concentrate on engineering science – not metallurgy.

In order to structure the presentation, we will start at the furnaces, and work our way through the process.

The Potroom/Casthouse Dilemma

In a smelter context, the casthouse problems commence with management of the potroom interface. In a smelter having a product mix consisting of VDC cast products and possibly some continuously cast remelt material, the casthouse demand for liquid metal is generally rather random over time – whereas the supply of potroom metal is much more regular – certainly not constant; but at least regular. So we have what is a fundamental mismatch between two processes exacerbated by shift changes, equipment breakdowns on either side, process delays and the like. There have been some interesting ways evolved to reduce the potentially serious impact of this mismatch ranging from:

- Alcan installed a 100T reservoir furnace at DC 45 in Arvida to provide a buffer between the potrooms and the two 67T tilting holding furnaces.
- DC 1 at the U.K. Lynemouth smelter has, what was for many years, one of the most productive DC centres in the world – by again having a 3-furnace configuration.
- Other parts of Alcan have "managed" the interface – and have essentially enjoyed potroom tapping on demand in order to achieve up to 15 casts per day from two 54T tilting holding furnaces on a single billet pit.

There has been a trend over the last couple of years – certainly in South Africa and Australia to try to put some more science into managing the metal flow, and we will have a very interesting presentation from Bayside Aluminium on their work in this area.

Two other issues further confound the interface.

The first has to do with sodium removal.

Sodium appears in metal tapped from reduction cells at a level of about 80 ppm. Many rolled products, and increasingly extrusion billets, now call for sodium levels of 2 – 3 ppm or less. Having been personally responsible for technology transfer of TAC, and having nurtured the development of process intensivity in furnace fluxing, we will see what Martin Taylor has to say about these two quite efficient but competing technologies.(i.e TAC vs RFI)

The last serious issue at the interface is the consideration of metal temperature. Metal is tapped from cells at about 960°C. This has sufficient superheat to melt about 10% run-around scrap without the need for supplementary energy – if only we could get the metal from potrooms to casting without excessive delays, and the potential loss of this free energy. On the other hand, if we have a plant such as Tomago or Hillside or Portland where the dominant product is remelt ingot, we need to dissipate this superheat as quickly as possible – because now it is likely causing a delay to the start of a cast, because it's too hot.

Furnaces

The trends in smelter furnaces are away from long rectangular aspect ratio furnaces with multi doors to deeper, squarer, single door furnaces operated with much greater process intensivity by virtue of subsurface stirring of one form or another to promote improved reaction kinetics, convective melting, and temperature homogeneity.

I am sure Clark Weaver will concentrate on the philosophy of closed door furnace operation in his presentation. Suffice therefore just to say that furnace doors should be opened for the absolute minimum possible time because when the door is opened the burners go off and energy is radiated from the furnace. That is to say, there is a double loss of time – the time the burner is off and the time then required to bring the furnace back up to temperature.

Most people here will understand that the dominant heat transfer mode in a reverberatory furnace is by radiation – and radiation is a function of absolute temperature to the fourth power. This bit of engineering science can be exploited to dramatically reduce melting time and to improve energy efficiency by:

- Using mass flow control of fuel and combustion air to achieve proper air fuel ratio and maximum flame temperature.
- Using good furnace pressure control and properly sealed doors to again achieve maximum furnace temperature.

In the case where a furnace is melt rate constrained (e.g. in a remelt), supplementary oxygen or indeed straight oxy fuel burners are increasingly finding favour – to again exploit the T^4 effect.

Launders

This is one of the most neglected items of casthouse equipment, and yet it need not be so. The main problems are:

Temperature drop – especially at the start of a cast,
Launder maintenance
Launder sizing.

I recently visited GM's Saturn automobile plant in Tennessee. The launder from their holding furnaces to the die casting machines is about 100 meters long with zero temperature drop from one end to the other. This is achieved by good insulation and electrically heated launder lids (supplied incidentally by Schaefer Furnaces). I am not a lover of long launders – but the above example just illustrates what can be achieved.

