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# A modelling tool for ferrite **MnZn** design – Losses and dimensional resonance according to size and physical properties

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**INTRODUCTION:** A 2D simplified model is used to characterize the size and physical properties dependence of total power losses in a **MnZn** ferrite material at a given frequency around 300 kHz. The application is a high power induction system. The aim is to have guidelines for the design of the ferrite blocks constituting the magnetic circuit and their thermal management in order to avoid overheating and Curie temperature overrun, beyond which the material loses its ferrimagnetic properties .

**COMPUTATIONAL METHODS:** The COMSOL model is defined with a magnetic formulation (AC/DC module-frequency domain). The physics interface solves Maxwell's equations formulated using the magnetic field as the dependent variable (Faraday's law) :

$$j\omega\mu_0\mu_r\mathbf{H} + \nabla \times (\sigma + j\epsilon_0\epsilon_r\omega)^{-1} \nabla \times \mathbf{H} = 0$$

$$\nabla \cdot (\mu_r\mu_0\mathbf{H}) = 0$$

A magnetic field of peak value 'H<sub>0</sub>' is imposed along the external boundary. This value is set to maintain a constant magnetic flux inside the section of the ferrite block (flux 'φ<sub>0</sub>' in Wb) for each parametric cases. The norm value of the magnetic flux (φ<sub>0</sub>) was preliminarily calculated from a 3D complete model representing the whole induction device.

An analytical approach gives an approximation of the thickness e<sub>r</sub> where the resonance dimension occurs. Higher magnetic permeability reduce this thickness e<sub>r</sub> and higher electrical conductivity decrease the resonance amplitude.

