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New Perspectives for the Quality Control in Industrial Coatings

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The quality control plays an increasingly important role in every phase of the manufacturing process. In paintshops it is essential to guarantee a suitable monitoring operation and, consequently, perfect coatings. Here is an overview of the solutions developed by PhoenixTM for measuring temperatures.

Reliable production without effective quality control is impossible. The demands are constantly increasing. Customer specifications must be met and verified, as well as the specifications of the paint manufacturers. Especially in the coating industry, there are also more and more standards and certifications, to which compliance is essential. But how can all these specifications and decrees be integrated into the operating processes as effectively, economically and simply as possible?
PhoenixTM has been very successful in the design and development of temperature measuring systems for 10 years now. In addition to the well-known systems, there are always new products that are added to the product range and further developments. In addition to the new and innovative optical systems, there is the Epsilon-x system, which has been approved for ATEX zones and can be used safely in the hazardous areas of the paint shop, legally complying to the working environmental classifications. In addition, there is a completely revised user software that has been specially optimised for the paint shop monitoring operation.

Phoenix's TS04 Finishing System

The TS04 Finishing System is a complete solution for monitoring temperature data, especially in coating processes. The system is easy to operate and records the temperature data of the product during the oven cycle. By attaching the thermocouples directly to the product, such as a car test body, it is possible to introduce the monitoring system onto the coating line at any time. There, the actual product temperatures are recorded.
The data obtained in this way is stored in the data logger. This

Standard FIS04 temperature measuring system.

is protected from the temperatures prevailing in the oven by a thermal barrier. At the end of the process, the data logger is removed and temperature data downloaded. With the help of the ThermalView finishing software, the raw data is converted into meaningful process data. With this information, quick and well-founded decisions can be made to solve baking problems. The measurement results are available as a complete temperature profile at a glance and can be used, for example, for process or product optimisation, customer audits, reduction of operating costs, saving of resources and much more.

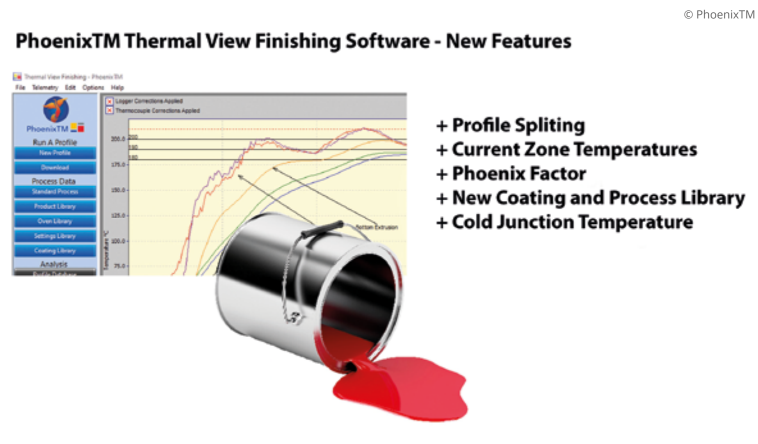


Figure 1: **New ThermalView Finishing Software.**

ThermalView Finishing Software

This software has been specially developed for the coating industry and is an easy-to-use tool. The entire oven process is displayed using detailed graphical data. For example, the heat source and fan positions can be stored so that problem areas can be located quickly. The ability to apply library paint cure parameters allows accurate, efficient analysis of profile data directly against the coating supplier cure specification. Profile comparisons with other measurements are also possible. A standard report shows all relevant information and a graph. Subsequently, various detailed evaluation reports can be created.

Phoenix Factor

The Phoenix Factor is a curing index, a numerical factor that accurately quantifies, from the complete temperature profile, how well the paint/powder cure conditions match the paint supplier's specification (activation temperatures, cures schedules, **Fig. 1**). The curing of the coating (polymerisation = cross-linking) is dependent on both time and temperature. For this reason, paint and powder manufacturers specify "recipes" or curing charts according to which the paint should be "baked" in order to achieve a good quality result. This "recipe" is stored in the software as a "time at a certain temperature" curve.
If we look at these curves taking into account different cure/oven conditions as shown in **Figure 2**, we find that the time at 180°C is identical for both curves, although the curves are in fact very different. If we take these curves and analyse them as they are against the

