AMERON
Coatings

Powder Coating Wood and Wood Composites

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Introduction

Powder coating is a technique whereby "Dry Paint" is electro-statically applied (by Corona or Tribo techniques) to, in the main Metallic substrates. After electrostatic spraying the ground powder could be described as a high Tg (>40ºC), non cross-linked, non-coalesced particulate film. This loosely coherent layer is then melt fused by thermal energy to form a highly viscous 'liquid coating' having a melt viscosity many orders of magnitude greater than for a solvent borne coating processed at the same temperature. This highly viscous material then increases in viscosity as it cross-links to form a three dimensionally cross-linked, tough, chemically resistant film. This film exhibits excellent mechanical properties when all cross-linked functional groups are cross-linked to ca. 90% of conversion.

Powder coatings have been well established and are 'mainstream' for the coating of metallic substrates e.g. Iron, Aluminium, Galvanised Steel and so on. Environmental pressure and impending legislation, technical excellence and economic reasons have forced a huge and extensive developmental programme to realise the goal of powder coating Heat Sensitive Substrates. This short paper will dwell on one of the technologies that is available in the market place for Powder Coating of wood composite substrates – in this case MDF.

Some of the differences (and reasons for the differences) developmental hurdles and challenges that exist between powder coating of metallic substrates and MDF will be briefly discussed. In addition, the performance attributes of powder coated MDF will be described in some detail. The commercial possibilities and avenues for exploitation of this technology with MDF and other Heat Sensitive Substrates will be briefly described.

Practical and Technical challenges: Powder Coating MDF

The coating of metallic substrates and the Powder technology for the coating of metallic substrates is well developed. Some obvious difficulties and differences between powder coating metallic substrates and MDF are as follows:

- Metallic substrates are conductive (refer Table One); the surface resistance of MDF needs to be adjusted (by either chemical doping and/or preheating techniques) to enable the substrate to have suitable conductivity for efficient powder coating. To use a straightforward analogy, metallic substrates are efficiently chemically pre-treated for reasons of adhesion, corrosion control and the like. Quality control of this process for metallic substrates is simple- checking chemical concentrations, deposition rates and so on. The 'pre-treatment' is to ensure that it can be properly powder coated efficiently, this process just as per the metallic analogy needs careful thought, control and attention to detail.

- Metallic substrates do not exhibit differential stress build up (edge/centre or centre/panel face) upon thermal heating, MDF does. Incorrect or relatively minor variability of heating regimes around the object to be powder coated will result in differential stress and subsequent failure of the cured powder.
- Infrared (usually medium wavelength IR) and convection ovens are commonly utilised to provide the energy needed to cross-link powder coatings applied to metallic surfaces. For MDF, IR technology (either Gas IR or Electric IR) is a prerequisite. Infrared emitter technologies differ markedly from convection technology. Convection technology heats the air, which in turn transmits this thermal energy to the part being powder coated (the metallic substrate is, of course, thermally conductive as well). IR energy is either directly absorbed or transmitted through the Powder to the substrate. It heats what it sees – i.e. all surfaces which need to attain cure need 'to see' the IR source. Refer to table 1 for a list of some materials and their thermal conductivity values.
- The use of convection ovens with highly conductive metallic substrates means that control of the 'energy source' is relatively simple. When using IR ovens to cure MDF composite substrates the operator needs to carefully monitor the temperature of all surfaces being painted. This is to ensure that all surfaces are being equally and evenly cured. Incomplete chemical conversion (cross-linking) of the powder coated film manifests itself as differential cure – differential cure will in effect, equate to internal stress building up in the powder coated film - the nett result being powder checking and/or cracking.
- Conventional powder coatings (as utilised for metallic substrates) are usually cured at higher temperatures and for longer dwell times. I.e. the powder coating traditionally cures @ 180 ºC for 10 minutes or 200 ºC for 10 minutes (metal temperature). MDF substrates will not tolerate these harsh temperatures so lower temperature curing schedules and more reactive powder coatings must be developed.
- A variety of powder technologies have been investigated in the literature for use on Heat Sensitive Substrates via thermal curing i.e. Anhydride chemistries, Uretdione, Polyacrylate GMA etc. In general terms powder coatings utilise high Tg resin systems (Tg>50 ºC) to ensure that the powder coating material does not undergo agglomeration or pre-reaction at the molecular level during storage conditions. Lower temperature cure powder technologies must still pass standard storage condition protocols to be commercially viable.
- Conventional powder coating technologies can be 'catalysed' to cure at lower temperatures. The Powder Coating system needs to have negligible 'activity' during melt/shear extrudate processing (for short dwell times at ca. 120-130 ºC). It is expected that there will be some partial cross-linking during pre-reaction in the extruder as typically reaction rates follow classical Arrhenius temperature dependence. (This is a logical statement as we are curing these coatings at temperatures approaching 120 ºC) .The result of this 'pre-reaction' will be a building in cross-link density and a subsequent melt viscosity increase. What this means to the customer, of course, is poorer flow or orange peel. (This summary is 'holistically simplistic' – Resin and Coating suppliers have spent countless man-hours developing resin systems (I.e. semi crystalline, crystalline, hyper-branched polymers etc) with "rapid melt viscosity drop" profiles so that suitable resins can be utilised for coating Heat Sensitive Substrates).