Most plants nowadays routinely apply boron nitride coatings to launders, as this is a very effective non wetting agent to facilitate skull removal between casts. It is crucial however, not to preheat launders with plain gas burners, since at temperatures over 1,000°C the boron nitride is destroyed and aluminium will stick to the residue better than it will to refractory. Therefore, temperature regulated hot air burners must be used for launder preheat – and, launders should be the minimum possible length consistent with sensible layout, and launders should have insulated covers.

Casting launders should be sized so as to give a metal velocity not exceeding 10 m/min at maximum casting rate. This will provide a stable skim surface on the metal in the launder.

In Line Metal Treatment

Steady progress continues to be made in the area of grain refining. At this years TMS Conference in New Orleans, two papers were given citing the effect of the so called Growth Restriction Factor (Q) on grain size – and fortunately came up with similar conclusions. David St. John was one of the presenters, and will give us a further update on his work which will help to reduce the cost of grain refining by optimising rod use – based on alloys being cast, and possibly combined with supplementary additions of titanium to the furnace prior to casting.

My observations indicate that in most plants the rod grain refiner addition rate of ½ kg per tonne of metal is sufficient, in lieu of the more traditional 1 kg/tonne.

Steady progress also continues to be made in dual stage plate filtration although two issues persist:

- The first is the need for excellence of preheats and temperature control of the plates, and the cast start strategy – recognising that the plates can lose temperature quickly after the preheaters are removed.

- The second is that the inclusions capture mechanisms are very subtle (delicate) – and disturbances in metal flow rates, changes of metal head or physical disturbance of the filter box can result in liberation of inclusions.

New degassing installations continue to be dominated by the Alcan Compact Degasser with the other Canadian product from Casthouse Technologies also making some headway. The attractiveness of these technologies is of course, that there is to all intents and purposes, "zero hold up". That is to say, there is no residual metal left in the degasser at the end of a cast, with none of the alloy change and temperature control issues, which complicate conventional box type degassers.

The initial ACD's were designed to run "with at least 200 mm metal depth." It has been found retrospectively that better performance is achieved with some 300 mm – but this is frequently quite difficult to achieve after the event (i.e. to change from 200 to 300 mm).

DC Casting

True totally automatic DC casting of large sheet ingot is now taken as a given, and there are many plants around the world which start, run and terminate such casts without any operator intervention. The results are higher recoveries, better quality, and importantly, significantly improved safety.

Billet casting has been slower to ride this automation wave – due I suspect to operators misconceptions about smaller billet run outs being easier to manage than sheet ingot run outs – especially for hot top level pour type configurations for billet. Thankfully however, we now see technologies such as Wagstaff's Rapid Fill, and automatic run out detection systems providing the same opportunity for billet caster automation as for sheet ingot automation.

As to the casting machine itself, most machines are now fitted with internally guided cylinders thereby obviating all of the problems of rail and shoe adjustments, cleaning spills off shoes, and quality issues caused by platen hesitancy from damaged rail surfaces. Platens and stool bases are now commonly open web design rather than tented, permitting some savings in pit depth.

Continuous Casting

Having worked in the steel industry prior to joining the aluminium sector, I am hyperconscious of the impact that continuous casting had on steel. Virtually all of the world's steel ingot teeming practice has been converted to continuous casting for billet, bloom, slab and sheet – for reasons of productivity, capital cost, operating cost, and yield. The same drivers exist in the aluminium industry, and we will see the further replacement of DC cast product with continuously cast product whether it be for wire bar, billet, remelt ingot, or sheet products – witness the 3 presentations we have later in the week on this subject.

Doesn't it seem just a little silly that we in the aluminium industry continue to make sheet ingot 500 mm thick and then roll this down into 6 – 7 micron foil? It's hardly near net shape processing is it?

Automation

I have already mentioned our fully automated sheet ingot DC casting processes operating primarily on what I call level 1 process control (i.e. programmable logic controllers).

