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ANALYSIS OF MECHANICAL PROPERTIES OF THE “BEARING” PART BASED ON POLISHED SAMPLES

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Abstract: Presented work describes the use of algorithm for the computation of thermo-elastic properties of randomly reinforced composite which is based on histogram from image analysis done on ITAM, CAS. Three polished samples from “Bearing” part were analyzed. Results are used for verification of the algorithm functionality and primarily for computation of thermo-elastic properties which were compared with each other and used in modified FE analysis.

KEYWORDS: Image Processing, Monte Carlo, Random Reinforcement

1 Introduction

In [1] were described image processing methods and developed algorithm for evaluation of thermo-elastic properties of composite plates randomly reinforced with chopped C/PPS pellets. Monte Carlo simulation was used as an input for Classic Lamination Theory (CLT). Matrices of membrane stiffness A, coupling stiffness B and bending stiffness D were evaluated and from them were evaluated effective engineering constants of the composite plate. This method was used for evaluating effective engineering constants of part “Bearing” which had been earlier analyzed as isotropic (see [2] for details) and comparison between these approaches was done.

2 Data processing

Three polished samples from “Bearing” part were analyzed with image processing methods on ITAM, CAS. Results of this analysis are histograms for the angles of two main axes of evaluated ellipse (Fig. 1) [3]. Histogram (Fig. 2) serves as an input to AntHill™ software which computes off-axis stiffness matrices $\bar{Q}$ (see for example [4, 5, 6] for details) which are later use for evaluating effective engineering constants of each analyzed polished sample. Position of the cross-cuts on “Bearing“ part can be seen in Fig. 3. In Fig. 4 - 6 can be seen detail of analyzed cross section from position 1, 2 and 3.

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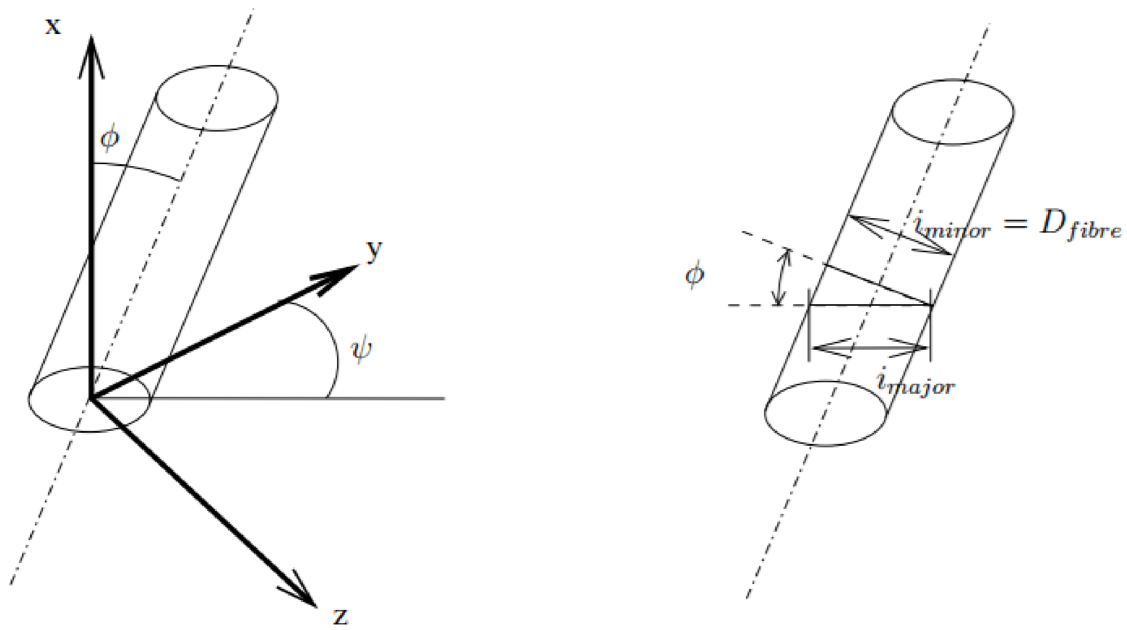

