Developments in die coating Technology

Background

Something in the region of 40% of aluminium castings produced globally are made via the gravity diecasting (permanent mould) and low pressure diecasting processes. It has always been accepted that a major contributor to the successful manufacture of quality parts is the coating which is applied to the die surface. FOSECO has had for many years a comprehensive range of coatings which give:

- ❑ Insulation control
- ❑ Release from the die
- ❑ Encouragement to fill thin sections fully
- ❑ Control of surface finish
- ❑ Soundness (feedability)

The use of DYCOTE die coatings has been widespread in the foundry industry for more than 60 years with the traditional product range modified to satisfy specific customer requirements. The products have also evolved to reflect the change in casting requirements, however, no **major** developments have been made for some considerable period.

Over the past 5 years the market demands regarding die coatings has been changing with productivity and plant utilisation becoming more important within the foundry industry. Any interruption in production and subsequent down- time while cleaning and recoating is a major cost and inconvenience to the foundry so improvements in DYCOTE life will offer significant benefits.

This has given FOSECO the opportunity to reassess its strategy towards the DYCOTE product range.

Traditional DYCOTE die coating range

The DYCOTE die coating range can be separated into three distinct product types:

- ❑ Insulating coatings
- ❑ Heat conductive coatings
- ❑ Lubricating coatings

The insulating coating range is the largest of the three groups. These coatings help maintain metal temperature and therefore metal fluidity during the filling of the mould. The insulating characteristics of the coating will come partly from the constituents and partly from the surface roughness of the coating. The surface roughness is generated by the particle size of the refractory fillers and varies between 10 and 100 microns. In general the coarser the coating the higher the insulation effect. When selecting a die coating for each specific application there is always a compromise between surface finish of the casting and the filling of the mould cavities.

Listed below are some typical coatings taken from the FOSECO Insulating coating range.

Type of Coating	Typical Grain Size µm	Thinning Ratio	Application, Description
Base Coat			
DYCOTE D R 87	18	1:1 - 1:3	Primer, increases adhesion and thereby lifetime of the top coating
Insulating Coatings			
DYCOTE D R 787	10	1:3 - 1:5	Can be applied at higher temperature than standard coatings
DYCOTE D 39	15	1:3 - 1:5	Where excellent surface finish is essential
DYCOTE D BN 120	35	1:10 - 1:20	Coating containing boron nitride for smooth surfaces, although the coating itself has a rough surface, and long holding times
DYCOTE D 140	35	1:3 - 1:5	Mid range coating for standard applications. Coarse coatings often used for thin walled automotive castings.
DYCOTE D 7039	78	1:3 - 1:5	
DYCOTE D BN 7039	78	1:3	
DYCOTE D 34	80	1:3 - 1:5	
DYCOTE D 6 ESS	85	1:3 - 1:5	

In certain applications it is necessary to apply conductive coatings to increase heat transfer and encourage rapid cooling. These coatings are all graphite based and can also be used for lubrication.
Below is a list of typical coatings from this range:

Heat Conductive and Lubricating Coatings	Typical Grain Size µm	Thinning Ratio	Application, Description
DYCOTE D 40		Diluted with mineral oil	Graphite/oil ingot coating
DYCOTE D 38	5	1:10	Colloidal graphite, lubricating coating for low tapers, without binder
DYCOTE D 11	10	1:10	Semi colloidal graphite, for parts with low tapers, chill coating, without binder
DYCOTE D 36	35	1:3 - 1:5	As DYCOTE D 11, however, with additional binder

All the above listed coatings are delivered in a concentrated form and have to be diluted with water, except for DYCOTE D 40, which has to be diluted with mineral oil.

Selection of die coatings

A number of factors must be taken into consideration when selecting a die coating. Firstly the section thickness of the casting. One of the main properties of a coating is its ability to aid the filling of the die. When the casting concerned has a thin section then a DYCOTE die coating with high insulation properties should be considered. Secondly there is the surface finish requirement of a casting. This is very important, however, coatings which give very good surface finish do not also give good insulation. The balance of surface finish and insulation will therefore always be a compromise. Another important factor is the geometry of the casting which can also be critical for efficient feeding. If a casting has isolated thick sections then a specific coating may be required to help directional solidification. Where a casting has small draft angles, then a coating with excellent release may be required. Finally the casting process may also influence DYCOTE die coating selection. For example low-pressure castings can be made with coatings which have different characteristics from gravity castings. By carefully selecting the DYCOTE die coating with the required features, then optimum performance can be achieved.

