MTS 1500 automated Metal Treatment Station

Introduction

Today's aluminium foundries operate in a competitive environment and are focused on production of higher quality castings with low scrap and waste rates and increased productivity. In order to compete, an improved metal yield in a safe working environment is essential. These needs must be fulfilled in order that the foundry can:

- ❑ Provide the customer with the best quality product
- ❑ Produce castings that are reliable, safe, and conform to specification
- ❑ Be competitive in an increasingly difficult market
- ❑ Ensure the working environment is safe, healthy and stress free
- ❑ Improve the environmental performances as set out in 'ISO 14001'
- ❑ Operate a profitable and successful business.

One process stage within the foundry that impacts on all these needs is metal treatment. Having the optimum metal quality is fundamental to the production of quality castings but it is arguably the most difficult to control and has potentially the biggest impact on the environment. The optimisation of metal treatment processes has been the subject of much development work in the recent past, which has resulted in new, more efficient and cleaner treatment processes. One such improvement, the MTS 1500 - automated Metal Treatment Station - is a recent development by FOSECO that addresses all the various technical requirements and is capable of making a significant contribution to the modern aluminium foundry.

MTS 1500 Technology

The machine

The MTS 1500, an automated metal treatment station (figure 1), comprises five components (Foundry Degassing Unit - FDU*, the hopper system, a screw dispensing unit, an automatically controlled baffle plate and a control panel) as well as consumable products (fluxes and rotor) specifically designed for the MTS 1500.

- ❑ The FDU is a rotary degassing unit, this forms the basis of the MTS 1500 by providing a firm and stable platform. Generally, most of the existing FDU types are compatible.
- ❑ The hopper system is made up of one or two containers in order to supply one or more different fluxes (for example, cleaning and/or modifying). The hoppers are closed to prevent moisture pick-up; a minimum sensor checks the product level to prevent shortage during a treatment.
- ❑ The flux dispensing unit is mounted on the hopper outlet and allows for a fully automated dosing of flux into the vortex. The dispensing unit is an electrically driven screw feeder which is capable of delivering accurate and consistent amounts of flux. Changing the length of duration that the screw operates can control the amount delivered.
- ❑ The automatically controlled baffle plate is an electrically driven two-position device that controls the speed of the metal at any time during the treatment cycle. In position 'A' (deactivated), the baffle creates the vortex needed for the efficient mixing of the treatment products. In position 'B' (activated) the baffle plate eliminates the vortex to create optimum conditions necessary for cleaning and degassing.

Figure 1 The MTS 1500 automated metal treatment station

- The control panel contains a Programmable Logic Controller (PLC) to enable the optimum treatment cycle, to establish, maintain and ensure consistent treatment. The PLC regulates the principle functions of the MTS 1500 machine: lifting and submersion of shaft and rotor into the melt, the shaft and rotor speed, the dispensing of the desired quantity of flux/fluxes, the positioning of the baffle plate to initiate and terminate the vortex as well as the flow rate of inert gas.

Consumable products

The XSR rotor and COVERAL* MTS fluxes are products, which are key to the satisfactory performance of the MTS 1500.

The novel design of the patented XSR rotor (figure 2) helps to create the optimum vortex during the addition of the treatment products. In addition, it is highly efficient in removing oxides and dissolved hydrogen from the melt.

Figure 2 XSR rotor

A range of new fluxes branded COVERAL MTS has been specifically formulated for use with the MTS 1500 which includes cleaning/drossing, sodium modifying, grain refining, and element removal fluxes (Table 1). All these fluxes have been developed to keep smoke and fumes to a minimum.

Name	Application	Classification
COVERAL MTS 1524	Cleaning/Drossing	Xi-Irritant
COVERAL MTS 1560	Cleaning/Drossing, Na free	Not classified
COVERAL MTS 1565	Cleaning/Drossing Na-Ca free	Xi-Irritant
COVERAL MTS 1572	Sodium modification	T-Toxic
COVERAL MTS 1576	Sodium modification	Xn-Harmful
COVERAL MTS 1584	Grain refining + cleaning	Xn-Harmful
COVERAL MTS 1591	Cleaning/Elements removal	Not classified

Table 1 COVERAL MTS flux range

Process steps

A standard treatment cycle with MTS 1500 is in four steps:

- Shaft and rotor introduction: the shaft and XSR rotor are lowered into the melt. Then, the baffle plate is moved into position 'A' where a vortex is created.
- Vortex formation: the rotor speed is increased to a point where a vortex is created around the shaft.
- Addition of fluxes: the required amount of flux(es) is dispensed directly into the vortex and drawn down into the melt.
- Vortex termination and degassing: after the additions are complete, the baffle plate is moved into position 'B' where the vortex is stopped, thus initiating the degassing phase.