Fig. 1 Evaluated angles during image analysis in ITAM, CAS [3]

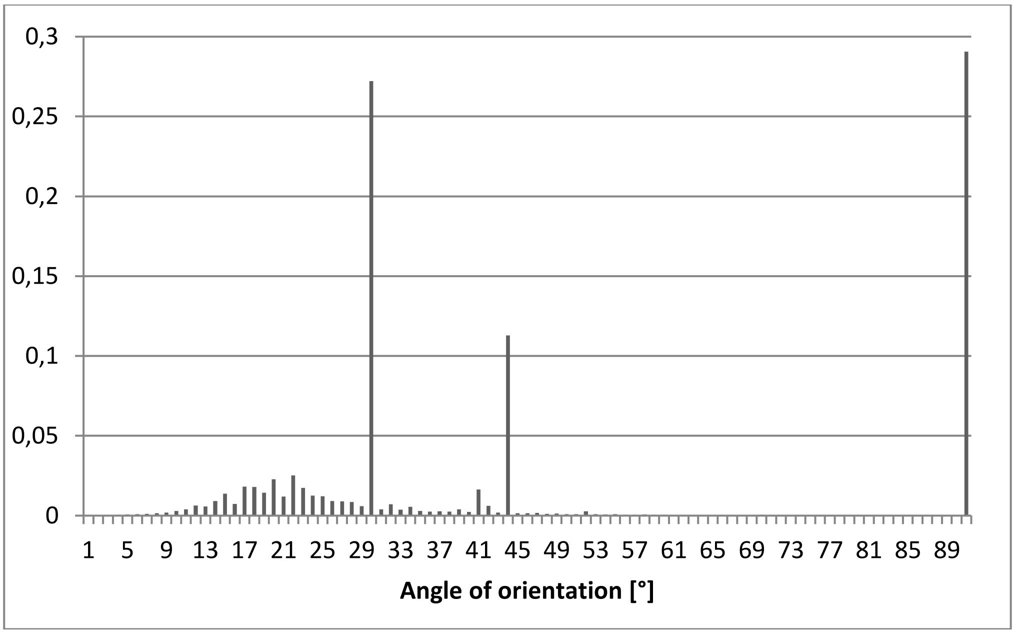

Fig. 2 Histogram of Φ angle

Fig. 3 Positions of analyzed cross-cuts on “Bearing” part

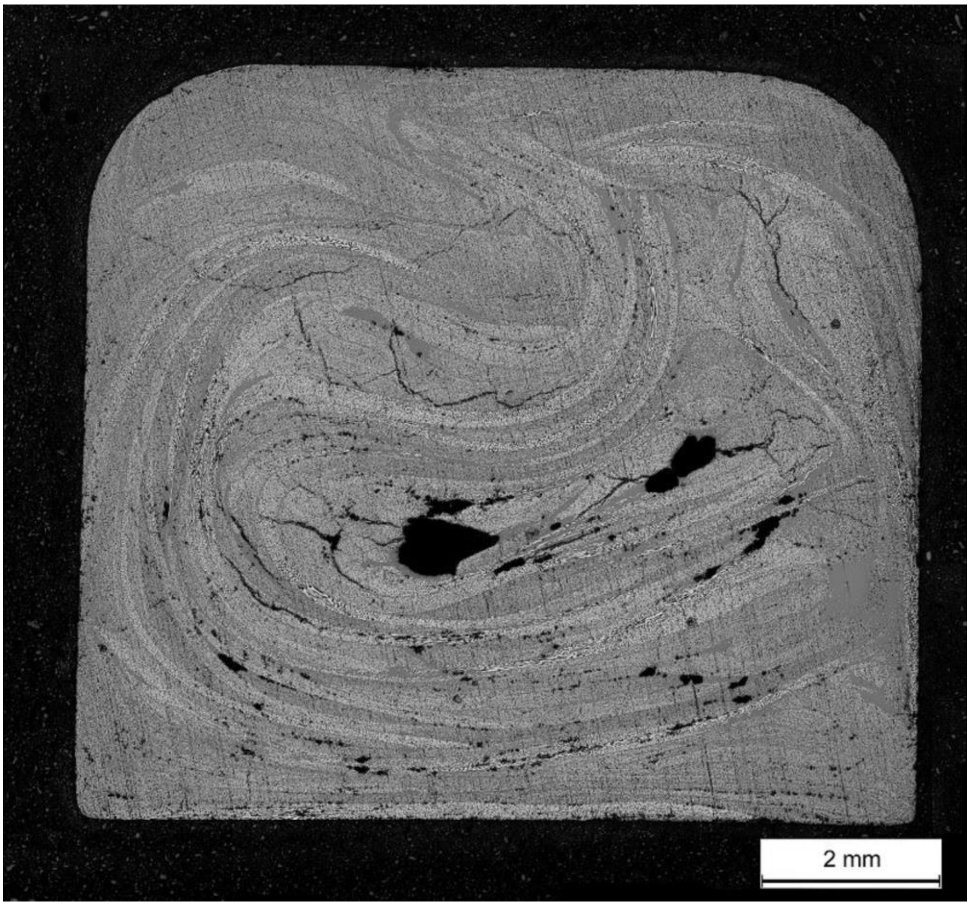

