Influence of air-gap length and cross-section on magnetic circuit parameters

Aleksander Polit, Radoslaw Jez
ABB Corporate Research Centre, Krakow, Starowislna 13A, 31-038 Krakow, Poland PL

Introduction:

Air-gap is one of the most crucial part of magnetic circuits especially in high power inductors. It significantly modifies the parameters of magnetic. Therefore the optimal selection of shape and dimensions of air-gap is very important from designing point of view.

The presented work is focused on presentation of optimal dimensions of the air-gap with rectangular cross-section in function of air-gap length and cross-section ratio. The COMSOL Multiphysics® software was used for simulation magnetic field distribution for chosen cases in such magnetic circuit.

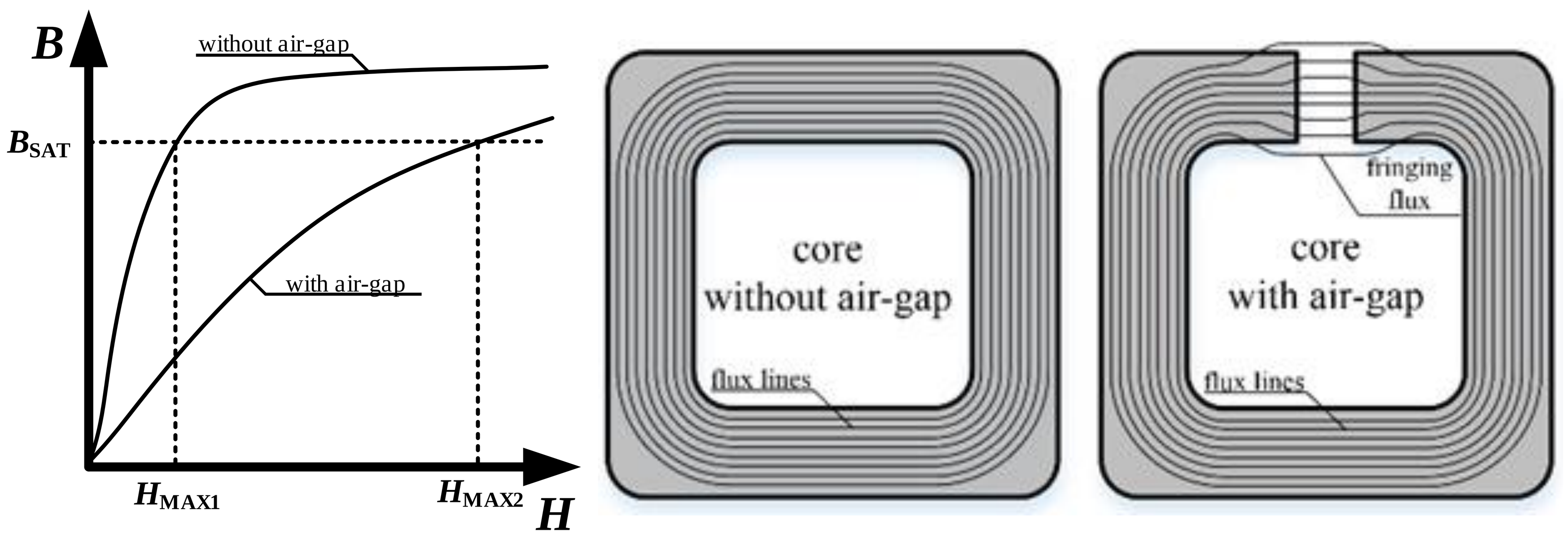


Figure 1. Scheme of the simulated case

Computational Methods:

- AC/DC module was applied for the calculations
- By varying cross-section and air-gap optimal solutions for this kind of magnetic circuit are proposed
- The magnetic flux in the core is produced by external vector of magnetic field - additional boundary condition to surfaces of model ($\mathbf{H}_x$=0; $\mathbf{H}_y$ = 0; $\mathbf{H}_z$ = 1000 A/m)
- Determination of total magnetic flux amount in the magnetic core cross-section compare to the magnetic flux in the air-gap area with the same cross-section as magnetic core - F_{FR} (factor of magnetic fluxes ratio)

