

# The Alcan Compact Degasser - Operational Experience and Performance

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## INTRODUCTION

The presence of alkali elements, dissolved hydrogen, and non-metallic solid impurities can adversely affect the physical and chemical properties of cast aluminum products. The molten metal must therefore be subjected to a preliminary treatment prior to casting. An in-line degassing process efficiently controls dissolved hydrogen which forms undesired porosity upon cooling and solidification of the aluminum. If the treatment gas in the degasser contains a reactive component such as chlorine, alkali element impurities can also be removed while nonmetallic solid particles are swept to the metal surface by flotation where they accumulate in the dross.

In-line degassing processes, employing rotary gas injectors, are now widely accepted in the aluminum industry due to their numerous advantages. For example, continuous metal treatment does not affect the productivity as batch treatment does, and it is also more efficient in terms of chlorine consumption than furnace fluxing. Presently, there is no alternative to in-line treatment for providing consistently low hydrogen levels in the cast metal.

Although in-line degassing processes are efficient and provide the required level of metal treatment, plant personnel are becoming more attentive to serious operational limitations. Depending on the treatment capacity, between one and three tons of molten aluminum are retained within the degassing unit between casts. Metal retention is a serious drawback for multi-alloy cast shops, due to scrap metal produced by draining the degassing unit at alloy changes. In addition, retention of metal necessitates complex equipment for metal beating and draining. The size and complexity of presently commercialized in-line degassing units result in significant capital and operational costs. The floor space requirement of up to 15 m<sup>2</sup> can also make their use impossible in smaller casting centres.

The Alcan compact degasser<sup>(1)</sup> is a new multi-stage in-line degassing process which treats the metal directly in the trough. This degasser provides metal treatment efficiencies equivalent to or better than existing technologies and eliminates metal retention between casts. The equipment technology is also greatly simplified. This article describes process operation, metallurgical principles and equipment.

## PROCESS OPERATING PRINCIPLES

The Alcan compact degasser (ACD) consists of a series of rotary gas injectors arranged within the casting trough as shown schematically in figure 1. The argon treatment gas forms bubbles that rise through the molten metal, removing hydrogen by diffusion. Rotors are separated by vertical baffles that divide the trough into several treatment stages where the metal circulates at a plug flow regime.

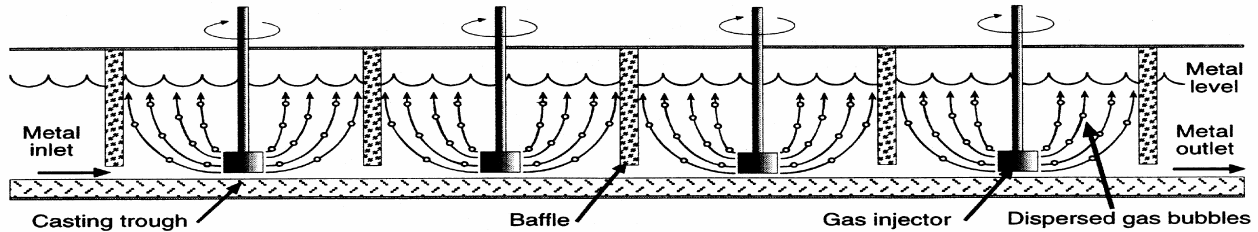


Figure 1 : Schematic representation of a multi-rotor compact degassing unit

Although in-line degassing processes in general provide efficient removal of hydrogen, nonmetallic inclusions, and alkali/alkaline earth impurities, only hydrogen removal is considered for process sizing and selection. The kinetic factors which influence degassing rates have been documented elsewhere<sup>(2, 3)</sup>, but it is generally accepted that diffusion of the hydrogen through the liquid metal phase is the dominant rate controlling step. As a result, the gas-metal interfacial contact area generated by the inert gas bubbles plays a critical role in establishing the degassing efficiency. The gas-metal contact area is proportional to the metal depth and the treatment gas flow rate and inversely proportional to the bubble diameter and the terminal rise velocity of the bubbles through the metal.

