Electromagnetic Fields and Losses

There is a significant distinction between the resistance in a DC circuit and that in an AC circuit under voltage. Various components such as motors, lighting installations, cables, electrical supply panels, transformers, and switches are susceptible to external influences, such as inductive voltages from neighboring cables. These external effects can result in an increase in impedance, leading to a rise in power losses ranging from 10% to 25% of the power demand in a typical industrial installation. Precisely calculating the various losses contributing to the total losses is a complex problem that can be addressed through a theoretical model developed by SENERQON's scientists.

The following analysis provides a summary of the primary factors contributing to losses in the electrical installation of an industry. It is important to note that losses are dependent on the current and can therefore be reduced by minimizing additional currents flowing through the electrical installation.

A. Joule Losses

Due to the inherent ohmic resistance of cables, thermal losses are generated when current flows through them, and these losses are proportional to the square of the current. These ohmic losses occur as electrons collide with the metal lattice of ions that make up the current conductor (see Figure A.1).

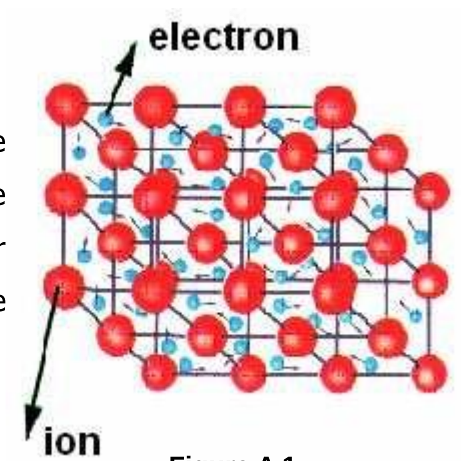

Figure A.1

Moreover, additional thermal losses occur at the connection points of cables with switches, fuses, motors, and other components, especially when these connection points are sufficiently worn.

Typical losses in supply cables of an electrical installation, expressed as a percentage of the total power demand, can vary from 1% to 3%.

B. Skin Effect Losses

The real resistance of a conductor is higher in the AC than in the DC current. The alternating magnetic flux that is created by AC current that pass through a conductor, interacts with the conductor itself and produce a reverse electromagnetic field, which resists in the passage of current. Thus, current can't exploit all the beneficial cross-section of the conductor for his passage, but only a small part in the exterior surface. This phenomenon is known as the skin effect. This un-uniform distribution of current increases the real resistance of the conductor and the losses accordingly (Figure B.1).

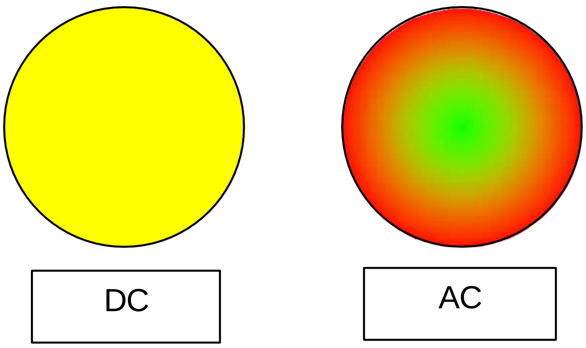

Figure B.1

Typical losses due to the skin effect of an electrical installation as a percentage of the total power demand may vary from: 2% to 8%.

C. Contiguity Effect Losses

When cables that supply various loads are in near from each other distances, specifically in the case that cables are mounted in racks, currents produce electromagnetic fields that interact with each other. These electromagnetic fields create an un-uniform distribution of density of current in the section of conductor. This leads to an important increase of resistance in the cable (Picture C.1).

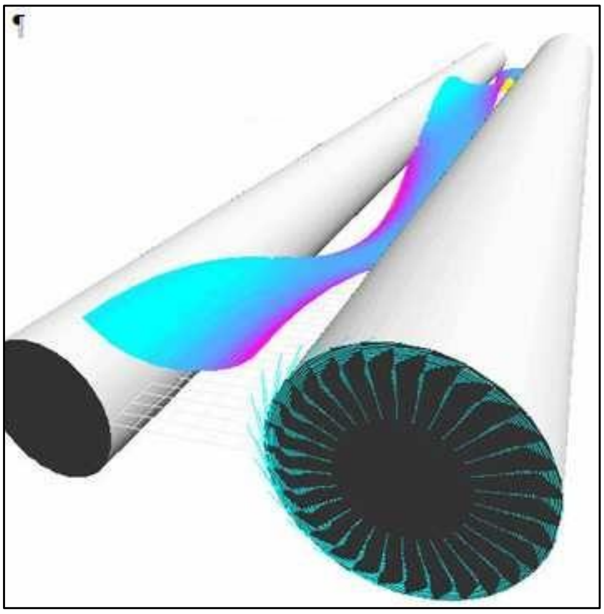

Figure C.1

Typical losses due to contiguity effect of an electrical installation as a percentage of the total power demand may vary from: 4% to 10%.