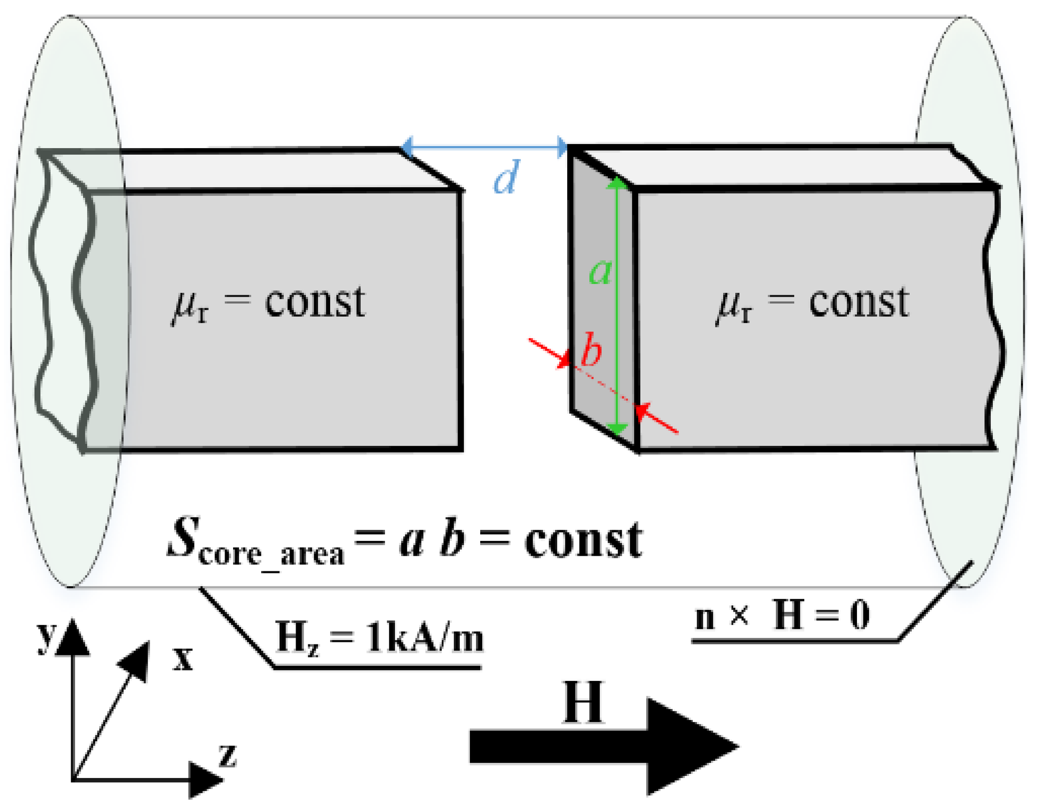


Figure 2. Model description

