Electromagnetism is physical factor, which determines a form of the stressed state field in mechanics of solid body and fluid stream

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It is showed that electromagnetic energy is physical factor, determining form and intensity of field of mechanical stresses, appearing in solid body and fluid stream under action of external forces with its mechanical nature. It is also showed that modern mathematical theories of elasticity, plasticity and hydromechanics remain helpless in solution even of such problems as "simple" tension, pressing and torsion in axisymmetric statement until these sciences remain strictly in framework of classical mechanics. Correspondingly, the whole multitude of computer programs for analyze of strained and stressed state in solid bodies and motive forces in fluid streams has the same "defect."
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Introduction

Geometrical unity in reproduction of a solid body in process of its plastic deformation and problems of hydro- and gas dynamics, shown in previous articles of the author by means of curves from set of conic sections, in combination with physically adequate unity in reproduction of trajectories of principal stresses in field of motive forces in elastic-plastic solid and fluid in the same articles, assuring full correspondence of the results theoretical analysis to the known observable phenomena and experiments – both these factors objectively testify to unity of cause of such behavior of the solid bodies and fluids.
Elucidation of this cause is an object of the given article.

Approach

Founder of scientific approach to research of phenomena in nature and engineering Aristotle has left to us a principle in kind of warning: "The primary for us is the secondary for nature." In the framework of the principle we can suppose classical mechanics (1687) as primary for us knowledge, since one is based on speculative hypothesis in kind of first law and on the results of generalization of sufficiently simple experiments with interaction of spheroidal solids in kind of the second and third laws.

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In parallel with it, R. Hook (1678) established the proportionality law between force applied to elastic body and its deformation on base of generalization of sufficiently simple experiments, which together with modulus of elasticity, established by T. Young (1807), made a base of the modern elasticity theory. The theory, in that way, is also primary for us knowledge.
Simple experiments with A. Pitot's device (1732) led to development of hydraulics, hydromechanics and aero- and gas dynamics also as primary for us knowledges.
And then, in first third of the XIX century, in parallel to creation of applied science entitled Study of strength of materials, it is going on intensive development of knowledge on classical electromagnetism. This knowledge as well as mechanics is bound up with solid body and fluid, but in contrast to classical mechanics, here ones use such notion as field of forces, introduced by M. Faraday (1834), which ones describe in simplest examples by means of curves from set of conical sections, and phenomenon of induction as analog of Newton's second law, so called current of displacement and time of relaxation, introduced by J.C. Maxwell (1863).
Notions of electromagnetism turn out the primary for nature relatively to classical mechanics since ones possess more thorough, fundamental sense. In particular, notion on the displacement current, introduced by Maxwell (1861), allows conceiving electromagnetic energy as physical factor, determining a form and intensity of field of stresses and motive forces, appearing in solid body and fluid stream under action of external forces with its mechanical nature.

Solution

Fig.1 shows a rod in kind of circular cylinder from medium-carbon steel under action of smoothly and slowly growing longitudinal tension. Since the rod possesses known length, density and modulus of elasticity of its material, one possesses fixed frequency of its own longitudinal oscillation, and one takes external load, applied to it, cyclically, with frequency, determined by time of run of longitudinal elastic (sound) wave. For example, time of run of longitudinal sound wave in a steel rod with its length $L = 5$ cm (half-period of oscillation) and speed of sound $c = 5{\cdot}10^3$ m/s is $t_r = 5/(10^2 \cdot 5 \cdot 10^3) = 10^{-5}$s and frequency $f = 1/2t_r = 50$ kHz. This frequency is resonant to a speed of loading of the rod by external force, i.e. the loading can be sub-resonant, resonant or super-resonant; in the latter of these cases, external loading will be localized in near-contact zone of the rod in kind of its plastic deformation. These oscillations are, as a rule, invisibly for our eyesight and inaudibly for our ear. When tension of the rod is going on smoothly and slowly (sub-resonant tension) under action of two the same in its quantity and oppositely directed forces, the tension process is cyclically accompanied by running waves of lengthening (in beginning by elastic and then by elasto-plastic) from every end of the rod, and every of these two waves transfers only half lengthening of the rod. These waves freely walk through each other and reach the opposite end of the rod. Superposition of these waves against each other gives full lengthening of the rod in every cycle of its tension. Front of every running wave excites running displacement of particles in the rod material and thereby one excites running current of displacement. In the case of the rod tension, displacement of the rod material particles is going on in direction opposite to motion of the running wave front, and in case of pressing of the rod, a displacement direction of the rod material particles coincides with direction of motion of the running wave front.

