"One, two…cured!"

Space technology provides ultimate cure

Speed is critical in any industry. In the coil coating industry, line speed dictates process efficiency – and curing dictates line speed. The faster the cure, the greater the throughput – and the higher the profit. In this article, Dr Kai Bär presents a radical new technique known as NIR® Near Infrared thermal processing. Developed by leading German technology innovator AdPhos, it is revolutionising the field.

Applying space technology that has grown directly out of the European Space Programme's leading edge research, the NIR® technique leaves conventional technologies standing. As well as ideal for curing a wide range of printing inks and adhesives, and for use in the thermal forming of plastics (stretch blow moulding, deep drawing) and industrial coatings, NIR® ensures instantaneous curing of waterborne, solvent-borne and powder coatings, requiring no major or general changes in the standard commercial formulas.

Developed in-house at AdPhos, this NIR® thermal-curing technology – as already noted – derives from research work conducted by the company's founders in connection with the European Space Programme. NIR® technology

- involves high energy sources that radiate near the infrared spectrum (more than 90% of the energy emitted is below 2 µm);
- permits major energy densities up to 1.5 MW/m2 (double-sided radiation, to as much as 3 MW/m2) or focusing at line geometries of up to 10 MW/m2s, using special focusing reflectors;
- enables extremely high process efficiencies (up to 80%) and system reliability, based on special systems engineering expertise.

The unique characteristics of NIR®

What makes the characteristics of the NIR® thermal processing system so unique is that the instantaneous power dynamics apply to the complete process-system, not just the radiation emitters. It also differs from other current conventional thermal process technologies in that it enables defined and precisely controlled heating and drying/curing processes. And it can also be applied to curing solvent-borne coatings in specially hazardous (e.g. explosive) environments, as well as controlled atmospheres.

Even when used in extremely hostile operating environments, NIR® thermal technology offers high systems reliability and demands minimal maintenance. The installed base of more than 1,000 successful production systems demonstrates the unique experience already gained and the high proven performance of these application-optimised solutions.

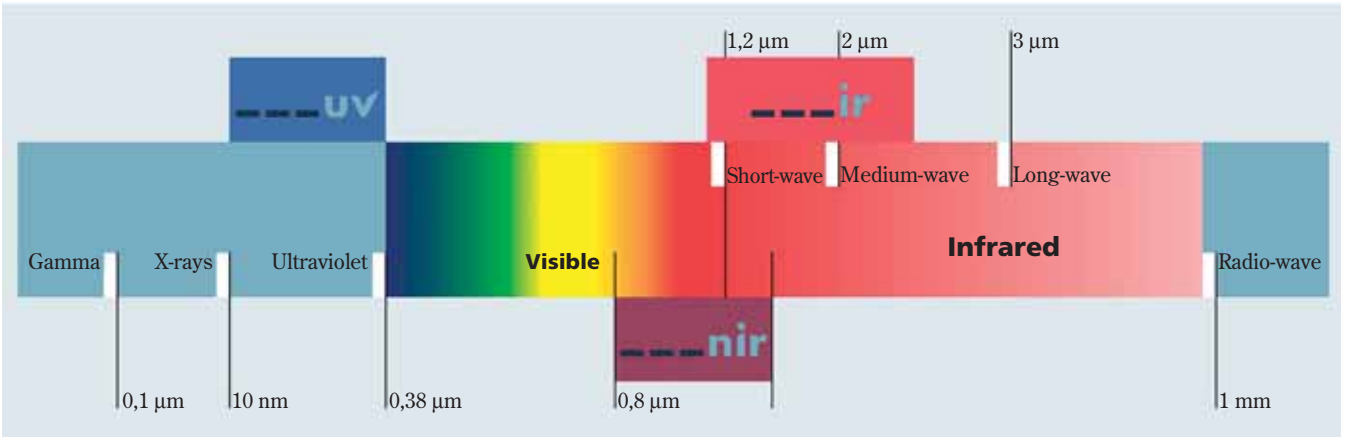
Other potential applications for the new technology, in addition to standard metal substrates, include ceramics, plastics, glass, wood-based and even mixed-material sandwich-based components. NIR® thermal technology permits near instantaneous drying/curing, where conventional techniques (such as hot air, electrical, gas infrared or induction systems) might at best require 5 to 10 times as long, more probably 100 times as long and, in some cases, as much as 1,000 times as long. In some cases, the extreme reduction in process time permits applications that with conventional techniques would cause severe thermal damage or material degradation (as when using powder coatings on wood or plastics). Typical processing times for various applications are given in the table below.