In addition to the gas-metal interfacial contact area, the hydrogen removal efficiency of an in-line degasser depends upon other factors including: the metal residence time, the reactor volume, and the number of treatment stages. The low reactor volume and metal depth of the Alcan compact degasser act to reduce hydrogen removal efficiency. In order to counter-act the negative influence of low reactor volume and metal depth, and to achieve degassing performance comparable to a conventional in-line degassing process, the Alcan compact degasser must generate treatment gas bubbles one half to one third of the average diameter compared to those generated by conventional in-line degassers. By use of rotary gas injectors, a high specific (mechanical) energy input is generated which is crucial not only for the generation of small bubbles but also to stabilize the relatively high volume holdup of gas present in the liquid metal. As a result, the volume fraction gas holdup in the Alcan compact degasser is approximately 10% to 15 % compared to typically less than 5% for conventional degassers.

Table 1 shows a typical operating cost breakdown for a commercial Alcan compact degasser processing 100,000 TPA. The largest portion of the operating costs are the treatment gases. The costs for refractory and maintenance are estimated on the basis of a 12-month service life for refractory components and average maintenance requirements of 5 hours per week.

**Table 1 - Typical Breakdown of  
Alcan Compact Degasser Operating Costs**

Items	Cost (\$ CDN per tonne)
Consumable parts	0.35
Treatment gases	0.45
Maintenance	0.15
Refractory	0.05
Electricity	Negligible
<b>Total</b>	<b>1.00</b>

The maintenance includes lubrication of bearings and rotary joints, replacement of belts, standard maintenance of gas panel parts, and cleaning of the exhaust ducts. Other maintenance operations are minimized by the simplicity of the mechanical design and the absence of a heating device. The maintenance of the degassing trough refractory requires the same operations as any other regular trough section.

It is to be noted that there are no costs associated with the Alcan compact degasser while in the HIGH position. This represents a significant advantage for plants degassing only a part of their production but having to keep the degasser operational full time.

### PLANT IMPLEMENTATIONS

The Alcan compact degasser was first tested in molten metal towards the end of 1992 in Alcan's Arvida Research and Development Center. Shortly after these trials, the development effort continued in two nearby plants: Alcan Smelter & Chemical's Grande-Baie Works and Alcan Wire & Cable's Lapointe Works.

The first prototype of the Alcan compact degasser was installed in Grande-Baie Works in 1993 and later replaced by the first industrial unit in mid 1994 which operates at a maximum flow rate of 750 kg/minute. It is located in a section of trough common to both casting furnaces, upstream from an Alpur D-5000 degasser. Because Grande-Baie's Alcan compact degasser was in series with the Alpur, which minimized the impact on production, this was the site where most of the metallurgical process demonstrations took place. After completion of the metallurgical trials by the technical group, the Alcan compact degasser was operated for a few months by the plant production group, in parallel with the Alpur, to assess its reliability and obtain qualification from the customers. The Alpur was finally stopped in the second quarter of 1995.

Grande-Baie Works' main benefits in replacing its conventional degasser was a simpler operation and lower operating and maintenance costs. It also has more flexibility for alloy changes.

The number of treatment stages is another aspect of the Alcan compact degasser design which has a considerable impact on the metallurgical performance. The chemical driving force for hydrogen diffusion during the degassing process is the hydrogen concentration difference between the treatment gas and the molten aluminum. The multiple stage design for an in-line degasser is advantageous since the hydrogen concentration in the metal reaches its minimum level only in the last treatment stage. This increases the concentration driving force in all previous stages, and as a result, the argon treatment gas is utilized more efficiently.

### TYPICAL METALLURGICAL PERFORMANCE

The number of rotors used in the Alcan compact degasser, for a given casting plant depends on the alloy compositions and casting rates, and to a limited extent, on the trough design. A typical metal depth of 20 cm to 25 cm is used in the trough.

Over the past two to three years, several Alcan plants have implemented the ACD for regular production. The following metallurgical data represents typical performance of the Alcan compact degasser with direct comparison to a conventional in-line degassing unit.

#### a) Hydrogen removal

The hydrogen removal performance of the ACD compares well to conventional in-line degassers. Figure 2 shows measurements taken before and after each degasser using an Alcan  $\tau_m$  analyzer. Hydrogen levels show that the Alcan compact degasser typically maintains a 55-60% hydrogen removal efficiency for casting rates of up to 750 kg/minute.

