



HAL
open science

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

Michael Dumont, Etienne Rousset, Patrice Brun

► **To cite this version:**

Michael Dumont, Etienne Rousset, Patrice Brun. A modelling tool for ferrite MnZn design - Losses and dimensional resonance according to size and physical properties. COMSOL Conference 2019, Sep 2019, Cambridge, United Kingdom. , 2019. cea-04742475

HAL Id: cea-04742475

<https://cea.hal.science/cea-04742475v1>

Submitted on 17 Oct 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

Michael Dumont¹, Etienne Rousset², Patrice Brun³



1. Emdpi -Jam consulting, 20 rue Felix Esclancon, 38000 Grenoble, France
2. Orano Group, 25 av. de Tourville, 50120 Cherbourg-En-Cotentin, France
3. CEA, DEN, DE2D, SEVT, BP 17171, 30207 Bagnols-sur-Cèze, Cedex, France



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 'H₀' is imposed along the external boundary. This value is set to maintain a constant magnetic flux inside the section of the ferrite block (flux 'φ₀' in Wb) for each parametric cases. The norm value of the magnetic flux (φ₀) was preliminarily calculated from a 3D complete model representing the whole induction device.

An analytical approach gives an approximation of the thickness e_r where the resonance dimension occurs. Higher magnetic permeability reduce this thickness e_r and higher electrical conductivity decrease the resonance amplitude.