The developments in process control have also been enhanced by some significant improvements in level 0, field instrumentation such as laser level sensors and the like. However, the greatest opportunities for cost savings, productivity improvement, and higher quality, will come from greater attention to the level 2 – Supervisory Control and Data Acquisition systems. If we say that we want to operate a furnace with Closed Door Furnace strategy, then we must know how long the door was open, and why.

Similarly, we must know when scrap was added, when the burners went on, what is the furnace melt temperature, when to alloy, stir, flux, sample, settle and be able to tune these activities. The only sensible way to do this is by having a real time SCADA system in place to capture these key data – and where appropriate trend it, alarm it, and control it.

There are plants around the world, which do all of this routinely, and as a result enjoy world's best productivity, fuel efficiency and product quality.

Modelling

Mathematical modelling of our processes, in the widest sense of this term continues to provide tangible benefits in the casthouse and we have a number of presentations dealing with process simulation, solidification modelling and mould stress modelling. All of these applications put computers to work for us and save time by not having to run experiments to achieve results- rather just to validate the computer model results.

Conclusion

The purpose of this presentation was to provide you with a snapshot of some of the more important trends in casthouse technology, and to alert you to the fact that we have experts from around the world who will deal in much more detail, with what I have glossed over.

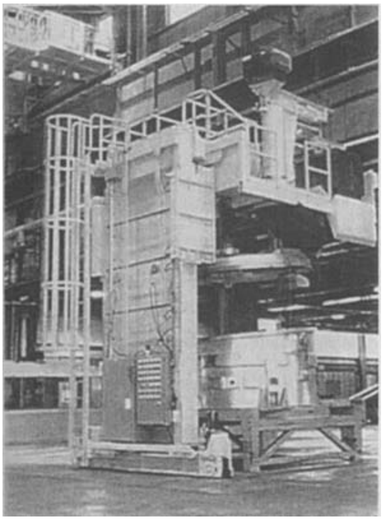
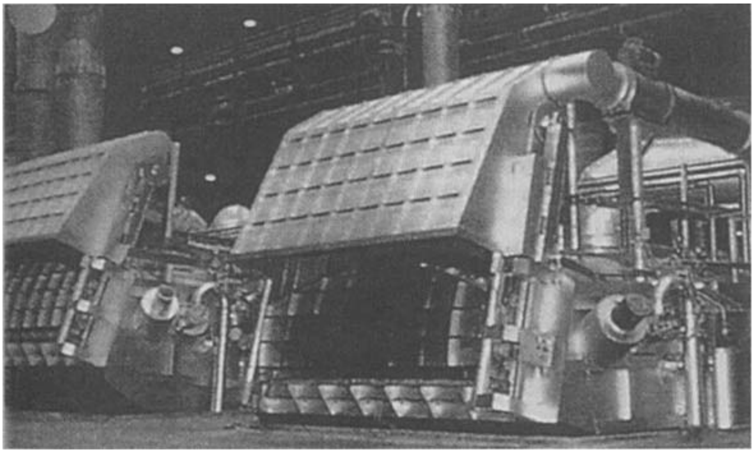