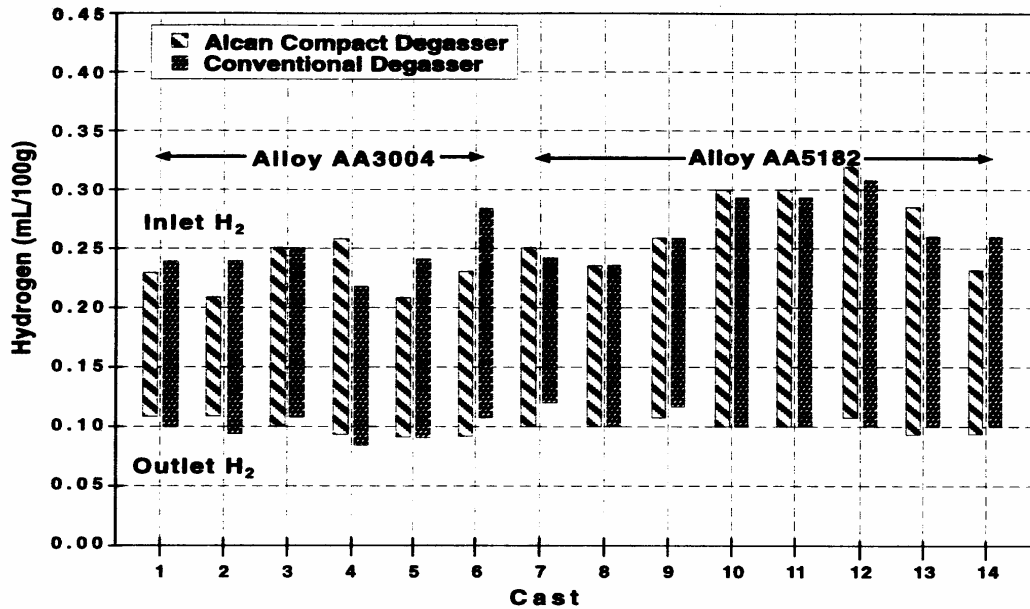


Figure 2- Hydrogen removal performance comparison of the Alcan compact degassing unit and a conventional in-line degasser

## b) Metal cleanliness

Metal cleanliness measurements were taken at the inlet and outlet of the Alcan compact degasser and other conventional in-line degassers using the PoDFA technique. This data covers a variety of alloys and casting rates at several plants. Based on data from approximately 100 and 75 casts for the compact degasser and conventional degassers respectively, the inclusion removal efficiency distributions are presented in Figure 3. The compact degasser averaged an efficiency of 70% +/- 20% compared to 60% +/- 30% for the conventional degassers. The compact degasser provided more efficient and more consistent inclusion removal than conventional degassers. The variability of these results reflects the different species of inclusions present in the metal as well as changed degasser operating conditions covered by the data which both affect the metal cleaning capacity of the degasser.

