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Optimization of the Coating Application – Hot Spraying Instead of Brushing

The Problem

In the foundries, coatings are used as mold coating materials. These help reduce the chemical reactions between the melt and the mold material for cores and molds. They also smooth rough mold surfaces and reduce the volume of cleaning work. The coating is mainly applied to the mold or core surface. The coating layer acts as a barrier between the mold material and the liquid metal.

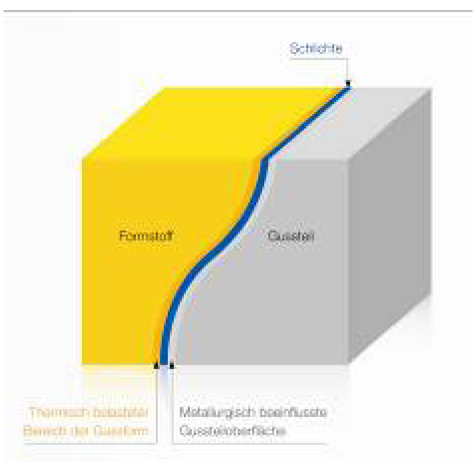

Figure 1: Application of the coating

The different coating methods such as flooding, dipping, spraying, brushing and powder coating can be used here.

The application method is selected in accordance with the following criteria:

- Size of the core and mold
- Handling
- Minimum periphery
- Surface quality
- Reliability
- Space requirements
- Restrictions
- Efficiency
- Drying of the coating
- Investments

The manufacturers of large-scale castings mainly use two methods (e.g. flooding and brushing) to apply the coating to the core or mold surface. Due to the cast dimensions and the handling, most foundries prefer brushing. This method has specific advantages and disadvantages. These are listed in Table 1.

Table 1: Advantages and disadvantages of brushing

Advantages	Disadvantages
Easy to handle	Paintbrush strokes almost impossible to avoid
Good value for money	High time outlay
Can be used anywhere	Technical experience required for complicated molds/cores
Low material losses	Fluctuations in layer thickness
Simple, low-emission paintbrush cleaning	

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Due to the visible paintbrush strokes on the casting surface, the high time outlay and the irregular coating application, an attempt is frequently made to improve/optimize processes.

Suggested Solution

In a joint project with Meuselwitz Guss Eisengießerei GmbH, ASK Chemicals and WIWA, a manufacturer for spraying technology, the spraying method was adapted in terms of casting quality. There are different spraying systems on the market today. Due to the wide application range and the following advantages, an Airless spraying unit manufactured by WIWA was selected for the tests:

- Suitable for both water-based and alcohol-based coatings. The odor pollution during spraying of the alcohol coating is no higher than during brushing.
- Nozzles with openings of different sizes and different spray angles can be used to meet the most varied of requirements.
- A working pressure of up to 8 bar can be set.
- With the spraying unit used, little to no spray is generated when the coating is applied. The spray depends on the coating structure and the dilution of the alcohol and water coatings. In many other systems, the spray constitutes a major disadvantage, as coating losses and employee health-related issues arise here.
- For this reason, no suction systems are required for water- or alcohol-based coatings. Only protective masks are to be

Figure 2: Professional series Airless spraying technology from WIWA

With this unit, a particularly comprehensive range for industrial coating jobs of any type can be created. These Airless high-pressure pumps are ideal for use in paint circulation systems as well as in the coating area. They are particularly suitable for processing high-viscosity, low-solvent and solvent-free materials with a high share of solids, and are optimally designed for longer material hoses, larger nozzle boreholes and high spraying pressures. This spraying unit was specially developed for applications with coarsely pigmented or abrasive materials with low to medium viscosity, such as zinc primer, micaceous iron ore, solvent-based zinc silicate, glass flake, printing inks, flame protection and other heavily pigmented or fibrous materials. Thanks to the high delivery volume, a slow piston speed is ensured even with large nozzle boreholes, and this keeps wear and tear low. [1]

In addition, the sprayed material is not mixed with air in the Airless units. This reduces the spray. Nevertheless, selecting a suitable nozzle and optimizing the working pressure can result in optimum atomization of the sprayed material.

Tests and Method

Initial Tests at Meuselwitz Guss

Meuselwitz Guss Eisengießerei GmbH is a manufacturer of cast pieces for wind power systems and mechanical engineering with a unit weight of up to 80 t. These large cast parts are produced in the pit molds or mold boxes with particularly large dimensions. The mold and core manufacturing method is the no-bake method, a cold self-hardening method based on furan resins. The pit molds, in particular, cannot be flooded. As a result, they had to be brushed in the past, and this is a time-consuming procedure. As part of this project, an alternative was to be found to reduce the time outlay for coating and improve the casting surface, if

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Figure 3: Blade adapter

Figure 4: Rotor hub

The first spraying tests were restricted to two components from the wind power industry. The blade adapter acts as a connection piece between the rotor blade and the rotor hub. It can rotate the rotor blade into the wind, or out of the wind for servicing work. The net weight of this component is approx. 3.2 t, and its walls are between 30 and 40 mm in thickness.

