ISACOAT  Work package 3: Process models

Description of specific categories: reference cases and development options

Sector 4: Coating of construction parts for buildings

Introduction

The basic task is the description of reference application processes in five selected areas: automotive OEM coating (small installations), vehicle refinishing, spare parts coating and job coaters, coating of construction parts for buildings, coating of agricultural and other machinery. The description includes general items which allow to extend the application area and to cover more industrial sectors. Due to environmental, qualitative, technical, and economical reasons, these application processes undergo substantial changes. The description of alternatives include process changes, material changes, technology changes, and abatement options, which interfere with basic information about size of enterprises and potential changes due to developments of the market and the social environment. For a set of different alternative options necessary investment, the related running cost and the environmental benefit in terms of VOC emission reduction are determined. So finally ecological and economic features can be evaluated. This kind of work was done by DFIU some years ago for other industrial sectors and is actually repeated by CITEPA for large installations under the IPPC directive. We use a similar form and include some more aspects which are relevant for the scenario analysis.

Technology description

Common items for the whole sector of coating parts for buildings:
- high degree of specialization for objects, as e.g. facade elements, sun protection elements, construction parts, ventilation ducts and outlets, ceiling elements, doors, portals, windows, trims, heating radiators, tubes and piping systems, fences, concrete steel, armaments
- high requirements, depending on place of external or internal use, for mechanical, chemical and physical resistance against UV radiation, acid rain, polluted atmosphere, corrosion, temperature oscillation, concrete and other alkaline construction materials, soil, mechanical impact during construction work, cleaning and maintenance, fire propagation
- new emerging requirements like self-cleaning, climate control
- long warranty duration for functional and optical properties
- limited complexity of shapes
- tendency to improve optical properties due to design needs (gloss, effects, structure)
- different substrates (steel, galvanized steel, stainless steel, cast metal, aluminium)
- uniform process and baking conditions at specialized sites
- increasing pressure on cost as main purpose of construction is for commercial use
- option of integrating additional process steps like blasting, degreasing, sanding, pre-assembly etc.

a. Coating materials

Most current technologies mainly for high-bake application.
Primer, on weldable construction parts, heating radiators, aluminium substrates: polyvinyl butyral based, or acid hardened alkyd (phosphoric acid), epoxy based (solventborne or
waterborne for spray application), epoxy based electrocoats (waterborne), epoxy powder for concrete steel, solvent-free alkyd for tubes
Topcoat or monocoat: polyester/alkyd/melamine (solventborne or waterborne), isocyanate hardened acrylate/polyester (medium solids, high solids), acrylic or polyurethane dispersion (waterborne), epoxy/tar based (medium solids, high solids), PVDF based (plastisol or solventborne), polyamide based, polyvinyl based, epoxy/polyester powder blends

Many enterprises are still using solventborne products typically for primers and for external use coatings. Therefore this taken as a reference for all possible changes. However, there is already a widespread use of high-solids, sprayed waterborne, electrocoat and powder applications.

b. Size/characteristics of enterprises

Small installations: There are small enterprises coating primed parts at construction sites. As these activities are not covered by regulations for stationary sources they will not be further examined by this study.
Medium size installations: They are having several spray stands, spray booths and separate ovens where mainly solventborne coatings are atomized by spraying. Automation level is only average. Typically, they possess a core competency around a core business and try to spread this and integrate additional jobs. Paint consumption is between 10 and 100 tons per year, thus exceeding the threshold of 5 tons per year solvent consumption.
Large installations: For their extended and very specific throughput, they make use of specifically designed processes and coating technologies: dip-coating, automated flat-bed spray coating, electrophoretic coating with adequate pre-treatment (degreasing, pickling, phosphatation, passivation), powder application with adequate pre-treatment. Paint consumption is typically above 100 tons per year. Solvent consumption depends on coating technology.

c. Environmental impact

Depending on the location of enterprises, and due to the relatively large quantities of solvents which may be used, there typically are nuisances and adverse impacts for the neighbourhood. The continued use of hazardous heavy metals in primers and topcoats includes specific hazards for operators, but also for the environment as a whole.

Reasons for technology changes

a. Environmental demands (SED, NEC)

The SED does not contain any provisions for installations consuming less than 5 tons per year of solvents for the coating of metal and plastic and less than 2 tons per year of non-halogenated solvents for degreasing. So enterprises have the option to remain in this niche position, to reduce actual solvent consumption to values below threshold or to plan new sites of this magnitude as an outsourced activity. The larger ones basically have the choice between reducing VOC emissions to 100/75 mgC/m³ for contained emissions and to 25 %/20 % of solvent consumption for diffuse emissions, or diminishing overall emissions to 0.6/0.375 kg VOC per kg consumption of non-volatiles (so-called reduction scheme). It is important to say that the limits according to the reduction scheme apply to the whole site as far as coating of metal and plastic is concerned. Thus the use of powder, high solids or waterborne coatings
may give space for a certain amount of high emission paints as long as the overall relation between non-volatiles and VOC emission is in the right balance.

In addition some countries allow for a so-called simplified reduction scheme which is based on a maximum VOC value (in g/l) of 250 g/l. Specialized manufacturers of construction parts with a limited choice of technologies (e.g. electrocoat) might go this path.

