TECHNISCHE UNIVERSITÄT
ILMENAU

50. Internationales
Wissenschaftliches Kolloquium

September, 19-23, 2005

Maschinenbau von Makro bis Nano / Mechanical Engineering from Macro to Nano

Proceedings

Fakultät für Maschinenbau /
Faculty of Mechanical Engineering

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=15745

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Andrea Schneider
	Fakultät für Maschinenbau Univ.-Prof. Dr.-Ing. habil. Peter Kurtz, Univ.-Prof. Dipl.-Ing. Dr. med. (habil.) Hartmut Witte, Univ.-Prof. Dr.-Ing. habil. Gerhard Linß, Dr.-Ing. Beate Schlütter, Dipl.-Biol. Danja Voges, Dipl.-Ing. Jörg Mämpel, Dipl.-Ing. Susanne Töpfer, Dipl.-Ing. Silke Stauche
Redaktionsschluss: (CD-Rom-Ausgabe)	31. August 2005
Technische Realisierung: (CD-Rom-Ausgabe)	Institut für Medientechnik an der TU Ilmenau Dipl.-Ing. Christian Weigel Dipl.-Ing. Helge Drumm Dipl.-Ing. Marco Albrecht
Technische Realisierung: (Online-Ausgabe)	Universitätsbibliothek Ilmenau ilmedia Postfach 10 05 65 98684 Ilmenau
Verlag:	isle Verlag ISLE, Betriebsstätte des ISLE e.V. Werner-von-Siemens-Str. 16 98693 Ilmenau

ISBN (Druckausgabe):	3-932633-98-9	(978-3-932633-98-0)
ISBN (CD-Rom-Ausgabe):	3-932633-99-7	(978-3-932633-99-7)

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=15745

50. Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
19.-23. September 2005

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Tense Distorted Condition of Bimorphous Piezoelectric Console Plate

ABSTRACT

Problems of bending of transversely polarized bimorfic thin piezoelectric plate of the class 6mm are considered.

THE EQUESTIONS OF PROBLEM

The problem of bending of the thin bimorph piezoplate plates rigidly fastened among them through their faces is being considered. The plates are polarized on thickness. Constant potentials are set on the facing of bimorphs, i.e. the electric field is constant, and the reverse piezoelectric effect is not taken into account (Fig. 1).

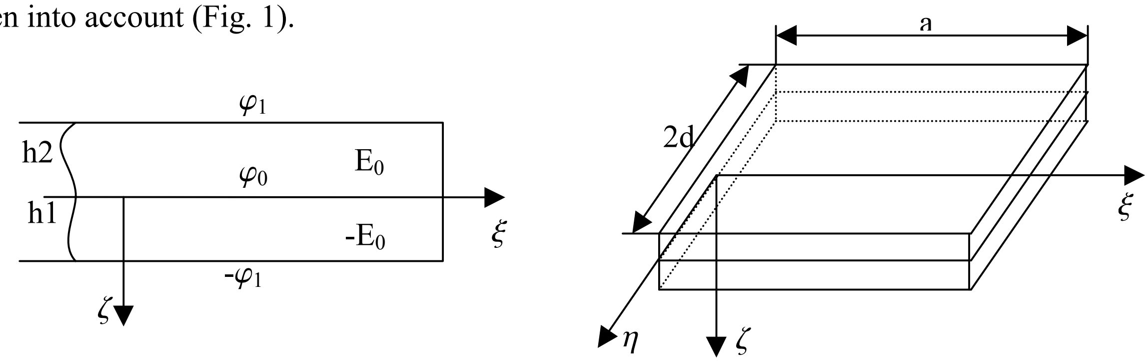

Fig. 1. The platte geometry

The equation of bending of a plate in the specified coordinate system looks like:

$$\Delta^2\widetilde{W}=0, \quad \text{where} \quad \Delta = \frac{\partial^2}{\partial \eta^2}+\frac{\partial^2}{\partial \xi^2}.$$

Expressions for generalized bending moments and shearing efforts for the chosen system of coordinates look like.