D. Eddy Current Losses

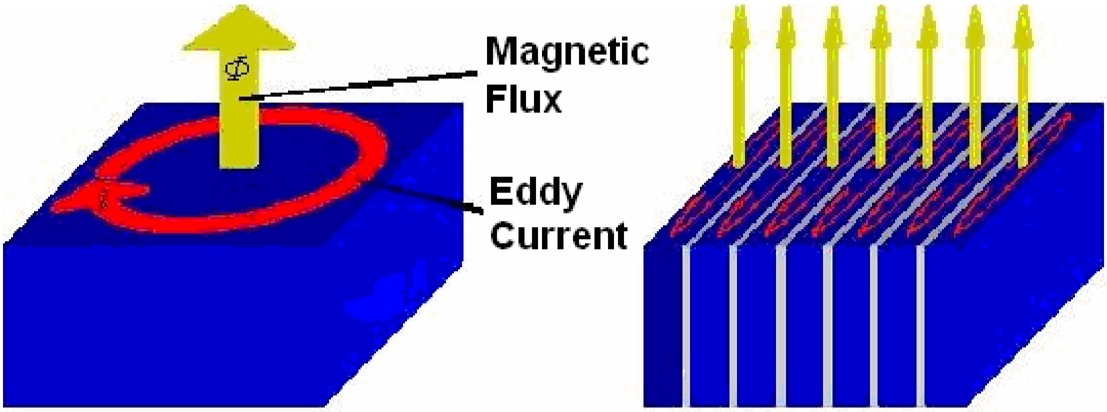

Figure D.1

The eddy current losses are presented in power switches, in ballast of lightings, in transformers, in power relays, in isolation transformers, in over- current relays, even in supply cables especially when these neighbor with steel or iron installations as distribution cabinets and cable racks (Figure D.1). These losses are owed to the production of circular currents in conductive stuff that is under the effect of alternating magnetic fields.

Typical losses due to eddy current effect of an electrical installation as a percentage of the total power demand may vary from: 1,5% to 4%.

E. Magnetic Hysteresis Losses

Hysteresis losses are heat losses that are caused because of the magnetic capacity of the ferromagnetic circuit (e.g. AC motor) (Figure E.1). During the operation of the motor the ferromagnetic circuit is submitted in a magnetic field and his magnetic dipoles tends to be aligned with the magnetic lines of field. Because the magnetic field is alternating, the continuous movement of magnetic dipoles, while they try to be aligned with the magnetic field, produces molecular friction. This friction produces heat and then energy losses. These losses tend to be increased when the motor is underloaded.

Hysteresis losses are presented as well in power switches and relays, in ballast of lightings, in transformers etc.

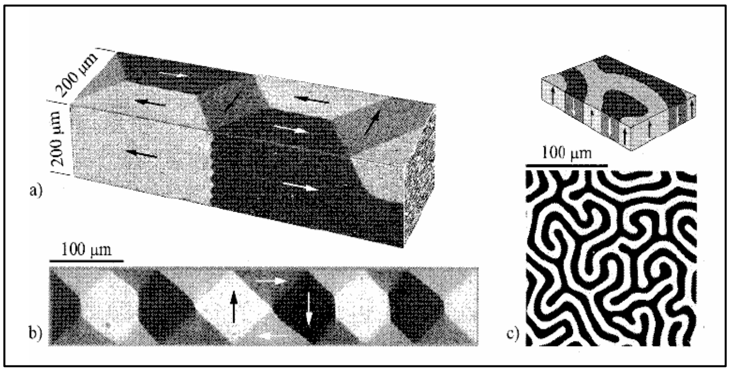

Figure E.**1**

Typical hysteresis losses as a percentage of the total power demand may vary from: 1% to 2%.