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CTE'S POLYNOMIAL CURVES OF A THIN COMPOSITE SANDWICH

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Abstract: *This paper presents coefficients of thermal expansion (CTE's) polynomial tendency curves of rank two in case of a thin composite sandwich structure with dissimilar skins. This structure presents following layers: 1 layer – RT500 glass roving fabric/ 2 layers – RT800 glass roving fabric/ 1 layer – CSM450 chopped strand mat/ 1 layer – nonwoven polyester mat/ 1 layer – CSM450 chopped strand mat/ 1 layer – gelcoat. Thermal expansions have been measured using a DIL 420 PC dilatometer from NETZSCH GmbH, on both glass fabric reinforced polyester skin and for the whole structure. The coefficients of thermal expansion have been experimentally determined only for the structure's upper skin.*
Keywords: *coefficients of thermal expansion, polynomial curves, thermal expansion, composite sandwich, dissimilar skins*

1. INTRODUCTION

Composite sandwich structures are widely used in many applications in which the ratio between strength and specific weight must be very high. One of the most important characteristics of a sandwich structure is represented by the bond between skins and core. This link is essential for the structure's subsequent loading. Stiffness represents also a very important feature of a sandwich structure. Three and four point bending tests as well as compression tests have been accomplished to obtain useful mechanical properties regarding the sandwich structures. General references [1], [5], [7], [9], [25] and [31] put into evidence the huge problematics regarding the composite materials. Behavior of composite structures subjected to the influence of temperature, modeling and analysis can be found in references [2], [15], [27] and [28]. Other important researches regarding theoretical as well as experimental approaches on various composites are highlighted in references [3], [4], [6], [8], [10-14], [16-24], [26], [29], [30], [32-37].

2. MATERIAL AND PROCEDURE

Thermal response of a sandwich structure with thin nonwoven polyester mat as core has been experimentally determined. The structure presents dissimilar skins from which one is a glass fabric reinforced polyester. A sandwich plate has been manufactured at Compozite Ltd., Brasov with the following structure:

- One layer RT500 glass roving fabric of 500 g/m^2 specific weight;
- Two layers RT800 glass roving fabric of 800 g/m^2 specific weight;
- One layer CSM450 chopped strand mat of 450 g/m^2 specific weight;
- One layer 4 mm thick nonwoven polyester mat as core;
- One layer CSM450 chopped strand mat of 450 g/m^2 specific weight;
- A usually used gelcoat layer which is a pigmented polyester resin.

From this sandwich plate, specimens have been cut for the experimental characterization. Thermal expansions have been measured using a DIL 420 PC dilatometer from NETZSCH GmbH, Germany, on both glass fabric reinforced polyester skin and for the whole structure. The coefficients of thermal expansion have been experimentally determined only for the structure's upper skin. For each sample, two successive heating stages, in order to size the influence of the thermal cycling and temperature interval from 20^{0}C to 250^{0}C at a heating rate of 1 K/min, have been used. To eliminate the system errors, the dilatometer has been calibrated by measuring a standard SiO_2 specimen under identical conditions.

3. RESULTS

Distributions of thermal expansion and coefficients of thermal expansion (also known as technical alpha) have been presented in Figs. 1-4.