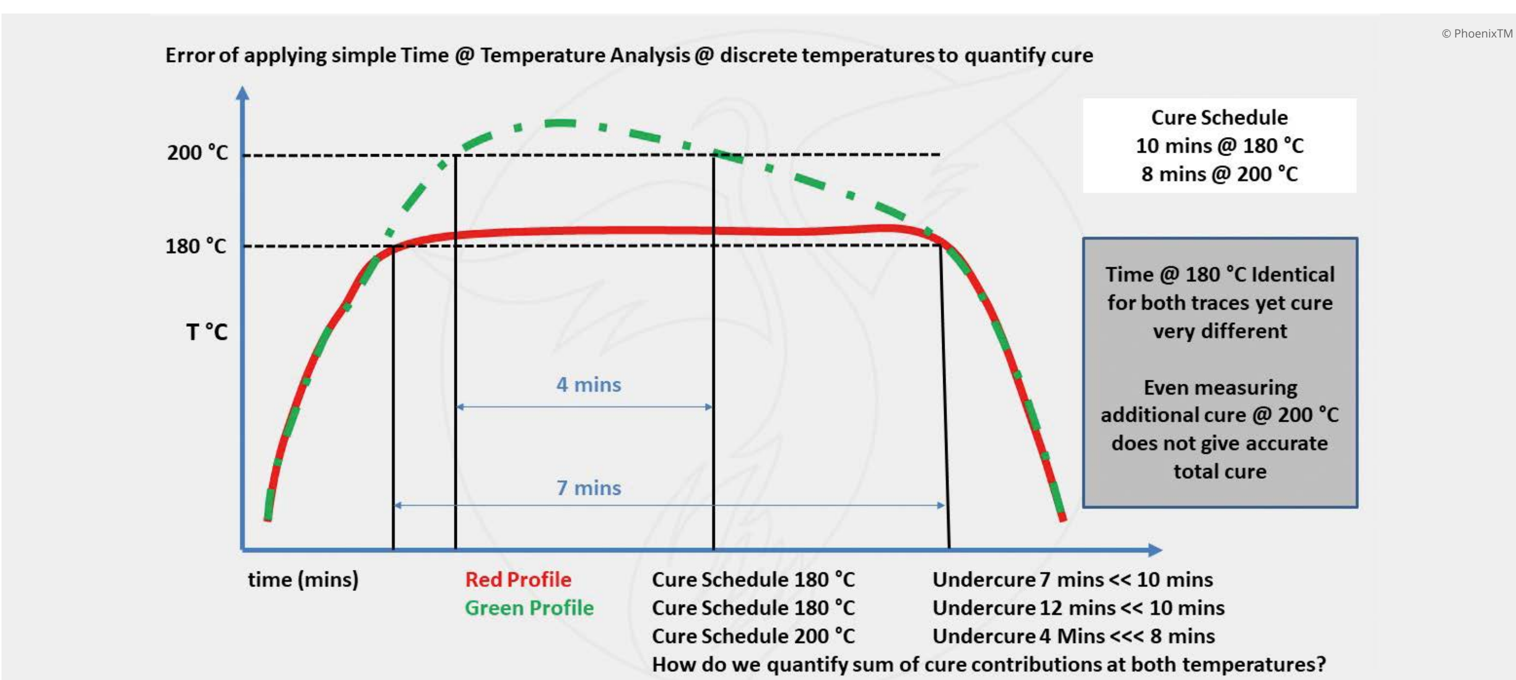


Figure 2: **Simple setpoint/actual temperature curve.**

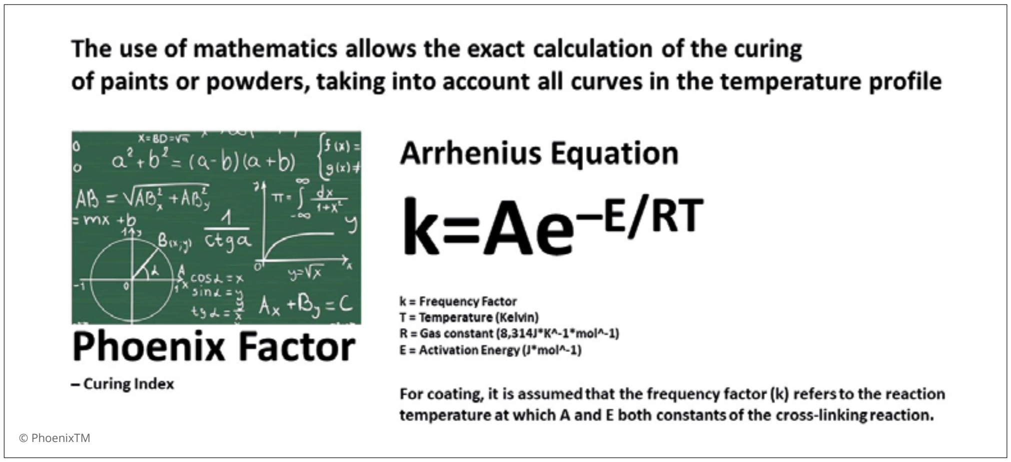


Figure 3: **Arrhenius equation - Phoenix factor.**

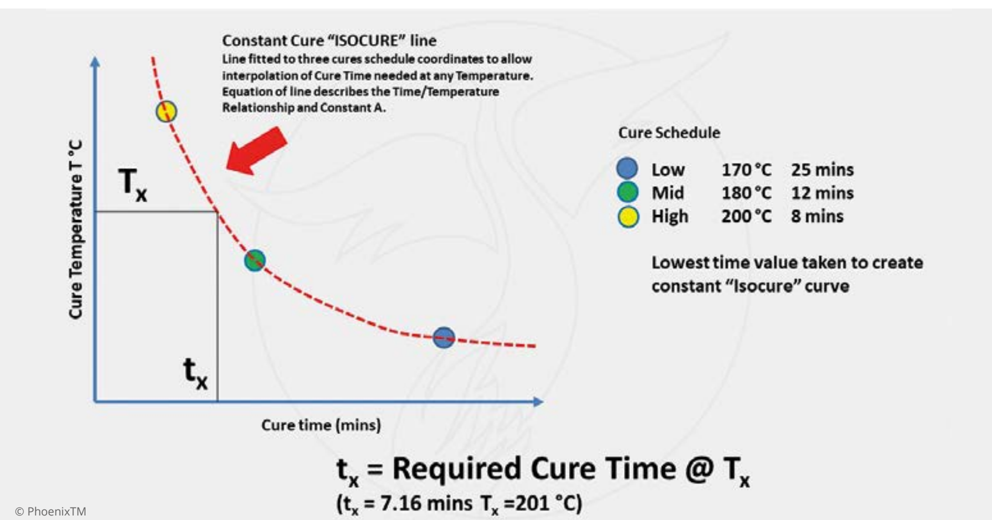


Figure 4: **Constant curve - reference curve of three points.**

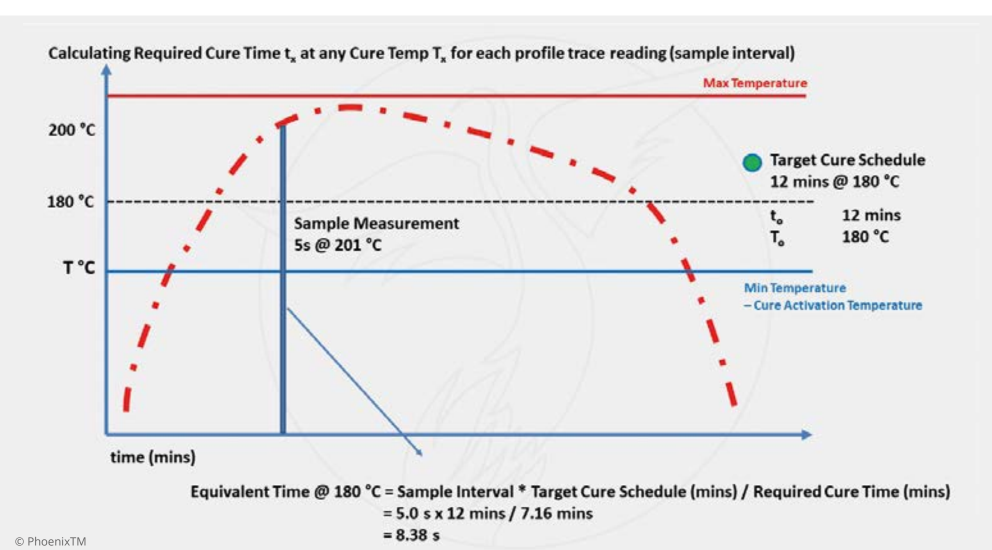
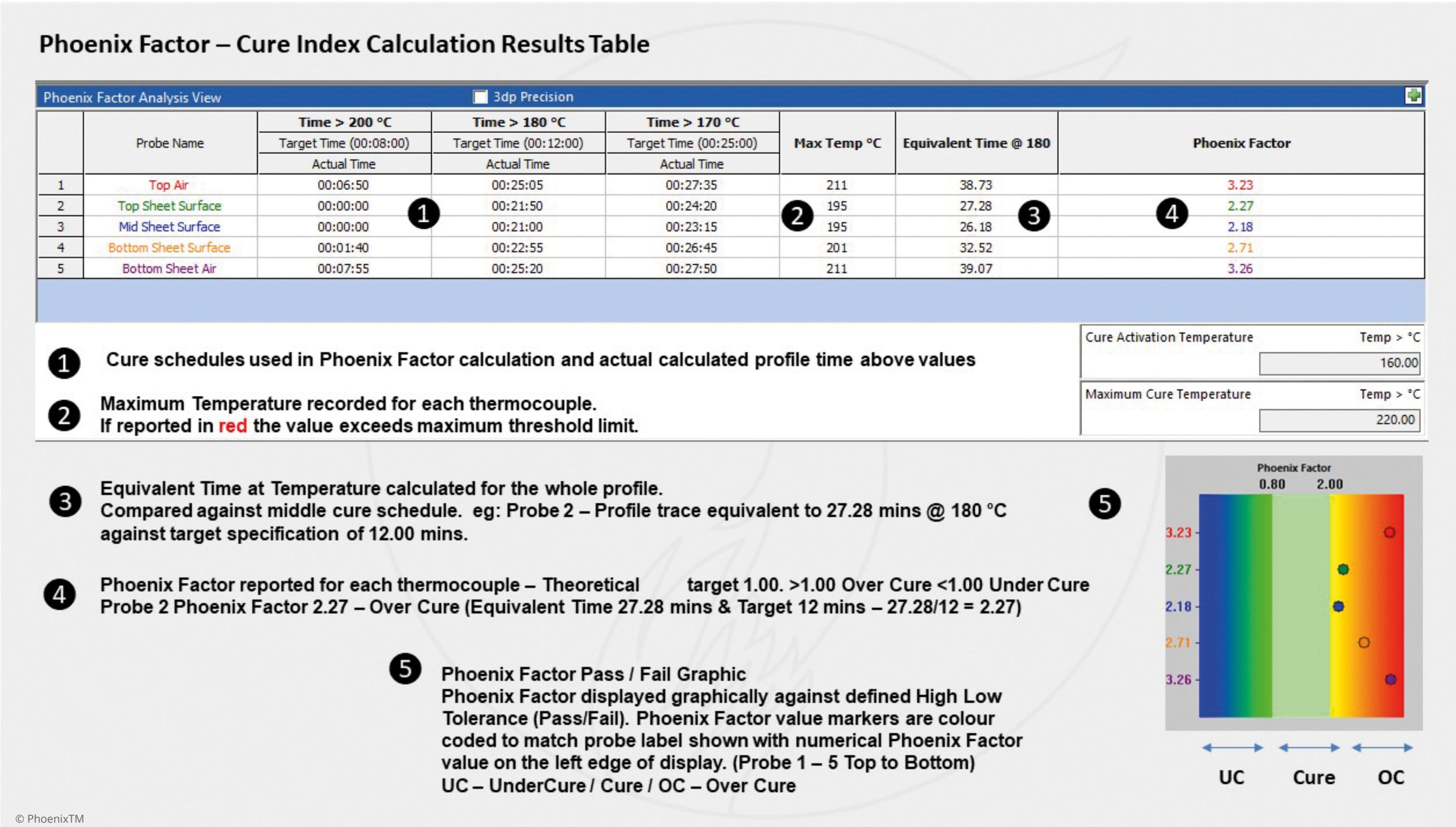


Figure 5: **Calculation of the Phoenix factor.**

specifications, we must conclude that undercuring has occurred here. Time at 180°C for only 7 min instead of the specified 12 min. But how to analyse the holistic nature of the results? The application of mathematics allows the exact calculation of the curing of paints or powders including all curves in the temperature profile. The Arrhenius equation, named after its inventor Svante Arrhenius, describes approximately a quantitative temperature dependence in physical and chemical processes in which an activation energy (here the transition to cross-linking) must be overcome at the molecular level (**Fig. 3**). For coating, it is assumed that the frequency factor (k) refers to the reaction temperature at which A and E both constants of the cross-linking reaction.