Benefits

The MTS 1500 offers the foundry several benefits that can be divided into four main categories: metallurgical, environmental, health and safety as well as economical benefits.

Metallurgical benefits

The use of COVERAL MTS fluxes in combination with the MTS 1500 machine enables foundries to get metallurgical benefits such as consistent mechanical and physical properties, homogeneous microstructure and composition, acceptable levels of metal cleanliness and controlled gas porosity.

The technology is of interest to all foundries but particularly those in which the castings are required for safety critical applications.

Environmental benefits

With the introduction of increasingly strict environmental legislation, there is greater emphasis placed on foundries to reduce the amount of pollution they produce. ISO and other key accreditations provide necessary guidelines on how to achieve this. The MTS 1500 helps foundries to achieve better environmental performance by the use of fewer consumables (flux and inert gas), lower dross levels, reduced emissions as well as shorter treatment times and melt superheat with associated energy savings.

Health and safety benefits

The MTS 1500 contributes to a healthier and safer environment. Unacceptable emissions are reduced compared to conventional treatments because the MTS 1500 uses less flux, the action of the vortex draws the flux down into the melt where it is quickly mixed into the metal, and the flux used in the metal treatment is fully consumed and does not continue to react post treatment. As the MTS 1500 is a fully automated process the operator involvement is reduced and a safer environment results.

Economic benefits
MTS 1500 enables foundries to make substantial cost savings by reducing treatment costs and improving performance.

Treatment costs can be minimised because inert gas and flux consumption is reduced, aluminium losses in the dross are lower and less labour is required. General performance is improved by fast metal turn around, reproducible metal quality, increased reliability and decreased maintenance.

A set of case studies for different melt treatment steps such as cleaning, grain refining, sodium modification, and/or element removal gives an overview of the process and attendant benefits.

Grain refining

The grain size of cast alloys is dependent on the number of nuclei present in the melt as it begins to solidify and on the rate of undercooling. Grain refining improves hot tear resistance, reduces the harmful effects of porosity and redistributes shrinkage porosity in aluminium alloys. Titanium, particularly in association with boron, has a powerful nucleating effect and is the most commonly used grain refiner.

Case study 1
A test in a die casting foundry for brake components for automotive industry was carried out to compare AlTi5B1 rod with the newly developed COVERAL MTS 1584 grain refiner. The treatment was carried out in electrical heated crucible furnaces (Table 2).

Die casting foundry	FDU plus manual treatment	MTS 1500
Product used	AlTi5B1 rod	COVERAL MTS 1584
Alloy used	AlSi7Mg	
Furnace type and capacity	800 kg; electrical heated crucible	
Treatment temperature	730°C	
Addition rate	0.10 %	0.04 %
Titanium yield	46 ppm	55 ppm
Boron yield	4 ppm	3 ppm
Dross weight per treatment	12.0 kg	4.5 kg

Table 2 Trial parameters and results for grain refining

A comparison of yields for the two treatments can be seen in figure 3, and the respective microstructures can be seen in figure 4.

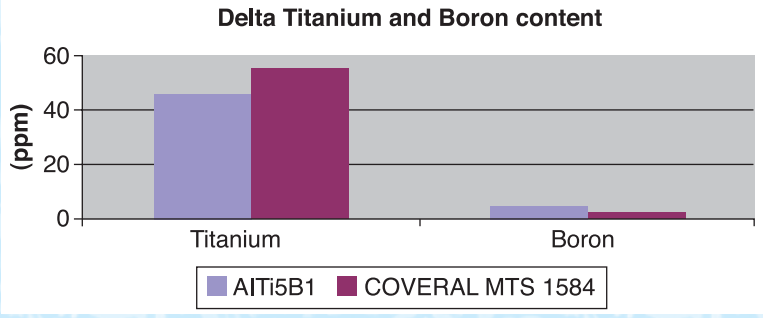
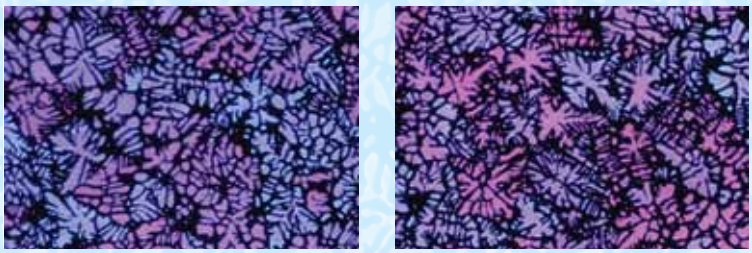