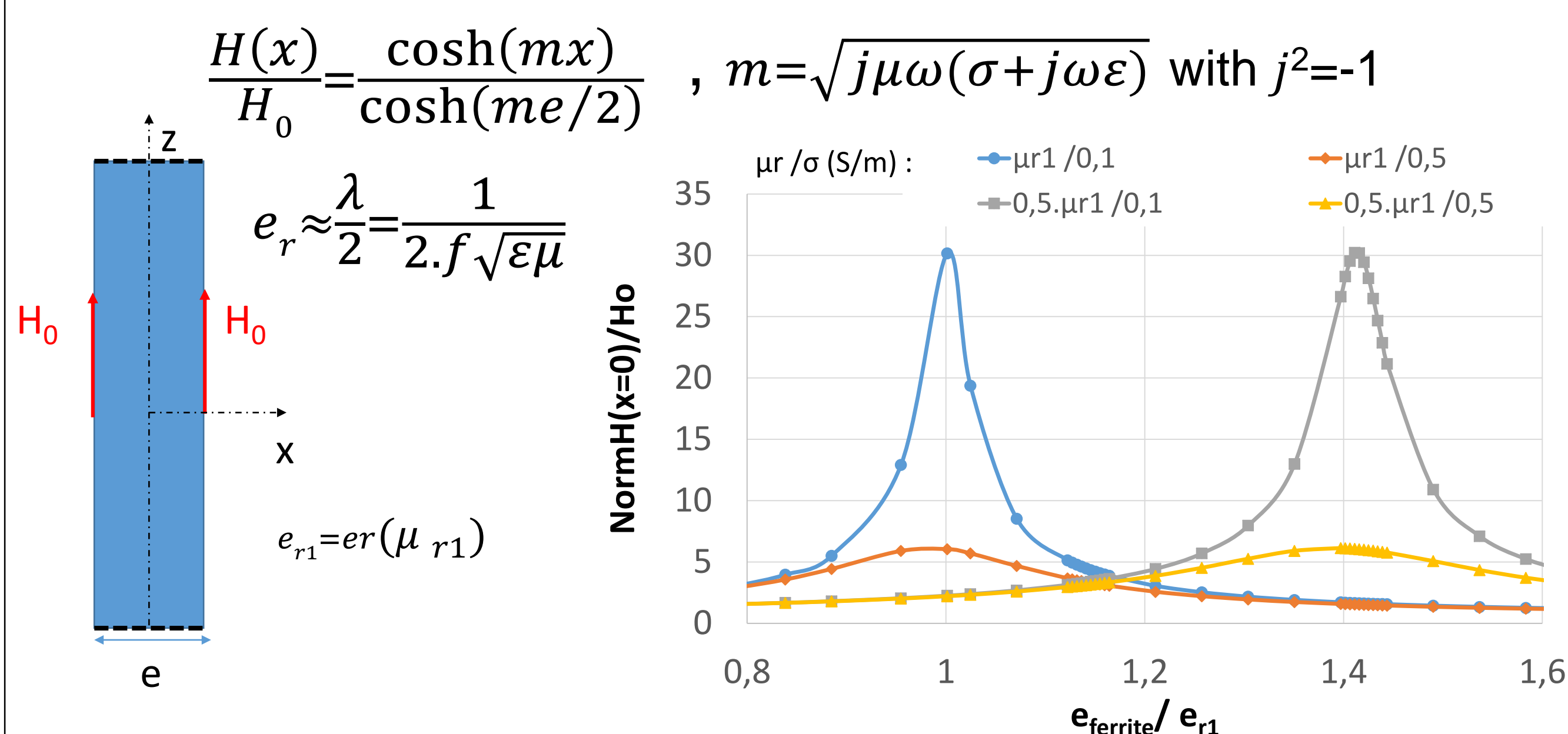


Figure 1. Analytical approach-Infinite block along z and y

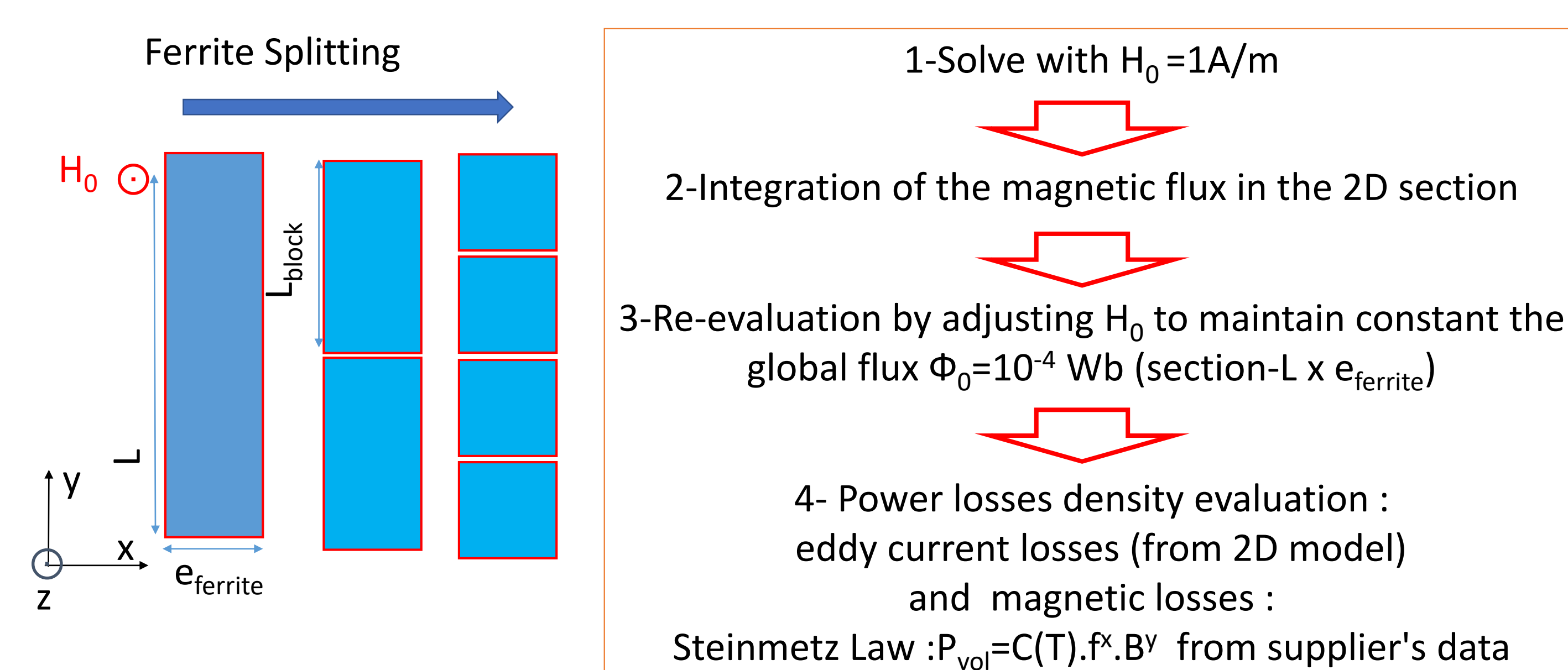


Figure 2. 2D Approach and Geometry

**RESULTS:** Dimensional resonance effect

## 1-Sensibility with block thickness