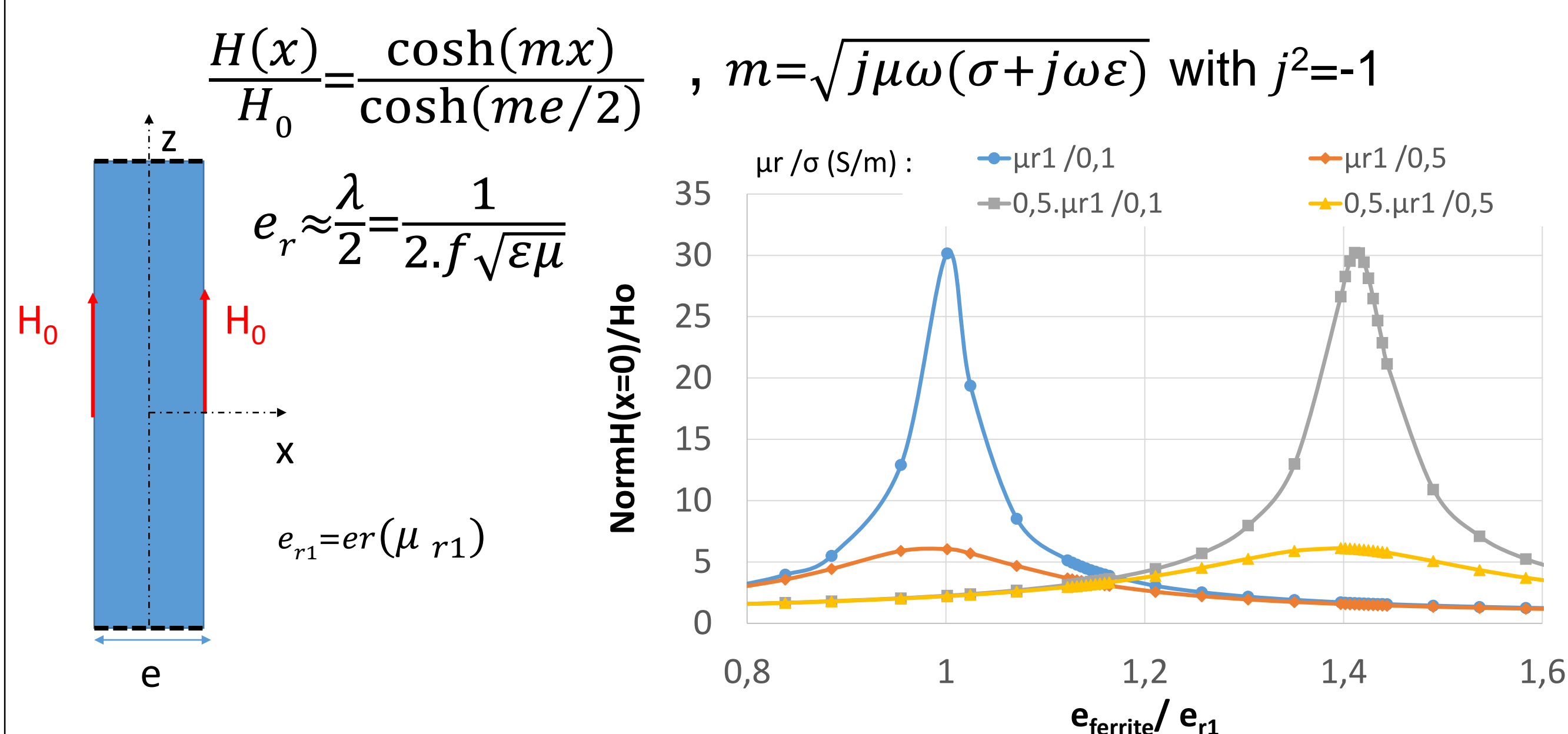


Figure 1. Analytical approach-Infinite block along z and y

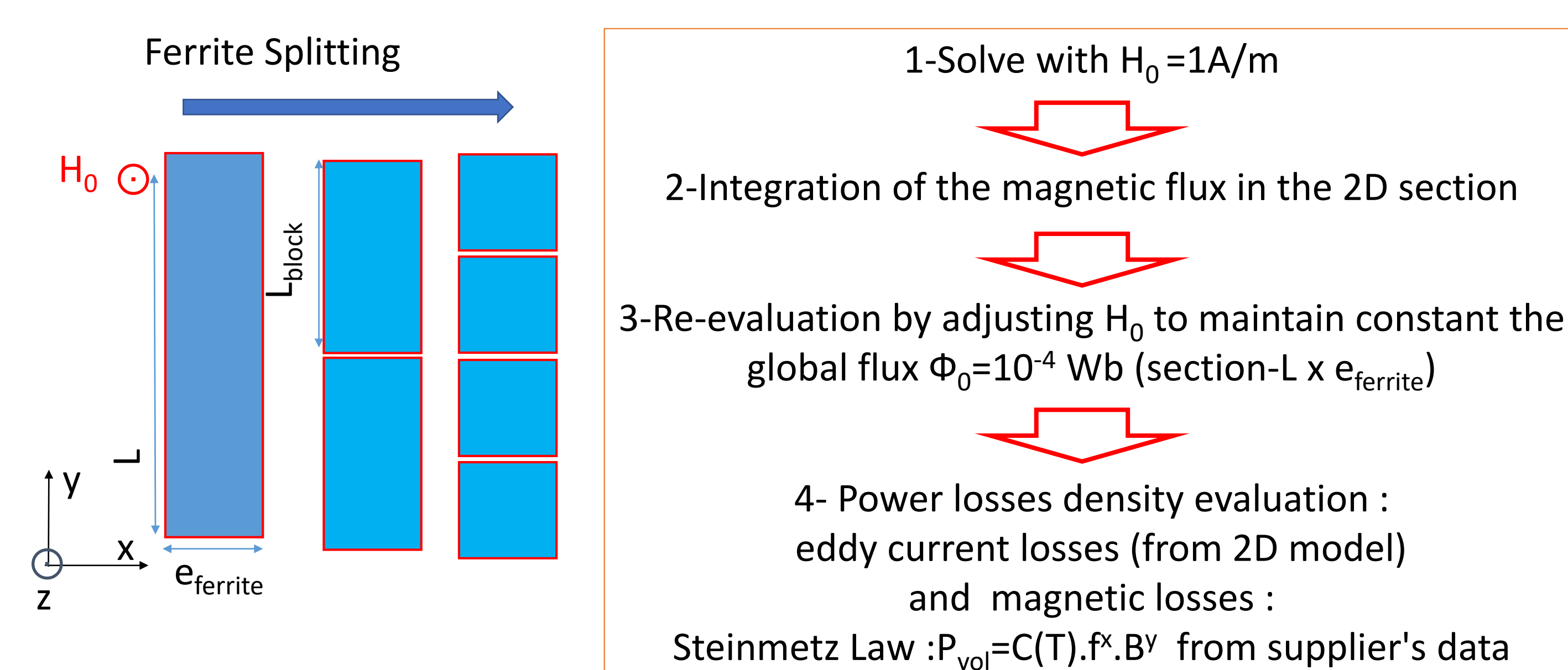


Figure 2. 2D Approach and Geometry

RESULTS: Dimensional resonance effect

1-Sensibility with block thickness and permeability

