

Gelcoat 층의 print-through 현상에 대한 실험적 고찰 및 평가

Experimental investigation and evaluation of print-through phenomenon of gelcoat layer

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1. Introduction

Gelcoat is a polyester resin which is sprayed on the mold before fiberglass lay-up in the manufacturing process. Supposedly, after removing the mold, the gelcoat surface should be as smooth as the mold; however, this is not the case in practice. Often twisted or wrinkled reflections can be seen on the surface, and they look like fibers exposed on the surface. This phenomenon is called print-through phenomenon (PTP) [1]. PTP influences the strength of structures and aesthetics of the product surface such as smoothness or color. A lot of studies have been done by researchers related to the cause and methods of improvement of PTP [1], [2]. In this study, we consider the effect of thickness of layer, percentage of hardener and temperature of making factors on PTP of gelcoat layer only.

2. Theory and experimental

The multiple linear regression model [3] is used in this investigation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + e \quad (1)$$

Where: y is the dependent variable; x_1, x_2, \dots, x_k are the independent variables; β_i are coefficients; e is the random error. In this work, the independent variables are assigned as follows: x_1 = thickness of specimen, x_2 = hardener rate, x_3 = temperature and dependent variables include arithmetic mean value (R_a) and mean height of profile irregularities (R_z) of roughness.

The number of samples was divided into 27 types. The properties of gelcoat was shown in Table 1. The specimens were made from gelcoat with one layer

only. The gelcoat is layed-up onto a glass plate (mold) with 9 specimens for each time (Fig. 1).

Table 1 Properties of gelcoat resin

Parameters	Units	Values
Density	g/cm ³	1.2-1.3
Viscosity at 25°C	poise	120-160
Gel time at 25°C	minute	12-15
Catalyst level (MEKP-925)	%	~1.8
Coef. of thermal expansion	1/°C	5×10 ⁻⁵

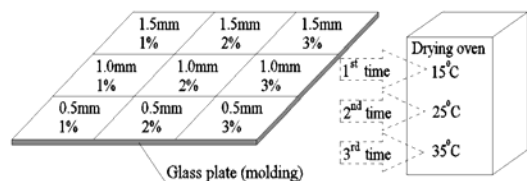


Fig. 1 Manufacturing process of specimens

The specimens were heated by SHYSC oven. The roughness and microphotographs of the specimens were carried out by the KEYENCE laser microscope.

3. Results and discussions

* The values of surface roughness

The results(Fig. 2) show that the higher the thickness and percentage of hardener and temperature, the higher roughness. The roughness increases quickly when temperature increases from 25 to 35°C and hardener rate increases from 2 to 3% (the PTP will occur strongly in these conditions). The effect of hardener rate on roughness is the strongest and that of thickness is negligible.

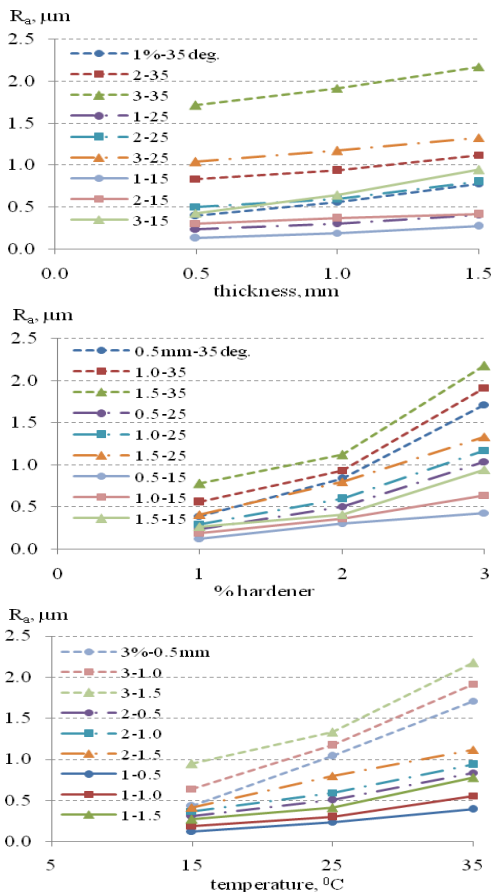


Fig. 2 Effect of input factors on roughness

*** The microphotograph of surface**

At low thickness, hardener rate and temperature, the surface is smooth. When these factors increase, the wrinkles and cracks occurs on the surface(Fig. 3).

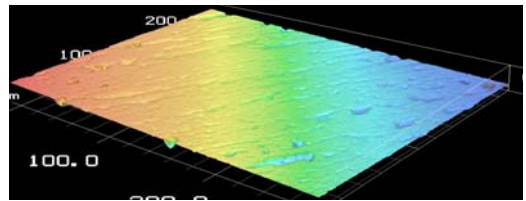
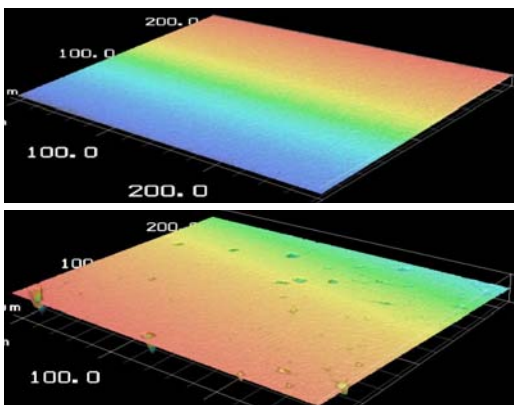


Fig. 3 3D shape of surface

*** Prediction of surface roughness**

The values of roughness were processed by SPSS software and regression equations are obtained.

$$R_a = -1.372 + 0.296 x_1 + 0.450 x_2 + 0.037 x_3 \quad (2)$$

$$R_z = -7.975 + 3.188 x_1 + 2.740 x_2 + 0.258 x_3 \quad (3)$$

From equation (2), (3) we can predict the roughness of surface in production conditions practically. Or conversely, to obtain a roughness value, we can select thickness, hardener rate and temperature suitably.

4. Conclusion

Three input factors (thickness, hardener rate, temperature) were studied to evaluate the PTP of gelcoat surface. The results show that the effect of hardener rate on PTP is the highest and thickness is negligible. The PTP will increase if three input factors increase. Besides, we can predict the roughness or determine the input factors from experimental regression equations.

References

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