Fig. 4 Detail of analyzed polished sample from position 1

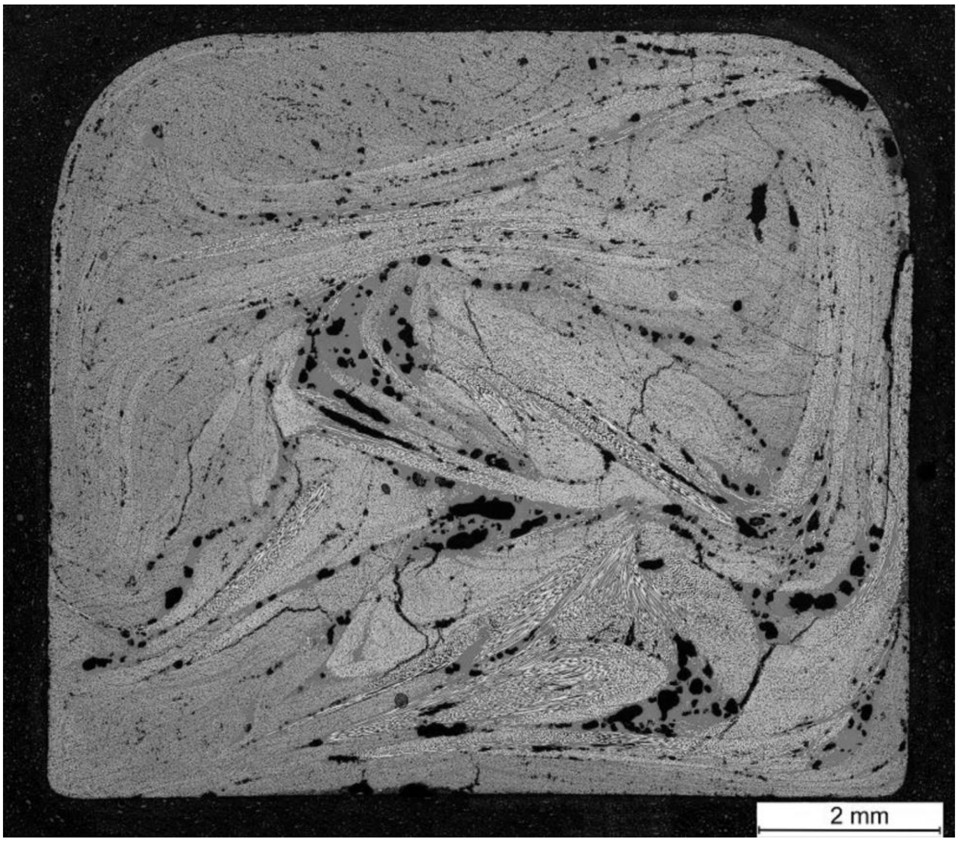

Fig. 5 Detail of analyzed polished sample from position 2

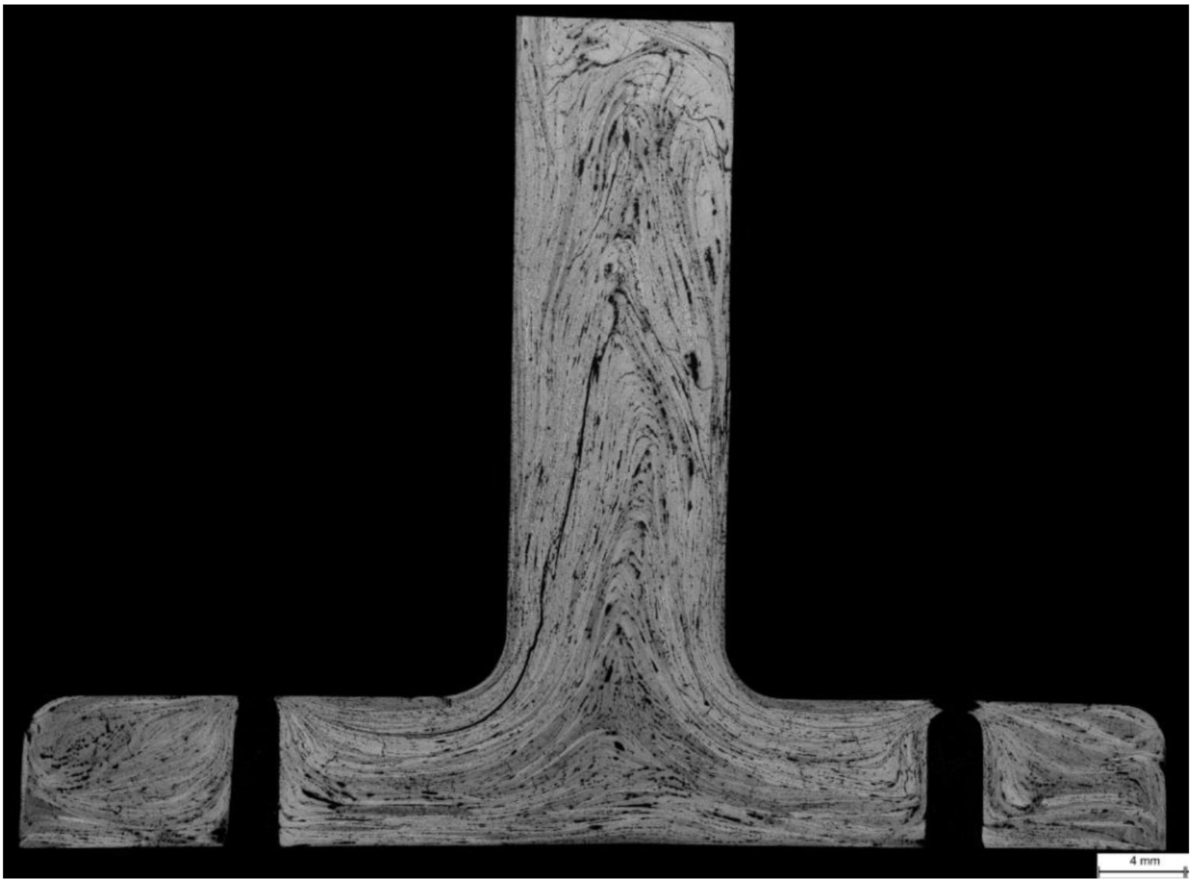

Fig. 6 Detail of analyzed polished sample from position 3

Evaluated thermos-elastic properties for each polished sample can be seen in Table 1 – 3. Thermo-elastic properties based on CLT isotropic calculation [1] are shown in Table 4.