The second component on which the spraying tests were performed is a rotor hub. The wind power system's rotor blades are attached to this. In order to meet the challenge posed by these high stresses, the wall thicknesses must be adapted to the distribution of forces or the load. This cast part therefore has wall thicknesses of approx. 75 mm to approx. 175 mm. The net weight is approx. 13 t.
Due to the different wall thicknesses, the effects on the surface of the cast part can be checked and evaluated by means of the different thermal loads.

The aim of the spraying tests was to replace the brushing method with spraying as far as possible, and to find a suitable coating with the appropriate setting parameters.

The cores were flooded up to the test and the molds brushed. This means that direct comparisons can be made between spraying and flooding/brushing. At Meuselwitz Guss, water coatings and alcohol coatings are used to coat the core and mold surfaces. Only water coatings were used for the spraying tests, as the water coatings had already achieved positive results compared to the alcohol coatings in prior investigations.

One of the most important basic settings involves selecting a suitable nozzle. For flat molds and cores, nozzles with a large exit angle should be used. Nozzles with an angle of 50° are available for this. For molds and cores with many contours, nozzles with a small exit angle should be used, so that the more complex parts can be sprayed more evenly. Nozzles with an exit angle of up to 20° are available for this. Care should also be taken to ensure that the nozzle opening is the optimum size; this depends on the proportion of solids in the coating. If the nozzle openings are too small, the nozzle may become blocked. If a reversible nozzle (can be rotated 180°) is used, the blocked opening can be flushed easily and quickly in the reverse direction, but the abrupt stop may cause deposits to appear on the surface, and this may result in irregular layer thicknesses. In addition, the working pressure and the temperature of the sprayed material are of decisive importance in ensuring an optimum spraying result. If the working pressure is too high, the sprayed material is so heavily atomized that the likelihood of spray increases. As a result, the coating losses increase, meaning that more coating is required in order to spray a specific area. Excessively low working pressures cause insufficient atomization. As a result, entire drops are sporadically sprayed onto the surface to be sprayed, and this prevents a uniform, smooth surface from being created. The temperature of the sprayed material influences its viscosity. More will be written about this later on.

The first spraying tests resulted in sintering on the cast piece. The cause of this was that the coating was unable to penetrate far enough into the sand surface during the highly viscous coating application. As a result, the coating did not stick to the mold material strongly enough. This meant that the coating was only applied to the surface.

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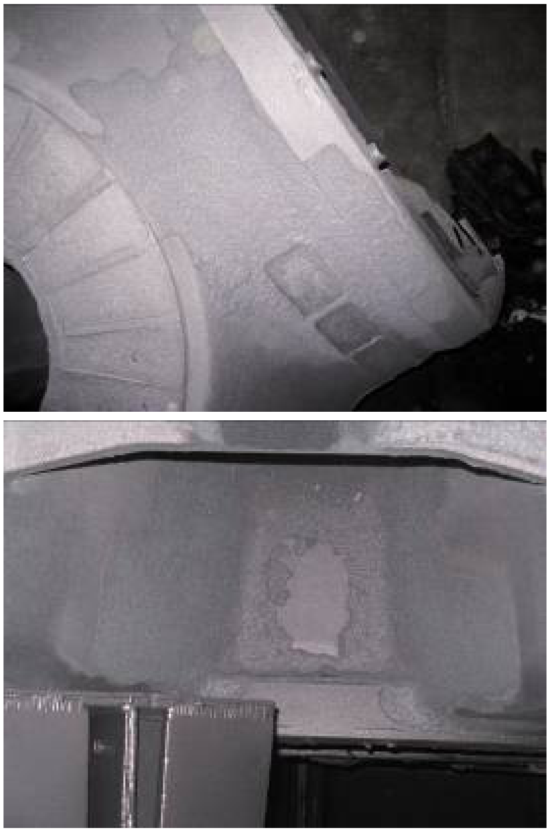

Figure 5: Casting surface of the rotor hub, casting defect – metallization

In the next step, the coating was further diluted with water so that it connected better with the sand subsurface. As the proportion of water rises, the proportion of solids (required for fire resistance) in the coating falls and the mold material surface is exposed to a greater thermal load. This test showed that the amount of sintering was reduced but the surface quality of the brushed or flooded cast parts could not be achieved because the cleaning outlay was too high.

