DROSS Engineering

DROSS PROCESSING & SCRAP MELTING IN TILTING ROTARY FURNACES

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Abstract:

The tilting rotary furnace or TRF has come to the forefront during the last ten years as a tool for aluminium dross processing and general scrap melting. The concept of this furnace, sometimes known as a 'converter' furnace presents a number of major advantages over traditional dross processing techniques. This presentation explains some of the background, the process advantages and the latest developments.

Introduction

The concept of the tilting rotary furnace TRF or converter furnace is simple: it is in fact, a rotating closed well, combining the advantages of rotary furnaces, reverbs and dry hearths in a single unit.

Benefits of the converter furnace

The necessity to maximize metal yields, increase production speed and improve economy whilst respecting the environment are a constant and ever increasing reality in all aspects of industry. Ongoing research for equipment capable of improving performance, increasing yields and production rates whilst diminishing production costs is essential for those companies wishing to survive in today's market. And, within all aspects of the aluminium industry, an ever greater emphasis on recycling and the efficient recovery of every ounce of metal has forced the industry to review melting and recovery practices to reduce dross generation through 'best practice' on the one hand and on the other to maximise metal recovery from this inevitable 'by product' of the aluminium melting process through investment in the latest technology.
The TRF or converter furnace puts at the disposal of the aluminium industry a tool that:

- Eliminates or greatly diminishes the need for salt and or flux in the melt process
- Improves working conditions for furnacemen
- Melts a wide range of feedstock:
- Diminishes or eliminates metal 'pollution' by trace elements in the charge (by free iron for example)
- Facilitates mixing the charge and guarantees its homogeneity
- Promotes the 'self cleaning' of the lining
- Offers low energy consumption and high thermal yields.
  - Examples of energy consumption (with conventional burners)
    - Trad. Reverb with good insulation: >1000 kW/tonne
    - TRF: <600 kW/tonne
- Ensures faster melt rates: 2 to 3 times higher than traditional furnaces

For metal recovery from aluminium dross the TRF concept itself presents considerable advantages over traditional rotary furnaces (not to mention current Indian practices that are more towards coal or gas fired crucible furnaces or small rotary salt furnaces*). A number of furnace engineering companies have taken this basic furnace concept that, in fact, has been around for many years and was first used for copper smelting in the 1930's in Europe, and are offering a variety of units that are either conventional burner fired or oxy-fuel fired. Each company has a slightly different approach to resolving the inherent technical problems of the TRF….

Dross Engineering's approach

Dross Engineering, an Anglo-French company with it's head office near Paris and with more than 25 years experience in non-ferrous furnace and foundry equipment design and manufacture, have their own particular approach to resolving the inherent technical problems of the converter furnace or TRF.

Firstly, they have approached the furnace as more of a 'machine tool' than a furnace. The movements and stresses, even for smaller models, are unforgiving and punish any misalignment. They demand a level of precision during assembly that is normally reserved for machine tools.

Drive mechanism

The primary aspect of the furnace requiring the application of the 'Dross Engineering approach' was the drive mechanism:

For the first furnaces of this type built, Dross Engineering chose to power the rotation via a hydraulic motor. The results were satisfactory but not without problems. This initiated design work that resulted in the adoption of an innovative drive system that is both direct and reliable and that guarantees a positive movement in both directions: The 'Power Ring'. The Power Ring is compact and ensures a smooth start to rotation under charge; it withstands a wide variation of load at temperature and all the aggression of a foundry environment with a minimum amount of maintenance. The 'Power Ring' system is patented and grants to Dross Engineering's furnaces a drive mechanism that is unique for this application.

Finite element design techniques

However, a good drive system is not, in itself, sufficient to guarantee trouble free rotation of the furnace. Efforts created by the movement under load and at temperature require a furnace structure that is both robust and precise. Dross Engineering uses the finite element method to provide accurate predictions and evaluations of component response when subjected to thermal and structural loads. Particular attention is paid to assembly tolerances and a large number of components are machined. Guide bands, or tyres, traditionally mounted 'floating', are welded to the shell and machined insitu to tight tolerances and run on 'elastic' rollers assembled to a high level of precision. This 'elastic roller' system is also covered by a recent patent.