Current applications

The applications described here illustrate the broad potential of NIR® technology.

NIR® processing times, compared to conventional techniques.

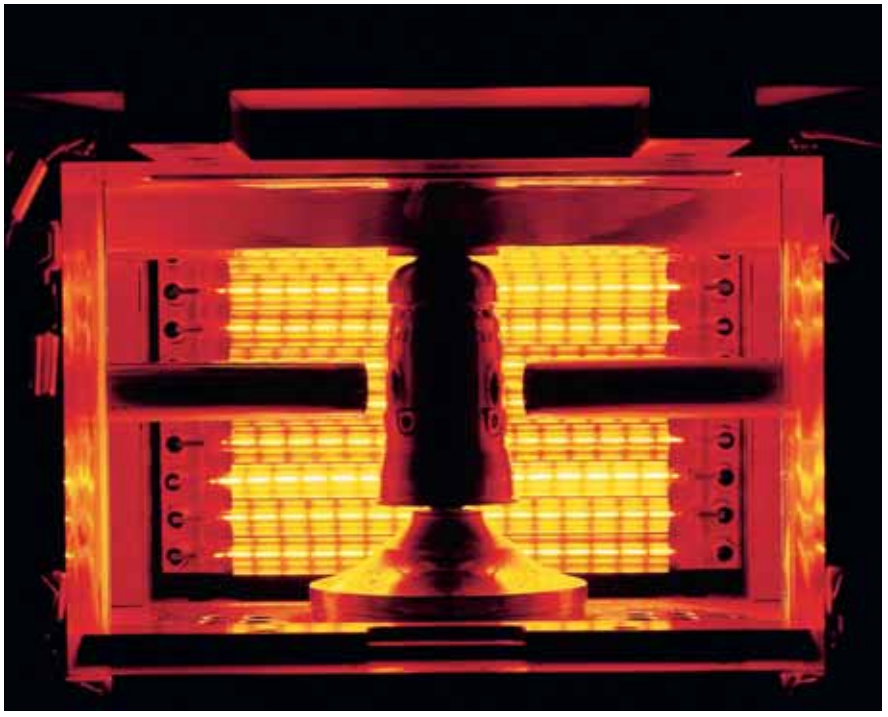
	NIR®	IR	Hot air
Powder coatings	1 – 10 s	30 – 300 s	120 – 1,200 s
Automotive coatings	5 – 120 s	300 – 1,000 s	600 – 300 s
Industrial coatings	1 – 8 s	30 – 600 s	60 – 1,200 s
Wood coatings	2 – 6 s	15 – 60 s	30 – 300 s
Coil coatings (≤ 10 µm)	0.5 – 1.5 s	8 – 12 s	15 – 25 s
Coil coatings (> 12 – 20 µm)	1.5 – 3 s	12 – 15 s	20 – 40 s



NIR® offers a whole new spectrum of opportunities.

Coating airbag gas generators
The gas generator used to instantly self-inflate an airbag on impact is filled with an air/argon mixture, pressurised to approximately 300 bar. To ensure long-term corrosion resistance (at least 15 years), a waterborne zinc coating is applied to the welded areas of the pressure component. Since the generator also contains an explosive for rapid opening of the membrane to inflate the airbag, it is naturally temperature sensitive. The risk of explosion above 120° C precludes use of a conventional high temperature gas-convection curing process, which requires an air temperature of at least 150° C and 30 minutes drying time. Furthermore, a conventional coating process with five-second curing intervals in a fully automated production system would require an unacceptably long line. With NIR® technology, drying can be completed in less than three seconds, ensuring a maximum component temperature of not more than 60° C – and the NIR® dryer is no bigger than a regular shoe box (see figure 1). With this configuration, the complete automated coating and drying facility, including handling and paint preparation, is no larger than 5 x 5 m^2 (see figure 2).

Figure 1: Detail of NIR®-dryer for airbag gas container.

