

# Selection, application and control of gravity and low pressure diecoatings

## Introduction

Ever since the gravity and low pressure die casting processes were introduced the need for a diecoating has been recognised. The selection and controlled application of the optimum die coating, or combination of coatings, is as important to the production of sound castings as other aspects of the process such as die-design, metal treatment and the running/gating system.

The advantages of die-casting processes over sand casting are well documented; better metallurgical properties, improved surface finish, closer tolerances, faster production and – for long runs – more economical. However the rapid heat extraction of the metal mould substrate induces a different metal flow and solidification profile on the alloy employed and the die-dressing can help control these properties.

## Coating functions and characteristics

The diecoating serves several essential purposes, most notably:

- Protection of the die
- Ease of release of the casting
- Control of heat flow from the metal to the die
- Provision of good surface finish

Since the production of good quality sound castings requires control over die-filling and solidification, thermal insulation of the die and control of heat flow is undoubtedly the most important function of the die dressing.

## Control of heat flow

Thermal insulation properties of the applied coating layer are determined by three key factors, namely:

- Coating composition
- Layer thickness
- Coating layer porosity

## Coating composition

Permanent mould coatings are typically formulated using water as 'carrier', a high temperature binder (normally sodium silicate), and a refractory filler or blend of fillers.

Three broad categories of coatings exist:-

- **Insulating** Containing blends of insulating minerals such as talc, mica, kieselguhr, titanium dioxide, alumina, etc. (DYCOTE 34, 140, 39)
- **Lubricating/conductive** Typically based on colloidal or semi colloidal graphite to aid release of the casting and/or to alleviate 'hot-spots' (DYCOTE 11, 38)

- **Semi-insulating** 'Hybrid' products designed to combine good release properties with moderate insulation (DYCOTE 36).

At normal casting temperatures of aluminium alloys the refractoriness of the fillers is sufficient to ensure that chemical change does not occur and their function is essentially physical. Thermal conductivity and granulometry are key properties and the diecaster needs to consider the most important aspects of the particular casting to be produced when selecting the diecoating or coating combination, for example high insulation to avoid misruns, lubrication to aid casting release, or casting surface smoothness.

It is generally accepted that a rough coating surface provides maximum insulation behaviour through the formation of an 'air gap' at the metal/coating interface during pouring, resulting from the momentary high surface tension of the alloy as it passes over the surface of the die. The low contact area significantly reduces heat transfer and consequently aids metal flow.

In addition, coarseness and angularity of the refractory particles enhances metal flow by continuously rupturing the oxide skin on the molten metal surface as it flows over the mould.

Conversely a smooth coating based on fine fillers provides a larger contact surface area and higher heat transfer rate.

Figure 1 shows a simple test plate casting used to illustrate the effect of coating insulation and granulometry on metal 'flowability'; in this case showing the effect of varying DYCOTE 140 thickness.

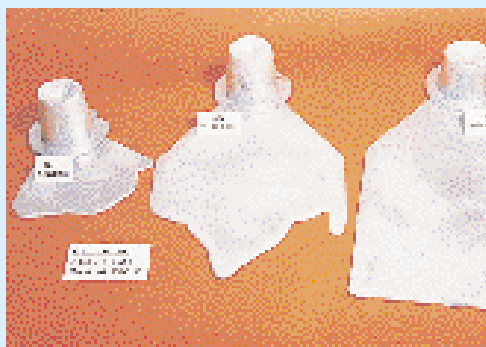


Figure 1.

## Coating layer porosity

Insulation of the coating layer is dependant not only on thickness but also on inherent porosity. This property in turn is influenced greatly by the application method and conditions – the degree of pore formation essentially being determined by the rate of evaporation of the water carrier on contact with the die.

Although die dressings are occasionally applied by brushing, especially in running, gating and riser areas, the most common method is to apply by spraying.

Application of the dressing at a mould temperature of around 170-200°C usually gives optimum results although coating consistency and spray equipment also influence the quality of the deposited coating layer and slight deviations from this temperature may be necessary.

Higher mould temperatures usually result in greater layer porosity due to a more 'vigorous' reaction between the water carrier and the hot die. Although insulation is accordingly higher, coating adherence and durability are adversely affected. Excessive die temperatures can lead to violent 'kick-back', where the coating does not adhere to the surface at all.

