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STUDY OF DIFFUSION HIGH MAGNETIC FIELDS INTO PLANE AND CYLINDRICAL CONDUCTORS*

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Diffusion of high magnetic field has been studying since the last century. It has a number of applications: electromagnetic acceleration of solids, electromagnetic energy transport through vacuum transmission lines, and compressing metal shells with single-turn solenoids (inductors). The main problem of latter is low durability as they are used in highly strain conditions. High pulsed magnetic fields with an amplitude of 50 T and a half-wave duration of 5-20 microseconds cause strong heating of the surface, thermomechanical stresses, deformations and finally breakdown. A possible solution was suggested in [1], where the author without considering thermal effects showed that in the material with resistivity decaying exponentially by depth Joule heating diminishes remarkably. Detailed analysis of how gradient resistivity of the material influences on possible durability is the aim of the current work.

Simulation was carried out in both plane and cylindrical one-dimensional geometries. Corresponding magnetic diffusion equations coupled with heat flux equations were solved. Mechanics processes were described with Hooke's law and yield criterion von Mises. Temperature dependence of resistance and tensile strength were approximated by linear function. Spatial resistivity was assumed as three parameters function. The first parameter is the ratio of the surface and bulk resistance ρ^*/ρ_{bulk}, the second is depth of modified layer x_c and the third N_γ is sharpness of the profile. Sharpness determines whether profile is close to exponential or to step form. Other parameters of the material were assumed constant. The magnetic field at the inner boundary of the specimen was set as a decreasing sine. The amplitude of the magnetic field at the inner boundary B_{th} that does not result in plastic deformation at the cooling stage was used as a criterion for estimating durability.

The simulation shows that under the same impact material in the radial geometry, especially with small inner radius, has lower B_{th}, since current and Joule heating concentrate at the inner surface. Therefore, the smaller radius of the specimen the resistive material at the surface must be to shift destructive impact into the depth and distribute it. The influence of the main parameters of the material on B_{th} was studied as well. The temperature at which plastic deformation occurs was obtained analytically for cylindrical and plane geometries.

REFERENCES

[1] G.A. Shneerson, Fields and transients in equipment superstrong currents, Leningrad: Energoizdat Publ., 1981.

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