Figure 3 Yield comparison for grain refining trials

AlTi5B1 rod (0.10%)

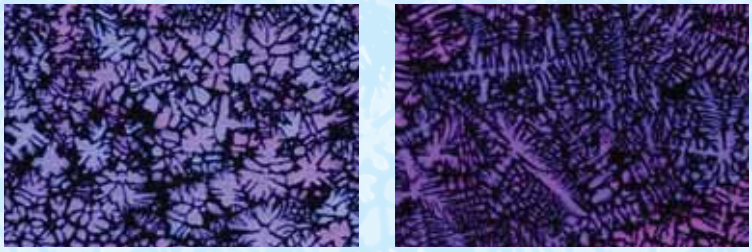


Dendrite Arm Size (DAS)

207 µm **Before**

161 µm **After**

COVERAL MTS 1584 (0.04%)



Dendrite Arm Size (DAS)

186 µm **Before**

120 µm **After**

Figure 4 Microscopic structure for grain refining comparison

The material costs per treatment for AlTi5B1 master alloy (at 0.10% addition rate) and COVERAL MTS 1584 (at 0.04% addition rate) are generally similar, although this depends on specific master alloy prices.

The microstructure of the castings was improved by using COVERAL MTS 1584; the result was supported by thermal analysis curves. Additionally the grain refining granular product assists with cleaning and drossing.

Grain refining with COVERAL MTS 1584 in combination with MTS 1500 technology is a new and effective option for titanium boron nuclei addition into aluminium alloys.

Sodium modification

Modification is normally recommended for Al-Si alloys with 5 - 13% of silicon content and sodium is accepted as one of the most effective modification agents. It improves feeding properties and hot tear resistance and reduces shrinkage porosity. In the past, powder fluxes, tablets and metallic sodium were the most common products added manually. The new MTS 1500 technology gives the opportunity to automate and control the process using granular products.

Case study 2

The problem faced by a gravity die casting foundry producing safety critical componets was variability in flux additions due to operator error. This variation could be significant resulting in unacceptable scrap levels. A MTS 1500 treatment was introduced as seen in Table 3.

Gravity die casting foundry (automotive)	FDU plus manual treatment	MTS 1500
Flux used	Powder flux	COVERAL MTS 1572
Melt capacity	500 kg	
Treatment temperature	740 – 760°C	
Amount of flux used/ treatment	4.5 kg	1.8 kg
Sodium pick up	150 ppm	150 ppm
Variation in sodium content	± 13%	± 5%

Table 3 Trial parameters and results for sodium modification

Once the MTS 1500 treatment cycle had been optimised there was less than 5% variation in the sodium content of the treated metal as the cycle is constant. The foundry saved 60% of the amount of modification flux, but the biggest benefit for the foundry has been achieved through producing sounder castings with reduced scrap rates.

Case study 3

A sand foundry intended to change its melt treatment practice to MTS 1500 to achieve a better consistency. Due to its particular location near a housing estate, the use of a non-toxic material was not allowed. FOSECO developed an environmentally acceptable product which is non-toxic i.e COVERAL MTS 1576. The parameters for the process are outlined in Table 4.

Sand foundry	FDU plus manual treatment	MTS 1500
Flux used	Modifying tablets plus drossing granulate	COVERAL MTS 1576
Melt capacity	450 kg	
Treatment temperature	740 - 760°C	
Type of alloy	AlSi6Cu3	
Amount of flux used/ treatment	Modifying tablet: 0.25% Drossing granulate: 0.05%	0.23%
Sodium pick-up	80 - 100 ppm	

Table 4 Trial parameters and results for sodium modification

The intensive mixing of product with the melt given by MTS 1500 enabled the use of a non-toxic sodium modifier. The use of COVERAL MTS 1576 with MTS technology reduced significantly the operator involvement, and minimised the number of injuries caused by burns. Also it improved the working environment, which is benefical to the employees and to the local community.