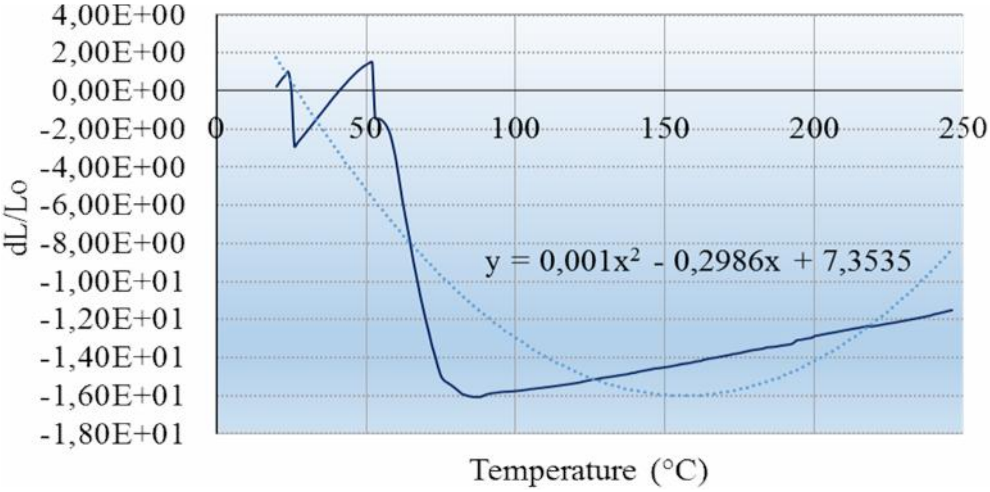

Figure 1: Distribution of upper skin's thermal expansion

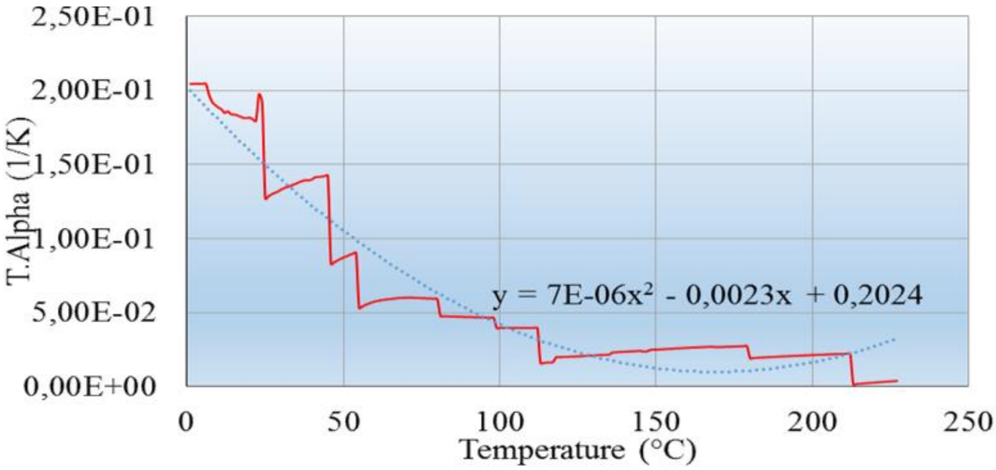

Figure 2: Distribution of upper skin's coefficient of thermal expansion (technical alpha)

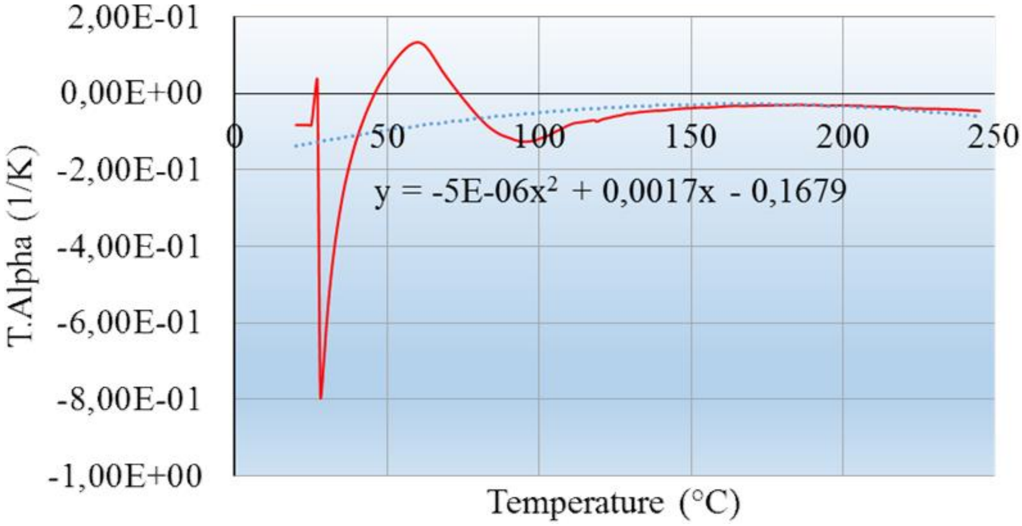

Figure 3: Distribution of sandwich structure's coefficient of thermal expansion in the first heating stage

