ISACOAT Work package 3: Process models

Description of specific categories: reference cases and development options

Sector 1: Automotive OEM coating (small installations)

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

The EU solvent emissions directive distinguishes between automotive OEM coating (passenger cars, vans, trucks, busses) and vehicle refinishing. By definition of SED, the refinishing sector includes automotive OEM applications of refinish type coatings outside the OEM manufacturing line and coating of trailers. For the purpose of this reference process description, these automotive OEM applications belong to this sector category. Large sites with solvent consumption above 200 tons per year will be excluded as they are described in Best available techniques reference documents (BREF) under the IPPC directive.

Common items for all kinds of automotive OEM spraying of vehicles (passenger cars, vans, trucks, busses, others):

- complex three-dimensional objects
- multiple substrates (steel, cast metal, aluminium, magnesium, zinc, wood, thermoplastics, duroplastics, fibre-enforced plastics)
- multi-layer system (primer, surfacer, basecoat, clearcoat, topcoat)
- superior quality of pretreatment, application and finish with regard to gloss, corrosion protection, physical and chemical resistance, adhesion, elasticity etc.
- option to apply a multitude of fleet and individual colours on carbodies and add-on parts
- mixture of automatic and manual application
- plenty of intermediate process steps using manual labour (masking, cleaning, sanding)

a. Coating materials

Primer: epoxy based (electrophoretic dipping, 2 component solventborne or waterborne for spray application)
Surfacer: polyester (1 component high bake or 2 component low bake), or polyurethane (solventborne or waterborne)
Basecoat: polyester/melamine with cellulose acetobutyrate (solventborne) or polyurethane/acrylic dispersion (waterborne)
Clearcoat: acryl/melamine, or isocyanate hardened acrylate/polyester (medium solids, high solids, waterborne)
Topcoat: polyester/melamine or alkyd/melamine with siccative for rapid reaction with airborne oxygen, or isocyanate hardened acrylate/polyester (medium solids, high solids), or acrylic dispersion (waterborne)
Chassis coat (monocoat): polyvinyl butyral based, or epoxy/alkyd, or waterborne polyurethane dispersion

Most passenger cars have a clear-over-base topcoat. Single-layer topcoats are more typical for commercial vehicles (vans, trucks), and public transportation (busses, trams).

The typical reference products are still: electrophoretic primer or solventborne spray primer, polyurethane surfacer (solventborne), solventborne basecoat, solventborne clearcoat, topcoat and chassis coat (medium solids).

b. Size/characteristics of enterprises

Small installations: paint consumption below 30 tons per year; solvent consumption below 15 tons per year; capacity below SED thresholds; no electrophoretic application; use of pre-primed bodies or parts (pre-primed parts/assembled CKD bodies , pre-primed carbodies, pre-surfaced carbodies); mainly manual spraying even for external surface areas; one application line.
Medium size installations: paint consumption between 30 and 100 tons per year; solvent consumption between 15 and 50 tons per year; no electrophoretic application; mixture of automatic and manual spraying; two application lines for topcoats (high runners, i.e. typically 10 % of colour shades for 75 % of production volume, low runners, i.e. multitude of different colour shades for limited production volume, sometimes individual objects with single colour).
Large installations: paint consumption between 100 and 500 tons per year; solvent consumption between 50 and 200 tons per year; electrophoretic application of primer; mainly automatic spraying on external surface areas; two application lines for topcoats (high runners, low runners).

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 (end of life vehicle directive with its ban on lead and hexavalent chromium does not apply for trucks and busses).

Reasons for technology changes

a. Environmental demands (SED, NEC)

The SED urges sites to reduce their VOC emissions. Small installations basically have the choice between reducing VOC emissions to 50 mgC/m³ for contained emissions and to 25 % of solvent consumption for diffuse emissions, or diminishing overall emissions to 1.2 kg VOC (some countries with more stringent limits) per kg consumption of non-volatiles (so-called reduction scheme), which are the same demands as those for vehicle refinishing.

In addition some countries allow for a so-called simplified reduction scheme which is based on a list with maximum VOC values (in g/l) for most products and a tolerance of 10 % for non-compliant coatings.

More severe restrictions apply to medium size and large installations. The total emission limit values expressed in g/m² of total carbody surface are derived from large scale installations where electrophoretic dipping, automated electrostatic spraying, use of low-emission coatings, and partial abatement are belonging to the state of the art. For sites with solvent consumption between 15 and 200 tons per year, the SED restrictions are much more challenging.