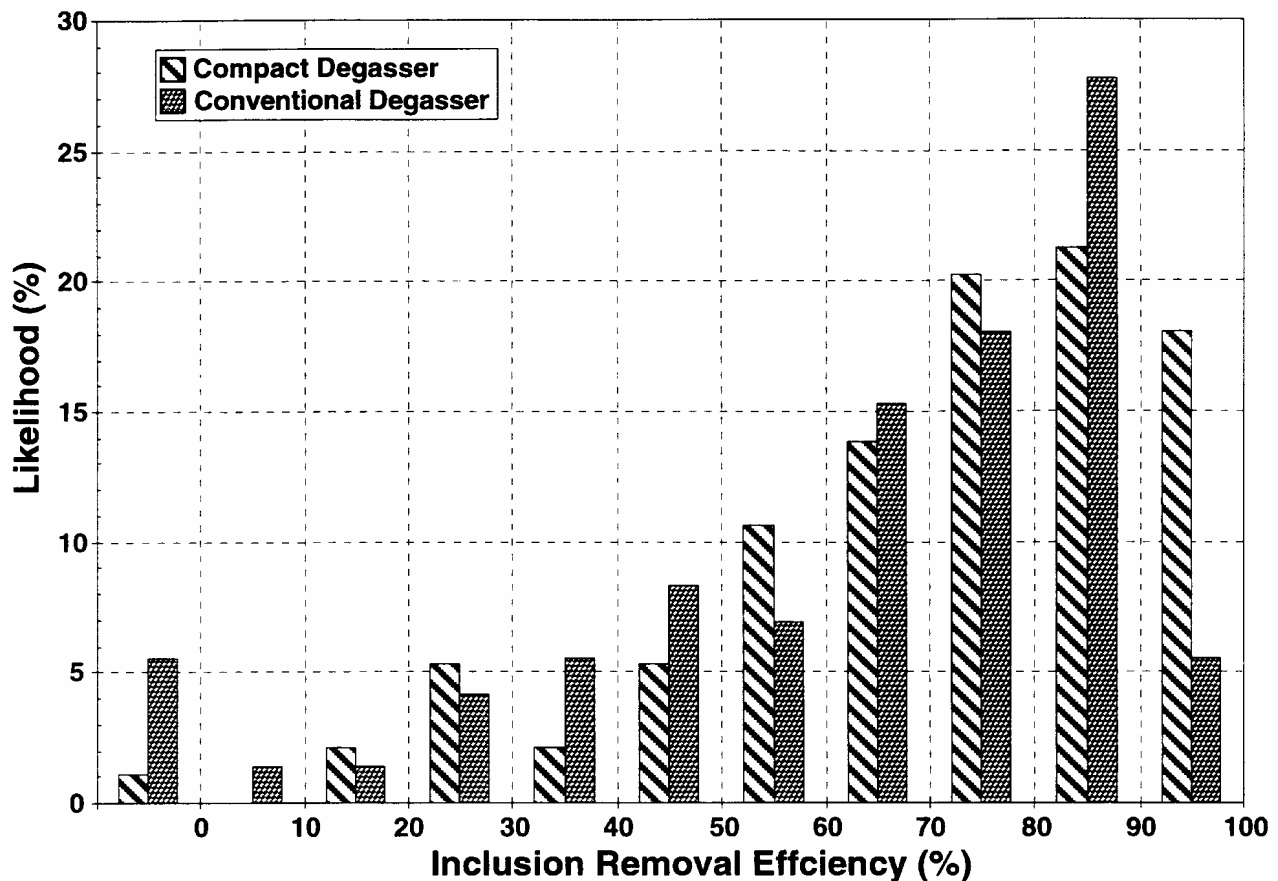


Figure 3 - Inclusion removal performance comparison of the Alcan compact degassing unit and conventional in-line degassers

For specific test cases, direct comparison of the Alcan compact degasser with conventional degassing technology under identical casting conditions, also showed the ACD with an improved inclusion removal efficiency averaging 10% greater than conventional degassing technology.

### c) Alkali removal

Figure 4 shows typical calcium and sodium removal results of the ACD, as a function of chlorine ( $\text{Cl}_2$ ) input. For equal (stoichiometric) chlorine input rates, the Alcan compact degasser provides alkali removal performance equal to the conventional in-line technology. As in the case of conventional in-line degassers, the alkali removal efficiency of the Alcan compact degasser could be further increased with higher chlorine input rates.