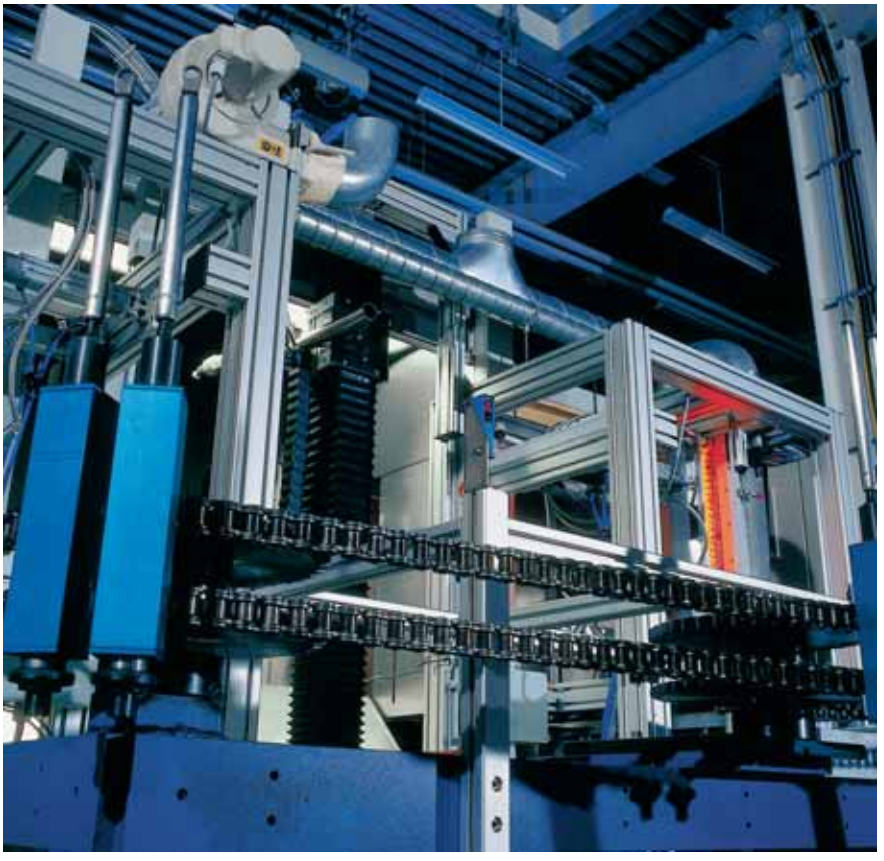


Coating furniture gas cylinders
Temperature-sensitive components are not limited to the automotive industry. The gas cylinders used as components in office furniture (adjustable chairs and desks), for example, must also be powder coated. Once finally assembled, filled with gas and properly sealed, the high and extended temperatures inevitably generated by the conventional curing techniques applied to powder coatings would destroy the components. NIR® technology completes curing in less than five seconds. The internal temperature of the component remains well below the danger limit. Furthermore, the custom engineered NIR® curing oven permits precise power adjustment according to the size of the component (height and mass), making it possible to process a broad range of products (more than 50 geometries), from 10–35 mm wide and 50–750 mm high, energy-optimised for each defined process. The extremely compact design is an additional bonus. The entire powder coating and curing facility, with a process time of

Figure 2, left: Fully automated airbag gas container facility.

Figure 3, left below: Powder coating and NIR®-curing facility for gas cylinder.

Figure 4, right: NIR-MicroSpot-Repair® in use.



just six seconds, requires no more than 3 x 3 metres of floor space (see figure 3).

Defect-free with MicroSpot-Repair® system

The conventional technique used to repair surface defects detected late in the automotive production line (1–2% defects) normally involves a 10–20 minute curing process, in which infrared (IR) panel heaters are used to ensure a properly cured and blister-free surface. This interrupts the continuous car production process, as the damaged vehicles are removed for repair in special "Spot-Repair" booths. The NIR-MicroSpot-Repair® system is a small hand-held device, originally developed in association with a German car manufacturer. It performs an equivalent curing process on this type of microspot defect in a mere 15–45 seconds, depending on the type of defect, body area and car type. The NIR-MicroSpot-Repair® curing process provides fully controlled closed-loop thermal treatment. It even determines the re-

quired curing profile for the specific defect, ensuring consistent high-quality in-line repair of surface defects on the production line. The commercial benefits speak for themselves. The working principle of the NIR-MicroSpot-Repair® system is illustrated in figures 4 and 5.