- MDF is a highly complex, somewhat variable substrate, this can best be realised when one views the typical specifications of commercial MDF. Some highlights are of interest – MDF differs markedly in density (from ca. 650-850kg/m³) usually this is related to varied MDF thicknesses (typically from 3mm through > 30mm). Humidity content within the MDF board varies considerably with relative humidity, (MDF will reach an equilibrium moisture content (EMC) with the surrounding environment); for a typical MDF data sheet, please refer to www.woodpanels.org.au/publications/datasheets/8.ASP.

Factors that are of particular concern with powder coating MDF are:

a. Type of MDF substrate (MDF, MUF, Particle Board, etc.) and constituents/additives.
b. Moisture content, which is known to relate to conductivity, and potentially blistering and outgassing issues during the curing process.
c. Fibre size/porosity/fibre grain raise related to surface finish.
d. If pre-conditioning is too severe then the edges will loose moisture in preference to the centre of the board.
e. Rough, routed edges can be hard to dress, and can suffer from porosity issues.

Table 1: Thermal Conductivity of Common Materials

Material	Density of Material	Material Specific Thermal Conductivity
	(kg/m³)	(w/m°k)
Air, low humidity	1	0.026-0.023
Vermiculite	64-160	0.06-0.08
Plywood	530	0.138-0.116
MDF	500-600	0.14
Low quality concrete	2100	1.70
Corrugated metal sheet steel	7800	50.58

(From Roberto Escardo May 2003 http://www.crest.org/discussiongroups/resources/stoves/Escardo/valores R.htm)

Environmental Issues Pertaining to Coatings

Type in these two strings of vocabulary into any Internet search engine, "Volatile Organic Content" and "Green House Gases" and you could literally spend the rest of your days sifting through the volume of Internet 'hits' that are processed. Needless to say, VOC concerns with coatings are global VOC concerns. VOC/HAPS are scientifically proven to generate low level Tropospheric Ozone. Ozone a toxic, light blue gas with a pungent odour, is a deadly contributor to low level smog and is toxic to flora/fauna and Human health. Hazardous air pollutants (HAP's) are a subsection of VOC's, which are particularly ecotoxic, & mutagenic having intolerably long half-lives in our ecosystems.

The burning of fossil fuels to generate global warming gases is even more topical. A recent article in the NZ Herald states that Earth has "passed the threshold" of no return. Professor James Lovelock stated "before this century is over billions of us will die, and the few breeding pairs of people that survive will be in the Artic where the climate remains tolerable".
The Kyoto protocol makes it clear that the indiscriminate use of fossil fuels as energy sources cannot and will not be tolerated for much longer. In addition, extreme legislative

pressure is being brought to bear on coatings that are high in VOC. In summary, the future of coatings technologies will rest with powder, water borne, & high solids - all solvent free technologies.

These coatings will comply with the three E's – excellence in technology, efficient and environmentally friendly.