and permeability

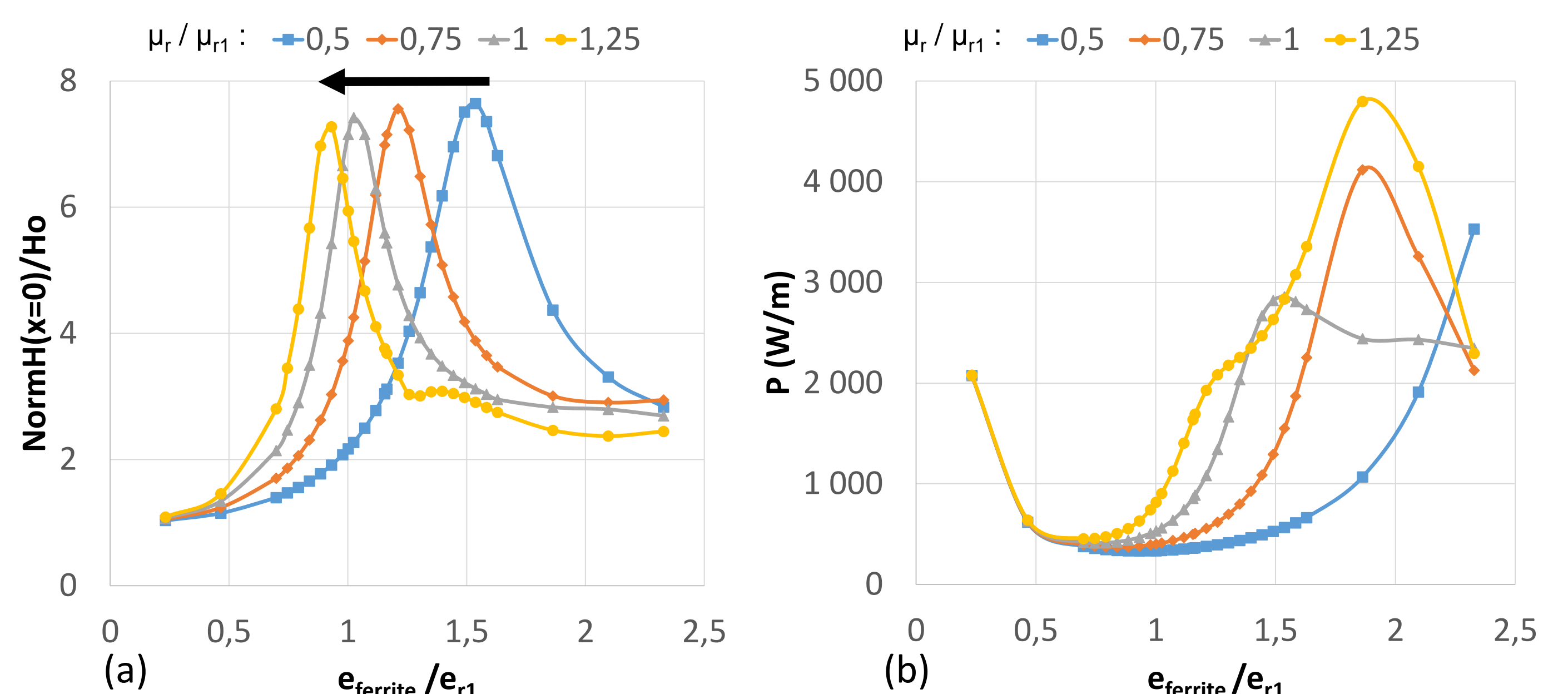


Figure 3. (a) Magnetic field in the center of the block, (b) Total Power loss

f=300kHz-Ferrite -Length L=3,5 e<sub>r1</sub>, ε<sub>r</sub>=1,5 10<sup>5</sup>, σ=0,5 S/m -Φ<sub>0</sub>=10<sup>-4</sup> Wb