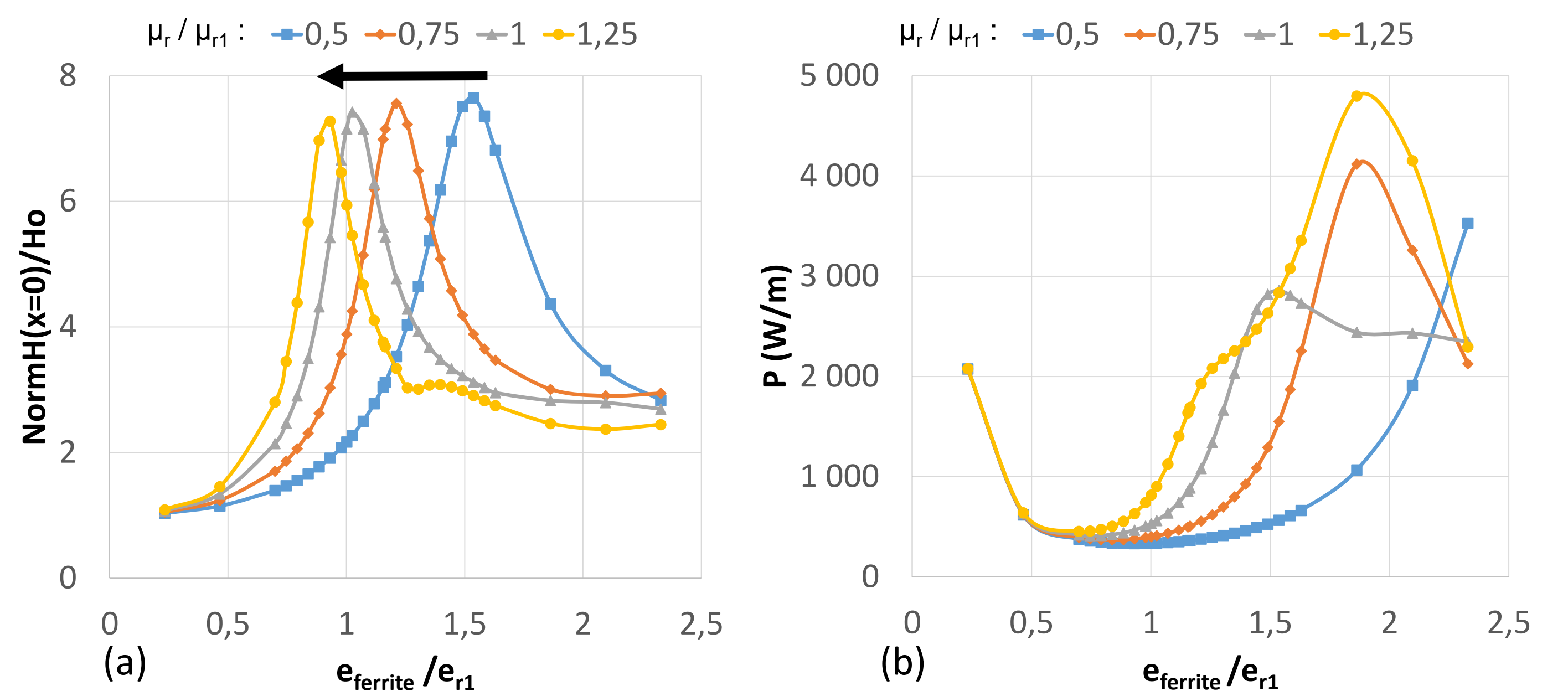


Figure 3. (a) Magnetic field in the center of the block, (b) Total Power loss

$f=300kHz$ -Ferrite -Length $L=3,5 e_{r1}$, $\epsilon_r=1,5 \cdot 10^5$, $\sigma=0,5 S/m$ - $\Phi_0=10^{-4} Wb$

