FINAL REPORT

of Ilona Dzenite

Marie Curie Control Training Site Fellowship HPMTGH0100278109

Research Project: Impedance Change and the Calculus of Variations

Home Institute: Riga Technical University, Latvia

CTS Host Institute: University of Aveiro, Portugal

Home Supervisor: Prof. Maximilian Antimirov* / Associate Professor Inta Volodko
(* Prof. Antimirov unexpectedly died during my CTS stay)

CTS Host Supervisor: Prof. Delfim F. M. Torres

CTS stay: 6 months (January 3, 2005 – July 3, 2005)

According to the research plan approved by CTS, I worked within problems of nondestructive testing by eddy current testing. The main attention was given to the basic formula in this area - formula for the impedance change that occur due to the presence a defect (so-called flaw) in the conducting medium to be tested. In the case of the flaw of an arbitrary shape, there does not exist an analytical solution so that different approximate and numerical methods were developed for solving this type of problems. In this connection, the significant moment is a formula for Z^{ind} used in the literature:

$$Z^{ind} = -\frac{(\sigma_F - \sigma)}{I^2} \iiint_{V_F} \vec{E} \cdot \vec{E}_F \, dV, \tag{1}$$

where V_F is the region of the flaw, σ_F and σ are the conductivities of the flawed and flawless regions, respectively, $\vec{E}_F$ is the amplitude electric field vector in the flawed region, $\vec{E}$ is the amplitude electric field vector in the same region in the absence of the flaw. As part of my PhD thesis a new formula for Z^{ind} is obtained in the form

$$Z^{ind} = \frac{\omega^2 (\sigma_F - \sigma)}{I^2} \iiint_{V_F} \vec{A} \cdot \vec{A}_F \, dV, \tag{2}$$

where $\vec{A}_F$ is the amplitude vector potential in the flawed region, $\vec{A}$ is the amplitude vector potential in the same region in the absence of the flaw. Thus, my first goal was to prove the equivalence of Eqs. (1) and (2). In my opinion, I have done it very well. Besides, these results were partially used for the Research Report of Department of Mathematics of University of Aveiro:

> Antimirov M.Ya., Dzenite I.A. and Ligere E.S. ***Application of integral transforms to some problems of nondestructive testing and magnetohydrodynamics***. Research report CM05/I-27, Department of Mathematics, University of Aveiro, Portugal, June 2005, online version is available at http://www.pisharp.org/dspace/handle/2052/76

The preprint, made during my CTS fellowship, is about integral transforms and its applications to some problems of nondestructive testing and magnetohydrodynamics. It is based on content of the lectures which Prof. M.Ya. Antimirov was going to present at the Department of Mathematics in the University of Aveiro in Spring 2005. To our greatest regret, that couldn't

happen because of unfortunate and sudden death of M.Ya.Antimirov. In honor to Prof. M.Antimirov, we (me and CTS fellow Lena Ligere, who also is at the University of Aveiro under Host Supervision of Prof. Delfim F. M. Torres) did our best to finish and extend this preprint, as this is one of Prof. Antimirov's last works.

The next step of my researches was devoted to the approximate methods for obtaining the vector potential of the flawed region. I have developed the method of additional currents, which is based on assuming that in the region of the flaw there exists current which is equal by module to the current in the conducting medium around the flaw and it is opposite by direction to the same current. After solving this problem, the obtained solution for the vector-potential can be substituted into the new formula for the impedance change. Numerical calculations carried out with the help of Prof. Torres and the Computer Algebra System Maple, showed that for evaluating the formula of impedance change, the method of additional currents is proper as well as the Layer approximation known in the literature.

I also tried to extend the formula for impedance change for the case of n arbitrary shapes flaws. I am still working on evaluating the new obtained formula and verifying its fairness. Unfortunately, because of the death of my home supervisor - a specialist in this area - it may take much time for me. Anyway, I already have got the new home supervisor, Associate Professor I. Volodko, and the defending of my PhD thesis is postponed to March 2006.

Finally, my work with the host supervisor Prof. Torres was very productive and good for my scientific growth. The Theory of Optimal Control seems to be useful for the problems of nondestructive testing, especially for the inverse problems, where we are to minimize parameters. The first results of our co-authorship were already presented at the conference:

> Delfim F. M. Torres, Ilona A. Dzenite. *A remark on Noether's theorem of optimal control*. **10th International Conference on Mathematical Modelling and Analysis, and 2nd International Conference on Computional Methods in Applied Mathematics**, Trakai (Lithuania), June 1-5, 2005, abstract, p. 33 or see the link
> http://www.techmat.vtu.lt/~art/k_abs_files_k_abs_f_file_bv.php?key=628

Moreover, the detailed results were got up in the following preprint of the University of Aveiro:

> Delfim F. M. Torres, Ilona A. Dzenite. ***A remark on Noether's theorem of optimal control***. Research report CM05/I-23, Department of Mathematics, University of Aveiro, Portugal, June 2005, online version is available at http://www.pisharp.org/dspace/handle/2052/72

Besides, our common paper is under the consideration in order to be published in a reviewed International Journal.

I am very grateful to CTS and to the University of Aveiro for this great possibility for me to work in the excellent conditions and collaborate with people. Separately I would like to thank my host supervisor Prof. Torres for the new knowledge and the future perspectives.

11 July 2005

CTS Fellow: Ilona Dzenite

CTS HOST Responsible: Prof. Delfim F. M. Torres