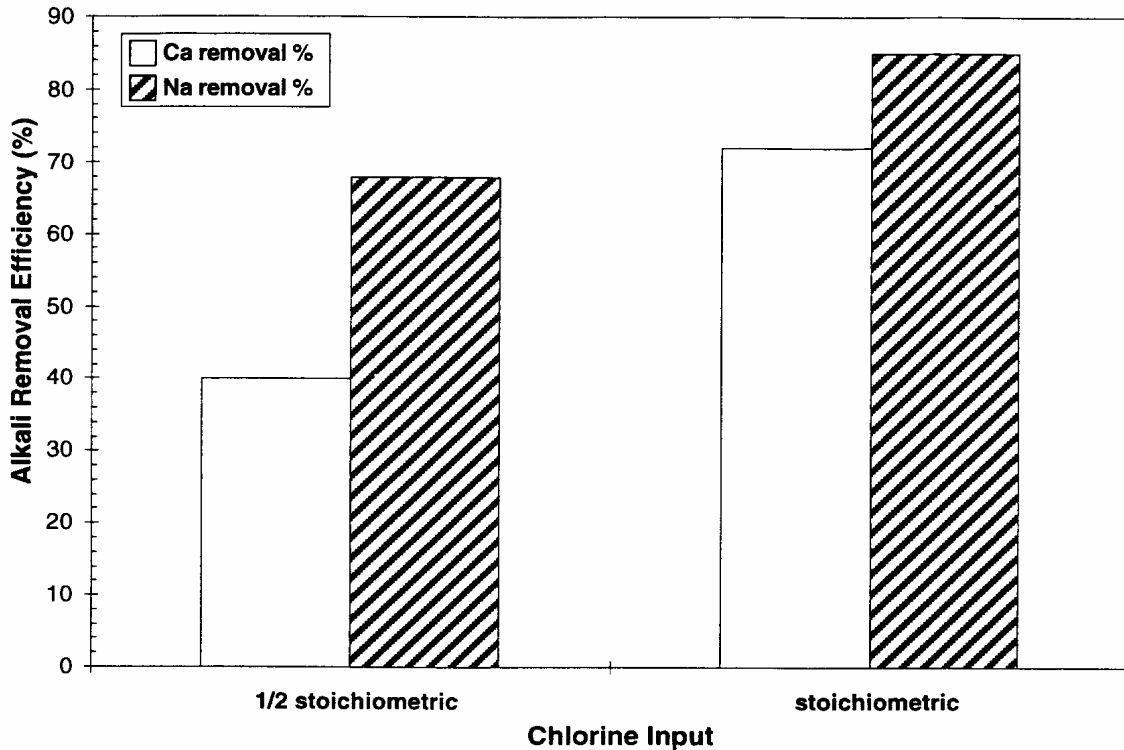


Figure 4 – Calcium and sodium efficiency of the Alcan compact degassing unit

### d) Dross

With a liquid surface area only 1/10 that of a conventional in-line degassing unit and a slight overpressure of argon gas during operation, the Alcan compact degasser forms comparatively less dross due to oxidation. The ACD can be operated for casts of several hours without the need to skim off the dross. If desired, skimming can be done very easily and rapidly with smaller, lighter tools than required for conventional in-line degassers.

## EQUIPMENT DESCRIPTION

The main mechanical components of the Alcan compact degasser, shown in Figure 5, are:

- the degassing trough
- the degasser hood, including the baffle plates
- the drive modules, including the rotors
- the lifting mechanism.

The other components, shown in Figure 6, are:

- a gas mixing panel
- a fume exhaust system
- a programmable logic controller panel
- a man-machine interface
- a trough metal level sensor.

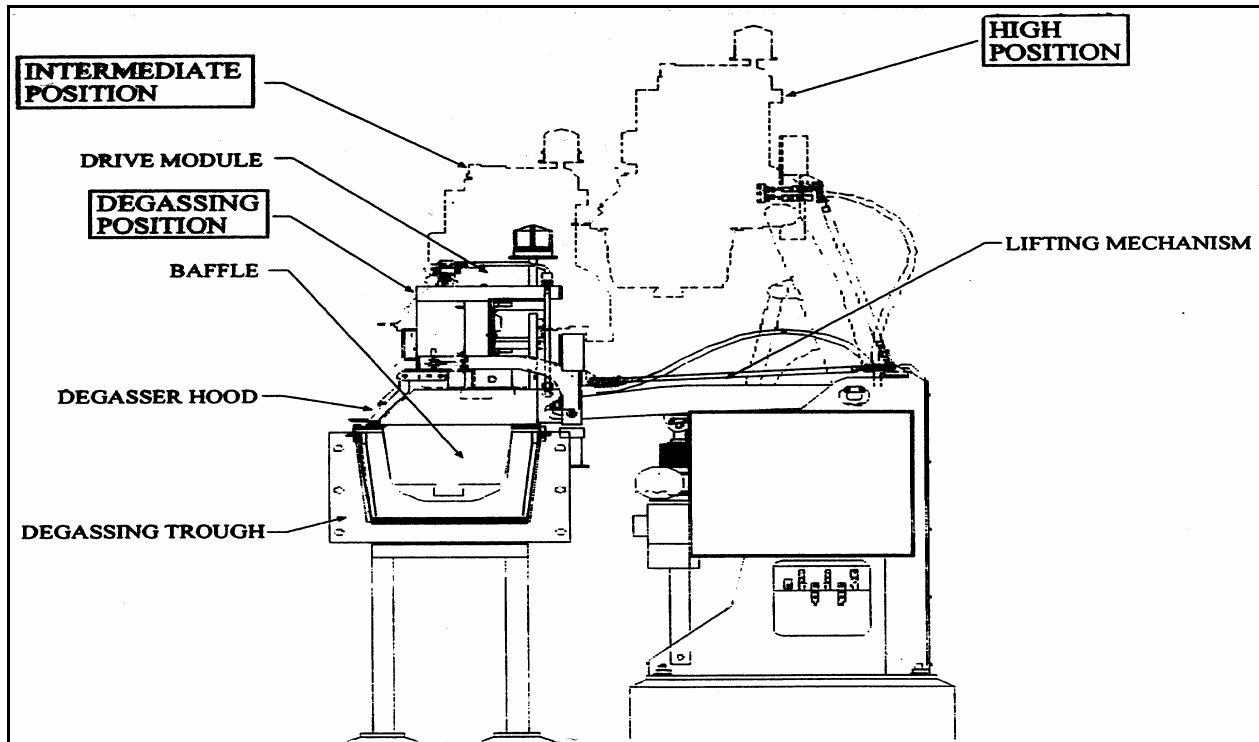


Figure 5 – Main mechanical components of the alcan compact degasser.