Conversely, a lower mould temperature results in a denser, less insulating layer, albeit of greater durability. Excessively low temperature can lead to 'puddling' of the coating, resulting in cracking and blistering defects as the die is heated to operating temperature and 'trapped' moisture ruptures the binder film as it escapes.

Porosity in the coating layer actually decreases the greater the distance from the mould surface due to progressively less vigorous water evaporation during coating application.

Figure 2 shows a typical graph of insulation as a function of thickness indicating that a 300 micron coating layer would not be significantly more insulating than one of 200 microns. As heavy layers over 300 microns also tend to be more susceptible to 'flaking' or lamination from the die, the optimum target operating range for dry coating thickness is 150-250 microns.

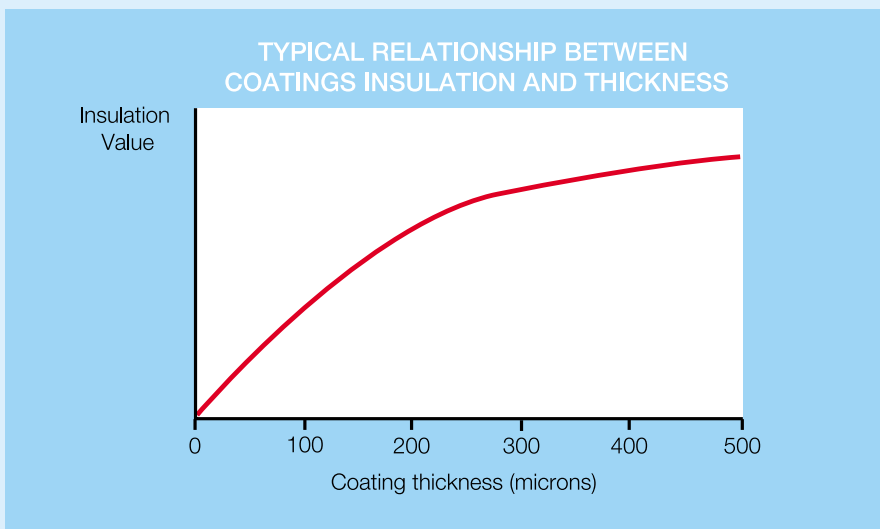


Figure 2.

## Coating the die

Selection of the correct coating for a particular casting only results in high quality castings if the coating operation itself is controlled and consistent. However this is one of the most abused and variable aspects of the entire casting process. Careful attention to die preparation, coating preparation, and the type of coating equipment utilised can yield significant quality and productivity benefits.

### Die preparation

As with all coating applications, careful preparation of the substrate is critical to the ultimate performance of the die-dressing.

New moulds need to be thoroughly cleaned to dispel any lubricants or rust preventative treatments whilst moulds already in service must have the old coating layer completely removed.

Traditional cleaning methods include wire-brushing and blasting with either sand, metal shot or grit. Problems of excessive wear and tear of the die surface with these techniques has prompted die-casters and suppliers alike to look at non-destructive cleaning methods including wet chemical methods and resin media as used in the aircraft industry to remove old paint. Neither of these options has yet been developed commercially due to environmental and cost concerns respectively.

Die-cleaning through blasting with carbon-dioxide pellets is now becoming popular however, particularly in North America.

After cleaning, the die should be heated uniformly to around 300-350°C. This is usually achieved through the application of gas burners appropriately positioned inside and around the die, although temperature variations over the surface of the mould are inevitable with this method. Many foundries are now pre-heating dies in dedicated ovens under tightly controlled conditions to achieve an extremely even, uniform temperature profile across the die.

Dies are normally cooled to around 180°C for coating application. A primer – either a water/surfactant solution or dilute version of the regular coating – is often used to promote enhanced adhesion of the main coat.

### Coating preparation and application

Proper control of coating properties at application is critical. Traditionally operators have used approximate dilution ratios when preparing the coating for use but control methods such as baume and density are now being more widely adopted. These simple tests can be conducted easily and quickly 'on line' and in conjunction with other information provided by the supplier, can give good control over 'in-can' properties.

Many foundries now monitor applied coating thickness during spraying of the die and as an 'in-line' control using compact portable gauges operating on the magnetic and eddy current principle.

Mould temperature during spraying is critical to the behaviour of the coating in service and consequently an increasing number of foundries now measure die temperature using either optical pyrometers, computer-lined thermocouples, or simple contact thermometers.

