USE OF MAGNETIC MATERIAL MODELS IN ELECTROMAGNETIC CAD

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New possibilities to extend GiD preprocessor functionality using the Tcl/Tk scripting language are investigated. The paper presents a function dedicated for creating a material library in GiD format. The modeled material characteristics are imported from an electromagnetic CAD tool developed in-house, called HystMag and the visualization can be done for specific classes of materials, which may be given in a simple text file.

1. Introduction

The CAD pre- and post- processor offered by GiD software [3] may play an important part in solving electromagnetic field problems involving several different magnetic materials. The procedure starts with the preprocessor, which was extended to import materials from HystMag [1] – an in-house developed software for advanced characterization of magnetic materials. GiD can be used to define the geometry (including the mesh) and associate to it a problem type, containing information related to the materials, conditions, interval data, problem data and data units. Then, the preprocessing information are passed to a dedicated electromagnetic solver (e.g. for the quasi-stationary magnetic field computation, based on the numerical method presented in [2]). The results obtained by the solver may be better visualized with the GiD postprocessor, including facilities for displaying graphs, mesh, contour lines, iso surfaces, line diagrams [3] etc.

The work described in this paper is situated at the level of the interoperation between HystMag and GiD and is based on a previously developed procedure for importing materials in GiD, presented in [4]. Here the Tcl/Tk scripting language is used to create a new function dedicated for creating a material library in GiD format, with a classification specified by the user and more visualization facilities. The import is done from the magnetic material library, which has been created and maintained with HystMag.

2. Classification of the material library

HystMag allows the description of magnetic materials and the creation of an information base, which may be continuously enriched. It integrates the experimental data with the numerical modeling of magnetic materials. The materials may have more characterizations, each one corresponding to an associated model, because the hysteretic behavior is described by analytic, differential or statistic models of hysteresis, whose parameters are identified from the experimental data supplied by equipment like Vibrating Sample Magnetometer or Hysteresisgraph.

A hysteresis model contains information regarding its input and output magnitudes, the type of its parameters (constant or functions) and integrates executables implemented in any language, on a

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Windows platform. The selection of a material-model pair allows the user to run the identification procedure corresponding to the model (e.g. Preisach [5]) with the inputs taken from the experimental data characterising the material. The description of the model is saved into a configuration text file with "cfg" extension and for a selected material, the model identification program creates an output file in the same subdirectory, with the name "output.txt".

In the following presentation, a material actually means a material modeled by an associated model, whose parameters have been identified. For example, the material named Steel_Hodgdon is steel modeled by a Hodgdon model. Thus, recreating this kind of materials in GiD is not convenient and the Tcl/Tk scripting language was used to introduce a new function in order to import the whole material library from HystMag. The materials used in our application have been parted into the following classes:

- Linear materials
- Non-linear materials (e.g. Steel-Hodgdon)
- Hard materials (e.g. Alnico-Frolich and NdFeB)
- Soft materials
- Recording materials (e.g. Recording-Gaussian-Preisach and Recording-Moving)

A linear magnetic material is defined by its constant permeability and a non linear material is modeled by an analytical curve or by a numerical average curve corresponding to a thin hysteresis cycle (e.g. an electrical steel with the hysteresis described by Hodgdon model). The magnetic materials with hysteresis may be included in one of the following classes: "hard" (like Alnico or NdFeB permanent magnets), "soft" (like ferrites) or "semi-hard" (used in magnetic recording). Each material can be characterized by an analytical model (for non linearity) or by a hysteresis model (e.g. Hodgdon, Preisach, Stoner-Wohlfarth, Jiles-Atherton, moving or complete models). The parameters for each model are identified by the experimental data of given material and are stored in HystMag library.

3. Implementation with Tcl/Tk

A new problem type was introduced in GiD in the directory /ProblemTypes/Electromagnetics/Hyst_Mag_Material_Library (see Fig. 1). It contains a file called Hyst_Mag_Material_Library.tcl, that generates a new submenu File->Import->Hyst_Mag_Library, giving the user the possibility to import the library of modeled materials from HystMag. The information are read from the files generated by HystMag: MaterialName.cfg and output.txt and are converted in the format of a .MAT file in GiD.
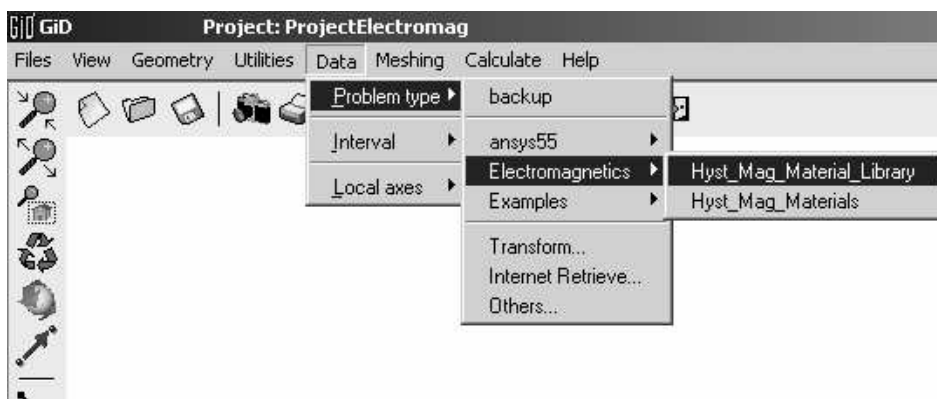

Fig. 1. The new problem type Hyst_Mag_Material_Library.

