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FACTORS AFFECT A MULTILAYER PRINTED CIRCUITS BOARD'S BENDING RIGIDITY

Abstract— The need to minimize weight, environmental requirements and customer requirements forces automakers to focus on Printed Circuit Boards (PCBs) design. These multi-use PCBs usually contain multiple layers of epoxy composite sandwich fiber s reinforced with epoxy glass fiber between copper foil. This multilayer PCBs essentially show mechanical stress due to their flexural stiffness. This multilayer PCBs can have mechanical properties determined by their flexural stiffness. However, flexural stiffness analysis is complicated by complex woven composite properties. In this study, an analytical model proposed a Finite Element (FE) describing the flexural behaviors of multilayer woven fiber composite PCBs. This study used both FE modelling using CREO Parametric 7 software and experiment. The availableness of this FE model was verified by a comparison with each other, as there was little difference between numerical simulations and experimental results.

Keywords— Multilayer Printed Circuit Board, Finite Element Method, CREO Parametric, Woven Fibre, Bending Stiffness.

I.Introduction

The material mesh density is governed by the space between the threads which is usually not the same for the two orthogonal directions that know as fill yarns and warp yarns and vertical to the bottom. One among the foremost common fiberglass fabrics used for computer circuit boards is “type 7628 (FR-4)”. Thus, in multilayer PCBs, the fabric properties for the fiberglass/epoxy layer are orthotropic. Generally, the strain-stress relationship is as follows:

$$\varepsilon_i = S_{ij}, \quad i, j = 1, \dots, 6$$

For an orthotropic material, the number of “independent elastic constants” might be decreased to 9 if “one” is chosen as reference coordinate of the system along the principal planes of symmetry of the material. In terms of engineering constants, the ratio of deformations and stresses are:

E_i $(i = 1, 2, 3)$, v_{ij} $(i, j = 1, 2, 3)$, G_{ij} $(i, j = 1, 2, 3)$ Where; E-Young's modulus, v – Poisson's ratio, G - shear modulus.They can be determined using the pure shear and the uniaxial tension tests and is normally formulated as bellow:

$$[S_{ij}] = \begin{bmatrix} \frac{1}{E_1} & -\frac{v_{21}}{E_2} & -\frac{v_{31}}{E_3} & 0 & 0 & 0 \\ -\frac{v_{12}}{E_1} & \frac{1}{E_2} & -\frac{v_{32}}{E_3} & 0 & 0 & 0 \\ -\frac{13}{E_1} & -\frac{v_{23}}{E_2} & \frac{1}{E_3} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_{23}} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_{31}} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{12}} \end{bmatrix}$$

II.Material properties

Typically, multilayer PCBs are composed of multiple layers of woven fibreglass/epoxy composite backing sandwiched between copper foils. Woven glass cloth is usually made from long glass fibre s or strands. To make a woven glass fabric, a large number of strands are tied together and woven up to and materials, like the actual PP used for a cell phone.Nevertheless, the two types of samples have a different thickness value as 1.0 mm (1.0 t) and 0.8 mm (0.8 t) which were laminated using a vacuum pressure (V-press) and then cut into 50mm x 30mm with a router. TABLE1 shows the properties of the material that were employed in preparing the prototypes i.e. the FR-4 "woven glass fibre/ epoxy resin" and the copper.

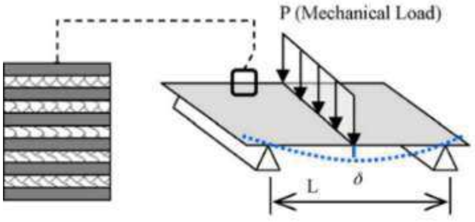

Fig.1 Three -point bending test (schematic diagram. oration).

TABLE.1 Shows The Properties Of The Material

Material	E1 (GPa)	E2 (GPa)	G12 (GPa)	v_{12}	$\rho(Kg/m^3)$
FR-4	22	22	3.5	0.28	1940
Copper	103	103	39.7	0.33	8940

For each test piece, the holding force has been shown to increase almost in proportion to the deflection. Once the 1.0 t was twisted to 5 mm, it released a force value of 99.3 N, while the 0.8 t revealed a force value of 47.7 N when it was bent to the same value.

III.RESEARCH METHODS.

1- To reduce the computation effort and because of the multilayer PCBs symmetry, only half of the definite piece was modelled and simulated, Fig. 2 (a).

2- The system coordinate i.e., XYZ was set towards the main PCBS material guiding system with 1, 2& 3 coordinate system to make the PCBS width and the length in the Y and X directions, respectively.

3- Similarly, the simply maintained and symmetric about the X plane was appointed as boundary conditions while the mechanical load was simulated in the same way of the real test, Fig. 2 (a).

