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THE INERT GAS DROSS COOLER (IGDC)

INTRODUCTION

The IGDC was developed by Alcan nearly a decade ago and was patented in 1989. The intent of this paper is not to detail the process, which has been well discussed elsewhere ([i, ii, iii, iv, v]); it is rather to explain how well the system is being applied in practice.

Drosses are always generated whenever molten aluminum is processed and contain valuable aluminum alloys in metallic form. These drosses, by weight between 1 and 6% or higher of total production, are skimmed from the furnace into pots whilst hot, and then need to be cooled in some manner. Due to thermiting, the cooling time may take many hours to cool below 400°C, the temperature at which thermiting ceases depending on the cooling process.

Various cooling methods are in existence: the vibrating table, the rotary drum cooler, the inverted bell with a water seal, the dross compressor, and last but not least, the Inert Gas Dross Cooler (IGDC). Each of the above methods, with the exception of air cooling and the IGDC, uses water for either cooling the equipment or for providing a seal with the attendant risk for explosions to occur. Each method strives to minimise the losses of aluminum metal due to thermiting.

It will be shown that the IGDC is the most efficient, safest and environmentally sound of all the cooling methods.

THE IGDC SYSTEM

An ideal cooling system has the following features:

1. Completely safe, because no water is used either in the cooling of the dross or with the equipment.
2. Environmentally sound, therefore no emission of dust or fume.
3. Provides for easy working conditions, therefore is operator friendly.
4. No moving parts, thus minimising maintenance costs as well as emitting no noise.
5. Retains as much of the aluminum alloy present in the dross immediately after skimming (can range from 18% to 80%) as possible.
6. Treats all kinds of drosses (black and non reactive or white and reactive).

The IGDC system meets all of the above criteria.

The principle of operation is the use of a compartmentalised cast steel or cast ductile iron pan into which the drosses are skimmed and cooled in an inert gas atmosphere. The pan may contain drainage holes to allow molten alloy to drain to a collecting pan underneath.

The pan is transferred as rapidly as possible to a station following skimming. It has been determined by various authorities that as much as 1% of Al can be oxidised for each minute the uncooled dross remains exposed to air. This is particularly true for reactive drosses; not all the cooling methods can deal with reactive drosses.

A station consists of a base together with a hood, which is lowered to provide a seal once the pan is placed inside. Immediately the hood is sealed, there is an injection of argon gas at 10 SCFM (280 Nl/min) for 5 minutes in order to displace as rapidly as possible all the air. Following the first purge, the argon flow is reduced to 0.4 SCFM (11.5 Nl/min) for the remainder of the cycle, which may last up to 12 hours for the very reactive alloys (5XXX) but typically lasts between 4 and 7 hours. The cooling cycle is considered complete once the temperature of the dross falls below 400°C, the temperature below which thermiting will cease. It is to be noted that most of the cooling (70%) is provided through the pan; a negligible amount is cooled by the gas.

Nitrogen, sometimes considered inert, is not used as a shrouding gas because of the formation of nitrides.

The whole IGDC operation is handled by either a small programmable controller or a timer and relay system.

DESIGNING A TYPICAL PLANT DROSS COOLING EQUIPMENT

One of the many advantages of the IGDC system is its adaptability to any amount of dross produced in a plant whilst respecting space limitation – no special building is required, the units being hooked up as close to each furnace as possible.

Being modular, the number of stations may be conservatively estimated until actual experience has been obtained. Should more units be required, they can be added later. On the other hand, there is less risk of overdesigning.

STEP 1:

The first step in the design process is the sending out of a questionnaire, which requires, amongst other things, the following information as a base:

1. Total annual dross production (in tonnes), with details regarding the number of skims plus the quantity of dross per skim per furnace over a given time period.
2. Dross characteristics such as reactivity, density as well as the composition, particularly the alloy content.
3. Alloy series, and temperature of alloy at time of skimming.
4. Type and quantity of flux used per batch plus any special treatments such as degassing.
5. Furnace information, including sill height and door dimensions.

6. Present dross cooling method, including operating/maintenance costs.
7. Present aluminum recovery method, including percentage of alloy recovered.

STEP 2:

Once the above information is obtained, the capacity of the pan size can be determined as well as the number of pans and hoods (stations). The principle is to determine how many dross coolers are required simultaneously as a function of the skimming frequency and the cooling time.

A complete system consists of a:

- compartmentalised pan
- sealed hood
- argon gas, flow rate and duration controlled automatically.

