



# NONLINEAR ANALYSIS AND APPLICATIONS

April 2–4, 2009, Kiev, Ukraine

Book of Abstracts

# Nonlinear Analysis and Applications

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VALERY SERGEEVICH MELNIK

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## Book of Abstracts

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В сборнике рассматриваются вопросы нелинейного анализа, многозначных отображений, теории оптимизации, теории управления и моделирования, а также применения математических методов.

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## Variational problems for damage accumulation models of heritable type

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On the basis of scalar model of damage accumulation at hot deformation

$$\psi(t) = \int_0^t \varphi(t - \tau; I(\tau)) f(\dot{\varepsilon}_u(\tau)) d\tau, \quad (1)$$

(where  $0 \leq \psi \leq 1$ ,  $\psi(0) = 0$ ,  $\psi(t_*) = 1$ ;  $t_*$  -- limiting time which corresponds to the specimen destruction;  $t, \tau$  -- time;  $\varphi(t - \tau; I(\tau))$  -- heredity kernel;  $f$  -- some function) and taking into account the dependence of cumulative deformation  $\varepsilon_u$  on strain rate  $\dot{\varepsilon}_u$

$$\varepsilon_u = \int_0^t \dot{\varepsilon}_u(\tau) d\tau, \quad (2)$$

two important for practice variational problems of isoperimetric type are formulated. The first problem is formulated as follows: to define the strain rate change law  $\dot{\varepsilon}_u = \dot{\varepsilon}_u(t)$  at which preset cumulative deformation  $\varepsilon_*$  is achieved in the shortest time  $t_*$  provided that  $\psi(t_*) = 1$

$$\begin{aligned} t_* &= t_*(\dot{\varepsilon}_u(t)) \rightarrow \min, \\ \varepsilon_* &= \int_0^{t_*} \dot{\varepsilon}_u(\tau) d\tau, \\ \int_0^{t_*} \varphi(t_* - \tau; I(\tau)) f(\dot{\varepsilon}_u(\tau)) d\tau &= 1. \end{aligned} \quad (3)$$

The problem (3) is not a classical problem of isoperimetric type because value of definite integral is known, but the upper bound of definite integral is being minimised. The second problem formulation: to define the strain rate change law  $\dot{\varepsilon}_u = \dot{\varepsilon}_u(t)$  at which for preset time  $t_*$  the material gets the greatest deformation  $\varepsilon_*$  provided that  $\psi(t_*) = 1$

$$\begin{aligned} \varepsilon_* &= \int_0^{t_*} \dot{\varepsilon}_u(\tau) d\tau \rightarrow \max, \\ \int_0^{t_*} \varphi(t_* - \tau; I(\tau)) f(\dot{\varepsilon}_u(\tau)) d\tau &= 1. \end{aligned} \quad (4)$$

Euler's equation for problem (4) is not differential. Necessary conditions of extremum existence are carried out only in trivial cases which have no practical importance. In the statement (4) an important condition which from the physical point of view displays that destruction of material cannot occur till  $t_*$  was not taken into account, i.e.

$$\int_0^t \varphi(t-\tau; I(\tau)) f(\dot{\epsilon}_u(\tau)) d\tau \leq 1, \forall t \in (0, t_*). \quad (5)$$

By feasible functions region reduction to the piecewise constant functions class, specifically for two-level schemes

$$\dot{\epsilon}_u(t) = \begin{cases} \dot{\epsilon}_{u1}, & 0 \leq t \leq t_1; \\ \dot{\epsilon}_{u2}, & t_1 \leq t \leq t_*, \end{cases} \quad (6)$$

the problem (4) subject to (5) is converted to the nonlinear programming problem

$$\begin{aligned} \epsilon_* &= \dot{\epsilon}_{u1} \cdot t_1 + \dot{\epsilon}_{u2} \cdot (t_* - t_1) \rightarrow \max, \\ \left(\frac{t_*}{t_{*1}}\right)^n + \left(\frac{t_* - t_1}{t_{*2}}\right)^n - \left(\frac{t_* - t_1}{t_{*1}}\right)^n &= 1, \\ t_1 &\leq t_{*1}, \end{aligned} \quad (7)$$

in which efficiency function depends on three unknown variables  $\dot{\epsilon}_{u1}$ ,  $\dot{\epsilon}_{u2}$ ,  $t_1$ . Here  $t_{*i} = t_{*c}(\dot{\epsilon}_{ui})$ ,  $i = 1, 2$ ;  $t_{*c}$  — known function which characterises the material properties.

By the instrumentality of the LagrangTs multipliers method the problem (7) has been convert to the problem of finding of one-variable function optimum value. According to the found solution optimum scheme is the one where  $\bar{\epsilon}_{u1} > \dot{\epsilon}_{u2}$ . The received result allows to assume, that optimal resolution of the variational problems (3) and (4) exist for many other feasible functions classes.