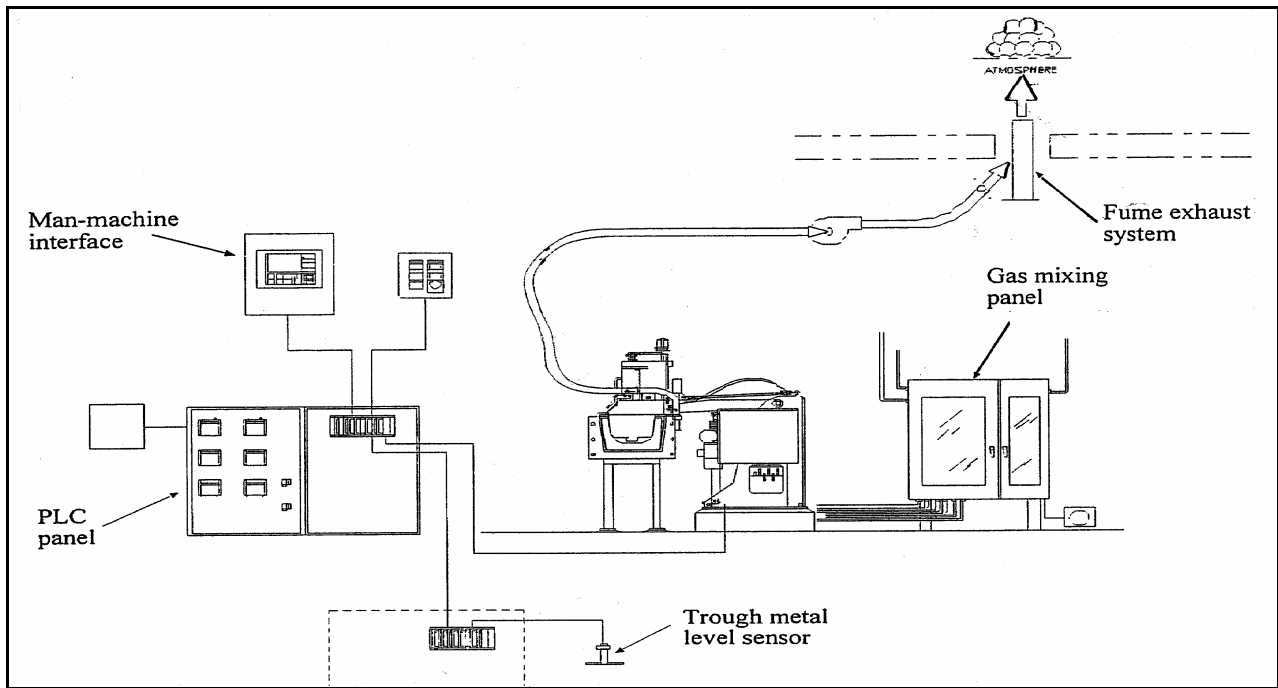


Figure 6 - Other components of the Alcan compact degasser.

The degassing trough consists of a section of 1.5 to 2 meters of conventional trough. The refractory material used also provides minimal heat loss in the trough.

The main function of the degasser hood is to isolate the metal surface from the ambient environment. For this reason, it is designed to be as tightly sealed as possible. In addition, it supports the drive modules and the baffle plates, and it contains the fumes and dust generated by the degassing process.

The Alcan compact degasser is fitted with several modules designed to run the rotors at the design speed. Each module consists of a frame on which an electric motor and a simple belt drive mechanism are mounted. The assembly is light and has small overall dimensions. A defective module can be easily and rapidly replaced between casts for off-site maintenance without disturbing production.

The degassing rotors are designed to optimize degassing and to minimize metal turbulence at the surface of the melt. Installation and removal are done easily and quickly using common tools. They are generally made of graphite but ceramic materials have also been used successfully. The baffles plates separate the trough section into a sequence of metal treatment stages. An area in each baffle allows metal to flow without generating a metallostatic head. The height below the baffles allows the metal to flow at the rate required to ensure optimum efficiency of the process.

