An accurate heating process is essential for product quality, especially when it comes to paint drying. The paint system manufacturer supplies bake windows for paint curing which must be adhered to. Under or over curing can lead to numerous quality problems, such as lack of adhesion, low impact resistance, polishing problems and similar issues. This, in turn, leads to increasing costs. Datapaq, with over 20 years of experience in temperature monitoring, has taken a further step towards achieving an optimum process by continually improving the Insight Oven Tracker software. The following example taken from the headquarters of MAN Nutzfahrzeuge AG in Munich, Germany, describes the use of an Oven Tracker system with the new Oven Tracker Insight software.

Within its main plant in Munich, MAN coats truck cabins in several production steps. The diverse primer coats, paint coats and adhesives used during body assembly require individual bake temperatures and oven settings. Furthermore, the diverse body parts and their various conditions (sheet thickness, cavities etc.) must also be taken into account. Precise temperatures play an important role for achieving high quality standards. The Datapaq Oven Tracker system is a robust and easy-to-use tool for collecting and evaluating process data.

Temperature values are collected via a data logger which travels through the process together with the car body and which is connected to the points to be measured through up to 20 thermocouples. Protection from the process temperatures is ensured by placing the logger into an isolating container. The data logger has a storage capacity of up to 130,000 measurement values which are downloaded after the run or transferred during the process to a computer via radio telemetry. The powerful Datapaq software allows the measured temperature profile to be analysed quickly and precisely. The new BakeChart feature, which is based on the Insight software, results in improved analyses and process evaluations.

Using the Datapaq Oven Tracker systems to regularly check the probe traces has been a matter of course for MAN for many years. With the new Insight Oven analysis
software and the new Tpaq21 data logger, Datapaq provides the answer to constantly increasing quality standards and market needs.

Temperature profiling on a regular basis makes certain that the heating characteristics in the oven are correct. This ensures that all areas of a body are properly cured. The software analysis feature helps to control the process so that the paint manufacturer’s specifications are met, optimising product quality and appearance. Correcting defects such as lack of hardness, embrittlement, and discoloration can be avoided.

During temperature data analysis, the user must compare the bake windows specified in the process definition to the measured temperature profile.

To ensure that the temperature profile is correctly and quickly compared to the paint system manufacturers’ original bake windows, the specifications can be entered into the Insight Oven Tracker software with only a few mouse clicks or imported directly from an Excel file provided by the manufacturer. In doing so, up to five different bake windows can be overlaid to represent different paint systems or adhesives, for example. The software then maps the time and temperature data for each individual probe traces onto the bake windows. This step can be triggered automatically by the integrated process management feature. This means that even inexperienced operators need only select the desired process when downloading temperature data.

The analysis feature allows the operator to see at a glance whether the bake conditions are within the acceptable parameters. Moreover, intersections formed by different paint and adhesive systems may be taken as a basis.

If the temperature profile is to undergo a more detailed analysis, the Datapaq Value may be used. The Datapaq Value provides an overall evaluation of the temperature profile above the paint system’s reaction temperature. Based on the bake window, an ISO cure function is defined which represents minimum paint cure and parameters.

The Datapaq Value can then be defined for each single point in the bake window. Thus it is possible to define ideal target points for different materials and material thicknesses in a very simple way. This analysis mode allows the operator to see at a glance the overall cure experienced by the individual probe positions and allows him to take a simple go/no go decision. This is possible for several paint systems at a time.

The temperature measurement results shown in this example were taken from the MAN plant in Salzgitter, Germany. The measurement system consists of a Tpaq21 data logger, a TB0021 thermal barrier and type K thermocouples with magnetic probes.
The reason for this measurement is MAN’s plan to switch to a different paint system which is said to allow shorter process times and, at the same time, lower bake temperatures. As soon as the bake window of PPG, the paint system manufacturer, was entered into the software, the measurement set-up was attached to the car body during production following “Ecoat” cataphoretic painting and passed through the dryer. The thermal barrier containing the data logger was placed in the cabin, and the probes were fixed to the points of interest. By using different probe attachment methods such as magnets and clips, or by using exposed-junction probes, the temperatures experienced by the measurement body can be measured quickly, easily and in a reproducible manner. This provides optimum flexibility for allowing different drying conditions, such as convection and infrared radiation. In this example, the magnetic probes were positioned in such a way that all critical points of the body – points with different material thicknesses and exposed to different heat flows – were monitored. All data collected during the run were transferred in real time to a computer outside the oven by radio telemetry. Thus, the MAN and Datapaq staff were able to monitor the current temperature state of the paint system at any time and, if required, to intervene in the process. Subsequent to the oven run, the data was downloaded and analysed.

As the process data collected was immediately overlaid with the new integrated bake windows and subjected to a go/no go analysis, the measurement curve could be compared to the old and the new bake windows. This allowed the MAN process engineer to evaluate at a glance the overall temperature profile with regard to the bake windows specified by the paint system manufacturer. Temperature profile analysis is often difficult because the results have to be compared to the specifications. Evaluating different substrates or material thicknesses causes further difficulties. By providing an overall analysis of the curve which is mapped onto the bake window and by providing Datapaq Values, the software shows exactly where the process lies within the tolerances. This substantially facilitates process optimisation by reducing cycle times or increasing process safety, for example.

The Datapaq example above shows that the drying process for the new paint system with simulated shorter drying times is within the manufacturer’s bake conditions. By overlaying the oven profiles of a repeated measurement with shorter cycle times, it was possible to compare the future drying profile to the previously measured profile.

**SPC analysis for long-term process monitoring**

A powerful documentation system and automatic SPC analysis enable the measurement data to be automatically transferred to internal measurement control systems.

The aim of statistical process control is to monitor the most important parameters of a process in order to detect deviations in time so that suitable corrective action can be taken before defective products are manufactured. In addition, SPC is designed to inspect the facilities before their intended use to determine whether they are fully capable of meeting the requested tolerances.
Trend analysis enables Cpk, the process capability index based on an estimated standard deviation, and Ppk, the process capability index based on a standard deviation calculated from individual data, to be calculated for statistical process control.

When analysing the long-term process capability Cp or Cpk, quality capability is determined under real process conditions. Thus the effect of process improvements are made visible. This means that Cpk is used to measure whether the potential capability of a system meets customer needs.

The preliminary process capability, Pp und Ppk, determines whether the actual performance of a system meets customer needs.

The analysis of Cpk and Ppk is a feature of the Insight software which should be used in conjunction with the trend analysis functions. Variation in any production process is a natural, inevitable occurrence. The calculation of these measures allows the Process Manager to verify that the natural variations within the production process will not result in defective products. The calculation of standard deviation provides an indication of the spread of variation within a population or sample from the mean value. A range of three standard deviations either side of the mean accounts for 99.74% of the total within that population. If a process can be controlled sufficiently well that a range of three standard deviations falls within the outer tolerance bands, then the process should produce defect-free products to 99.74% of its throughput.

One of the benefits of SPC analysis is that it can help to implement a no-defects strategy, which aims at avoiding rather than detecting and eliminating errors. Necessary process interventions are detected before the defect actually occurs, reducing inspection and defect costs. At the same time, customer satisfaction is also increased considerably.

Conclusion

By using the Datapaq Oven Tracker system with optional BakeChart analysis, MAN was able to undertake optimum preparatory steps for optimising process temperatures and assuring paint process quality. By providing quick and accurate comparisons of temperature profiles to the paint system manufacturers’ bake windows, the software enables correct analysis and fully-traceable documentation.