Some advantages of powder coatings over other coating materials is as follows:

a. Powder is nil to very low in VOC
b. Depending upon the formulation the overspray can be recycled, hence utilisation of powder can approach 95%+.
c. Waste from powder coating operations is easily discarded in an environmentally friendly manner.
d. Excellent coating properties can be afforded by this technology.
e. Single coat systems, high in film build (>100µm) can be processed in one layer on awkward, geometrically complex surfaces.

Whilst this is not the format to compare and contrast powder technology with other low VOC technologies – suffice to say powder is predicted to survive, grow and prosper.

Performance Requirements of Surface Finishes according to FIRA Standard BS6250

Typical required properties of Commercially available LTCP to the local market are shown in Table 2.

Table 2: Typical Specifications of LTCP for MDF Substrate

Attribute	Test Method	Test Result
Applied Thickness	ASTM D6132-04 (Ultrasonic Gage)	Pass, 80 – 130 µm
Impact Resistance	Reverse impact on metallic substrate, refer also FIRA results	Pass
Marr Resistance	Ameron In House Test [1]	Pass
Scratch Resistance	DIN 68861: Part 4	Pass, 4B
Crosshatch Adhesion	ISO 2409:1995	Pass, 0
Typical Surface Appearance	Coating Surface Roughness (Texture) [2]	Pass Rz values within tolerance
Gloss	ISO 2813:2000	Pass, within Tolerance
Cure Profile	20 minutes at 130 degrees C	Pass, Solvent Resistance tests, Coating well cured
Powder Storage Stability	480 hours @ 40ºC ageing in a convection oven	Pass, Appraisal of sintering

[1] Ameron in House Test, [2] Climate Coating in House Test

The overall confidence for consumers of LTCP on MDF is enhanced when one refers to the ‘Fitness for Purpose’ tests in Table 3.

These tests have been designed to assess the suitability of surface finishes to withstand abuse, abrasion, accidental spillage and assess heat marking in humid and dry environments.

Mechanical damage such as indentation, scratching and abrasion tests are also excellent tests to ascertain real life abuse (both during fabrication and end use) of this LTCP Technology coated panels.

Table 3: Finish Performance FIRA Standard 6250

Sample Ref: – Cream powder coated panel PROPERTY	Test Result	FIRA 6250 OTHER SURFACES General
BS 3962 : Part 6 Resistance to mechanical damage.		
crosscut	5	3
scrape, surface penetration	5	2
scrape, substrate penetration	5	3
impact	4	3
BS EN 12721: Resistance to wet heat)		
55°C	5	3
70°C	2	2
BS EN 12720: Resistance to marking by liquids (1 hour covered)		
ethanol 96%	3	2
ethanol 48%	5	3
tea	5	5
coffee	5	5
disinfectant (phenol)	5	3
disinfectant (chloro)	5	3
paraffin oil	4	3
blackcurrant juice	5	3
ammonia solution (3)	5	3
acetic acid (4.4 % solution)	5	3
olive oil	5	5
BS EN 12720/FIRA Procedure (4): Resistance to oils and fats (24 hours uncovered)		
Oils (solid vegetable oil)	5	4
Fats (butter)	5	-
BS EN 438 Resistance to wear (revs)	180	-

(Rating 5 excellent, 1 total failure)

Commercial Realities created by LTCP

During the past few years there has been a growing awareness of the need to expand the flexibility of supply of MDF panel products to the furniture & Joinery market segment. Indeed the uptake of powder coated MDF panels has been swift once designers and specifiers saw the inherent flexibility that LTCP brings to the table, particularly where colour choice and minimum run sizes are concerned. Core to this has been the metallic and speckle effect LTCP finished panels now supplied into the market.
It has been this aesthetic as well as cost flexibility that has won over the adopters.

Whilst powder coated MDF opens up opportunities for edge-finished components, particularly for the Kitchen, office furniture, and POS (point-of-sale) display areas, there are still challenges with industry acceptance. Edge taping (or banding) is universally accepted and there is little financial incentive for fabricators to move away from this lucrative process in their businesses. As New Zealand and Australian companies compete with the influx of product from international countries, particularly Asia based, new manufacturing techniques such as “Nesting” are becoming commonplace in local fabricator plants. Nesting is highly efficient and prefinished nested components are cheaper to produce than corresponding edge finished components overall.