The running current of displacement inducts round axis of the rod equal to itself in intensity a running magnetic field. In the result, total vector of electromagnetic motive forces – Pointing's vector – reaches maximum quantity near external surface of the rod and one is inclined under 45° to the cylindrical rod generatrix. In that way field of electromagnetic motive forces determines field of trajectories of principle – mechanical – stresses in kind of two sets of helical lines – left- and right-handed – at 45° to the cylindrical rod generatrix.
This type of principal stresses acts mainly in a shell part of the rod on all stages of it tension up to fracture, when sudden local straightening of helical trajectories, keeping initial quantity of its incline 45°, forms the neck in kind of the right one-hollowed hyperboloid of rotation.
The same electromagnetic motive forces determine mechanics of transform of a falling compact water jet into consequence of the falling droplets.
The right part of this **figure** shows the same cylindrical rod loaded by torsion. In contrast to axial tension or pressing of such rod, when both sets of principal stresses in equal measure and jointly act correspondingly to external force, torsion excites tension in the one and pressing in the other set of principal stresses; naturally, a load-carrying ability of the rod is practically half decreased in comparison with axial load.

Fig.2 offers a result of known experiment, adopted from book [1]: thin-walled metal tube with closed ends was submerged vertically in water, and not great charge of explosive, placed under lover end of the tube, was put in action. Experimenters could not explain cause of one-sided helical deformation in the tube and they offer to readers to resolve this riddle.
As a matter of fact the one-sided helical deformation is in the given case a straight consequence of one-sided longitudinal pressing of the tube in contrast to "static" pressing when two equal in its quantity forces are simultaneously applied to a body.

Conclusion

Motion of water in pipe and especially spontaneous narrowing of the stream in kind of a right one-hollowed hyperboloid of rotation in the pipe sharp contraction is straight consequence of action of electromagnetic motive forces, and dynamics of such danger natural phenomenon as tornado is also quite corresponding to dynamics of electromagnetic forces, acting in simple solenoid made by A.M. Ampere (1822). Ones can also compare H. Magnus' transversal force (1852), acting in fluid stream, and Maxwell's transversal force (1873), acting onto a conductor in magnetic field.
Examples of positive solution of problems in fields of mechanics of solid, hydraulics, hydro- and gas dynamics, adduced in the author articles, these testify at least to the following:
1. Atomistic structure of ponderable matter predetermines necessity in use of methods and laws of classical electrodynamics for solution of problems in classical mechanics, in particular, in problems on fields of stress and deformation in solid body up to its elastic-plastic or brittle fracture and also problems on fields of motive forces and trajectories of fluid motion, in the same measure both from electro conducting and dielectric materials.
2. Doctrine on oscillations and waves, equally effective in classical electrodynamics and classical mechanics, introduces notions on fields of stresses and motive forces in initial homogeneous isotropic medium of solid body and also liquid and gas stream, and thereby one allows detecting in

its internal structure of the forced interaction, corresponding to a form of the given body, stream; in conformity with the doctrine, we must suppose a compact isotropic body in kind of aggregate containing, for example, shell and core with mass of every of its equal to half mass of cylindrical rod, loaded by longitudinal external forces, and two mass along of its length, and also a near-axial very thin bar, as singularity, which one decreases to considerable extent the rod buckling stability, as it follows from results of experimental research, carried out by E. Hodgkinson (1840); in one's turn, in spherical solid and water droplet, we must at least suppose presence of shell and core with the same mass in every of its and also central singular spot.

As to modern mathematical theories of elasticity and plasticity and computer methods of analyze of stressed-strained state, these theories and methods remain helpless in solution of such problems as a "simple" tension, pressing and torsion in axisymmetric statement until these sciences and methods remain strictly in the limits of classical mechanics.

3. Ability to see the invisible, to conceive the inconceivable and to explain the incomprehensible (Faraday's insight) **determines,** and in mechanics also, a **possibility** for constructing of physically adequate **conceptual model** of real phenomenon, process in wordy and graphical forms **as object** to its consequent mathematic description (Maxwell's insight), in contrast to "mathematic models" [1].

Final remarks

In his work over the given article, the author used also a book [2]. The book is a beautiful example of harmonious combination of Word, of Drawing and of Formula for clear view of such fundamental subject as Electromagnetism is.

"Mechanics Electrodynamic Elements" is actual direction in modern development of mechanics.