The retraction system is an electro-mechanical assembly which consists of a metal frame and a screw actuator system provided with electric driving systems.

Thanks to a pantograph mechanism, only one actuator is required to move the degassing hood to its TREATMENT, MAINTENANCE or WAITING positions. Another small actuator is also used to actuate the safety locking mechanism of the retraction system. Given the simplicity of the assembly, maintenance is minimum and reliability is excellent. Alternate designs are adaptable to accommodate specific layout requirements.

The gas mixing panel of the Alcan compact degasser was designed to provide a precise gas mixing ratio while being fully automated. For that purpose, mass flow controllers are used to accurately supply argon and chlorine flows according to the metallurgical requirements. Safety was also considered in the design of the gas mixing panel. First, a chlorine detector, fitted in the panel, activates when there are leaks. Second, the control logic and piping allow for a complete argon purge of the chlorine circuit at the end of each cast for safer operation and maintenance. Finally, at cast start-up, a low gas flow rate is supplied while the rotors are being introduced into the metal to avoid splashing.

The electrical and control systems are greatly simplified by the absence of heating devices. The operational sequence is entirely controlled by a programmable logic controller system. Control of the metal level at nominal height is essential. Generally, this could be accomplished by a metal level sensor such as the one used for furnace tilt control. An industrial man-machine interface is used to adjust gas flow rates, and to warn of any abnormal conditions.

Finally, as for any degassing unit, the dust/fume exhaust system is an essential part of the equipment. All the fumes and dust must be captured before being emitted into the cast house. Then, the fumes should be cooled down to reduce the risk of fire in the exhaust ducts. This is done by adding dilution air at the inlet of the exhaust duct. The accumulation of particles in this duct is eliminated by providing sufficient gas velocity in the duct by a carefully optimized ducting device. The system should also have a well balanced draft to provide sufficient capture while controlling the amount of air infiltration. The arrangement of the Alcan compact degasser exhaust system is schematically shown in Figure 6. Dust emission rates of about 1 kg per hour have been measured. If required, this dust can be collected using a cyclone or an air filter.

## OPERATION

Figure 7 illustrates the basic positions of the Alcan compact degasser, which are the DEGASSING position, the INTERMEDIATE position and the HIGH position. The totally automatic operating sequence is as follows. During the cast preparation period, the Alcan compact degasser is automatically moved from the HIGH position to the DEGASSING position above the casting trough. The exhaust fan is then activated. While in the HIGH position, consumable parts can be inspected before initiating the degassing process. Upon confirmation of the presence of metal in the trough, a low flow of argon circulates through the rotors to avoid blockage and splashing. The degasser is fully operational within a few seconds after the start-up signal. For safety reasons, the rotation of the gas disperser and the chlorine flow are authorized only if the

proper metal depth in the trough is reached. At the end of the cast, upon a signal based on the cast length (or any other specific signal), the reverse sequence is initiated. In the last minute before leaving its working position on the trough, the chlorine piping is purged using pure argon. After casting, the compact degassing unit is removed in its entirety from the trough. Post casting trough preparation/cleaning can then be done.

The manual operations required for the proper operation of the Alcan compact degasser consist essentially of skimming and housekeeping operations. Skimming requirements depend upon the casting conditions. The quantity of dross formed is generally less than a few kilograms and the operator has the option to skim only at the end of the cast after the removal of the unit. Skimming can also be easily performed while the degasser is in operation by opening the access door and, with a light tool, removing the dross floating on the metal surface.