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.

b. Quality requirements (warranty extension, benchmark, design evolution)

There is a continuous evolution of automotive quality standards, e.g. clear-over-base topcoats with improved etch, mar and scratch resistance, gloss and colour retention, elasticity, stone chip resistance, and corrosion protection. Warranties with regard corrosion last for up to 15 years, sometimes even longer. Small automotive manufacturers for high-class vehicles are heading for extreme performance (e.g. colours, effects, scratch resistance). Some of them have diverging carbody concepts with extreme mixtures of metal and plastic parts (space-frame with hang-on parts). Specialized manufacturers (e.g. convertibles, individual topcoat application) have to comply with standards of large installations without having same provisions.

c. Technical developments (waterborne, high solids, UV curing)

New materials (waterborne, high solids) need adaptation of application attitudes in the case of manual spraying and adaptation of technical equipment in the case of automatic spraying (e.g. climatic conditions, flash-off and baking schedules, inert pipelines). In general, new coating materials have a restricted application window which necessitates improved process control.

UV curing may emerge as a technology for clearcoats with drastically improved scratch resistance.

d. Economic aspects

It is obvious that the cost per unit shift due to the necessary environmental up-grading of installations tends to become more severe for medium and large installations described in this report compared with the cost of shift in installations covered by the IPPC directive.

For high-class and sports cars, increased cost may result in increased prices. Specialized partners for the automotive industry (convertibles, individual colours, etc.) may have the chance to find a new division of tasks and the related work. Truck and bus manufacturers may have options for low cost conversions.

Categories of gradual change (technical and financial assessment)

a. Reference installation size

00 Small installation: paint consumption below 30 tons per year; solvent consumption below 15 tons per year; capacity below SED thresholds
01 Medium size installation: paint consumption between 30 and 100 tons per year; solvent consumption between 15 and 50 tons per year
02 Large installation: paint consumption between 100 and 500 tons per year; solvent consumption between 50 and 200 tons per year; electrophoretic application of primer

b. Primary measures related to pre-treatment

00 Standard: sanding of pre-coated surfaces, degreasing with organic solvents
01 Switch to aqueous mixture for degreasing of pre-coated surfaces
02 Spray pre-treatment for degreasing and iron phosphatation of metal surfaces
03 Dipping process for degreasing and zinc phosphation of metal surfaces

c. Primary measures related to coating materials

00 Standard: solventborne spray primer, solventborne surfacer, solventborne basecoat and clearcoat, solventborne topcoat and chassis coat (medium solids)
01 Waterborne primer and surfacer, solventborne topcoats
02 Stage 01 + waterborne topcoats for high-runners and chassis coat
03 Stage 02 + waterborne basecoats and high solids clearcoat/low runner topcoats
04 2 component waterborne basecoats without surfacer application
05 Electrophoretic primer instead of sprayed primer
06 Dual electrocoat for vans and trucks (high runners)

d. Primary measures related to process features

00 No specific measures
01 Electrostatic application of primer and surfacer, topcoat, and clearcoat
02 Stage 01 + electrostatic application of topcoat and clearcoat
03 Automatic application on internal surface areas with optimized spray patterns

e. Secondary measures

00 Filtering of particle emissions only
01 Abatement of oven exhaust air
02 Abatement of spraybooth exhaust air

f. Achievable emission reduction and associated cost

Code	Emission	Abatement	Investment	Operat. Cost	Cost/Abatem
00 00 00 00		**0**	**0**	**0**	**-**

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. New division of coating tasks

Specialized partners for the automotive industry (convertibles, individual colours, etc.) may have the chance to find a new division of tasks and the related work. The application of primer and/or surfacer and may be done by the major automotive plants. Truck and bus manufacturers may cooperate with other industrial partners or concentrate own activities in order to establish electrophoretic coating instead of conventional spray processes for pretreatment and primer application.

b. Precoated parts (coil coating, primed parts, surfaced parts, finished parts)

Experience with spare parts and pre-primed parts for exterior assembly (CKD) shows that this kind of manufacturing process might be developed further. Besides electrocoat application and OEM primer application, coil coating might be used for pre-priming or even more extended pre-coating.

Depending on the carbody concept (monocoque or space-frame), not only add-on parts (bumpers, grids, mirror houses, fuel lids) might be finished at separate industrial lines, but also constructive parts (doors, hoods, tailgates, fenders) might be mounted as finished parts. Modular concepts of the automotive industry show this direction as part of future concepts.

c. Enlargement of installation size and capacity

Small installations below 15 tons per year solvent consumption may remain in a niche position. Some medium size plants may reduce their solvent consumption to values below this threshold by material changes or by outsourcing of activities.

All others are affected by the economy of scales. Substantial changes of processes need substantial investment which can in many cases only be earned back by increasing capacity and installation size. If there is no chance to grow sufficiently with own products, surplus capacities might be offered to other companies.