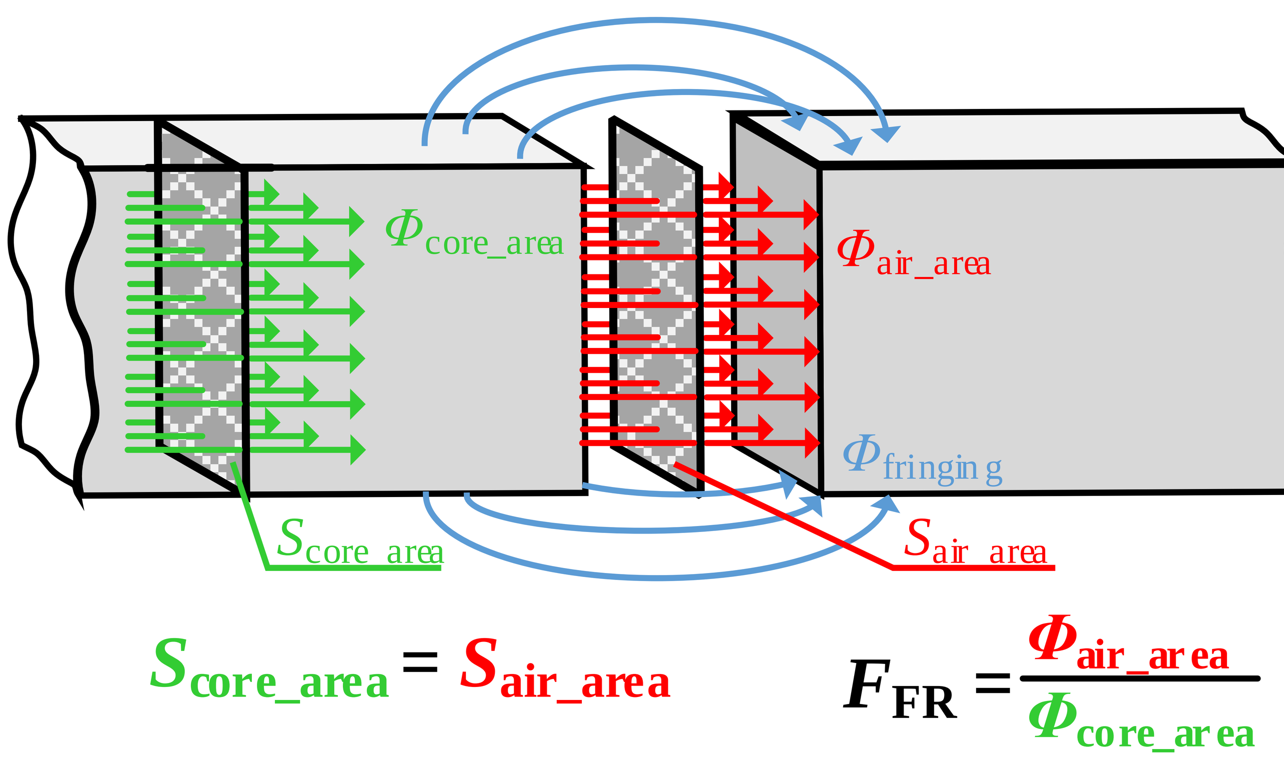


Figure 3. Scheme of the simulated case

Results:

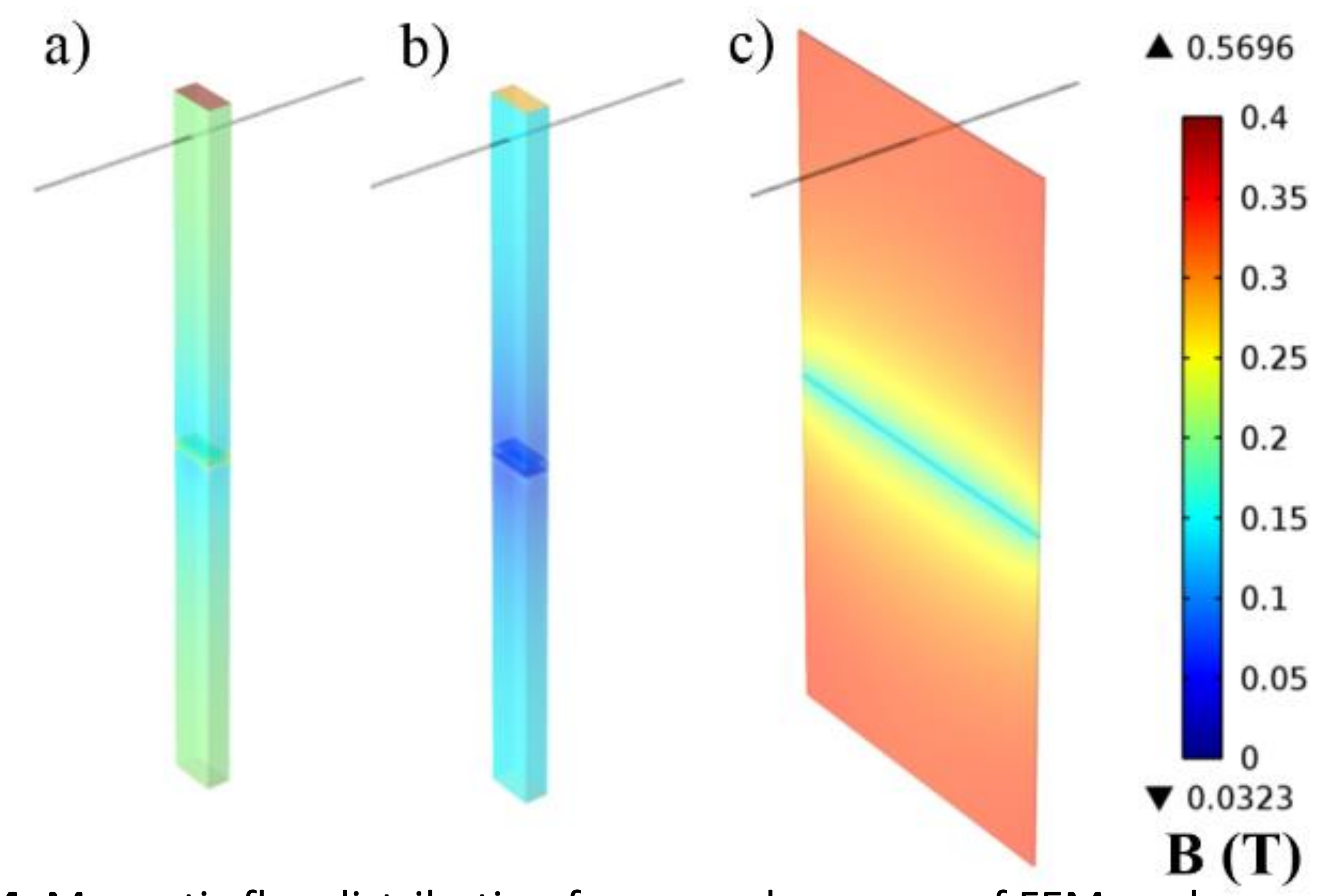


Figure 4. Magnetic flux distribution for exemplary cases of FEM analyses:
a) base case with given ratio of cross-section and given length of air-gap,
b) case with the same (as case "a") ratio of cross-section and bigger length of air-gap,
c) case with different ratio of cross-section and the same length of air-gap (as case "a").