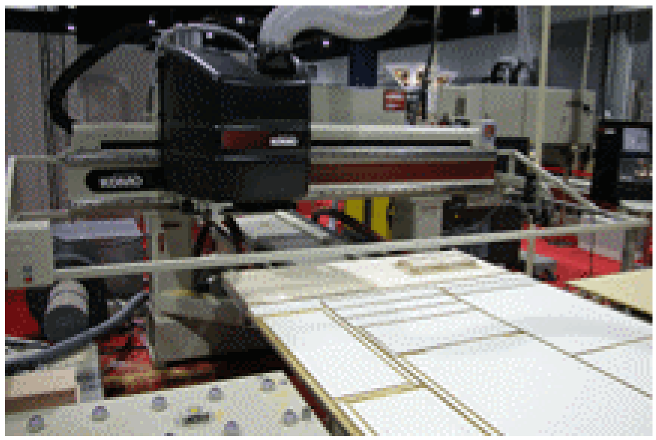

Figure 1 Nested Component Manufacture

There exists a niche for LTCP as an interior finish for factory produced building materials that sit comfortably along side other eco-friendly finishing technologies.

The consumer market has particularly high quality standards with tight tolerance requirements. Experience has shown that aesthetics and end use performance will not be compromised. With the majority of LTCP being low gloss subtle texture finishes, attention to tight gloss and texture level is paramount. This must be borne equally by the LTCP supplier and application house

Climate Coating Limited has invested heavily in developing its “Climate Application Process” to successfully apply LTCP to a variety of different variable wood fibre based substrates, including MDF, with out sacrificing the performance properties of the underlying substrate. This has been achieved with out the need to develop specialised expensive substrates. Proprietary new instrumental techniques have been developed with partner companies to measure panel moisture content AND conductivity in a non-destructive, non-contact way. This together with highly sensitive, Resistance spectroscopy instruments enables the successful application of the LTCP’s to the various types of MDF and other substrates.
It cannot be more important to note that the success of LTCP over MDF requires the partnership of the LTCP supplier and applications specialists to enable a truly successful solution that meets market acceptability requirements.

There is numerous end use applications for the LTCP coated MDF, a few examples of actual Climate Coating Limited *element*™ panels (LTCP coated MDF) are shown in figs 2-7;

Kitchens, interior claddings, POS display, retail store fit outs, residential and commercial furniture.

Figure 2: Commercial interior

Figure 3: Commercial interior

Figure 4: Modern Apartment Kitchen

Figure 5: Residential Kitchen

Figure 6: Commercial POS space

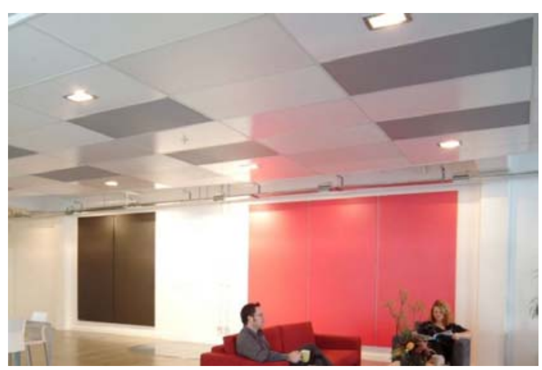

Figure 7: Interior claddings

Other composite substrates successfully coated with LTCP coatings include plywood and Gypsum panels, both extensively used in the interior claddings markets.

Summary

This concise paper has compiled some of the issues associated with the use of LTCP over MDF as a composite wood substrate in mind. Additionally, commercial application of LTCP over composite Plywood is forging its way into the housing interior and exterior claddings market. Other substrates are also soon to be launched into expanded end use markets.

LTCP coated MDF is a substrate, which more so is being utilised for a number of cost effective end-use application.

This paper illustrates that LTCP's are not only a scientific curiosity but is current commercial reality as well.

Technical Assistance

The assistance of Vicki Newey, Hampton Daruwalla and David Keung is gratefully acknowledged

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