The environment

A rotary seal system linking the hygiene hood with the base of the stack promotes efficient extraction and enables combustion products and fume to be 'captured' at source and channelled to an independent cyclone and filter unit or to the plant' filtration system.
The 'Power Ring' guarantees a wide range of rotation speeds, facilitates change of direction and stoppages – these can be programmed in individual 'recipes' according to the type of product processed and lead to a major reduction of particulate in the off-gas stream.

And of course the converter furnace or TRF concept offers the possibility of running completely salt free or with greatly reduced quantities of fluxing agents.

Combustion system

In itself, the concept of the converter furnace with its enclosed well allows both the furnace atmosphere and furnace pressure to be adjusted to give optimum stoichiometry and to avoid ingress of parasite air, thus promoting reduced energy consumption and minimal metal losses. Dross Engineering were not satisfied with this and wanted to take the concept even further:

To achieve good metal yields the normal practice is to adjust the burner to give an atmosphere inside the furnace that is slightly 'reducing' (gas rich). This adjustment usually takes place once and for all during furnace commissioning or during a regular service and is carried out by a qualified technician who manually sets the air and gas control valves after analysis of combustion products. However, certain products and feedstocks would benefit from being able to vary the air/gas ratio at different times during the melt cycle to create an atmosphere in the furnace that is either 'air-rich' (oxidizing) or 'gas-rich' (reducing) to obtain even higher yields, to optimise production or for metallurgical reasons. Such operational flexibility was not available to foundrymen until now. The patented 'Vari-gas' system from Dross Engineering is available as an option for all their furnaces. Completely programmable, the system splits the melt cycle into segments that can either be air-rich or gas rich depending on the charge and offers foundrymen and refiners alike operational flexibility unheard of till now.

Design features

The fixed chassis of Dross Engineering's converter furnaces is designed to house the control panel and the hydraulic power pack all of which are wired and piped in their fabrication shops. The refractory lining that is either in brick, castable or pre-cast blocks or even a combination of all three, is also carried out in the fabrication shop. Working this way Dross Engineering can ship furnaces that are completely finished (up to the Dross 700 - 7m3 furnace size), tried and tested in house and so limiting intervention and disruption at the customer's plant. Normally, from delivery, only 10 - 15 days are required to install and commission the furnace, including refractory drying time. It is almost a 'plug and play' furnace! For the furnace operator all the movements of the furnace are remote controlled by radio link. Rotation speed and direction, furnace tilt, door opening and charge machine movements are all controlled remotely for operator safety and ease of use.

Salt free process
In a 'classic' fixed axis rotary furnace salt has, above all, the function of protecting the charge whatever its nature. The 'classic' fixed axis rotary is a 'tunnel' with a burner at one-end and the off-gas exit at the other. Therefore it is virtually impossible to protect the charge from parasite air ingress without the use of salt in copious quantities and so avoid heavy metal loss through oxidation. However, in a converter furnace or TRF the furnace chamber is a closed well. The burner and the fume exit are located on the same face and so it is easy to control the atmosphere and pressure inside the furnace and to eliminate any parasite air ingress. Also any exothermic reaction during melting is avoided and charge oxidation does not occur as all the oxygen is consumed by the combustion process provided the burner is correctly adjusted.
Some engineers hold to the point of view that salt avoids the exothermic reaction of the dross or ash at the end of the melt even in a converter furnace or TRF. But Dross Engineering would argue that this reaction is a desirable part of the process to create what has been called 'thermal ash', which, if produced as part of a salt free process is composed mainly of aluminates and aluminium oxides and is completely inert and can be either land-filled in a non-classified site or, in certain circumstances, sold to the cement industry for example.
It is however, desirable to 'control' this 'natural' exothermic reaction at the end of the melt to maximise metal recovery. For this reason some of Dross Engineering's customers use a 'thermal shield' or screen to control (slow down) the arrival of air from the moment the furnace door is opened to the end of the pour.

