# Model of a pot core choke part 2

Laboratory exercise manual

*ver. 09.11.2015*

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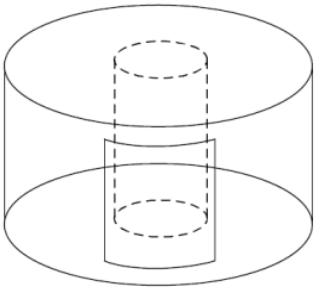
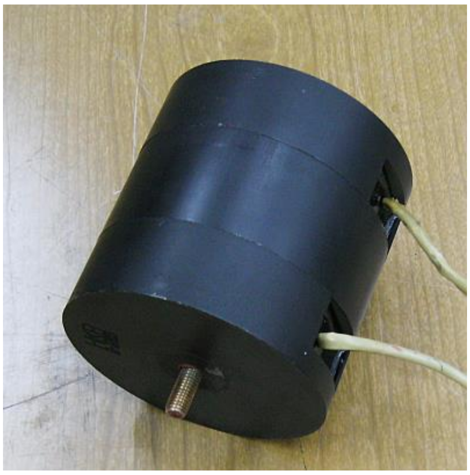
## 1. Description

The aim of the exercise is to prepare a model of a pot core choke and perform its analysis using the Lua script.

The pot core choke is shown in Fig. 1.



a)



b)

Fig. 1. Pot core choke: a) core diagram, b) photograph of the complete choke

## 2. Description

The choke core is an iron powder core. The material the core is made of is iron crushed into fine powder in special grinding devices. The iron particles range in size from 5 to 200 μm. They are layered with insulating material, 0.1 to 3 μm thick, ensuring galvanic separation. The material prepared this way is then formed into the desired shape using a press. The powdered cores are characterized by high saturation induction ($B_{sat}$=0,5-1,9 T), high resistivity (ρ=1 Ωm) and reduced losses due to eddy currents. The air gap is distributed along the whole core volume. Relative permeability of the material $\mu_r$ ranges from 10 to 550. The maximum working temperature may reach 175-200 °C. If it is exceeded, it causes damage to the insulating material and the short circuiting between the iron particles. Powdered iron cores are used in pulse converters with high switching frequency. Compared to other materials used in such applications, they are cost-competitive and allow the device dimensions to be reduced - Fig. 2.

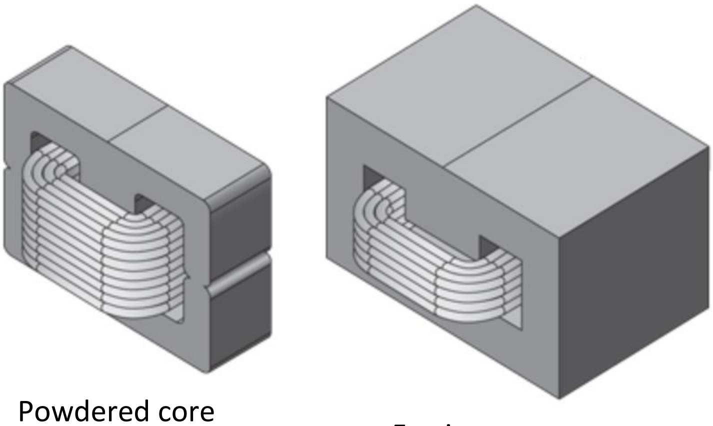



Fig. 2. Comparison of choke dimensions with a powdered and ferrite core designed for identical working conditions

In the following exercise, for the purpose of modeling, use parameters of powdered iron cores made by HaKRon company (*HKR - Elektronischer Gerätebau GmbH*) available on the website: http://www.hkrweb.de/ [1].

There are 5 types of powder materials available, marked: PA2, PA3, PA6, PB5 and PC3. The choke diameters are: 60 mm, 80 mm, 100 mm, 120 mm, 150 mm and 175 mm. For each of the choke diameters, the manufacturer specifies the height of the choke that can be selected. The available diameters of the chokes made of various materials are given in tab. 1.

Table. 1. Choke diameters offered by HKR for cores made of different materials [1]

| Średnica dławika [mm] | Materiał | | | |
|---|---|---|---|---|
| 60 | PA2 | PA6 | PB5 | PC3 |
| 80 | PA2 | PA6 | PB5 | PC3 |
| 100 | PA2 | PA6 | PB5 | PC3 |
| 120 | PA2 | PA6 | PB5 | PC3 |
| 150 | PA2 | PA6 | - | PC3 |
| 175 | PA2 | PA6 | - | PC3 |

## 3. Exercise plan

The exercise can be completed in two ways:

a. By creating a new project directly in FEMM program and performing calculations and analysis similar to exercise 1.

b. Creating a script in the Lua language, which automatically generates the results of the analysis.

1. Open a new project – a magnetics problem.
2. Define a new ferromagnetic material filling in its magnetizing characteristic B-H.
3. Define one coil wound using a copper wire. Assume a current density of $4 A/mm^2$ and copper filling coefficient of $k_{cu} \leq 0.3$.

4. Choose the number of turns and the current so as to achieve a maximum inductance in the core, as close as possible to the saturation induction $B_{sat}$ given in the manufacturer's catalogue).
5. In FEMM:
    a. plot the choke induction distribution in the cross section perpendicular to the axis of symmetry,
    b. read the maximum induction value in the core and determine where does it appear,
    c. read the inductance and circuit resistance,
    d. check the copper filling coefficient obtained.
6. Using the $A_L$ constant provided in the core catalogue data and the assumed number of turns, calculate the inductance of the choke. Compare it with the value obtained in FEMM.
   Calculate the maximum core induction analytically and compare it with the value obtained in the FEMM program.
   Maximum inductance can be calculated using the following equation:

$$B_{max} = \frac{L \cdot I_{max}}{N \cdot A_e} \qquad (1)$$

   where: $L$ is the choke inductance, $I_{max}$ is the maximum value of the choke current, $N$ is the number of turns while $A_e$ is the active cross section of the core.
   $A_e$ parameter is provided in the manufacturer's catalogue.

## 4. Literature


1. HKR Elektrotechnischer Gerätebau GmbH: *Finnovation in material and form. Technical data*. Germany, 2008. (http://www.hkrweb.de/ - *Data_book-E.pdf*)
2. Kazimierczuk M.K.: *High-frequency magnetic components*. John Wiley & Sons, 2009.
3. Xiaoguang Zheng, Tomoyuki Ishimine, Shinichiro Yamamoto, Terukazu Tokuoka, Shingo ohashi, Kenji Matsunuma, Hiroyuki Fujikawa and Toshikatsu Hayasaki: *Downsized High-Heat-Dissipation Choke Coil Designed with Powder Cores*. SEI Technical Review, No 75, OCTOBER 2012.
4. Konopiński T., Pac R.: *Transformatory i dławiki elektronicznych urządzeń zasilających*. WNT, Warszawa 1979.