In-mould surfacing with a silicone membrane

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Introduction

Many composite applications require a gel coated surface for cosmetic or durability reasons. The most common method of preparation is to paint or spray the mould tool, allow the coating to gel before laminating onto the tacky surface. During gelation, a proportion of the styrene (which is a major component of the unsaturated polyester resin system) is lost from the open mould tool as vapour into the workshop/environment. The Styrene Producers Association has recently recommended implementing a 20 ppm limit that ensures employee safety [1]. A new "ultra-low styrene content spray gelcoat" is reported to have achieved an average styrene concentration of 22.3 ppm relative to 54.3 ppm for a "standard gelcoat" [2].

The authors have recently reviewed in-mould gel-coating processes [3]. They [4] compared the conventional hand-painted gel-coating, in-mould gel-coating and in-mould surfacing processes to establish if styrene levels can be significantly reduced by the adoption of closed mould systems. For the open mould process, the average styrene levels were in the range 28-70 ppm. The two closed mould technologies had measured styrene levels in the range 0.23–0.37 ppm. Clearly the new processes offer a reduction in average styrene emission levels of >98% (worst new/best old). This has obvious benefits for worker health and the reduction of environmental burdens.

In-Mould gel-coating with a Silicone shim (IMS) [5] involves placing the reinforcement material and a silicone membrane into the mould before introducing resin that permeates the reinforcement material on one side of the membrane. The mould is then opened to remove the membrane before infusing a gel coating material into the space previously occupied by the membrane.

This paper reports experiments to develop the IMS process using a double glass plate mould to simulate Resin Transfer Moulding (RTM) of a flat plate and a complex double tetrahedron mould tool with Resin Infusion under Flexible Tooling with no flow medium (RIFT I) [6] to produce the component (Figure 1).

Workplace styrene levels were monitored using a Shawcity PhoCheck Tiger Photo-Ionisation Detector (PID) device with data reported in Table 1 for both a 15 minute rolling Time-Weighted Average (TWA) and the highest data point (Ceiling).

The surface quality of the produced components was monitored with a Gardner-BYK Wave-Scan Dual instrument for comparison to hand-painted surfaces. The parameters are dullness

(<0.1 mm), shortwave (0.3-1.2 mm), longwave (1.2-12 mm) and distinctness of image (DOI Dorigon correlated to ASTM E430). A small number is indicative of better surface finish for the first three parameters while a high number (maximum 96) indicates a good surface for DOI.

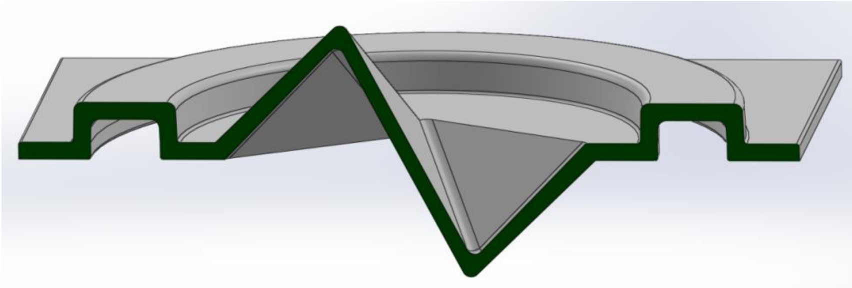

Figure 1: Section through the apices of the double tetrahedron moulding configuration with rotation.

Table 1: *Styrene levels (and percentage reductions) using the in-mould surfacing technology.*

Component	Styrene level	RIFT/IMS	Hand-paint
Flat panel	TWA (ppm)	0.23 (-99.2%)	71
Flat panel	Ceiling (ppm)	49 (-92.6%)	1017
Double tetrahedron	TWA (ppm)	0.37 (-98.7%)	29
Double tetrahedron	Ceiling (ppm)	107 (-84.0%)	668

Table 2: *Surface quality measurements from Wave-Scan*

	dullness	shortwave	longwave	DOI
Flat plate	8.7±0.6	2.9±2.1	2.1±0.9	92.8±0.3
Double tetrahedron (outside annulus)	44.7±2.0	61.2±22.5	50.7±5.1	66.7±1.6
Double tetrahedron (inside annulus)	41.8±1.7	50.3±7.7	38.4±4.1	70.2±1.3

The in-mould surfacing process shows promise for reducing styrene levels in the workplace, but further work is necessary to balance the flow and curing processes to achieve the optimum surface finish.

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References

[1] CEFIC, 2011, Reclassification of Styrene and the Influence on UP/VE resins, Conseil Européen des Fédérations de l'Industrie Chimique, http://www.upresins.org/upload/documents/webpage/styrene-position-paper-en.pdf accessed 24 March 2014.

[2] Low VOC gelcoat Crystic Ecogel S1 PA: VOC emission report, Scott Bader, 02-May-2012, accessed on 05-Nov-2013.

[3] William Rogers, Christopher Hoppins, Zoltán Gombos and John Summerscales, In-mould gel-coating of polymer composites - a review, *Journal of Cleaner Production*, available online 13 February 2014.

[4] Cristina Di Tomasso, Zoltán Josef Gombos and John Summerscales, Styrene emissions during gel-coating of composites, *Journal of Cleaner Production*, submitted 18 February 2014.

[5] AR Harper, Production of composite mouldings, World Patent Application WO2013/132211A1, published 12 September 2013.

[6] J Summerscales and TJ Searle, Low pressure (vacuum infusion) techniques for moulding large composite structures, *Proc IMechE Part L - Journal of Materials: Design and Applications*, February 2005, L219(1), 45-58.