In relation to the temperature curve in Figure 2, this means that a reference curve is created using three temperature points specified by the coating manufacturer in order to determine the values between the points by interpolation (**Fig. 4**). In this way, the required curing time at any temperature is calculated for each measuring point. Then, taking into account the total curing time, the total equivalent of the curve at a given temperature (here 180°C) is determined (**Fig. 5**).

The ThermalView software compares these values and determines the curing index, the so-called Phoenix factor (**Fig. 6**). This is clearly and simply displayed in a graph and, as shown in Figure 6, provides an immediate overview of the measurement taken and its result. Despite the (supposedly) measured underbake in Figure 2, it becomes clear after a close look at all curves and the holistic inclusion of the process times and temperatures that the component was in fact theoretically overcured. The evaluation in Figure 6 shows (thermocouple 2) an equivalent time at 180°C of 27:28 min instead of the manufacturer's optimum specification of 12 min. This is over twice the optimum bake time as shown with the Phoenix Factor being <2. A precise and holistic observation of the curing process, with the possibility of direct comparison of the



Phoenix Factor – Cure Index Calculation Results Table

Phoenix Factor Analysis View — 3dp Precision

	Probe Name	Time > 200 °C Target Time (00:08:00) Actual Time	Time > 180 °C Target Time (00:12:00) Actual Time	Time > 170 °C Target Time (00:25:00) Actual Time	Max Temp °C	Equivalent Time @ 180	Phoenix Factor
1	Top Air	00:06:50	00:25:05	00:27:35	211	38.73	3.23
2	Top Sheet Surface	00:00:00	00:21:50	00:24:20	195	27.28	2.27
3	Mid Sheet Surface	00:00:00	00:21:00	00:23:15	195	26.18	2.18
4	Bottom Sheet Surface	00:01:40	00:22:55	00:26:45	201	32.52	2.71
5	Bottom Sheet Air	00:07:55	00:25:20	00:27:50	211	39.07	3.26

Figure 6: **Evaluation of the Phoenix factor.**

parameters specified by the manufacturer, is thus the more accurate alternative to “time @ temperature analysis”.

Focus on operational safety

The focus of the considerations was to create a device that meets the strict requirements of explosion protection at the workplace according to the latest EU standards. The basis for further development here is the proven PTM1-200 data logger. The resulting Epsilon series is intended to meet the requirements of the ATEX regulations (ATmosphere EXplosive = Explosive Atmospheres, **Fig. 7**). PhoenixTM has further developed the data logger and the associated components so that they comply with the valid ATEX approvals according to Directive 99/92/EC (or ATEX 137). It has been certified accordingly and is approved for Ex zone 2. This is particularly important for wet painting systems, as the paints are outgassed during the curing process and, depending on the recipe, explosive gases can be produced.

The benefits of the Optic system

With the Optic system, PhoenixTM has added another effective tool to optimise process control to the product family (**Fig. 8**). Visual checks usually take place after the drying process. Defective products are then sorted out or reworked at great expense. PhoenixTM has now expanded its existing portfolio for in-process temperature monitoring in paint dryers with the new optical monitoring system. This is used by the technician to view the interior of the oven as well as the product under production conditions. Like the temperature measurement system, the system travels directly through the process and captures a video as it passes through the oven, providing a complete picture of the paint drying process.
In paint drying processes, so-called paint drips, sags or curtains can occur from time to time, which represent a quality defect. The causes are known, for example, fans or burners generate air currents that can disrupt the uncured paint or the melted powder. But it is not always easy to find out where and when these arise in the dryer. The new optical system now makes this possible directly in the process, in which a camera travels through the oven and records what happens to the paint at the relevant points. In this way, problems can be detected and rectified without having to interrupt production. Oven revisions can also be better controlled in this way. The recorded videos also provide information on whether there is any wear or tear, for example, on the oven cladding, the insulation material or

the racks. Defective fans or heating elements can also be detected, as well as deposits and dirt. In this way, the user knows at any time what condition the dryer is in and whether maintenance or repairs are necessary. The Optic System is available in different versions. It is possible to use both an independent system and a combined system that combines temperature and optical recording.

Conclusion

Precise knowledge of the various oven parameters is essential to optimise the product quality, productivity and efficiency of the coating lines. This is a very important criterion, especially in the current situation, as it helps to reduce costs, increase productivity and thus be able to act more economically.

Figure 7: Optical system with data logger.

Figure 8: ATEX-compliant Epsilon system.