## Application equipment

The most popular application technique still used today involves a 'home-made' venturi system comprising of a small container, copper piping and compressed air line, see figure 3. Whilst this system is extremely simple and capable of excellent results, it does lack control and can result in a great deal of 'spattering', giving rise to an uneven and irregular coating layer.



Figure 3.

More foundries are now adopting air-less spray systems and purpose designed spray guns which deliver a fine, uniform coating 'mist' via an adjustable fan width. Equipment has also been developed to provide not only agitation in the feed container but also re-circulation of material in the feed hoses themselves whilst the gun is not in use in order to help prevent separation of liquid/solids at all times, see figure 4.



Figure 4.

## Computer simulation

Computer simulation of die-filling and solidification profiles is becoming an extremely powerful tool for foundries in the design and optimisation of process parameters for new or prototype castings.

Today a number of programs are commercially available to assist die casters in predicting how dies will behave in service before they are built.

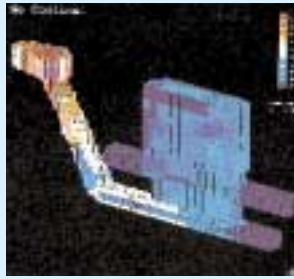


Figure 5.

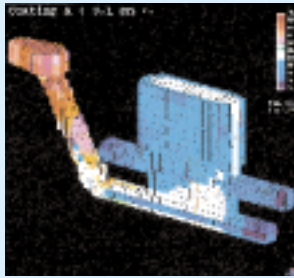


Figure 6.

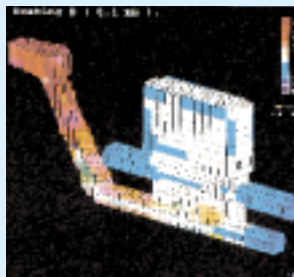


Figure 7.

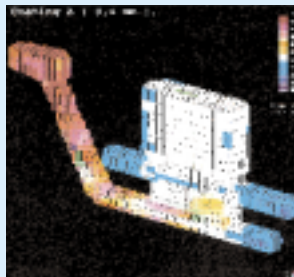


Figure 8.



Figure 9

Various design and process parameters can be tested and validated before tooling is built, thereby improving the die casters 'right first time' capability and avoiding time-consuming and costly start-up trials.

The impact of coating type and application on die-filling, solidification and casting and mould temperature profiles is just one process parameter which can be assessed.

Figures 5-8 show simulated temperature profiles immediately after mould filling for a test bar casting, complete with running and feeding systems, see figure 9. Alloy type, pouring temperature and other process parameters were kept constant for the simulations. The resulting temperature differences – in the order of 20°C for Coatings A and B at 0.1 mm thickness – illustrates the strong effect exerted by different coating types and the importance of controlling coating layer thickness. In this particular case it can be seen that Coating A would need to be applied at around 0.3 mm to provide the same insulation effect as Coating B at 0.1 mm.

A comparison of casting solidification times for the two coatings over a range of thicknesses, further emphasises the need for careful attention to coating selection and a controlled application process, see figure 10.

Clearly data of this kind can greatly assist the die-caster in understanding the likely effect of different coating practices and, combined with practical observations, can help in the process optimisation .

## Conclusion

The ability of the coating to affect die-filling and aid directional solidification makes coating selection and controlled application of paramount importance in the production of high quality, metallurgically sound castings by permanent mould processes.

There is little doubt that increasing demands for improved productivity and casting quality will result in the more widespread application of critical in-process control techniques and drive forward innovation and development in die coating technology.

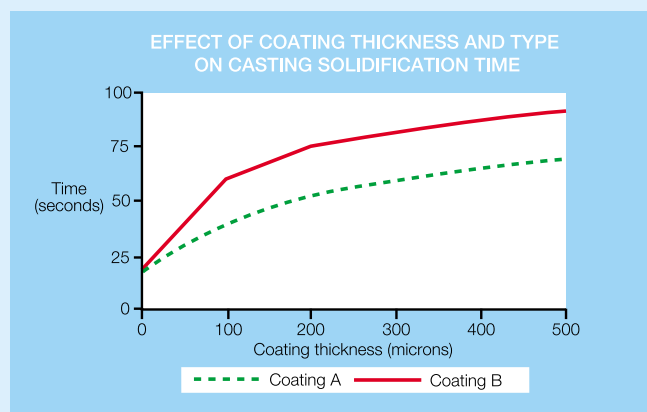


Figure 10.