Operation of an Electromagnetic Trigger with a Short-circuit Ring

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Abstract

Electromagnetic trigger is an essential part of electromagnetic circuit breakers. Its task is to disconnect the circuitry at overload or short-circuit faults. At normal operation the current through the coils of an electromagnetic trigger is sinusoidal. In case the current is not large enough to cause saturation of magnetic field in some parts of the core the force between the anchor and the core is sinusoidal as well and varies with double frequency of the applied current signal. This can result in large undesirable oscillations of the anchor especially at large currents. These oscillations can be reduced by inserting a small conductive (copper) short circuit ring around (inside) the core. The induced currents in the ring are "lagging" the applied current and produce additional magnetic field which is surrounding the ring. This magnetic field superimposes to the primary field and results in changes of the force on the anchor. Figures 1 and 2 are showing the electromagnetic force on the anchor at sinusoidal excitation current of 100 A amplitude and 0.01 mm distance between the anchor and the core. In case no ring was used (Figure 1) the force on the anchor drops to zero simultaneously with the current excitation while it levels off zero even at zero excitation current in case the short circuit ring was used (Figure 2). This is a consequence of a magnetic field produced by an induced current of the ring shown in Figure 2 with a blue line. Figure 3 presents the situation at increased excitation currents (amplitude of 400 A). In this case some parts of the core (and the anchor) are saturated (Figure 4) and as a consequence the induced current density as well as force does not follow the sinusoidal shape. Large saturations that affect the force on the anchor are in particular due to the large induced currents in the ring since the ring is positioned very close to the air gap and also reduces the cross-section area of the ferromagnetic. Further simulations will enable optimal positioning of the short circuit ring for desired device operation.

Figures used in the abstract

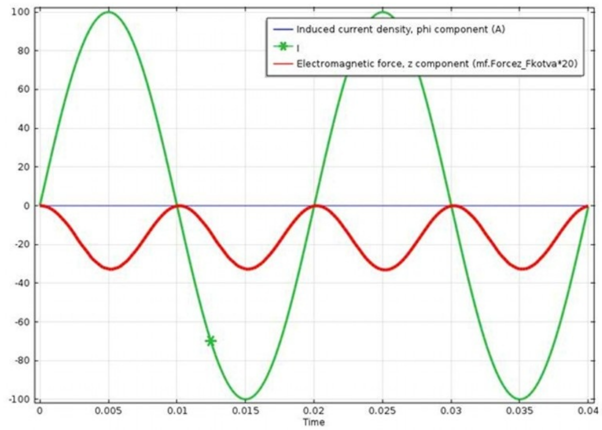

Figure 1: Figure 1: Simulation without a short-circuit ring: excitation current to the coils (green line) and force on the anchor (red line) as a function of time. The values of force are appropriately scaled to be presented on the same graph.

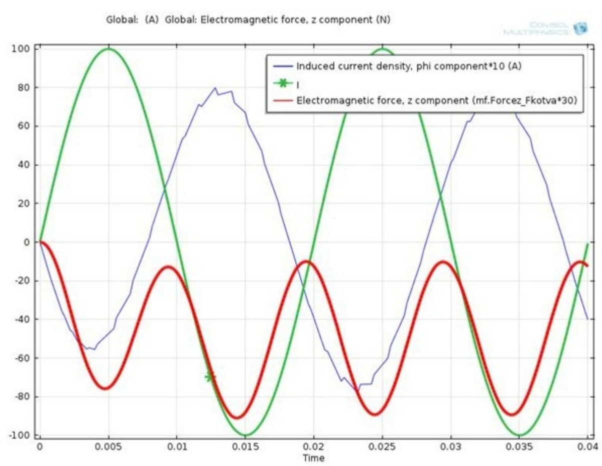

Figure 2: Figure 2: Simulation with a short-circuit ring: excitation current to the coils (green line) and force on the anchor (red line) as a function of time. The values of force are appropriately scaled to be presented on the same graph.

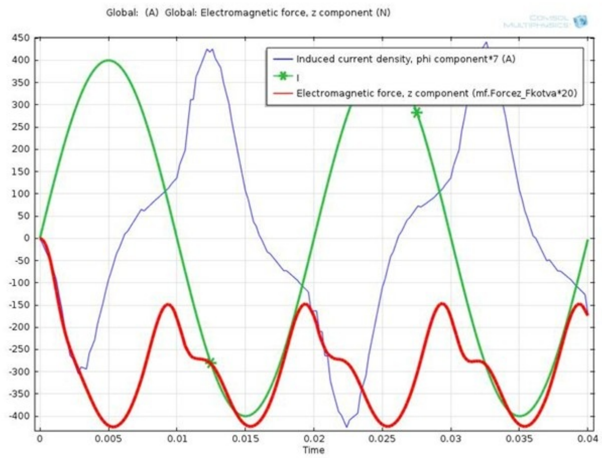

Figure 3: Figure 3: Simulation with a short-circuit ring for 400 A excitation current amplitude.

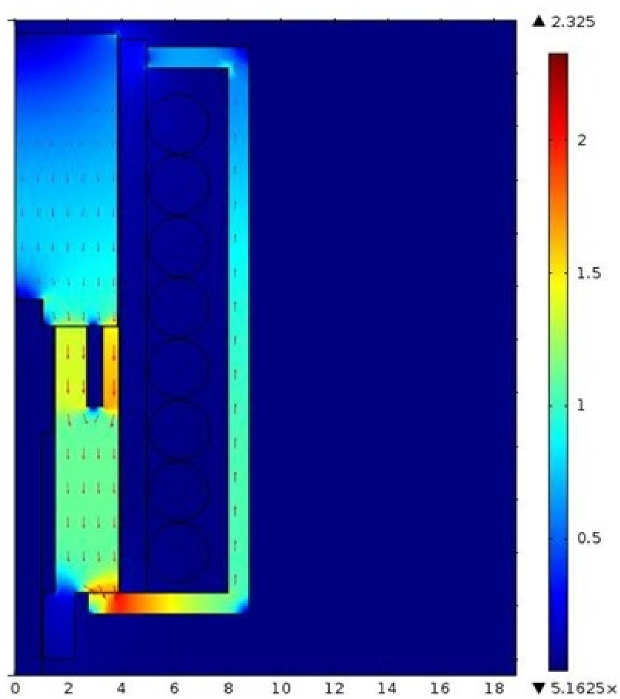

Figure 4: Figure 4: Magnetic field density of a structure with a short-circuit ring for 400 A excitation current amplitude. Left figure at time 35 ms (maximal excitation current) and right figure at time 40 ms (zero excitation current).