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Why High Pulsed Currents Shatter Metal Wires?

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There is a compelling experimental evidence that a sufficiently high pulsed current would shatter a metal wire in the solid state. As a result the wire disintegrates in the solid state into many pieces. The experiments have shown that the wires break in tension owing to a certain longitudinal force. The search for the nature of this force lead in past to some controversy. To determine the nature of the longitudinal tension induced in wires by high currents, and thus to establish the mechanism of the wire fragmentation, an extensive theoretical investigation has been performed. When a current passes through a metal wire two obvious effects occur. First, the wire material expands owing to Joule heating. Secondly, the wire is pinched radially by the Lorentz force. Both of these effects can induce stress waves in wires and lead to high tensile stress. Therefore, we have developed a magneto-thermo-elastic, numerical model of the phenomenon. As a result of the study several mechanisms of the wire fragmentation have been identified. These are: 1) The pinch effect and thermal expansion as a source of strong longitudinal vibrations. 2) The buckling instability due to simultaneous action of the thermal expansion and the magnetic force. 3) The flexural vibrations induced in initially bent wires. 4) The arc discharge created between broken wire ends leading to the appearance of strong longitudinal vibrations. These longitudinal vibrations result in further wire fragmentation into smaller pieces. It has been found that the induced elastic vibrations lead to the breaking of the wire in a wide range of parameters such as the total current and the wire geometry. The role of the skin effect in excitation of the oscillations has been identified.

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MHD Modeling of Magnetized Target Fusion Experiments

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Magnetized Target Fusion (MTF) is an alternate approach to controlled fusion in which a dense ~10e17-18 cm-3, preheated ~200 eV, and magnetized ~100 kG target plasma is hydrodynamically compressed by an imploding liner. If electron thermal conduction losses are magnetically suppressed, relatively slow ~1 cm/microsecond "liner-on-plasma" compressions may be practical, using liners driven by inexpensive pulsed power. Target plasmas need to remain relatively free of potentially cooling contaminants during formation and compression. Magnetohydrodynamic (MHD) calculations including detailed effects of radiation, heat conduction, and resistive field diffusion have been used to model separate static target plasma (Russian MAGO, Field Reversed Configuration at Los Alamos National Laboratory) and liner implosion experiments (without plasma fill), such as recently performed at the Air Force Research Laboratory (Albuquerque). Using several different codes, proposed experiments in which such liners are used to compress such target plasmas are now being modeled in one and two dimensions. In this way, it is possible to begin to investigate important issues for the design of such proposed liner-on-plasma fusion experiments. The competing processes of implosion, heating, mixing, and cooling will determine the potential for such MTF experiments to achieve fusion conditions.