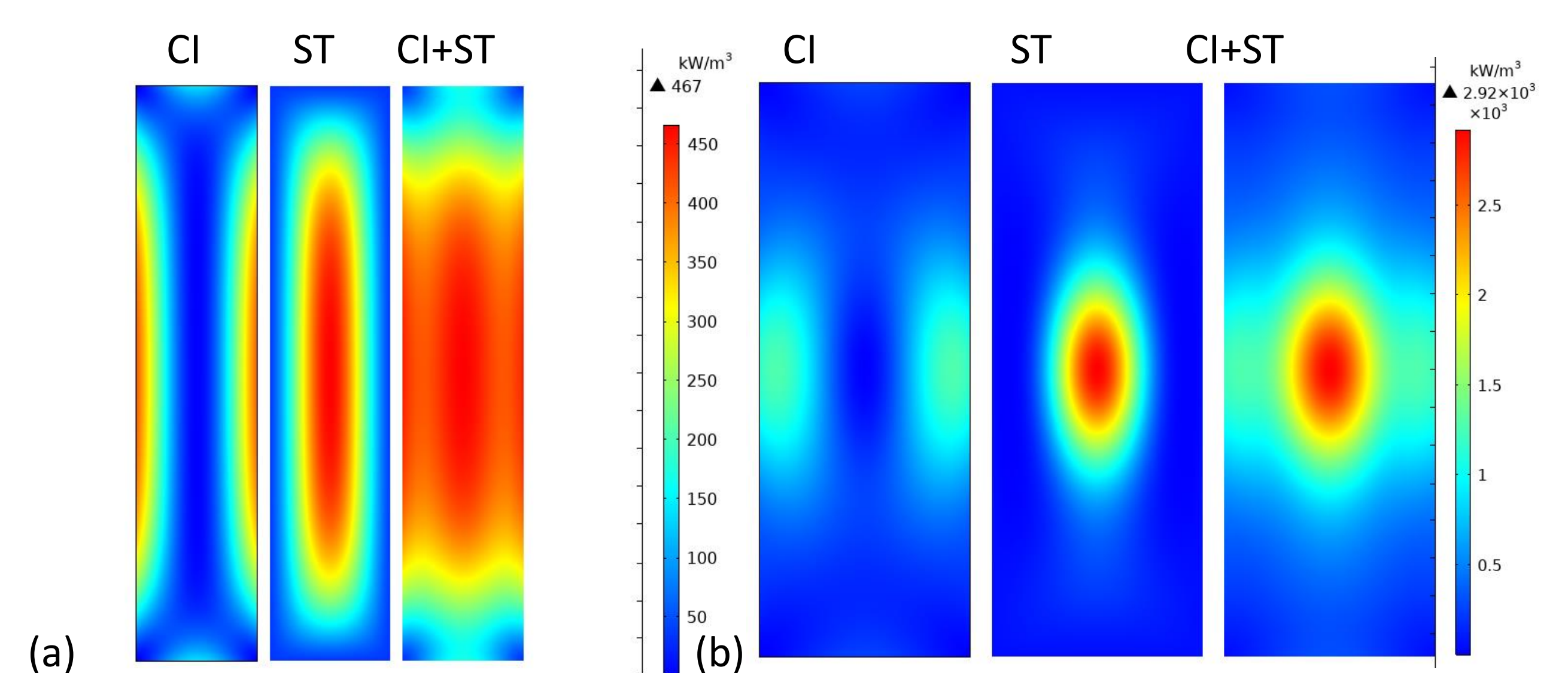


Figure 4 : Power loss density (kW/m^3)-CI: eddy current losses, ST: magnetic losses -Steinmetz law, or total losses, (a) $e=0,75 e_{r1}$ or (b) $1,3 e_{r1}$

With high magnetic permeability, the range of ferrite's thickness to have low power losses is shorter. Beyond resonance thickness value e_{r1} , magnetic power losses increase drastically in the centre of the block.