1. PANS

Pans are fabricated from either cast steel (ASTM 216 Gr WCB) or cast ductile iron (ASTM 536 Gr 60-40-18). The choice of material is largely a question of cost with ductile iron being approximately 40% cheaper than steel. The impact resistance (Charpy) and ductility for ductile iron are adequate at the operating temperatures [room to +300°C] (v). Two plants, one in Norway and the other in Canada, have used cast iron for more than two years with no apparent deterioration. Cast steel pans are still in use after ten (10) years at an Alcan plant where the first trials were carried out twelve (12) years ago, with four (4) compartments; some versions now have six (6) compartments.

Wherever possible, it is suggested to use drainage holes to drain as much as possible of the liquid alloys present in the dross; a drainage pan is provided for this purpose.

Pans are designed in varying capacities ranging from as low as 0.27 cu.m to as large as 0.95 cu.m with weights of dross varying respectively from between 250 kg up to 1000 kg.

2. STATIONS

A typical assembly will consist of a mild steel fabricated box into which the pan is placed. A stainless steel hood is lowered onto the base so that a seal (silicone sponge) prevents the entry of air. The dimension of the hood and base arrangement are changed slightly to accommodate the pan dimensions and, where necessary, the drainage tray. A hoist is operated to permit opening/closing of the hood.

The original fabrications were all of mild steel and are still in use in an Alcan plant. The use of stainless steel was made as a preventive measure for possible long-term corrosion. Several users have noted thin deposits of salts on the underside of the hoods, which once formed, have permitted a natural protection layer to occur. There have been no known cases of perforation, even with the mild steel hoods, first installed ten years ago.

Our experience with seals has shown that they can last for many years. We do not know of any locations out of more than 50 that have required changing the seal on a regular basis.

3. CONTROL SYSTEM

Two choices have been made available – relays or PLCs using two stations per control panel. With either system, an IGDC operation is completely automatic, thus not requiring the use of operating personnel. It is possible to control the duration of the cooling cycle by continuously monitoring the temperature of the bottom of the pan, which is a recent development, but most installations use the duration of the cycle based on time; temperature measurements nevertheless are available to indicate either the temperature of the interior gas or directly on the cover.

4. CASES

4.1. CANADIAN PLANT (ROLLING PLANT):

One plant in Canada was using a rotary drum cooler which had been repaired several months earlier when it suffered an explosion causing damage to the equipment and surroundings. A decision was made to replace this method with the IGDC.

A study indicated a requirement for dross cooler systems (9 pans of 0.95 cu.m, with draining pans, 6 stations, 2 control systems with PLC).

There were 5 melters, so that each station could be located in close proximity to each melter.

Previous results for the plant had shown an average percentage of about 45% aluminum recovery in the dross upon processing. Since the installation of the IGDC in 1992, this average recovery has increased to 55% aluminum, a gain of 10% Al. Price levels fluctuate for aluminum ingots but at today's prices, this difference represents an approximate value of $250,000 U.S./year for 6 systems.

Not only were the safety requirements met by the plant – no water is used, the cause of the earlier explosion – but also environmental concerns were addressed; no dust is given off during processing, as was the case with the previous drum cooler. It has been accepted very readily by the plant operators, not only for the improved cleanliness but also with the elimination of noise.

A final bonus was the saving of $35,000 U.S./year in maintenance and operating costs.

4.2. SCANDINAVIAN PLANT (SMELTER):

Following a trial period, this plant decided to install five stations in 1993 following a six-month trial period, using 0.95 cu.m pans without drain holes. Previously, all dross was air cooled outside on a concrete slab, with typical aluminum recoveries of 25 to 28%, sometimes as low as 18%.

Since the installation of all five coolers, completed in December 1993, the recovery in aluminum has been averaging 38%; the main alloy group at the plant is the 6XXX series.

Working conditions have been improved considerably with the elimination of smoke and dust on an open slab. Naturally, there is a high acceptance of the new method from the workers, particularly as the new equipment has virtually no maintenance and the added bonus of generating no noise and being absolutely safe.

4.3. SCANDINAVIAN PLANT (SMELTER):

This plant already had and used until last year a rotary plant cooler but wished to incorporate the IGDC, which it did so in 1992, in order to better meet its requirements. In September 1992, ten units were installed, each cast iron pan having a capacity of 0.95 cu.m. for treating mostly 6XXX and 5XXX alloy groups.

The average plant recovery of aluminum was estimated at 38-39%, which has been increased to 48% with the IGDC.

However, the main objective of the plant was to reduce the amount of dross dumped at the landfill. It is to be noted (see below) that the plant remelts internally the free aluminum present from the dross, the balance of which is sent out for processing.

Results since 1992 have been as follows:

	RECOVERY	DROSS AT LANDFILL
1992	49.43% out of 2,751,420 kg of dross	650,000 kg
1993	45.09% out of 3,150,230 kg of dross	94,000 kg
1994	49.45% out of 1,580,810 kg of dross	42,210 kg

Based on the results obtained, the payback of the cost of the new system was shown to be much less than one year.