Optimization of Spraying Technology

With the goal of further improving the quality of the casting surface, the spraying unit was retrofitted with a flow heater. This method is called hot spraying. The coating is pre-heated to approx. 40°C before being applied to the cast piece. The heating reduces the coating's viscosity and the coating becomes more flowable when hot. Unlike the previous test, very little water has to be used for the purpose of dilution. This means that the proportion of refractory materials remains almost unchanged, and the coating offers better protection against the thermal load. Thanks to the better flowability, the coating can penetrate into the mold material more easily and thus seal the cavities between the grains of quartz sand in the mold material layers close to the surface, thereby preventing the melt from penetrating. The coating was sprayed almost in the delivery state, but still managed to penetrate into the sand subsurface.

The cast results exhibited clean surfaces and were satisfactory. Thanks to this measure, it was possible to further reduce the sintering and penetration defects considerably. The surface quality was comparable to that of the cast parts from the brushed and flooded molds.

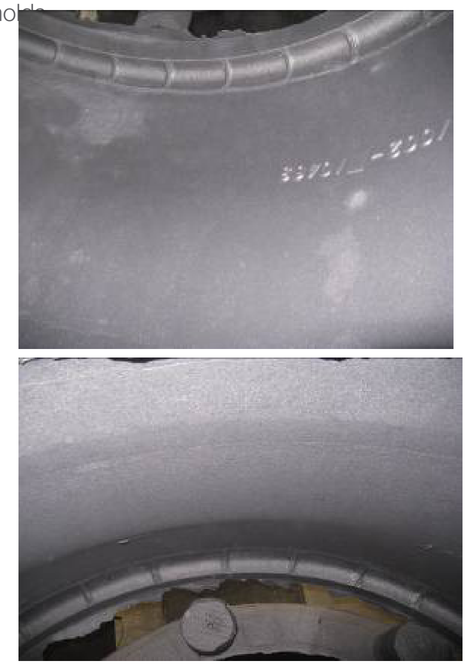

Figure 6: Casting surface following optimization of the spraying unit

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After the successful casting results, the Airless spraying unit with a heater was introduced at Meuselwitz Guss.

Confirmation Tests

As part of the project, an undergraduate dissertation was written by Mr. Vorrath on the topic “An investigation of coating application by means of spraying” at Meuselwitz Guss Eisengießerei GmbH. In this dissertation, the influence of the different setting parameters was investigated in order to achieve an optimum result with the best possible settings. The most important setting parameters were as follows:

- Viscosity of the coating
- Working pressure
- Nozzle (nozzle opening and spray angle)
- Temperature of the flow heater
- Characteristics of the coating

The influence of the coating characteristics was examined on the basis of four different coatings (SOLITEC® WP 401, SOLITEC® IM 701, SOLITEC® ST 801 and SOLITEC® EP3). The setting parameters varied depending on the coating specifications. All parameters such as coating viscosity, penetration behavior, layer structure and application behavior of every coating were recorded. It was discovered that the finer the solids in the coating, the greater the likelihood of spray mist during application of the coating. A rough, plate-shaped structure of the coating can cause blockages in the spray nozzles. In order to ensure an optimum spraying process, the nozzle, working pressure, filter and temperature on the flow heater must be adapted to the coating.

Typical Mistakes During Application of the

If the technique is not optimized for or adapted to the process, a wide range of different mistakes can occur, thereby preventing the desired result from being achieved. Excessively thick coatings, for example, in which the viscosity is too high, can quickly result in surfaces similar to orange skin, i.e. a corrugated, irregular surface is created that can lead to rough casting surfaces (Figures 7 and 8).


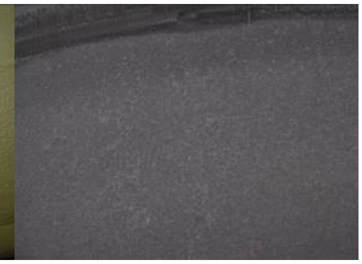

Figure 7: Sprayed core with orange skin Figure 8: Orange skin on the cast part

By contrast, coatings that are too thin can lead to sagging or the formation of tears due to insufficient viscosity (Figure 9). In this state, an orange skin can no longer be formed. However, the tears must be removed (e.g. by being brushed with a paintbrush) in order to prevent undesired indentations on the casting surface. In addition, excessively thin coatings result in thinner layers. This may necessitate additional spraying passes in order to achieve the required layer thicknesses.

Figure 9: Sagging during spraying

If the coating application is too thin, it creates an insufficient layer of protection against the thermal load. In such cases, burning, sintering (Figure 12) or metallization can be expected. If the coating application is too thick, the orange-skin surface mentioned above can form. In addition, a superficial coating application that does not allow the coating to penetrate into mold material layers close to the surface should be avoided. Otherwise, penetration defects are to be expected.

