

## Ignition Coil Simulation with Flux.

Samir Guerbaoui, VALEO - Anouar Kalai, CEDRAT.

As part of the development of ignition coils for the automotive industry, Valeo is trying to improve its design tools with the goal of finding a method that reduces design costs. This new method should also be easy to use. CEDRAT is working in partnership with Valeo to develop a simulation method using Flux software.

### ● Goal of the simulation

The goal of the simulation is to minimize costs by reducing the number of prototypes. Currently, the modelling approach used by Valeo is complex and involves several distinct phases that are not automated. The goal is to replace this complex method by an automated method that is user-friendly. The model should also take into account the Eddy Current which significantly influences the behaviour of the device.

Flux software has the capability to perform this type of simulation in a simple method through its magnetic transient application.

### ● Presentation of the device

Ignition coil is a device enabling the generation of a spark at a very high voltage through the electromagnetic induction phenomena. It consists of a primary coil, powered by the battery (12 V), a secondary coil and a laminated magnetic core.

It functions in two stages:

- 1) In the first step, magnetic energy is stored in the primary winding until the quantity of energy reaches a maximum.
- 2) In the second step, the primary circuit is opened and the accumulated magnetic energy induces a high voltage peak proportional to the ratio of the number of turns leading to the current in the secondary winding.



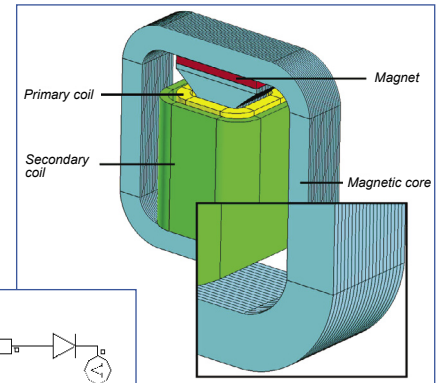
Valeo ignition coil.

### ● The simulation

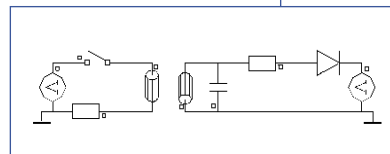
The device is represented in 3D in Flux software. Formulations used in the magnetic circuit enable it to account for the Eddy Currents.

Layers of the laminated magnetic core are represented in the Flux model because the number of layers may have an influence. Insulating face regions are used between each layer to prevent the Eddy current from going from one layer to another.

The coils represented in the finite element model are coupled with an external electrical circuit; the primary winding has 150 turns, secondary, 10000 turns.



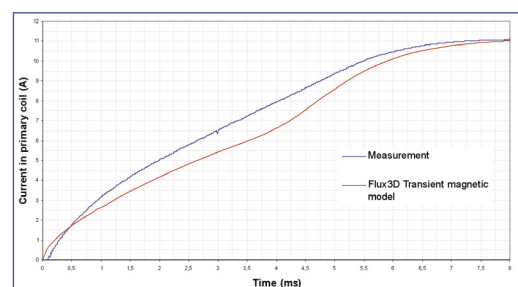
The 3D model in Flux and the electrical circuit



In the first step we will focus only on the energy stored in the primary winding. The simulation will be carried out over a period of 8 ms, which is the time required in order to establish the current in the primary coil.

### ● Results

The results obtained from the simulation are compared with the measurements performed on the real device. In the figure below we can see the varying current in the primary coil up to 8 ms.



Simulations vs measurements.

### ● Conclusion

The encouraging results obtained with the transient magnetic application of Flux enable us to consider improving the model through collaboration between CEDRAT and Valeo. A more precise model will improve the correlation between simulation and measurements. In the second step, the analysis will focus on the simulation of the spark generation. This simulation will easily be possible thanks to electric components available in Flux electric circuit, such as switches and diodes that can be used in the model.