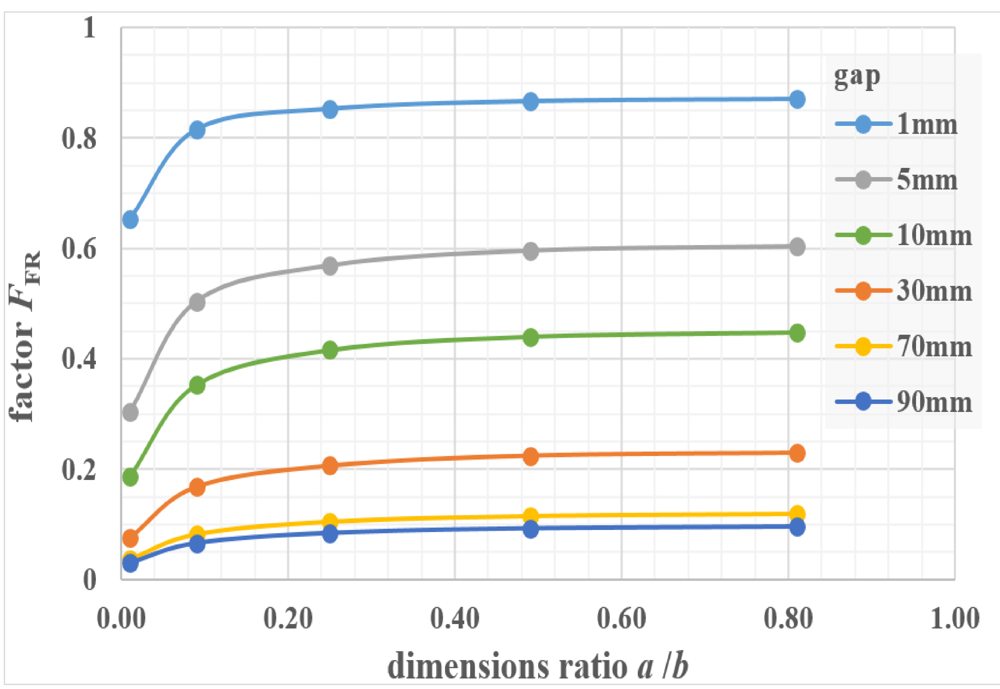
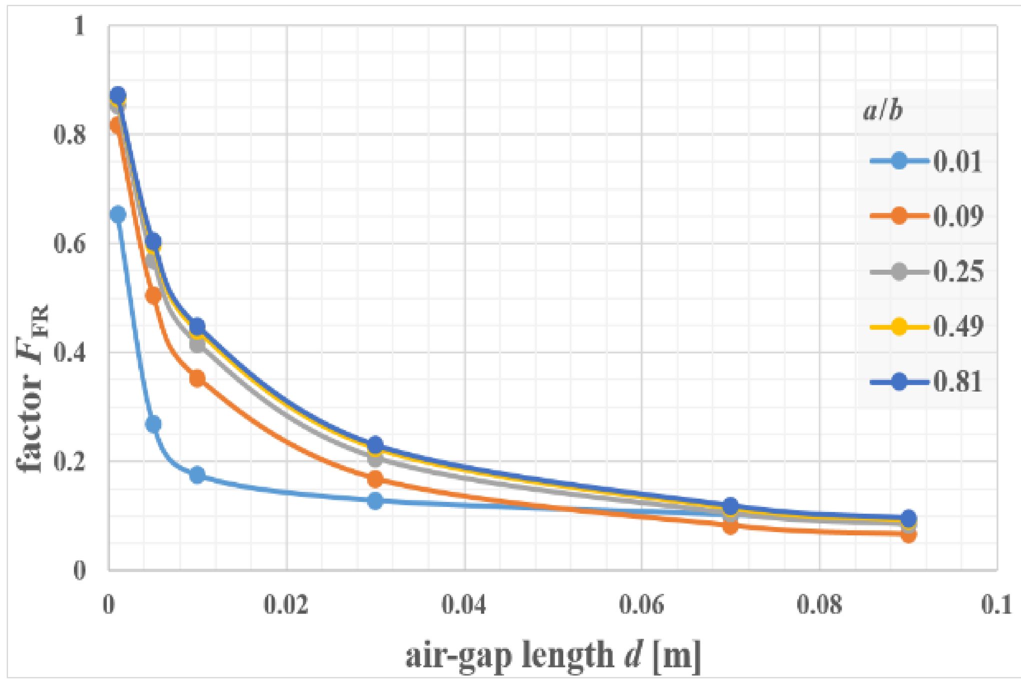


Figure 5. Exemplary characteristics of simulated cases:
a) factor F_{FR} as a function of a/b dimensions ratio for different lengths of air gaps,
b) factor F_{FR} as a function of air-gap length for different dimensions ratio a/b. Lines are to guide the eye.



Conclusions:

•FEM analyses allows to determine optimal dimensions of magnetic core cross-section, magnetic core dimensions ratio and level of fringing flux

•FEM calculation allows to optimise the magnetic circuit for specific requirements of applications (no fringing flux, strictly defined fringing flux, etc.),

•Determining of optimal length of air gap and dimension ratio of magnetic core cross-section is a one of the most crucial aspects in a designed process of optimised inductors

•Obtained results are useful for design engineers in the optimisation process of inductors and transformer designs.

Excerpt from the Proceedings of the 2014 COMSOL Conference in Cambridge