Energy Conservation and Poynting's Theorem in the Homopolar Generator

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Poynting's theorem states that the rate at which work is done on the electrical charges within a volume is equal to the decrease in energy stored in the electric and magnetic fields, minus the energy that flowed out through the surface bounding the volume. Most familiar applications of Poynting's theorem concern stationary currents or circuit elements. We apply Poynting's theorem to the homopolar generator, a disk-shaped conductor moving in a background magnetic field. This allows us to show that the phenomenon of magnetic breaking arises as a natural consequence of Poynting's theorem.