Aluminium Dross Processing

Recovery of metallic aluminium from dross in a furnace fitted with a conventional burner and without salt was, until recently, considered unfeasible and inefficient. From the 1980's western aluminium producers and research bodies have been involved in seeking to improve metal recovery from dross by the salt free thermal route. Some countries, particularly those rich in electricity resources have explored the plasma torch route or electric arc type furnace; both working on a similar principal of melting in an 'oxygen free' environment under pressure to avoid parasite air ingress and both of these techniques offer efficient recoveries but are not economically viable unless the electrical power source is very cheap. Also these techniques are limited to small production units (a few tonnes of dross at most). More recently other manufacturers have opted for TRF units fitted with oxy/fuel combustion systems - they have their advantages, the main one being the reduction of off-gas volumes but they remain complex and costly. Dross Engineering believes that conventional air/gas or air/oil burners offer greater advantages and flexibility particularly when fitted with the 'Vari-Gas' control system. All of Dross Engineering's installations are fitted with conventional burners and maximize the inherent advantages of the converter furnace or TRF.

Dross Engineering has proven that their particular design of furnace is not an 'oxide production machine' not by melting dross but by melting ingot in an automotive foundry. The Peugeot Automobiles high pressure foundry in Mulhouse, France has been using a Dross Engineering 2m3 (5tonne) furnace since 2002 to melt ingot, foundry returns and reject castings with cast-in iron inserts. They confirm a constant metal yield when melting ingot of 98.5%. Metal recovery from dross is more subjective but actual recovery efficiency of Dross Engineering's furnace design is well proven.

One thing is certain on the one hand the Dross Engineering TRF or converter furnace does not manufacture oxides but on the other it cannot 'produce' aluminium from oxide – it can only recover the metallic aluminium that is there in the first place!

It is important to note that there are several categories of dross each with its own characteristics and behaviour depending on its source. Dross from primary plants for example has a different comportment from diecasting foundry dross or from secondary refining plant dross, just as dross from a dry hearth is different from dross from a reverb. Taking the above into account, metal content in dross can vary from 20% to 80 % and above. Certain drosses can be melted without any salt or flux at all whereas others require a small amount of flux mainly to avoid coagulation and adherence to the furnace drum wall. (Note: pre screening of the poorer drosses can be beneficial to remove dust and non metallics prior to melting and could be a viable option in India but milling is not seen as necessary due to heavy investment etc…) – an amount of salt flux could be used but is it economically viable? Purchase salt heat salt and pay for its disposal or regeneration?)

Aluminium Scrap melting

Because the melt in a TRF is a batch process, contamination of the liquid charge by free iron, for example, is practically eliminated. Peugeot have achieved iron pick-up of less than 0.05%.

Some melt results

Charge	Melt time	Metal temp	Consumption (Nat gas)
a)1500 kg engine blocks with iron inserts	30min	730°C	< 400kW/t (i.e <35M3 gas per tonne)
b) 1800 kg iron free blocks	40min	710°C	<400kW/t

Other customers have achieved excellent recovery rates for example melting irony old rolled (pressed and sheared) and have recorded a total iron in metal analysis after melt of 0.45% and a fuel consumption of less that 600 kW per tonne (gas i.e. ~60 m3 of Nat gas or less than 60 litres of fuel oil)

Furnace Capacities

The advantages of these furnaces are not only reserved for major installations. Dross Engineering offers a wide range of units from their Dross 30 (0,3m3 useful capacity) to the Dross 1150 (more than 11m3 useful capacity). Because Dross Engineering supplies a range of industries working with a variety of metals they classify their furnaces by 'useful' liquid metal capacity. Therefore a Dross 100 furnace = 1m3 capacity = 2.5 tonnes of Aluminium or 7 tonnes of zinc or 10 tonnes of lead for example). With a Dross 100 furnace it is possible to process approximately 2000 tonnes of aluminium dross per year (working 3 shifts x 22 days per month) – The Dross 100 is probably the smallest unit for dross processing because it is necessary to give the charge 'sufficient room' to achieve best results. Metal content in dross is variable (based on the source etc…) and ranges from 20 to 80% or more. Given the high recovery efficiency of Dross Engineering's furnaces actual yields of 20 -23% are considered as the lower viability threshold. If the dross processed yields 35 – 40% major profits can be made and payback on investment is very short. For example for a Dross 100 with cyclone and filter payback is achieved in less than a year and for a diecasting foundry with very rich dross, payback is even faster. The whole range of furnaces is built using the same principals and benefits from the same drive system and can be fitted with Vari-gas control option. Therefore, secondary smelters producing 700 to 1000 tonnes of metal per month (i.e. 35 to 50 tonnes per month of dross ~ 5% of production as standard 'rule of thumb') can treat their own dross and serve as a processing centre for others locally Or for a diecasting foundry generating approximately 900 tonnes of general scrap (dross/returns/rejects etc…) to process their scrap internally.