Table 1 Thermo-elastic properties for cross-cut 1

E_x [MPa]	E_y [MPa]	G_{xy} [MPa]	ν_{xy} [-]
23 580	50 583	10 245	0,009

Table 2 Thermo-elastic properties for cross-cut 2

E_x [MPa]	E_y [Mpa]	G_{xy} [Mpa]	ν_{xy} [-]
27 740	43 028	9 895	0,047

Table 3 Thermo-elastic properties for cross-cut 3

E_x [MPa]	E_y [MPa]	G_{xy} [MPa]	ν_{xy} [-]
29 959	50 022	9 028	0,057

Table 4 Thermo-elastic properties according to CLT isotropic calculation [1]

E_x [MPa]	E_y [MPa]	G_{xy} [MPa]	ν_{xy} [-]
54 167	54 167	20 785	0,301

3 CONCLUSION

If we compare results from Tab. 1 – 3 with each other we obtain 21 % difference for Ex, 15 % for Ey, 12 % for Gxy and 84 % for νxy. Values from Tab. 2 were used in FE analysis of loading case JA-LI-23 (see [2] for details) and results (von Mises stress) were compared with previous analysis done with the use of isotropic material approach (Table 4). Results are shown in Fig. 5. We can see that the character of the stress field is similar and difference in maximal value is 6,7 %. The results should be viewed with caution because of the fact that photos of polished samples given to ITAM, CAS had low resolution (on the limits of applicability).

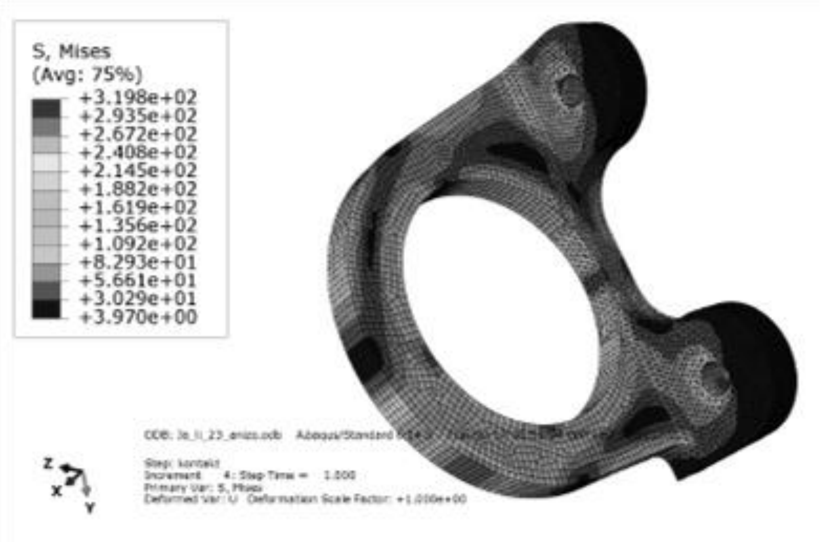

Fig. 7 von Mises stress for isotropic (up) and anisotropic (down) analysis

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REFERENCES

[1] Z. Padovec et. al. Comparison of Thermoelastic Properties of a Randomly Reinforced Composite Computed by Classic Lamination Theory and by Monte Carlo Simulation, *Mechanics of Composite Materials* **2017** (53), No. 1, 1 - 12.

[2] Z. Padovec et. al. Analysis and Optimization of Aircraft Composite Part "Bearing". In *Applied Mechanics 2016 - Book of Abstracts. Bratislava. Slovak University of Technology in Bratislava* **2016**, 39 – 40. ISBN 978-80-227-4547-5.

[3] J. Hos et. al. Calibration of an Image Processing Tool for Analysis of Fibre Orientation in Fibre Reinforced Composites. In *Proceedings of 13th Youth Symposium on Experimental Solid Mechanics. Praha. České vysoké učení technické v Praze, Fakulta dopravní* **2014**, 48 – 51. ISBN 978-80-01-05556-4.

[4] V. Laš. Mechanika kompozitních materiálů. Plzeň, Západočeská univerzita, **2008**. 200 pages. ISBN 978-80-7043-689-9.

[5] A. Choudhury et al. Effect of Lamination Angle and Thickness on Analysis of Composite Plate Under Thermo Mechanical Loading. *Journal of Mechanical Engineering – Strojnícky časopis* **2017** (67), No. 1, 5 - 22.

[6] A. Choudhury et al. A simple higher-order theory for dynamic analysis of composite plate. *Journal of Mechanical Engineering – Strojnícky časopis* **2010** (61), No. 3, 169 - 182.