Generalized bending moments:

$$M_\xi=-D\left(\frac{\partial^2\widetilde{W}}{\partial\xi^2}+\nu\frac{\partial^2\widetilde{W}}{\partial\eta^2}\right)+h_1h_2SE_0, \quad M_\eta=-D\left(\frac{\partial^2\widetilde{W}}{\partial\eta^2}+\nu\frac{\partial^2\widetilde{W}}{\partial\xi^2}\right)+h_1h_2SE_0.$$

Generalized shearing efforts:

$$\widetilde{N}_\xi = -D\frac{\partial}{\partial\xi}\left[\frac{\partial^2\widetilde{W}}{\partial\xi^2} + (2-\nu)\frac{\partial^2\widetilde{W}}{\partial\eta^2}\right],\ \widetilde{N}_\eta = -D\frac{\partial}{\partial\eta}\left[\frac{\partial^2\widetilde{W}}{\partial\eta^2} + (2-\nu)\frac{\partial^2\widetilde{W}}{\partial\xi^2}\right],$$

where

$$D = \frac{2h^3}{3}\left(C_{11} - \frac{C_{13}^2}{C_{33}}\right),\ \nu = \left(C_{12} - \frac{C_{13}^2}{C_{33}}\right)\left(C_{11} - \frac{C_{13}^2}{C_{33}}\right)^{-1},\ S = e_{31}\left(1 - \frac{C_{13}}{C_{33}}\right).$$

On the basis of the analysis model problems the decision of a problem of bending of bimorph piezoelectric plate rigidly jammed on the left edge is offered at the following boundary conditions:

$$\widetilde{W}(0,\eta) = 0,\ \frac{\partial\widetilde{W}}{\partial\xi}(0,\eta) = 0, \qquad \text{At } \xi = 0,$$

$$\frac{\partial^2\widetilde{W}}{\partial\xi^2} + \nu\frac{\partial^2\widetilde{W}}{\partial\eta^2} = \beta,\ \frac{\partial^3\widetilde{W}}{\partial\xi^2} + (2-\nu)\frac{\partial^3\widetilde{W}}{\partial\xi\partial\eta^2} = 0, \qquad \text{at } \xi = 1,$$

$$\frac{\partial^2\widetilde{W}}{\partial\eta^2} + \nu\frac{\partial^2\widetilde{W}}{\partial\xi^2} = \beta,\ \frac{\partial^3\widetilde{W}}{\partial\eta^3} + (2-\nu)\frac{\partial^3\widetilde{W}}{\partial\xi^2\partial\eta} = 0, \qquad \text{at } \eta = \pm\alpha, 0 < \xi < 1.$$

$\widetilde{W}$ - function of a deflection, β- parameter determining bending moments caused by the influence of an electric field, α - parameter determining a ratio of the sides of the plate.

THE SOLUTION OF PROBLEM

The problem is solved on the basis of decomposition in the series of Furje. The decision looks like.

$$\widetilde{W}(\xi,\eta) = \sum_{n=1}^{\infty}\frac{ch(\lambda_n\xi)}{ch\lambda_n}\{A_n[th(\lambda\xi) - g1_n\xi] + B_n\xi[th(\lambda_n\xi) - g2_n]\}\cos(\lambda_n\eta) +$$
$$+ C_n\frac{ch(\chi_n\eta)}{ch(\chi_n\alpha)}\{\eta\chi_n(\nu-1)th(\chi_n\alpha)th(\chi_n\eta) + \chi_n\alpha(1-\nu) - (1+\nu)th(\chi_n\alpha)\}\cdot$$
$$\cdot\sin(\chi_n\xi) + F_3\xi^3 + F_2\xi^2 + F_1\xi,$$

where $\lambda_n = \pi n/\alpha, \chi_n = \pi n$ and factors $g_n^{(1)}$ also $g_n^{(2)}$ look like:

$$g_n^{(1)} = \frac{\lambda_n(\nu-1)th(\lambda_n)}{\lambda_n(\nu-1) - 2th(\lambda_n)}, \qquad g_n^{(2)} = \frac{\lambda_n(\nu-1)th(\lambda_n) - 2}{\lambda_n(\nu-1) - 2th(\lambda_n)}.$$

Constant factors of the decision are determined from the reduced infinite system of the equations which turn out after substitution of the decision in boundary conditions.

The introduced form of the solution is tested on the basis of the solution of the several model problems conceding the solution in a self contained kind. Authors consider, that this approach to the solution of the indicated class of problems is more effective than finite elements method since allows calculating more precisely derivatives of the second and third order, i.e. the moments and shearing forces.

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