4.4. GERMAN PLANT (SMELTER/MILL):

A plant recently installed 16 units with a pan capacity of 0.41 cu.m for type 1000 alloys. The average recovery for air cooled dross was between 25 and 30%. Following the installation of the units in 1993, the recovery has increased to 45-50% aluminum. This plant is typical of several who have decided to add units – in this case 3 – following the initial analysis. It is a good example of the advantage of a modular system.

4.5. AMERICAN PLANT (EXTRUSION):

The plant had used a drum cooler for many years, which either needed to be overhauled or replaced. There were two major concerns with the cooler: although located away from the casting centre, at the far end of the foundry, was the unacceptable generation of dust, which not only affected workers health but also affected the quality of the products due to dust accumulating on the workpieces during processing. In addition, there had been two near explosions with the equipment.

The installation of the IGDC (8 units) has eliminated not only the generation of dust and the possibility of explosion, but also the difficult worker task of requiring the lancing of dross which sometimes blocked the feed chute to the drum cooler.

Previously, monthly operating and maintenance costs were averaging $6,500/month. The maintenance costs have been virtually eliminated with operating costs of only $4.70 per cycle.

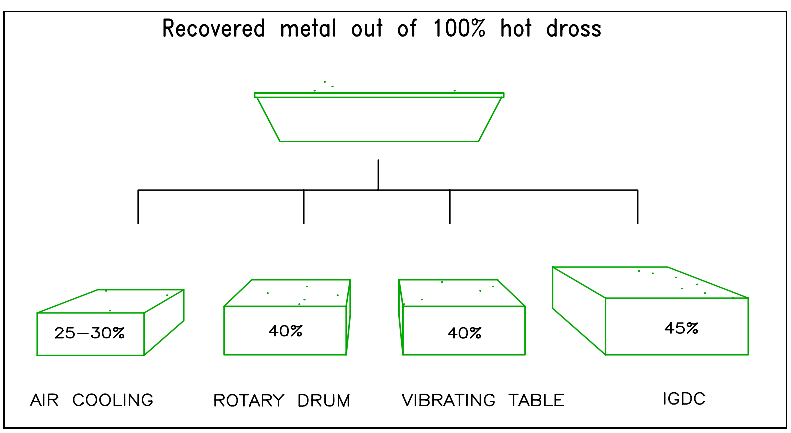
Recoveries of aluminum with the rotary cooler were typically between 46% - 50%. After the IGDCs were installed in 1993, the recovery has increased to between 52% - 54%.

SUMMARY

Our experience is based on long term installations (up to ten years), medium term (a year or more) and short term (less than a year) of more that 200 IGDC units placed in both Alcan and non Alcan plants around the world.

The recovery of aluminum with the IGDC method is nearly always higher than with other methods. This can be explained partly by the fact that therming is stopped as soon as the inert gas is applied. Air cooling on either a concrete or aluminum bed permits therming with a consequent loss of aluminum. Some cooling methods cannot cool reactive drosses.

With the rotary dross cooling method, there is a natural grinding action which causes the generation of dust (losses to a baghouse) and fines (containing low levels of aluminum), which are not recovered efficiently in subsequent furnace treatment. The IGDC method permits the highest recovery, because the cooled dross is mostly in the form of blocks, with relatively few fines, which is then charged to a recovery furnace (rotary salt or plasma, for example), to optimise the extraction of the aluminum metal or alloy.



Typical % Recoveries of Alloy
for Various Cooling Methods

A comparison is shown below between several cooling methods. All recovery figures are as reported by users of the different systems. The biggest gain is naturally between air cooling on a slab and the IGDC; there is also a gain with the IGDC in comparing with other methods. The IGDC can replace all these methods and still provide an adequate payback, usually around one year, based on the increased volume of aluminum recovered for a given quantity of dross.

Another financial incentive is the reduction in maintenance and operating costs when compared with the use of a vibrating table or rotary drum cooler.

Not only does the IGDC provide a good financial incentive, but the system also meets environmental requirements; there is no dust nor fume given off during cooling.

Working conditions are ideal – no safety risk to the worker or to the equipment, nor is any noise given off due to the absence of moving parts.

Because of the low capital cost of a unit and the fact that the system is modularised, it is easy to meet plant needs for dealing with any drosses, reactive or not, that are generated for an unlimited volume. Some plants take advantage of the ready separation of the different kinds of drosses generated in a plant making different alloys, thus making recycling more efficient.

In short, the IGDC is the system that best meets the criteria for an ideal system to properly deal with the problem of cooling hot drosses.

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