4- Because of the low thickness value for the PCB, the casing element was selected in the current model. The coat section was utilized to determine its material type, layer structure and layer's orientation.

5- During the FE modelling, each woven fibre glass/ epoxy layer was divided to 2 thin layers, Fig. 2 (b), to effectively express the woven fibre web bending since the woven fiberglass was fabricated from two layers. Fibber bundles are in two orthogonal directions. The filaments of the filling and bending directions were directed at 0 ° and 90 °, respectively.

6- displays information on finite element models for many multilayer structures as shown in Fig.2 (b). For numerical simulations in the three-point bending test, the mechanical load should linearly change as of 0 to the real value, during the test, after 1 minute.

7- The highest loading force of the class models is 99.3 N and 47.7 N respectively, which is consistent with the real results, during the test. The 195 quadrangular elements and 642 knots were interlaced to represent each FE for the PCB model.

8- Modelling results for the 1.0 mm layer model and the deflection distribution are presented in Fig.3 (a) and (b) respectively.

9- Each of the two models showed a deflection value of 4.997 mm and 4.992 mm, respectively which are similar actual bending test results at 5 mm deflection.

10- The 0.06% and 0.16% error rates in the simulation results can reflect the high reliability of the FE analyses that were carried out.

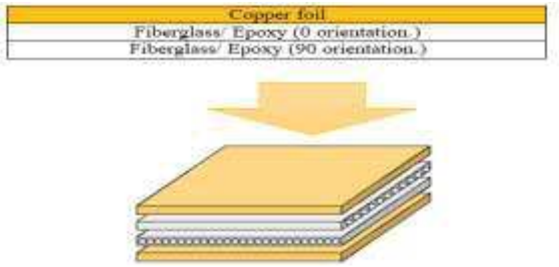

Fig. 2 Numerical assessment for the 3-point bending.

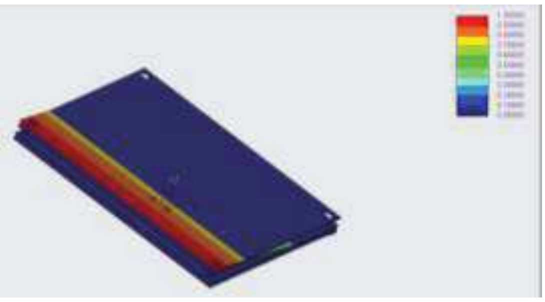

Fig.3 Deflection results of 47.7N model: test the layers and the fibre orientation model

IV.PARAMETRIC STUDY

Accordingly, various fibre size parts and textile pattern with changing textile properties of the multilayer optical fibre/epoxy of PCBs. More than a few FE models were developed to evaluate the effect of weave style and fibre size fraction on multilayer PCBs. The fibre size fraction and tissue type of all models are presented in Table 2. An equivalent structural load was utilized during the numerical simulation modelling.

TABLE 2. Fiber Volume Fraction and Weave-Style of Each finite Element Model.

Model number	1	2	3	4	5	6
0◦ direction Vf	0.52	0.6	0.66	0.6	0.6	0.75
90◦ direction Vf	0.4	0.6	0.52	0.4	0.75	0.6
Total Vf	0.46	0.6	0.59	0.5	0.68	0.68

To assess the bending stiffness, its model 1factor was assigned to 1. Then the bending stiffness factors of the opposite models, orderly, were found to be equal to 1.1, 1.15, 1.08, 1.13 and 1.36.

Compared to these results, it is shown that the direction of filling of a higher fibre volume fraction can increase the flexural stiffness of a glass fibre/epoxy laminated PCBs.

In spite of the fact that the portions of the total fibre size in Mode 2 and Model 3 are nearly the same, Model 2 showed lower flexural stiffness modulus than Mode 3. Similar behaviour (at similar working conditions) Mode 5 showed compared to Mode 6.

This can be related to reason of being the direction of filling the fibre volume fraction is more important than the direction of the winding.

V.CONCLUSION

The main target of the current research is focused on the development of a FEM that accurately describes the bending behaviour of a multilayer PCBS made of woven fibre composite, as well as assessing the influence of factors that can influence the flexural stiffness of a multilayer PCBS. Two kinds of woven composite fibre PCBS samples have been developed and tested with a 3-point bending test, and two types of woven composite fibre PCBS samples have been analysed. Two similar finite element models were subsequently developed and modelled with the software of CREO PARAMITRIC.Analysis of the outcomes of these models hewed that the flexural rigidity of multi-layer PCBs can be improved by high-fibres bundles in the direction of filling the network. Such results have practical implications and play an important role in the increasing demand in the present PCBS industry for thinning and bending PCBs.

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