The configuration file in HystMag has the structure: *Id[TAB]Name[CR][LF],* where *Id* is an ASCII character that may take the values: *i* – input parameter, *o* – output parameter, *c* – constant

parameter, *f* – 2D function-parameter, *g* – 3D function- parameter; *Name* – is a string that defines the parameter name; *[TAB], [CR], [LF]* – define the TAB, Carriage Return and Line Feed characters. The values of the model parameters are given in the same subdirectory, in the output.txt file, with the format: *ParameterName[TAB]value[CR][LF]*. If a parameter has more values (e.g. a function-type parameter) the line is simply repeated for each value set.

Taking an example for the inputs, they are specified in GiD as:

QUESTION: Input#

VALUE: InputName

where # represents the number of the input magnitude in the .cfg definition. The material classification into the classes presented in the previous chapter has been done with:

BOOK: MaterialClassName.

They appear a submenus of Data->Materials (see Fig. 2) and allow separate presentation of material classes, like the window captured in Fig. 3 for the non-linear materials. The material classes are read from the file Hyst_Mag_Material_Library.txt, which may be easily modified by the user with a simple editor. The material presentation contains tab controls for inputs, outputs, scalar parameters and function-type parameters, which are programmed with:

TITLE: TabControlName

The effect on the GiD graphical interface can be seen in Fig. 3.
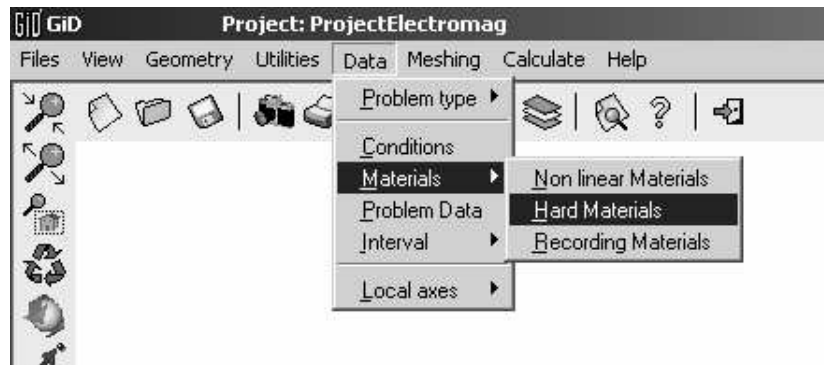

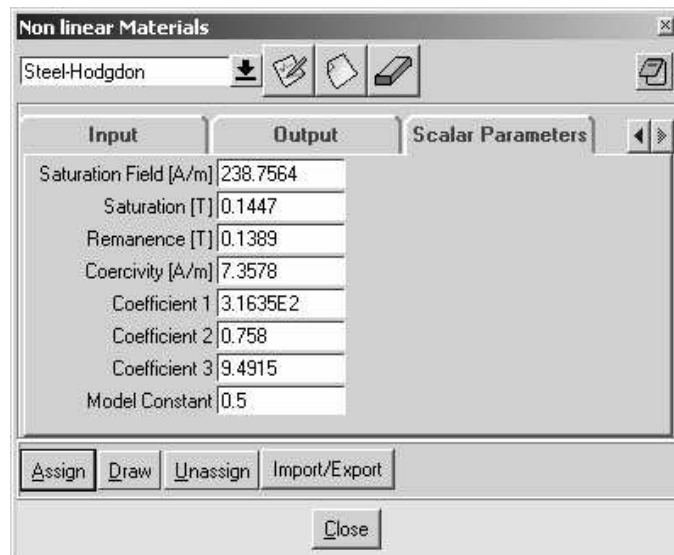Fig. 2. Classes of magnetic materials visualized with the extended GiD.

Fig. 3. Description of Steel-Hodgdon non-linear material presented with tab controls.

4. Conclusions

The Tcl/Tk scripting language was used for creating in GiD a material library imported from HystMag, a tool for advanced characterization of magnetic materials developed in-house. The library was converted into a.MAT file which contains a classification of magnetic materials into: linear, non-linear, hard, soft and recording materials. The library may be easily regenerated with new classes and materials.

This facility allows the coupling of some electromagnetic CAD tools for the analysis of the electromagnetic field. It also completes the advanced characterization of magnetic materials, by passing from experimental data of a given magnetic material, through a mathematical model, to the numerical implementation in a CAD software.

References

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