Figure 1: DYCOTE die coating management station

Process control

In order to achieve the optimum performance from a particular coating it is now accepted that the mixing and application of the coating is critical. To this end FOSECO have developed a DYCOTE die coating Management Station. This enables the foundry to mix the coating in ideal conditions by accurately measuring the water addition and also gives the option of pre-programmed dilution to eliminate operator error. The use of the FOSECO Carry&Mix mixer also ensures the coating is not only mixed well but is held in suspension during the working period. Cleaning of the Carry&Mix is simple and must be carried out thoroughly to avoid possible contamination with old coating. By creating a central, controlled mixing area then the preparation of the DYCOTE die coating will be given the level of importance and control which it deserves (figures 1 and 2).

Figure 2: FOSECO Carry&Mix mixer

New Developments

As productivity in foundries became ever more important over the years FOSECO were continually asked to develop new ranges of coatings which would improve die life. The original development work was carried out by FOSECO Japan. It was soon evident that by moving to a different binder and more carefully graded fillers then significant improvements could be made in die coating performance. By making these changes a range of coatings were developed equating to the current range, and sold in Japan.

A key feature in the improved performance of these products has been the final curing of the coating. The finished die is soaked for 60 minutes at 450ºC to drive off any chemically combined moisture, reducing the tendency to pick up moisture during storage. This also hardens the surface thus increasing the coating life in service.

European Experience

When the first trials were made in Europe, using the Japanese developed products, it soon became clear that these very fine coatings were not suitable for European casting techniques. Problems with mould filling were experienced and it was found that a coarser range of Long Life DYCOTES die coating were required for the European market. The European product range to date includes;

DYCOTE	Description
DYCOTE 1450	General purpose coating.
DYCOTE 2040	Coarser version of DYCOTE 2050 - for thinner walled gravity die applications such as cylinder heads.
DYCOTE 2050	Successful for automotive castings.
DYCOTE 3950	Excellent for low pressure wheel production
DYCOTE 3975	Good surface finish, excellent release.

Application

- ❑ Best results are achieved with dilution rates of around 1 : 3
- ❑ Spray on to the die at 200 - 250ºC
- ❑ To achieve the optimum life time of the Long Life DYCOTE the die has to be cured at 450ºC for just over one hour

Advantages of Long Life DYCOTE die coatings

- ❑ Improved Productivity - Dies run for longer and so the frequency of stopping production to change to a newly coated die is reduced.
- ❑ A reduction in scrap on start up of a newly coated die. It is common when a newly coated die is first cast that the temperature profile may not be correct. Shrinkage or mis-running sometimes results. Again the less frequently a newly coated die is introduced, the fewer problems are created.
- ❑ Reduction in frequency of coating leads to a reduction in labour required in die preparation.
- ❑ As the Long Life DYCOTE die coating is tougher and more wear resistant then the die will run longer at the optimum thickness and condition of the coating, resulting in better quality castings.
- ❑ With the special composition of Long Life DYCOTE die coatings there is less likelihood of settling and segregation during mixing.
- ❑ Reduction in frequency of die cleaning will result in less die wear, improved die life and consistent casting definition.
- ❑ A lower frequency of die cleaning means a reduction in cleaning consumables and less DYCOTE die coating being consumed.
- ❑ Foundries will traditionally touch up the coating on the die to extend the coating life, without removing and recoating. Again the amount of touching up required will be far lower with Long Life DYCOTE die coating.

Case Studies

Europe

In the following table a selection of castings produced throughout Europe using various DYCOTE die coating products are shown.

Casting	LLDYCOTE	Dilution	Spray temp	Curing	Performance
Suspension arm	DYCOTE 2050	1:3	200°C	400°C	12 shifts
Cylinder head	DYCOTE 2040	1:3	200°C	300°C for 3 hours	3 days
Wheel - Customer A	DYCOTE 3950	1:5	300°C	None	10 shifts
Wheel - Customer B	DYCOTE 3950	1:5	300°C	None	4 shifts
Wheel - Customer C	DYCOTE 3950	1:5	300°C	None	Double life.
Housing	DYCOTE 1450	1:3	225°C	None	5 shifts

Conclusion

The developments in DYCOTE die coatings have now given diecasting foundries a wider and more sophisticated range of products from which to choose. The products need to be able to perform such that they satisfy the requirements placed on the industry by casting designers and buyers.
By careful product selection, preparation and application better performance can be achieved with subsequent improvements in casting quality, consistency, finish and productivity.