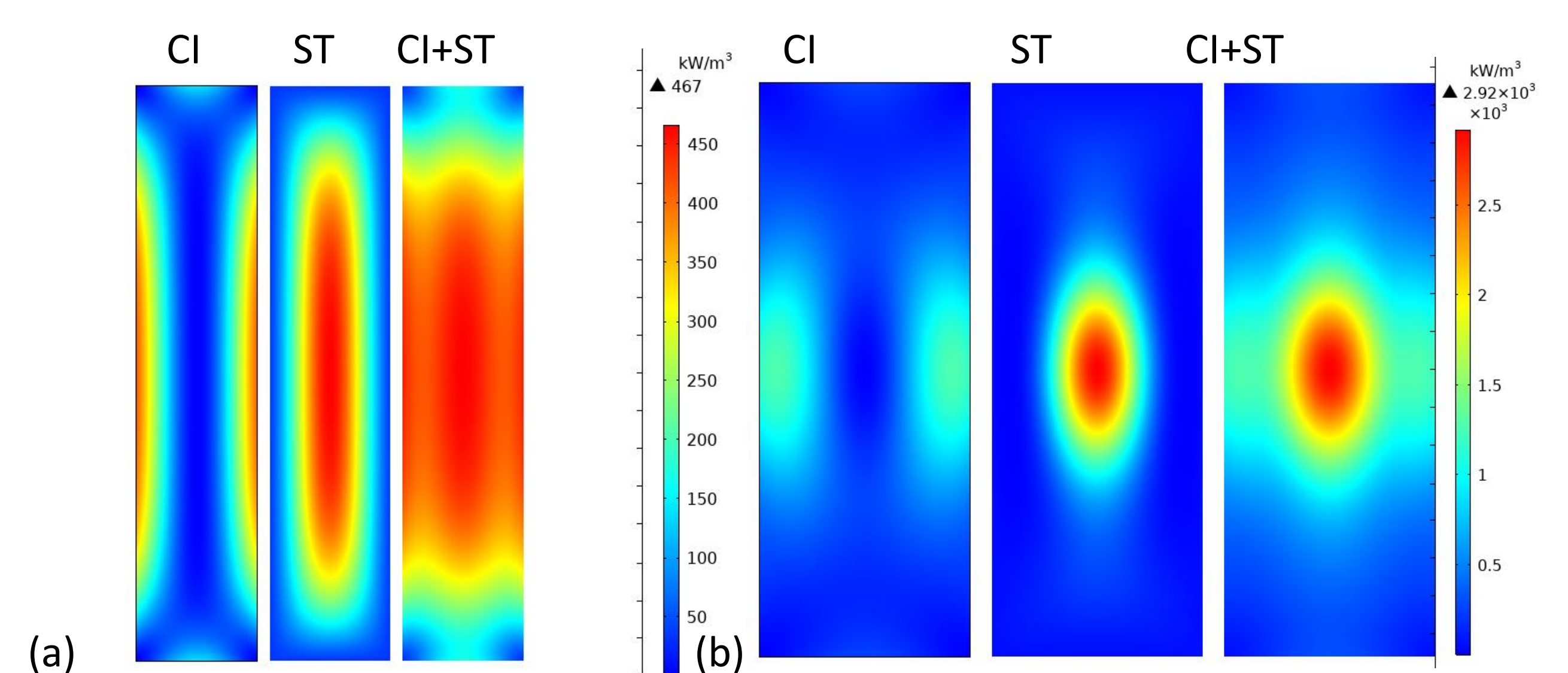


Figure 4 : Power loss density (kW/m<sup>3</sup>)-CI: eddy current losses, ST: magnetic losses -Steinmetz law, or total losses, (a) e=0,75 e<sub>r1</sub> or (b) 1,3 e<sub>r1</sub>

With high magnetic permeability, the range of ferrite's thickness to have low power losses is shorter. Beyond resonance thickness value e<sub>r1</sub>, magnetic power losses increase drastically in the centre of the block.