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[1] M.A. Lavrentjev, B.V. Shabat, Problems of hydrodynamics and its mathematical models, 2nd Ed, Nauka Publishing, Moscow, 1977

[2] A.A. Eichenwald, Electricity, 7^{th} Ed, State Engineering-Theoretical Publishing, Moscow – Leningrad, 1932

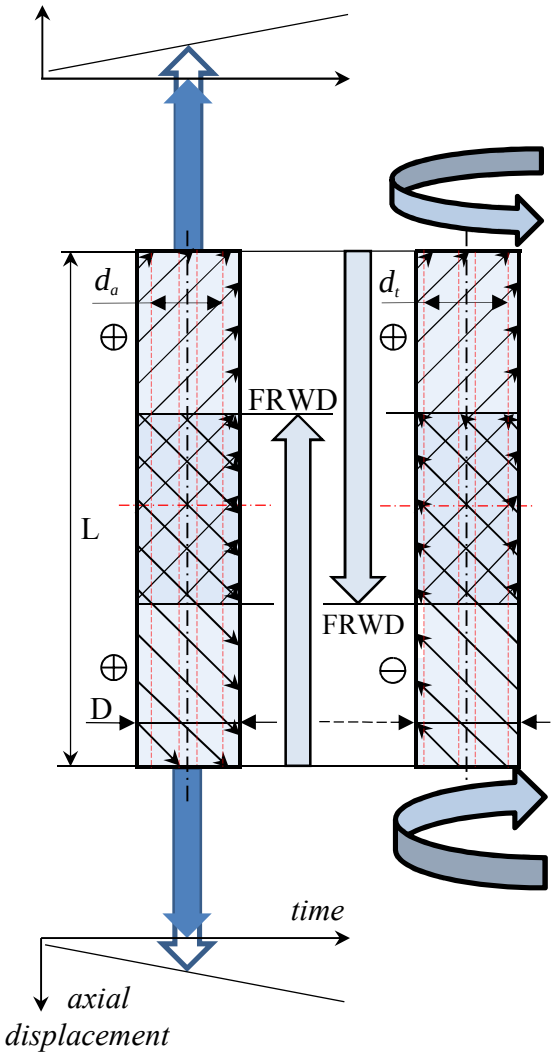

Fig.1: FRWD – *front of running sound wave of displacement;*
+45° *and* –45° are *constant angles;*
⊕ – *tension;* ⊖ – *pressing;*
d_a = 0.707D , d_t = 0.841D

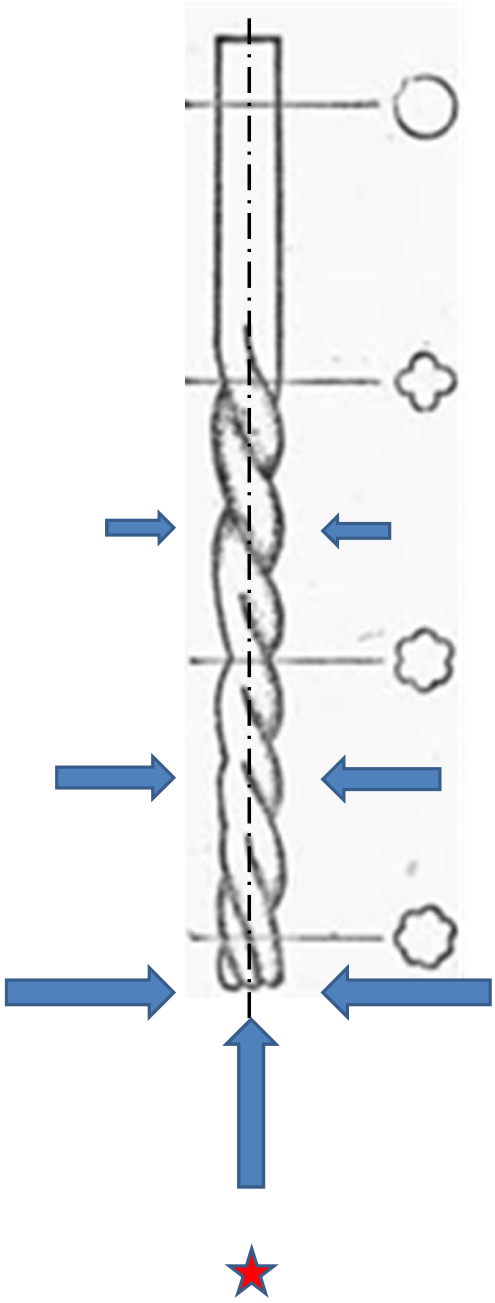

Fig.2: the picture in black lines is adopted from [1]