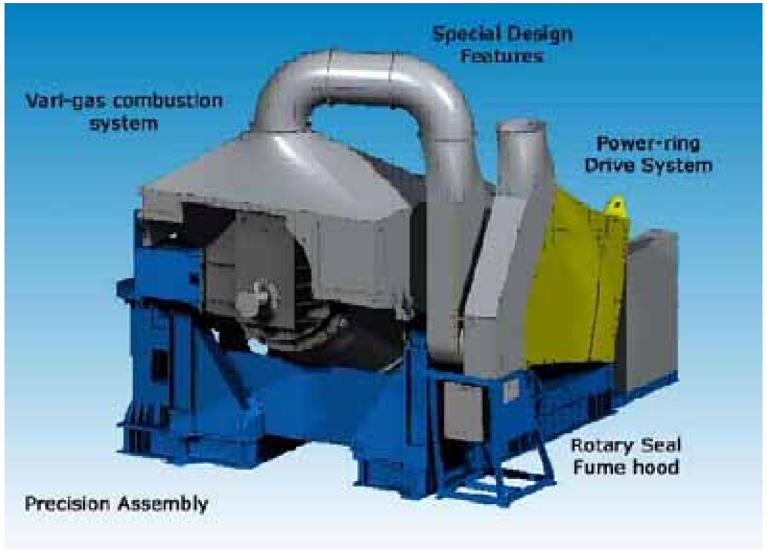
Conclusion

The concept of the converter furnace or TRF offers major advantages of flexibility and metallurgy and has an important role to play not just in dross processing but as it answers problems of yields, offers the possibility of a clean, salt free process and is operator 'friendly' also has its application in general scrap melting and even in diecasting foundries.

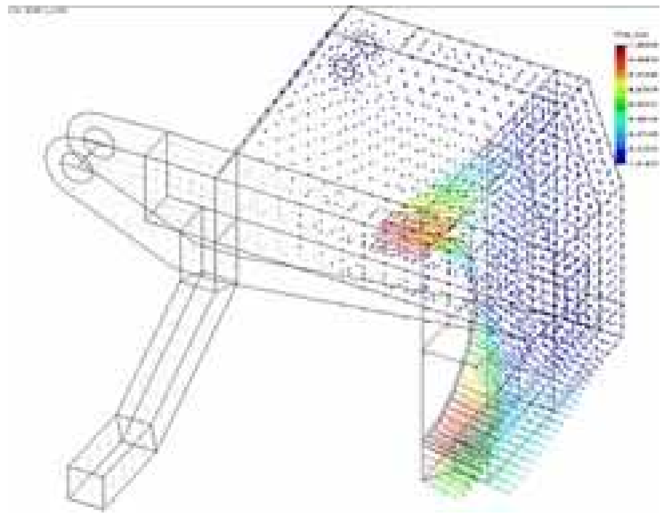
References:
*) M Nilmani & H.T. Makhijani: Melt loss minimisation and dross treatment 'An Indian perspective' Alcastek 2002.
J Simpson: Developments in converter furnace technology: Aluminium International Today January 2003

Author

After training as a teacher John Simpson, moved in industry and has worked in the commercial departments of a variety of engineering firms both in France and in the UK. He has worked with the team behind Dross Engineering for over 10 years and is now their Commercial Director.



Dross Engineering Converter furnace (or TRF)



Dross Engineering: Finite analysis of mobile chassis

Dross Engineering Dross 500 Rear view showing panel and patented 'Power Ring'

Dross Engineering Dross 500 Front view

Dross Engineering Dross 200 tap-out

Dross Engineering Dross 200 melting scrap engine blocks with iron inserts

Dross Engineering : Aluminium dross before recovery

Dross Engineering: pouring though thermal shield