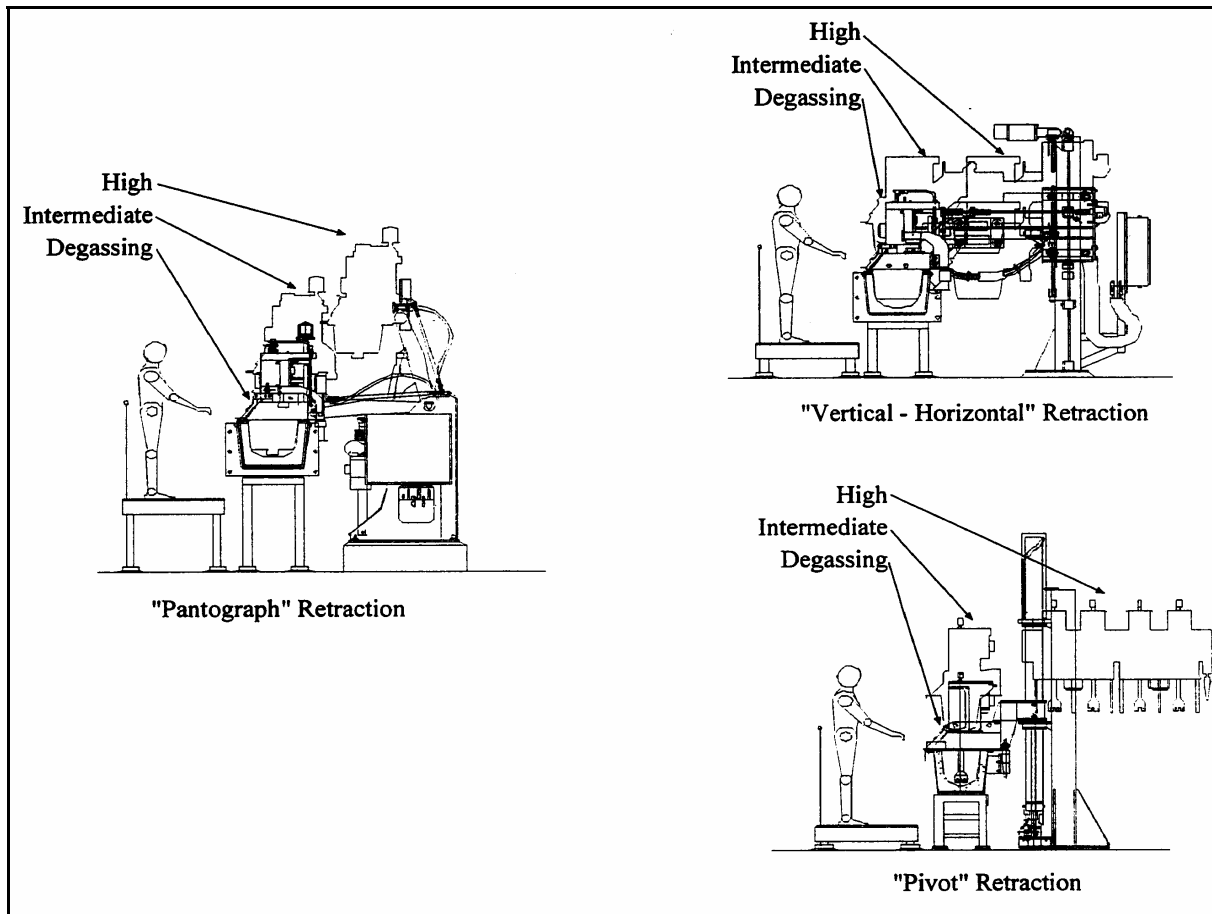


Figure 7 – Basic positions

The service life of the graphite rotors is typically around 100 casts or 200 hours of immersion in molten metal; life in excess of 600 casts (1500 hours) has even been recorded. The service life of the baffles is typically 100 casts, mainly because of material deterioration from contact with molten aluminum. The replacement operation, which requires only a few minutes, is easily done by removing the two pins holding each baffle.

In parallel, another prototype was installed in Lapointe Works to verify its performance against the existing SNIF degasser. Following early successes and because of other production constraints, the SNIF unit was

stopped shortly after and the Alcan compact degasser prototype was used as the only production degasser under the supervision of a plant technician. The use of the prototype as a production unit is by itself a good demonstration of the robustness of the technology. This first industrial prototype was replaced at the end of 1994 with a pre-series model of the industrial version.

Industrial implementation started with the installation of the Alcan Compact Degasser in Alcan at Isle-Maligne Works and NLM, Kambara Works (Japan) in 1995, Rogerstone Works (U.K.) and Pieve Works (Italy) in 1996. A project with Lynemouth (U.K.) is presently ongoing and should be commissioned in first half of 1997. Other projects are planned for 1997.

## CONCLUSIONS

The Alcan compact degasser is a new trough-based in-line treatment process that maintains equivalent or better levels of metallurgical performance as compared to conventional technology, while eliminating metal hold-up between casts. This eliminates the scrap metal generation normally associated with in-line degassers, especially in multi-alloy casting centres.

The equipment design objectives of the project were met : it can fit in almost any casting plant due to its modest size and the simplicity of its design.

Much of its development took place in production plants benefitting from the direct involvement of the end users. It is now a fully industrialized technology which has been operating for more than two years and its simplicity and low operating costs have been clearly demonstrated.

## ACKNOWLEDGMENTS

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