Fig 1 (Left)
TAC Station

Fig 2 (Below)
Modern Furnaces



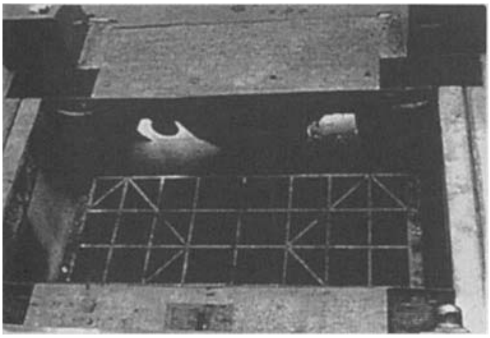


Fig 6 (Left)
Open Web Platen

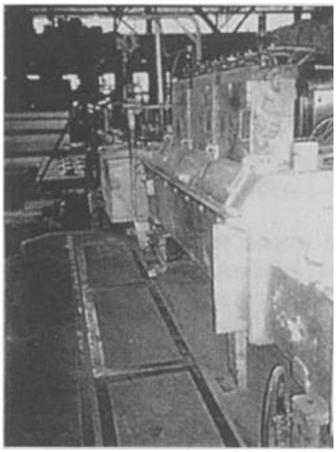


Fig 4 (above)
ACD Degasser

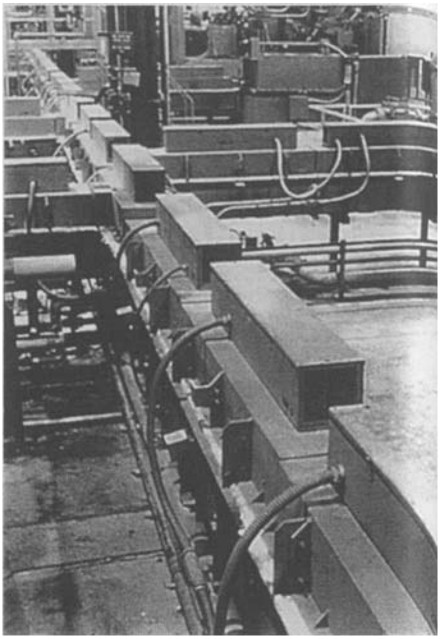


Fig 3 (above)
Very long heated launder

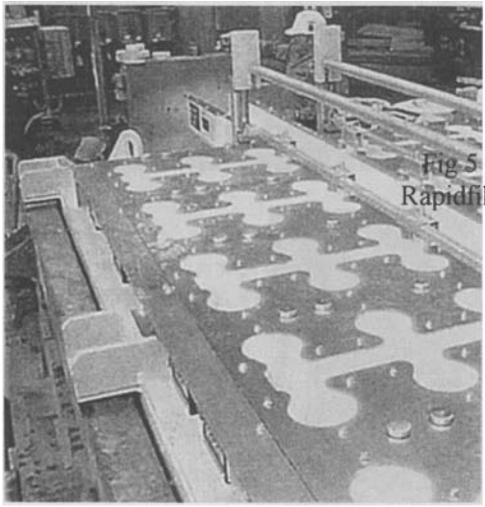


Fig 5 (Left)
Rapidfill Table

REVISED HOT METAL LOGISTICS AT BAYSIDE ALUMINIUM

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Abstract

Until recently Bayside Aluminium operated with Potrooms that used different ladle configurations. As these Potrooms had dedicated destinations for the ladles, the optimal utilisation of the metal was very complex.

The introduction of a "common" ladle has opened a whole new world for Bayside Aluminium. Not only has it meant proactively exploiting the metal composition derived from any of the three Potrooms, but also converting it into maximised value added products. This philosophy articulates the company's mission statement to become Billiton's best investment by maximising value added production in the Casthouse.

This paper discusses the introduction of the "common" ladle and the consequent single metal scheduling concept that it has precipitated and how this concept contributes to the improvement of Bayside's bottom line.

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Introduction

Bayside Aluminium is one of the three southern African primary Aluminium smelters owned by Billiton Plc, viz. Bayside, Hillside and Mozal. The smelter is situated on the north-eastern coast of South Africa at the port town of Richards Bay.

The Bayside smelter is the only one of the three smelters that produces value added alloyed products, servicing both the domestic and the export markets. Hillside and Mozal produce remelt ingot exclusively for the export market.

Bayside has an annual primary reduction capacity of approximately 180 000 tons. The reduction capacity is made up of one pre-bake technology Potline, called A line, which has an annual capacity of 92 000 tons and two smaller Soderberg lines, called B and C, which have a combined annual capacity of 90 000 tons. Input tonnage is bolstered by accepting liquid metal from the Hillside smelter in ad hoc batch lots to suit Bayside's requirements.