Cleaning/drossing

Melt cleaning fluxes are designed to remove aluminium oxides and other impurities from the melt. The action of a cleaning flux takes place within the melt, beneath the melt surface, by trapping the oxide particles and encouraging them to float out. The flux has to be in close contact with the melt, therefore it should be plunged and stirred intensively within the melt (figure 5).

Figure 5 The action of a cleaning flux

A successful drossing agglomerates the oxides in the dross and separates them from the liquid metal leaving dry and powdery dross. Skimming is thus facilitated and metal loss due to aluminium entrapment in the dross is reduced.

Case study 4

This is a wheel foundry, part of a European foundry group, operating a considerable number of melting furnaces. The molten metal is transfered by forklift to the low-pressure machines in an 800 kg transfer ladle. Degassing and melt treatment are carried out in this ladle. Table 5 outlines procedure and result using MTS.

European wheel foundry	FDU plus manual flux addition	MTS 1500
Production capacity	20,000 tons per year	
Number of ladles treated per day	65 - 70 ladles per day (INSURAL ATL 800)	
Treatment temperature	730 – 760°C	
Type of fluxes used	COVERAL GR 2410 (0.05%)	COVERAL MTS 1524 (0.03%)
Amount of flux used per cycle	400 g ± 20g	240 ± 10 g
Flux amount used per year	6,000 kg	3,600 kg
Dross weight per treatment	7.2 kg	4.4 kg
Dross amount produced per year	108 tons	66 tons
Metal dross content	44%	36%
Amount of aluminium lost per year	47.5 tons	23.8 tons

Table 5 Trial parameters and results for melt cleaning

Figure 6 compares the amount of dross and aluminium currently lost per year.

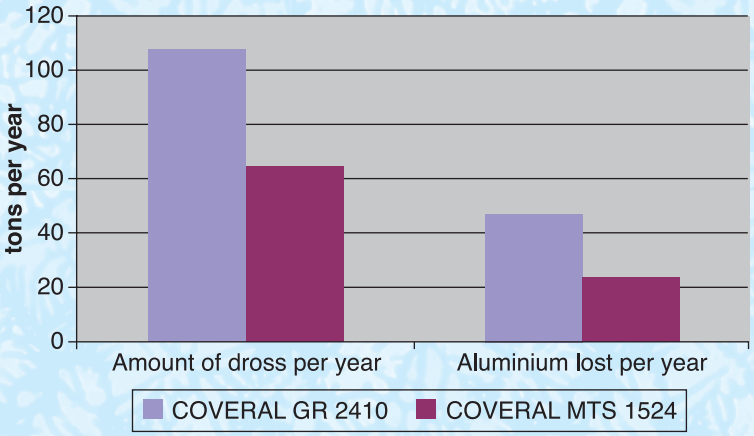


Figure 6 Comparison of dross amount and aluminium lost for melt cleaning

The installation of the MTS 1500 has resulted in immediate improvements in reliability, granular additions are precise and metal quality is consistent. The annual granular flux additions have been reduced by 20%, resulting in much lower emission rates.

The major economic benefit for the foundry has been achieved by the reduced quantity of dross and aluminum loss. The MTS 1500 provides a more intensive mixing of metal with the melt treatment product, which gives a better segregation of melt and oxides. The total amount of aluminium lost has been reduced by about 50%.

Element removal

For special types of alloys (pistons or Al-Mg alloys), the removing of sodium, strontium, and calcium is essential. COVERAL MTS 1591 is a granulated flux, which provides a strong cleaning action while removing these elements. This product is fluoride free and emits low fume.

The first results achieved with COVERAL MTS 1591 showed very low levels of calcium, strontium and sodium in the melt. Further trials on a longer period of time have to be conducted to confirm these results. The main goal is the replacement of chlorine use in foundries as chlorine is a hazardous material for people and the environment. It is likely that the chlorine use will be restricted in the future.

Conclusion

MTS 1500 system is a fully automated metal treatment station which performs all metal treatments in one single operation. It eliminates the influence of operator error and is consistent and reliable.

The use of MTS 1500 has given foundries significant metallurgical, environmental, health and safely and economic benefits.

Major cost savings are obtained by reduction of gas consumption, flux consumption, aluminium loss in the dross, energy costs by reducing treatment times and furnace temperatures, and labour costs. In addition, MTS 1500 gives a fast metal turn around, reproducible metal quality, increased reliability and decreased maintenance.