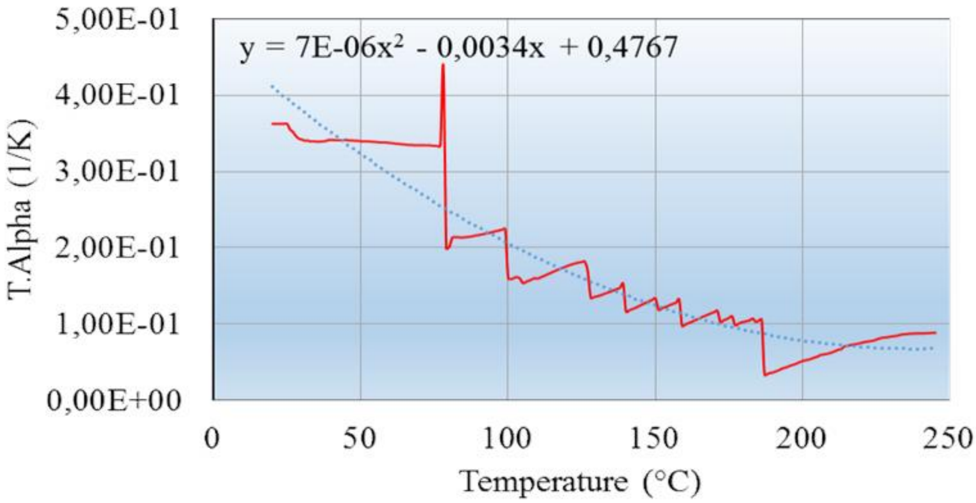

Figure 4: Distribution of sandwich structure's coefficient of thermal expansion in the second heating stage

4. CONCLUSIONS

In Fig. 1, the negative thermal expansion in the first heating stage is due to the beginning of curing in the upper skin's structure. Regarding Fig. 4, in the second heating stage, the significant peak is due to the high shrinkage that took place in the sandwich structure. An application of this kind of structure is an underground large spherical cap shelter and formed by twelve curved shells bonded together. To withstand the soil weight, the wall structure present a variable thickness. This kind of structure can be used in outdoor applications also. For each distribution, a polynomial tendency curve of rank two has been generated. These polynomial tendency curves are important to model a specific experimental test and their parametric form is:

$$y = Ax^2 + Bx + C \quad (1)$$

For upper skin's thermal expansion, the parameters A, B and C are presented in table 1.

Table 1: A, B and C parameters in case of upper skin's thermal expansion

A	B	C
0.001	-0.2986	7.3535

For upper skin's coefficient of thermal expansion, these parameters are shown in table 2.

Table 2: A, B and C parameters in case of upper skin's coefficient of thermal expansion

A	B	C
$7 \cdot 10^{-6}$	-0.0023	0.2024

For the sandwich structure's coefficient of thermal expansion in the first heating stage, these parameters are presented in table 3.

Table 3: A, B and C parameters in case of sandwich structure's coefficient of thermal expansion in the first heating stage

A	B	C
$-5 \cdot 10^{-6}$	0.0017	-0.1679

In case of the sandwich structure's coefficient of thermal expansion in the second heating stage, the parameters A, B and C are shown in table 4.

Table 3: A, B and C parameters in case of sandwich structure's coefficient of thermal expansion in the first heating stage

A	B	C
$7 \cdot 10^{-6}$	-0.0034	0.4767

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