FAST AND EXACT CALCULATION OF MAGNETIC FIELD

M. Truhlář, M. Novák, M. Košek, A. Richter

Technical University of Liberec, Faculty of Mechatronics

Magnetic field can be calculated using either integral or differential principles. Usually the famous Finite Element Method (FEM) based on differential equations is used. This approach is quite general. However in special cases the numerical calculation based on Biot-Savart Law can be efficient as well. The paper deals with application of this less applied method.

The basic formula used in calculations is the Biot-Savart Law that can be written for the most general case in the form

$$\mathrm{d}\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi} i \frac{\mathrm{d}\vec{r}_0 \times (\vec{r} - \vec{r}_0)}{\left|\vec{r} - \vec{r}_0\right|^3},$$

where $\mathrm{d}B$ is contribution to the magnetic flux density (at the point of position vector r) generated by element $\mathrm{d}V$ at position r_0. Volume current of density of $i = i(r_0)$ flows in this element. Only in very special cases the analytical formula can be obtained. In all other cases the numerical integration is necessary. The integration requires three sums in general.

There is no serious problem with programming, but the time of calculation is critical. One point of the result needs three cycles of at least 100 interactions for each of them. The MATLAB has solution in parallel programming, which is very simple in this case. Only two instructions are added to the script and the external cycle is changed a little. The possibility of parallel programming was examined on a computer with four core processor. Time requirements are summarized in Table 1. Time in seconds is an average from several attempts. The difference among attempts is small.

Table 1: COMPARISON OF CALCULATION TIMES

Transition to parallel mode	18
Calculation in parallel mode	66
Return from parallel mode	3
Total calculation in parallel mode	87
Total calculation in single mode	261

If the parallel computing is used, total time (on the test task) decreases three times and the pure time of calculation decreases four times according to number of cores in processor. Since the parallel mode is very simple for programming it should be used in every case for repeated calculations when the time exceeds 1 minute.

Among many applications we mention the calculated magnetic field in flow meter in Fig. 1. The agreement with automated experiment controlled by MATLAB is good.
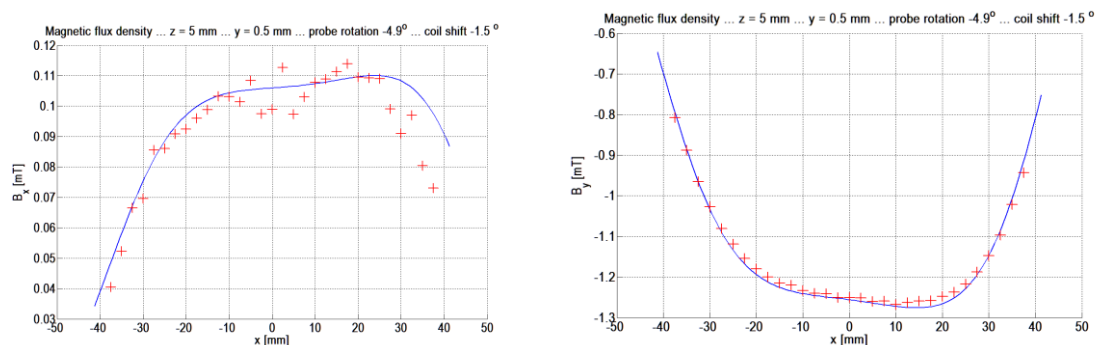

Figure 1: Magnetic field in flow meter. Parasitic component (left) and main one (right) are shown.

Martin Truhlář, Technical University of Liberec, Studentská 2, 46117 Liberec 1, martin.truhlar@tul.cz