IGP POWDER COATINGS

Processing guideline

VR218 – Use of convection furnaces for heat-sensitive substrates

Introduction

The cross-linking of powder coatings on heat-sensitive substrates, e.g. solid wood, plywood, fibreboard, etc., using infrared technology or infrared technology with convection support: Solid wood, plywood, fibreboard, etc. using infrared technology or infrared technology with convection support is an established and proven process. The challenges lie in the uniform heating of all substrate surfaces and a sufficiently fast heating rate in order to avoid thermal overloading of the substrate core. As infrared technology can only heat complex geometries evenly with a high degree of control, IGP Powder Coatings has developed a process with convection as the main energy source. In this process, infrared is only required for support at the start of the curing process. The realisation of this process in existing systems or the implementation in new coating plants is described below.

Basic principle

Infrared curing has established itself as the standard for heat-sensitive substrates, as a high amount of energy can be emitted to the surface in a short time using radiation. This enables a fast heating rate (approx. 1-2 K/s) to be achieved on the surface and at the same time prevents the substrate from overheating in the core.
In the past, it has not been possible to achieve sufficient heating rates when using circulating air systems. However, it was found that the workpiece was heated more evenly with good air flow. In order to increase the heating rate with circulating air, a two-stage curing process was therefore trialled:

In the first step, a sufficiently high energy transfer to the substrate is achieved by means of a high circulating air temperature and, if necessary, a high air speed in order to achieve heating rates of between 0.75-1 K/s. These are sufficient for the safe cross-linking of the powder coatings without overheating the core of the substrate.

In the second step, the component is fed into a zone with a lower air temperature and/or lower air speed. In chamber ovens, only the air speed is greatly reduced. This prevents further heating of the substrate. However, sufficient energy is still transferred to maintain the required object temperature. After the required retention time, the workpiece can be removed. The object temperature and retention time required in this case do not differ from the specifications in the technical data sheet.

Advantages/requirements

The acquisition costs for infrared technology are significantly higher than those for recirculated air. It is therefore financially attractive to minimise the number of infrared zones required, especially when building new systems. Infrared ovens are divided into several separately controllable zones, which can make adjustment complicated for the system operator, especially in the case of geometrically complex components or strong differences in the brightness of the coated colours. Circulation ovens usually only have the circulating air temperature and air speed settings. These parameters are easy to understand and quickly comprehensible for those responsible. The heating of different powder coatings (white/black) using circulating air does not produce the differences that can occur with infrared. This significantly simplifies familiarisation and adjustment for the system operator.

This process also offers the possibility of converting existing systems so that they can be used for heat-sensitive substrates as well as metals.
All that is required is a preheating facility (see next section) and, if necessary, an infrared booster zone (depending on requirements). For manual coating only, an experienced coater with a corresponding learning phase is required for the application. For automatic coating, a plastic booth (metal booths do not achieve appropriate electrostatics) with retrofittable counter electrodes is required. In addition, the necessary settings must be determined and the coaters must be trained.

For new buildings, cost savings can therefore be achieved through more favourable investment costs. For new buildings and conversions, it is possible to use coating plants for both metallic substrates and heat-sensitive substrates. This can open up new sales markets and spread the investment risk more widely.
The operation of convection systems is also easier for the system operator, as fewer setting parameters need to be trained or observed and operating errors are reduced.

However, all of these points must be considered individually for each system.

Practical realisation

Generally necessary preheating:
In order to coat wood substrates or fibreboards, they generally need to be preheated. Experience has shown that infrared technology delivers the best results for this.

General:
When using existing ovens, the air flow in the oven should be checked in advance and corrected if necessary. It is essential that there is an even air speed and temperature distribution in all areas of the oven. If temperatures or air velocities are uneven, cross-linking of powder coatings on heat-sensitive substrates is not possible.
Only after these points have been ensured can measurements be started using a measuring plate that corresponds to the material and geometry of the subsequent workpiece. The oven must be fully heated for this. The circulating air temperature must also be well above the required object temperature of approx. 130°C. Circulating air temperatures of approx. 210-230°C are recommended at the start of the measurement for MDF substrates (depending on thickness 15-25mm).

The values for solid wood are lower, depending on the type of wood. Higher air velocities enable improved heat transfer from the air to the substrate and therefore favour higher heating rates - the powder that has not yet melted must not be blown off the substrate. By using a simple IR zone in front of the circulation oven, the powder can be easily "glued" to prevent it from blowing off and thus realise faster air speeds. Ideally, a heating rate of approx. 1.5 K/s should be achieved.
However, values between 0.7-0.8 K/s are already sufficient.

Example for calculating the heating rate:
The component enters the oven at a room temperature of 20°C. The target object temperature is 130°C. The required temperature rise is therefore 110°C (130°C-20°C). Since a difference of 1°C also corresponds to a difference of 1 Kelvin [K], the temperature difference is therefore 110 K. The 110 K is then simply divided by the measured time until the required temperature is reached. For example, 2.5 minutes corresponds to 150 seconds. 110 K / 150 seconds = 0.733 K/s. The value is between 0.7-0.8 K/s and is therefore sufficient.

If heating rates of less than 0.7 K/s are measured, the circulating air temperature or the air speed (if possible) must be increased further. If a sufficient heating time cannot be achieved even at the highest possible air temperature, the use of pure circulating air is not sufficient and the use of an infrared gelling or booster zone is necessary to achieve the temperature.

In addition to the heating rate, care must also be taken to ensure that there are no large differences in temperature (<5°C) or heating time to object temperature (max. 10-15 seconds) between the individual sensor positions.

Once the heating rate and the uniformity of the temperature distribution have been ensured, the second process step - maintaining the temperature - must be started. There are various options available for this with continuous or chamber ovens:

Chamber ovens:
As the control of the air temperature in chamber ovens is sluggish, the fastest way to control the temperature is to reduce the air speed and thus the heat transfer. It may be necessary to lower the temperature setpoint at the same time. If possible, this should be programme-controlled in order to achieve a consistent process.
For initial trials or simple ovens, it may be sufficient to switch off the oven once the required object temperature has been reached. In this case, however, it is no longer possible to influence the temperature curve.

Conveyor ovens:
Conveyor ovens that do not have the option of realising different circulating air temperatures or air speeds in the front oven area to the rest of the oven are not suitable for this process without the use of the gelling or booster zone described above. Without controlling the air temperature or speed, heating cannot be stopped and over-curing of the powder cannot be prevented.

In conveyor ovens with different temperature or air speed zones, the heating rate must be set in conjunction with the conveying speed. It is important to ensure that the conveying speed is selected so that the object temperature is reached at the required heating rate to change a temperature or air speed zone. Once this has been achieved, the following zones should have a significantly lower air temperature and speed. Regardless of the oven type, the settings for the second process step must be selected so that the substrate does not cool down or heat up further. The maximum specified retention time must also not be exceeded, especially in conveyor ovens. During the retention time, the measured temperature of the workpiece should not deviate by more than +/-4°C from the recommended temperature. Otherwise, as with infrared technology, undercrosslinking of the coating or excessive stress on the substrate (blistering, cracking, etc.) may occur.

If all points regarding the heating rate, uniformity of heating and retention time are observed, the process produces equivalent - in some cases better - surfaces compared to conventional cross-linking using infrared ovens.

Applicable documents

Technical information TI 111 Process recommendations for powder coating of MDF.

Notes

This technical processing advice is based on the current state of knowledge, but is only non-binding and does not exempt the user from carrying out their own tests. The application, use and processing of the products are beyond our control and are therefore the sole responsibility of the user.