## 2- Effect of ferrite's core splitting along length :

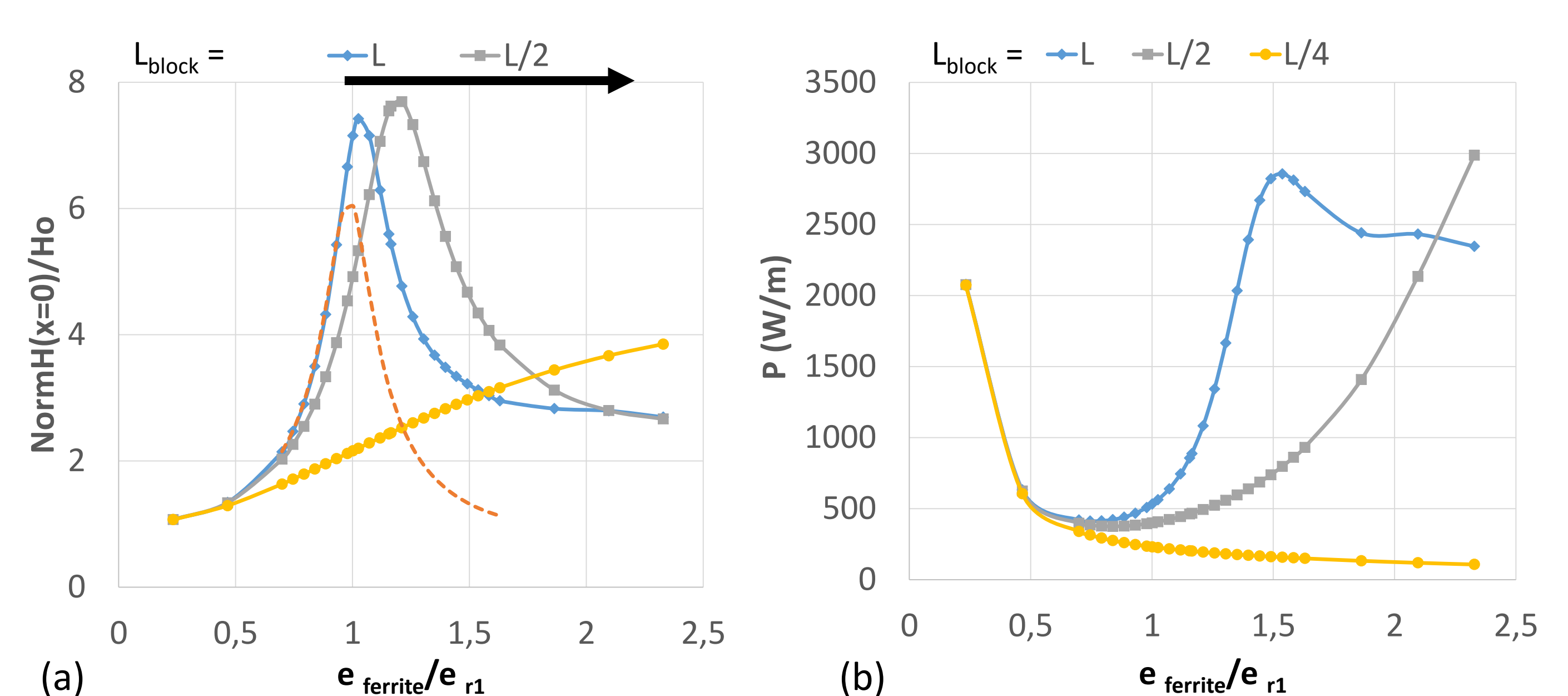


Figure 5. (a) Magnetic field in the center of the block, (b) Total Power loss

**CONCLUSIONS:** To minimize power losses and avoid the resonance effect, the ferrite core cross section is divided into four different parts along the length with an insulating gap between each parts. The sensibility to ferrite physical properties is reduced. These findings have helped to design a compact and reliable industrial device.

## REFERENCES:

1. Skutt G. R., Lee F.C., Characterization of dimensional effects in ferrite-core magnetic devices. PESC'96, 27th ann. IEEE record, pp. 49-54 (1996)
2. Ponomarenko N., Study of Frequency and Microstructure Dependencies of Magnetic Losses of Ferrite Materials and Components, PhD, Riga Technical University, (2014)