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Spraying is an activity that can also be quickly learned by employees who have no previous experience with spraying technology. The optimum distance from the spray gun to the mold/core surface must be complied with. If the distance is too low, the orange-skin surface will quickly form or tears will be created. If the distance is too large, the material losses will increase and only a small amount of coating will be applied to the surface. This may result in lower layer thicknesses.

In order to achieve an optimum spraying result, the surfaces should be sprayed at a vertical angle. However, this is not always possible in the case of undercuts, corners, ribs etc. This results in excessively thin and/or irregular layer thicknesses. Rough scabs have also emerged as a further problem; these can be caused by attrition of burr or insufficient compression. These rough areas need more coating than smooth areas. As a result, metallization, sintering, burning and penetration are to be expected in these areas. However, this can be avoided by means of pre-treatment

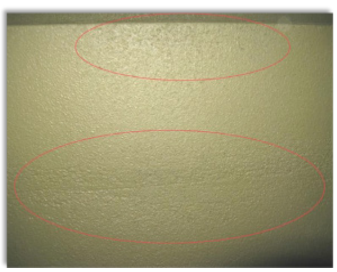

Figure 10: Core with differing surface characteristics

Figure 11: Metallization layer

The following points should be complied with when the coating is being applied in order to achieve defect-free casting surfaces, to lengthen the lifespan of the spraying unit and to create better working conditions for the employees:

- Select the right coating
- Optimize the coating settings so that the coating achieves good adhesion and high resistance against abrasion
- Ensure an optimum coating application without an orange-skin surface, sagging or streaks
- Adapt and optimize the spraying unit to meet the relevant requirements: Suitable nozzles (nozzle opening and spray angle), filter size, working pressure and, if necessary, check the outlet temperature of the coating if a flow heater is being used
- Pre-brush the rough scabs with a paintbrush before spraying. In the case of corners, pay particular attention to the risk of
- Deep, thin ribs and undercuts cannot be sprayed, or sometimes can only be sprayed with difficulty. Therefore, pre-brush these contours
- If there is no drying kiln available, drying takes 2.5 to 8 hours depending on the coating, coating settings, ambient temperature, air humidity, flow speed and warm or cold sprayed material. Experience has shown that if the air is moving, drying can be completed relatively quickly, even at very low temperatures. In this case, the ambient temperature can be disregarded
- Keep the spraying unit in a good condition. If using water-based coatings, clean it with water; if using alcohol-based coatings, clean it with alcohol. Clean the nozzles and piping on a regular basis if they are not being used or if problems occur
- When alcohol-based coatings are sprayed, a combustible aerosol made up of alcohol and air is formed (just like during brushing). Under specific circumstances, this may explode. In this case, an absolute ban on smoking is to be imposed and

Figure 12: Optimally sprayed cores

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Figure 13: Clean surface after the first blasting with optimum coating application

Summary

The spraying tests have shown that the spraying method constitutes a good complement to brushing. Particularly in the case of cast parts with simple and flat contours without all too many undercuts and ribs, the advantages of this method can be used to the full. However, the application limits of the spraying method were also reached on some occasions, and preparatory work / rework with a paintbrush had to be performed. Nevertheless, the time required to coat the molds and pits by means of spraying was reduced to 40% to 60% of the brushing time. In addition to the time saving, the cast part surface was improved, as the paintbrush strokes can no longer be seen. After the successful confirmation tests with the Airless unit and the different ASK coatings, the spraying method will continue to be used.

What was achieved using the spraying technique:

- A reduction in the time required to apply the coating
- Uniform application of the coating
- No paintbrush strokes
- A smoother casting surface

Figure 14: Flooded and repainted - casting surface with paintbrush strokes

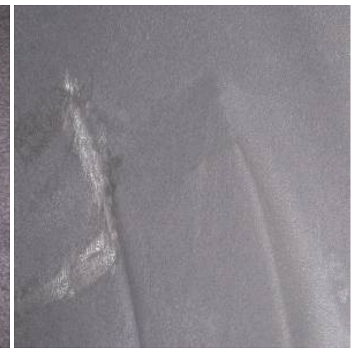

Figure 15: Sprayed →no paintbrush strokes

Besides benefits, the spraying method also has limits, as shown in Table 2:

Table 1: Advantages and disadvantages of brushing

Benefits	Limits
Large surfaces can be covered quickly	Wear and tear of nozzles and pistons
Clean surfaces	Undercuts difficult to moisten, non-uniform application
Uniform application	Material losses due to atomization
Rapid drying method	Trained personnel
Can be used anywhere	Service the spraying units

Due to these benefits and limits, the coating's application technique, coating parameters and spraying unit setting must be optimized for every product range so that a satisfactory casting result can be achieved. The investigations are continuing.

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