The metal is solidified in a Casthouse that is equipped with a variety of casting machines and technologies that span the following:

- Rod casting on a Properzzi rod line.
- Billet casting on a Wagstaff Hot-top airslip table and on a conventional casting table.
- Rolling slab casting on Wagstaff Hot-top technology and on a conventional casting table.
- Foundry alloy casting on an horizontal casting machine of Hertwich technology.

The metal is tapped in the Potrooms and transferred to the Casthouse on hot metal trailers that are drawn by industrial tractors. The ladles are weighed on entry to the Casthouse and then transported by overhead crane to the required furnace. In the one section of the Casthouse, the ladles are siphoned into the furnaces and, in the other, the ladles are placed onto hydraulically operated ladle tilters that pour the metal into the furnace.

The metal arrives into the Casthouse via a North and a South ramp, as the Casthouse and Potroom operating floors are at different levels. The Casthouse is serviced by a sufficient number of downshop overhead cranes to handle the ladle traffic. These cranes are remote controlled for ease of multi-level floor operation. The metal split between the North and South Casthouse sections is 50/50, i.e. 90 000 ton per annum each.

The North and South Casthouse sections used to operate as separate independent business units. Each Casthouse section was generally linked to a specific Potroom by virtue of its ladle handling capability, and this gave rise to an inefficient utilisation of metal. A ladle with high Fe originating in Potroom A would have to be dealt with in the South Casthouse. This did not always propagate the optimal value add that the ladle could have offered were it to have been blended with an ultra low Fe ladle that could have simultaneously been tapped in Potroom B for example, unless the ladle was decanted into a common ladle that was used in the North Casthouse section. This was a practice and was not encouraged. Unfortunately, the downshop overhead cranes could not cross into one another's sections to eliminate the handling discrepancies between sections, as they were on different gantries.

The common ladle

The common ladle has a net metal carrying capacity of 5.2 ton. It is a tall thin cylindrical vessel that is fitted with a round spout that is high up on the side of the ladle. The ladle has no lid and the top surface ring is relied upon in Potrooms B and C to achieve a vacuum seal for the siphon lid assembly that is used to tap the pots. It is equipped with two large trunion points, around which an independent spreader beam can be hooked. The spreader beam is hooked onto the overhead crane in order to lift and move the ladle from the trailer to the furnaces. Figures 1.1 and 1.2 show the old Potroom A ladle that has been retired and Figures 1.3 and 1.4 show the common ladle being tilted and siphoned.

