Skin deep

Nanotechnology is transforming the art of the possible in surface coatings – and opening up new material possibilities. Dr Tom Shelley examines some of the emerging options

Technical pointers

- Modern treatments now beat conventional systems. For example:
- Nano-sized metal oxide treatments can provide abrasion resistance 40 times better than organic-bound polyurethane
- Electro-deposited black thin film coatings can exceed the performance even of zinc alloys
- Transparent coatings, using nano-composites, can be made highly water- and oil-repellent

While it's still the case that bulk material properties decide overall engineering strength and mechanical performance, coatings increasingly determine not only appearance, but corrosion and wear resistance – and serious developments are afoot.

Which is just as well. Many traditional coatings are now considered so environmentally unfriendly and are so aggressively regulated that they are barely worth the trouble. But since some of the newly developed coatings are better than anything available before, the message is, forget the supposed benefits of lead paint and cadmium, and see what's now on offer.

Take a look at the Leibnitz Institute for New Materials (INM) in Saarbruecken, Germany. Speaking at a meeting of the Institute of Nanotechnology, CEO and scientific director Professor Michael Veith summarised achievements as ranging from coatings for the sole plates of irons to those now used on German drivers' licences. He also mentioned a hybrid coating with cerium oxide nano particles in polymer, now proven to work better than hexavalent chromium in 6,000 hours of salt spray testing.

"One year back, it was half as efficient as chromium, but now we are in the same region," says Veith. "Also, there is a self-healing effect. Cost is now only a little bit more than chromium: originally, it was three times the price."

In fact, INM has developed a vast range of coatings. Highlights include: transparent coatings, based on organic-inorganic nano-composites that can be put sprayed or applied by dipping, and made either water- or oil-repellent; and nano-sized metal oxide particles in inorganic-organic nano composites, resulting in transparent coatings with excellent adhesion on polymer surfaces, as well as high scratch and abrasion resistance.

Its recent coatings, based on polyurethane nano-composites, also show scratch and wear resistance up to 40 times greater than organically bound polyurethane systems – and work on both metals and plastics. And coatings have also been developed for wood and leather, apparently rendering these easy to clean and anti-microbial.

Advanced coatings

Meanwhile, the INM's great rival, Fraunhofer Institute for Surface Engineering and Thin Films IST in Braunschweig, Germany, has also been no slouch. At this year's Hannover Fair, Fraunhofer was showing scratch-resistant spectacle lenses and displays, stainless steel kitchen units that resisted fingerprints and anti-reflective glass on the instrument panels of motorcycles.

The big difference between the technologies from these two has to do with the coating methodology. INM tends to go for low temperature sol gel processes, while Fraunhofer works mostly with plasma deposition.

Both are regularly harnessed in the UK, which is also home to significant improvements. For example, the Armourcote division of Surface Technology, working with component manufacturer Sun Hydraulics, had developed a multi-layer anti-corrosion and anti-wear surface coating specifically to protect hydraulic components in the Pelamis wave power system, designed by Edinburgh-based Ocean Power Delivery.

Dubbed TriCcem 3800, it is described as an

electro-deposited black thin film coating that "dramatically exceeds the performance of zinc, zinc alloy and electroless nickel plated finishes". Interestingly, it adheres to all steel alloys, sintered metal, aluminium, cast iron, brass and copper. It gives a film thickness of less than 20 microns and is available in WEEE, RoHS and ELV compliant versions. Its surface is smooth, lubricious and hydrophobic and exhibits more than 2,000 hours' resistance to salt spray corrosion.

Armourcote tends to go in for electro-deposited coatings of various types. Incidentally, its Niflor coating is also a nano-composite, similar to those developed by INM and Fraunhofer, except that it is electroless nickel, with nano-particles of PTFE.

That said, preparing and cleaning the surface remains key to obtaining a high integrity coating, and here we're back to older techniques. For example, nobody has come up with a better method of preparing steel than shot peening and grit blasting – especially when the steel is rusty. Such processes also exhibit the added value of putting the metal surface into compression, enhancing fatigue life.

Amourcote anti-corrosion and anti-wear surface coatings are used to protect the hydraulic components in the Pelamis wave power system, developed by Ocean Power Delivery, and subject to one of the most cruel environments

Safety first

However, again there have been improvements with the technique and the equipment involved in its application. For example, a valve developed by Hidge Clemco greatly increases the safety of grit blasting operations by reducing the time taken for equipment to depressurise on shut-off.

On standard grit blasting equipment, there can be a significant delay between releasing the dead-man's handle and the system responding – leaving operators to be injured by abrasive. The danger is increased when an extended length of hose is used between the nozzle and the blast pot, because of the sheer volume of material in the hose.

Hidge Clemco's solution is a normally closed pneumatic valve that fits over the blast hose close to the blasting nozzle. It requires a minimum of 4.5 bar (65psi) to open and closes rapidly when the dead-man's handle is released. Air/abrasive stops in one-third of the normal time. The valve is suitable for virtually any type of grit-blasting equipment, and is quick and easy to fit with standard tools.

Beyond that, another invaluable surface preparation technique remains aqueous degreasing. Wheelabrator – which makes conveyor washing machines and aqueous degreasing equipment, as well as wheel blast, air blast and peening equipment – recommends aqueous degreasing as an environmentally responsible alternative to trichloroethylene.

Speaking at the company's recent forum in Birmingham, Malcolm Griffiths, who heads up a coatings advisory service called Ad Qual Castech, encouraged aqueous degreasing, not least because trichloroethylene is a known carcinogen and suspected of a host of other hazards.

He said that, with its use being curtailed by the Solvents Emissions Directive, the HSE suggests that trike should no longer be considered – and that modern aqueous process equipment, which uses the safest solvent of all (water) is capable of degreasing all types of engineered components.

Wheelabrator's technical forum also focused on the substantial cost savings available to plant engineers choosing the aqueous degreasing route, and incorporating effluent treatment and wash water recycling equipment into their remit.

Incidentally, there's a way to go here. Wheelabrator general manager Colin Worthington warned delegates that a staggering 60% of organisations are still failing to comply with UK rules governing the disposal of effluent from vibratory mass finishing processes, leaving them open to prosecution and heavy fines. PE

Verifying integrity

Coating integrity is always crucial, so recent investigations into the effectiveness of different non-destructive evaluation (NDE) techniques by TWI (the Welding Institute), in collaboration with the National Physical Laboratory, are welcome.

Funded by the DTI and with active involvement from industrial contributors, the 30-month project studied surface coatings produced by application methods including thermal spraying, electro-deposition, physical and chemical vapour deposition and painting. Its main conclusion: no single NDE technique is appropriate to all types of coatings.

For example, flash thermography has proved useful in detecting areas of delamination on 5 micron thick, vapour deposited chromium nitride on steel, while Terahertz pulsed imaging has been able to detect suspect areas on painted marine structures. Other techniques studied included C-scan ultrasonics and laser shearography. The key output is a good practice guide, which is to be made freely available via the Adhesive Toolkit at www.adhesivestoolkit.com