The development of environmental protection acts will have to be aligned with the requirements of the Gothenburg protocol (UNECE countries) and the National emission ceilings directive (EU member states), which define maximum acceptable VOC emission targets for all activities in a country not to be exceeded by 2010. Thus it might happen after 2007 that product-related regulations will be enforced which limit VOC values for small installations below the 5 tons per year threshold and for coating operations at construction sites, also in order to restrict escape strategies (outsourcing in order to avoid application of SED requirements).

b. Quality requirements

Buildings are generally having a long lifetime, and commercially used buildings are having long depreciation periods. Thus metal construction parts have to support this long perspective. Without using corrosion protection pigments based on lead and hexavalent chromium, long warranty durations can only be achieved by well aligned integrated concepts of metal pretreatment, application of conversion layers and durable coatings. This is the reason why in this sector relatively high filmbuilds are applied on parts for external or hidden use. In addition, epoxy based resins with good adhesion, as well as chemical and mechanical resistance are typical. Sometimes specialized PVDF, polyamide, polyvinyl and tar compounds are used in order to achieve outstanding properties. Special adaptation is often needed to coat galvanized steel with its zinc surface.

To a certain extent, the epoxy based coatings conflict with other technical and optical requirements, as epoxy resins degrade under UV radiation impact and tend to chalk rapidly. UV radiation also attacks many organic pigments and leads to visible colour shifts. In the case of elevated optical standards this may not be tolerable. On the other hand, architects tend to design commercial buildings with corporate or signal colours. In order to avoid an early re-coating of surfaces prior to planned refurbishing schemes, actual coating systems have to guarantee defined gloss retention and other items up to 15 years.

Another aspect of total life cycle costing is cleaning and maintenance of buildings. During the last five years, roofs and windows have already been conceived as self-cleaning (lotus effect, nano particles) or as easy to clean (non-adhesion films as protection against graffiti). This tendency will have an impact on coatings for metal parts.

c. Technical developments (electrostatic atomization, waterborne, high solids, electro dipping, powder application)

Electrostatic atomization is in most cases feasible. It achieves best performance in combination with automatic spraying equipment. Properly designed, it helps to reduce paint consumption, solvent consumption and waste formation and thus contributes to cost savings.

New materials (waterborne, high solids, very high solids) need adaptation of application attitudes, as otherwise too high filmbuilds may result which reduce the quality of coatings.
Also for economical reasons, filmbuilds have to be well controlled in order to avoid increased cost due to more expensive materials. In general, new coating materials often show restricted application windows; thus technical installations and knowledge of operators have to be improved.

New technologies like electrodeposition and powder application are widely available. There is sufficient experience, so that also medium size enterprises are meanwhile able to exploit these technologies.

d. Economic aspects

Due to high quality demands, partially new coatings, improved installations and equipment, better training of workforce, environmental and safety requirements, the total coating cost tend to increase. On the other hand, the industrial sector under consideration can only develop when its cost are competitive in comparison to other surface technologies.

Electrodeposition, dip coating and powder coating lead to very well balanced cost per part due to their good process efficiency, high degree of automation and improved process control. However, the high investment and the uncertainties of the construction business may represent an obstacle.

Categories of gradual change (technical and financial assessment)

a. Reference installation size

00 Medium size installations: several spray stands, spray booths and separate ovens; paint consumption between 10 and 100 tons per year
01 Large bodyshop: specifically designed processes and coating technologies; paint consumption above 100 tons per year

b. Primary measures related to pre-treatment

00 Standard: cleaning with organic solvents
01 Switch to aqueous mixture for cleaning
02 Spray pretreatment for cleaning and iron phosphatation
03 Dipping process for degreasing and zinc phosphatation (Fe) or chromation (Al)

c. Primary measures related to coating materials

00 Standard: solventborne materials
01 Switch to high solids paints or solvent-free liquid paints
02 Switch to waterborne coatings for specific purposes
03 Application of powder coating
04 Electrodeposition
d. Primary measures related to process features

00 No specific measures
01 Good housekeeping practices (closed cleaning devices, cautious use of cleaning solvents)
02 Dip coating instead of spray coating

e. Secondary measures

00 Filtering of particle emissions only
01 Abatement of oven exhaust air
02 Abatement of spraybooth/dipping tank exhaust air (adsorption, biofilter, incineration)

f. Achievable emission reduction and associated cost

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Matrix includes most relevant combinations of options from chapters a. to e. above. Figures will be entered during the ongoing project work including input from industrial partners, case studies, and further experience.

**Options for substantial technology changes**

a. Enlargement of activities at industrial manufacturing site

Actually many objects are primed or pre-coated at an industrial manufacturing site and afterwards painted at the building construction site. As this division of labour will probably become more difficult by 2007 after adoption of the new product-related VOC directive, industrial manufacturers may enlarge their activity and reduce the necessary work at non-contained conditions. This requires the availability of a broad range of special and individual topcoat colour tones and appropriate mixing and tinting schemes. And it may need the
readiness of architects to decide about colours at an earlier planning stage. The basic concept might also be used to think about the industrial application of special coatings like fire protection coatings.

b. Automatic application

Cost issues for robots and other automatic equipment are under development. So for the integration of new technologies into medium size paintshops, automatic application may become realistic in the years to come.

c. Substitution of metal coating by other technologies or other types of coating

For functional parts there is no remarkable tendency to substitute metal by plastic or wood with the exemption of window frames (only 20 to 30 % metal frames) and tubes. The alternative to coating metal parts is just not to coat them: stainless steel, galvanized steel, steel with limited surface corrosion, aluminium, electrically oxidized aluminium etc. offer options to avoid any organic coating. However this is mainly a matter of architectural design and not a matter of technological development. An alternative to some of the considered activities (e.g. facade elements) is the use of pre-coated metal sheets from coil coating. The main issue with coil coating is the coverage and adequate protection of cutting edges. If solutions are found resp. developed which do not conflict with the described quality requirements and warranty demands, coil coating might show up as viable.