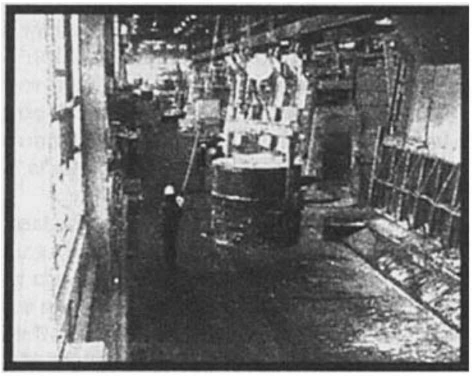

Figure 1.1 Old Potroom A ladle

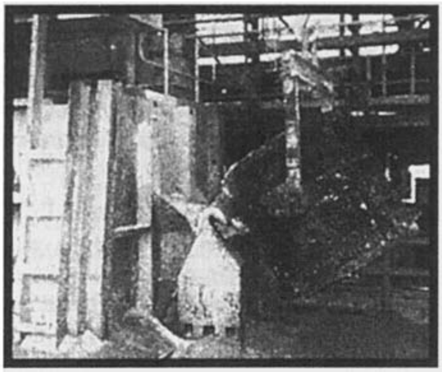

Figure 1. 2 Old Potroom A ladle being poured

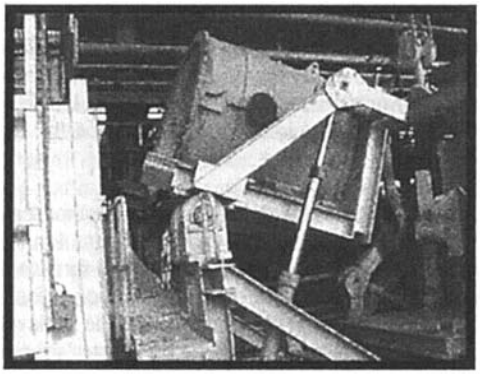

Figure 1.3 Common ladle on tilter

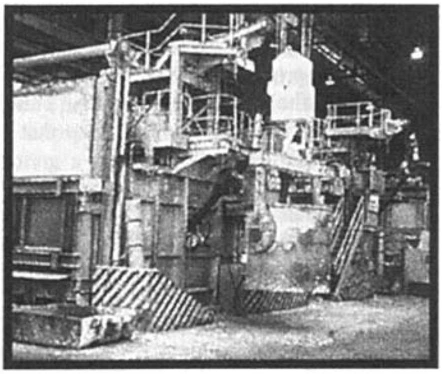

Figure 1.4 Common ladle being siphoned

The old hot metal flow system

Potroom A would generally have fed the South Casthouse where the rod plant and billet casting facilities are housed. Potrooms B and C would have fed the North Casthouse that houses the horizontal foundry alloy caster and the rolling slab casting facilities (see Figure 2.1).

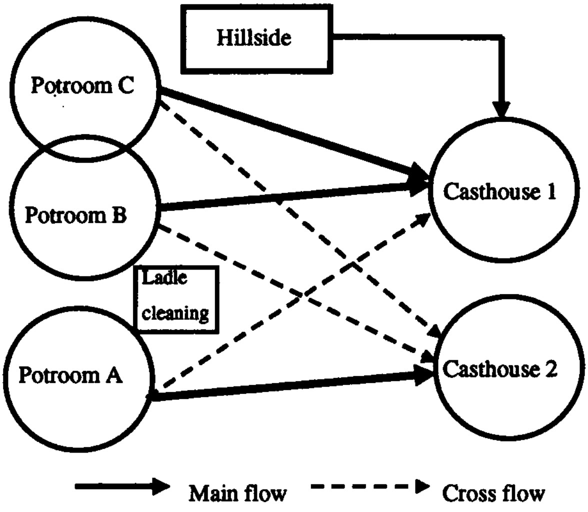

Figure 2.1 The old hot metal flow system

The metal would come to the Casthouse on a ***PUSH*** system basis from the Potroom and the Casthouse would have to take the metal and solidify it as quickly as possible as no excess casting capacity was available. This led to metal being solidified in an ad hoc system without any proactive scheduling to prevent low Fe metal being cast into slab and resulted in Fe being being added as an alloying element. The only time that any proactive scheduling took place was when alarm bells were rung to identify excessively high Fe ladles. These were blended into the process by staggering their tapping times via a verbal agreement between the Potroom and Casthouse shift supervisors. This effectively worked away the high Fe ladles, but did not address the extra low Fe ladles that sacrificed the value adding opportunities of the entire Casthouse.

No account was taken of the fact that ladles could be cross-dispatched between Casthouses and blended on the strength of the Fe levels. No proactive effort to blend the highest and lowest Fe ladles to provide two average-level Fe ladles that could be used in almost any furnace was carried out on shift. This would prevent the situation where a particular furnace on a foundry alloy casting line was half full but could not accept the next two ladles because the Fe level of the ladles was too high. These two ladles would be sent first to the rolling slab caster's furnace, thus delaying casting on both furnaces. The lack of cross-dispatching was caused by the Casthouse ignoring its general metal supplying Potrooms for its total input metal, instead of drawing on all three as potential, simultaneous metal sources. Cross-dispatching increases the chances of finding blendable Fe ladles to suit any situation simultaneously and improves casting station turnaround times by batching furnaces quicker.

Finally, the supervision of the metal-receiving ramp, the furnace preparation, casting and finishing fell under the control of a single shift supervisor. This task required a span of control too large for one person, given the poor literacy rates of the average operator on shift. Much of the computer scheduling and casting station control was carried out by the supervisor as well as the line function supervision of the entire shift.