Largest NIR® curing oven

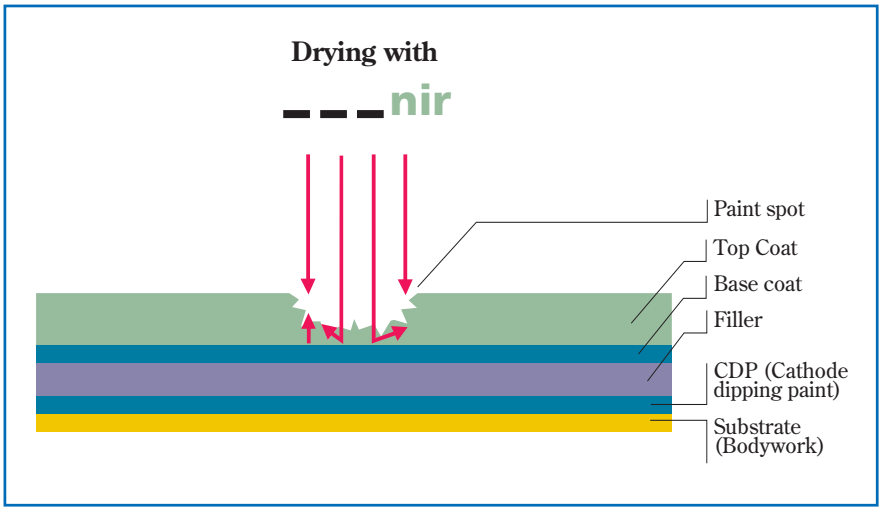
An essential part of the coil coating process, curing has traditionally imposed major limitations on line capacity. For decades, gas convection ovens have dominated this part of the process, in spite of the fact that the introduction of IR and induction curing systems would have secured significant space gains. However, the cost differential between gas and electricity led to a preference for gas-heated ovens. The development of NIR® technology, specifically engineered for the demanding manufacturing conditions of the metal processing industry, radically changed the situation. Now that the unique benefits of NIR® systems are fully appreciated, NIR® ovens for curing organic, solvent-borne, waterborne and powder coatings have already been installed on more than 50 coil coating lines.

An in-line NIR® system, constituting the industry's most powerful curing oven for organic coatings – was recently placed in operation on the coil coating line of one of Europe's leading steel manufacturers. The NIR® curing system ensures the production of a consistent and blister-free topcoat (up to 20 µm dry-film thickness) at a line speed of 180 metres a minute – or up to 120 tonnes per hour). The system permits a complete curing process in less than three seconds. Figure 6 shows a section of the in-line NIR® system. The radically shorter and simplified curing process enabled by NIR® technology permits off-line verification of curing quality, in which an NIR® pilot line is used to simulate conditions on the actual production line. This technique permits realistic verification of the feasibility of new coatings. It even permits advance estimates to be made concerning the NIR® oven's operating parameters. This makes any later adjustment in production, common when using conventional ovens, totally superfluous. Figure 7 shows an NIR® pilot line.

What makes NIR® thermal processing unique?

The true secret of NIR® technology is in the design and capacity of its emitters. They generate high filament temperatures (> 3,000 K up to 3,500 K), heat intensities from 1,000 kW/m² up to 1,500 kW/m² and ensure stable operation with no filament degradation in several application configurations (horizontal, vertical or angled). They are also ruggedly constructed for trouble-free operation in a broad range of chal-

Figure 5: The NIR-MicroSpot Repair® working principle.



lenging production environments.

NIR® emitters are designed for an average operational life of 5,000–6,000 hours – approximately equivalent to replacing one set of emitters a year in a typical production facility, operated on a three-shift round-the-clock schedule.

This advanced technology and in-built reliability is why AdPhos is still the world's sole provider of such high performance NIR® thermal sources. Ongoing systems and technical optimisation, combined with pioneer development work, suggest that future emitter performance could be extended to as much as 8,000 hours. But this is just one aspect of the overall system. The AdPhos range of NIR® thermal processes and technology involve far more than a near infrared, high-intensity thermal source.

An optimised ultra high-speed drying/curing process consists of a defined and carefully controlled thermal profile, a defined and controlled heat-intensity profile, a solvent evaporation rate and fume-exhaust profile as well as a thermal-air/gas-flow profile.

NIR® system technology must be tailored to the specified application conditions. For customers seeking a suitable and competitive solution to their production process needs, factors such as high systems efficiency, ease of operation, high reliability and ease of maintenance, as well as effective monitoring and error diagnosis, are of critical importance.

With more than 1,000 successful production systems installed over the past decade, AdPhos has more than adequately demonstrated the extraordinary capabilities (and in many respects unique system/process potential) of its NIR® technology. Ultra high-speed drying/curing solutions are not achieved by the mere substitution of existing components (including IR-based replacements).

A change to NIR® curing requires modification of the existing technology. But the result is a radical advance that yields huge gains in speed, efficiency and profitability. Time is money: the NIR® technique saves both.

Figure 6, above: Section of a NIR®-curing oven for the final coating/curing.

Figure 7, right: NIR® coil technicum.