2015 International Conference on

"Physics and Mechanics of New Materials and Their Applications" (PHENMA 2015)

devoted to 100-year Anniversary of the Southern Federal University

Azov, Russia, May 19-22, 2015

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Advanced materials and composites, including piezoelectrics, nanomaterials, nanostructures, functional materials, polymeric composites and so on, have very importance for modern sciences, technologies and techniques. The success of the Russian-Taiwanese Symposium "Physics and Mechanics of New Materials and Their Applications", PMNM-2012 (Russia, 2012, http://pmnm.math.rsu.ru/), 2013 International Symposium "Physics and Mechanics of New Materials and Underwater Applications", PHENMA 2013 (Taiwan, 2013, http://phenma.math.sfedu.ru) and 2014 International Symposium "Physics and Mechanics of New Materials and Underwater Applications", PHENMA 2014 (Thailand, 2014, http://phenma2014.math.sfedu.ru) predefined objectives and scientific directions of the new conference PHENMA 2015, devoted to 100-year Anniversary of the Southern Federal University (Russia). The following PHENMA abstracts are divided into four scientific directions: (i) processing techniques of new materials, (ii) physics of new materials, (iii) mechanics of new materials, and (iv) applications of new materials. These are present by scientists from 20 countries, demonstrating strong scientific collaboration, formed for last years.

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PREFACE

Advanced materials and composites, including piezoelectrics, nanomaterials, nanostructures, functional materials, polymeric composites and so on, have very importance for modern sciences, technologies and techniques. Their properties improve difficultly without intense chemical, physical, mechanical researches and development of modern numerical approaches and methods of mathematical modeling. Tremendous interest to similar investigations grows constantly, caused numerous applications and due to fast development of theoretical, experimental and numerical methods, requiring improvement of experimental equipment, theoretical and numerical approaches, computer hard- and software. These achievements create a new scientific knowledge. They allow one to understand and estimate very fine processes and transformations, occurring during processing, loading and operation of modern materials and devices under intense internal and external influences that lead to arising critical conditions and states. The modern devices and goods with sizes, changing from nano- up to macroscale ranges, possess very high accuracy, longevity and extended possibilities to operate in wide temperature and pressure ranges.

The success of the Russian-Taiwanese Symposium "Physics and Mechanics of New Materials and Their Applications", PMNM-2012 (Russia, 2012, http://pmnm.math.rsu.ru/), 2013 International Symposium "Physics and Mechanics of New Materials and Underwater Applications", PHENMA 2013 (Taiwan, 2013, http://phenma.math.sfedu.ru) and 2014 International Symposium "Physics and Mechanics of New Materials and Underwater Applications", PHENMA 2014 (Thailand, 2014, http://phenma2014.math.sfedu.ru) predefined objectives and scientific directions of the new conference PHENMA 2015, devoted to 100-year Anniversary of the Southern Federal University (Russia).

A significant interest to the PHENMA 2015 has led to the great sponsor support from Ministry of Education and Science of the Russian Federation, South Scientific Center of the Russian Academy of Science, Russian Foundation for Basic Research, Ministry of Science and Technology of Taiwan, New Century Education Foundation, Ocean & Underwater Technology Association, Unity Opto Technology Co., EPOCH Energy Technology Co., Fair Well Fishery Co., Formosa Plastics Co., Woen Jinn Harbor Engineering Co., Lorom Group, Longwell Co., Taiwan International Ports Co. (Taiwan), University of 17 Agustus 1945 Surabaya (Indonesia). Khon Kaen University (Thailand), Don State Technical University (Russia), South Russian Regional Centre for Preparation and Implementation of International Projects, Ltd.