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

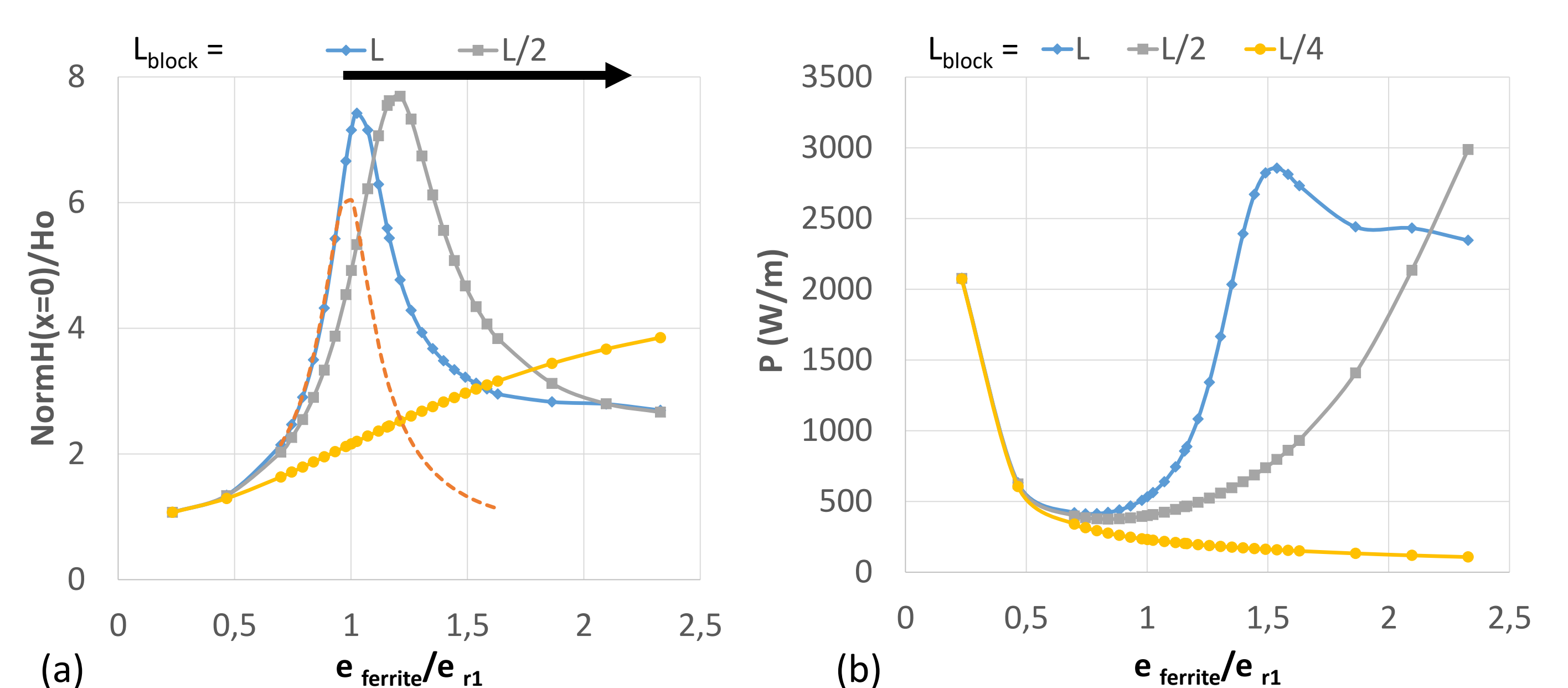


Figure 5. (a) Magnetic field in the center of the block, (b) Total Power loss

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)