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Symposium Chairs,

Prof. I. A. Parinov, Prof. S.-H. Chang

In the present report the degradation of polarization in the case of the long action of a high DC field was studied with the use of the parameters of the dielectric hysteresis loop on the setup, the principle of operation of which is based on the well-known Sawer – Tower scheme at room temperature at the 50 Hz external field frequency.
The dielectric hysteresis loops of these compositions have the high values of the rectangularity coefficient of the dielectric hysteresis loop (k_r = 0.9), the reorientation polarization (P_r = 35 – 37 mC/cm^2) and the coercive field (E_C = 5 – 5.3 kV/cm). The specific volume resistance is ρ_V = 10^{10} Ω·m.
In composition of (1) samples, after 10^6 cycles of switching, the remanent polarization P_0 decreases by 40% that is, accompanied by the increase of the coercive field E_c by 25%.
In composition of (2) samples the process of degradation of P_0 is markedly un-favor, the decrease of P_0 after 10^7cycles of switching does not exceed of 10%, and the changes in E_C of the samples were found to be negligible.
This evidence suggests that in the process of polarization reversal there takes place a cyclic induction of domain walls and, possibly, domain boundaries that leads to an accumulation of the defects of crystal structure. This gives rise to the formation of "frozen" domain structures leaving the switching process. It should be noted that the manifestation of the relaxor state in composition of (1) samples is higher considerable than in composition of (2) samples.

Finite Element Modeling and Analysis of Curing and Pultrusion Processes

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Curing and pultrusion present the modern technologies for a fast production of qualitative structural components made of composite materials and applied widely in different industrial sectors such as structural, aerospace, automotive and marine engineering. Curing process is a chemical reaction (polymerization) of polymer thermoset resins. This reaction is thermally activated and exothermic in nature. The degree of cure is defined as the ratio of heat evolved during the curing process up to present time to the total heat of reaction. Traditionally the rate of reaction is approximated by two functions: Arrhenius relationship and simple resin kinetic model. The curing rate depends on the resin properties and applied temperature. Pultrusion is a continuous and efficient process producing composite profiles with a constant cross-section. During pultrusion, the fibre reinforcements are saturated with the resin in a resin tank and then continuously pulled through a heated die by a puller. Inside the die, the resin gradually cures and solidifies to form a composite part with the same cross-section profile as in the die.
Curing process is modelled with the finite element software ANSYS Mechanical examining the transient heat conduction problem. A temperature distribution is obtained for each time step and the species equation is solved outside the software using the control volume method to obtain the degree of cure at each nodal point. An effect of the convection and exothermic

terms on the temperature is computed from the known temperatures determined at the previous time step. Pultrusion process is modelled using the same algorithm, as it was developed for the curing process, adding the movement of pultruded material in the examined problem by shifting the temperature and degree of cure fields after each calculation step. Another simulation algorithm developed for the pultrusion modelling is based on the fluid dynamic finite element software ANSYS CFX. Process is analysed as transient and the cure reaction is implemented as an additional variable in this algorithm.

The developed techniques were validated by using the experimental and numerical results published in open literature and demonstrating a distribution of the temperature and degree of cure along the control line of pultured profile. Three tests were analysed to demonstrate an application of the developed algorithms. There are pultrusion of cylindrical rod, flat plate and I-beam samples. Good agreement between present finite element results and published numerical-experimental results shows that the developed techniques can be used successfully for an accurate simulation of the curing and pultrusion processes.

Numerical and Experimental Study of Power Piezoelectric Stack Actuator for Rotorcraft Vibration Control

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The helicopter vibrations and noise are mainly excited by periodic forces generated especially in forward flight by the main rotor due to blade vortex interaction (BVI), high Mach numbers at the advancing blade, etc. These vibrations are transferred through the rotor hub and the gearbox into the fuselage that limits the operation capability, performance, reliability, handling qualities, and efficiency of helicopters.

Among the different solutions that allow to reduce the noise and vibration levels is Individual Blade Control (IBC), where actuators independently change the aerodynamic properties of each blade in the real time. The latest kind of IBC is the active trailing edge (ATE) flap concept, where the controlled flap is localized at a distance 75 − 90% of the blade span from the rotation axis. Most often ATE concept is implemented in the form of turned discrete trailing edge flaps driven by the power piezoelectric transducers. Generally, the most important requirements to the piezoelectric actuator for the active flap design are the following. High force and large displacement of actuators should be provided in compact sizes; force actuation must be able to react operational hinge moments, and stroke actuation must be capable of ±5° of flap motion; high resolution and very short response are necessary to effectively operate under control at the higher harmonics (> 5/rev); the actuation mechanism must either be protected against or withstand the forces and the large strains of the blade structure.

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