Visualising Finite Element Solutions in Virtual Reality Environments

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Abstract

The design process for electrical machines is more and more accomplished by using simulation techniques rather than prototyping. Thus development time and costs can be reduced. To replace a prototype of an electrical machine with a simulation model, accurate simulation results are needed. This is achieved by using the Finite Element Method combined with a precise problem definition and a detailed mesh. The outcome of this is a large amount of solution data needed to be regarded and understood. Virtual Reality environments are suited to achieve these demands. They offer the possibility to easy explore the simulation results also of complicated geometries. In this paper, a post-processing software with Virtual Reality capabilities is presented and application examples are shown.

1 Introduction

Simulations of electrical devices like electrical machines are more and more important. A well suited software for Finite Element simulations is iMOOSE [1], a Finite Element Solver environment. It allows simulating complex geometries with a high precision and resolution in space and time. Numerical data, resulting from 3D-magnetic field computation usually are a complex matter. Various possibilities to visualise such results in 2D plots or graphs are well known. However, results obtained from complex geometries still are difficult to evaluate. Therefore, we see a wide range of possibilities to use virtual reality methods and hardware to better understand complicated field patterns. It is obvious, that a better understanding of the field distribution enables the design engineer to optimise his technical product. In this paper we want to discuss the possibilities of applying principles of virtual reality to enhance design capabilities. The design engineer can now dive in a representation of 3D field lines and follow them on their path through the magnetic circuit. Also, users not experienced in electromagnetic problems can gain an impressive view of an electrical machine. Therefore, virtual reality environments are suited for teaching purposes as well.

2 Implementation

The post-processing software named iMOOSE.trinity.vr uses VTK [3] for the visualisation of Finite Element Solutions. VTK is open source visualisation software; therefore the source code is freely available. It combines object-orientation, a powerful structure and license freeness with platform independence. The object oriented design of this software is characterised by universal, easy to use data structures, where the universality encourage the reusability of algorithms acting as filter objects. The working principles of VTK are visualisation pipelines (see **Fig.1**).

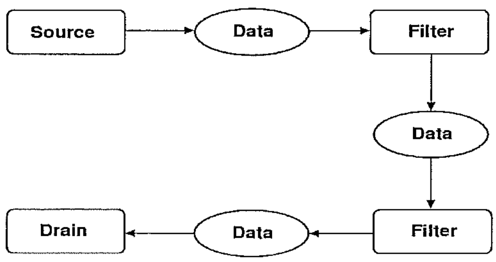

Fig. 1 Visualisation Pipeline of VTK

To use VTK, the simulation data of the Finite Element computations has to be converted to the VTK data structure. Afterwards, all available filter algorithms can be applied to the solution data (see Application in this paper).
Finally, using the virtual reality toolkit VISTA [2] offers the possibility, to plot the VTK visualisation data in a virtual reality environment.
By using various hardware like a holobench or a cave combined with a force feedback system and head position tracking system, the realistic effect of virtual reality environments can be increased significantly.

3 Application

By using VTK, various new visualisation methods in the form of filter algorithms are available. This includes the extraction of equipotential surfaces or field lines in 3D models (see Fig. 3). Furthermore, the deformation and the generation of vectors can be controlled very accurately and additional functionalities like smoothing meshes and decreasing the number of shown vectors are available.

All visualisations presented here are created utilising the nodal solution data calculated by the iMOOSE solver environment.

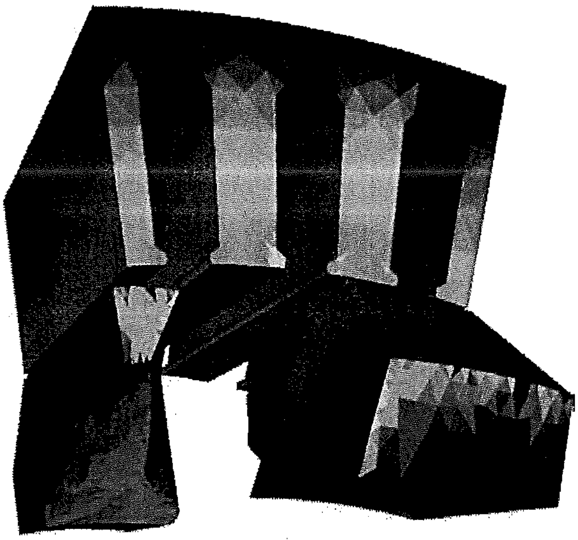

Fig. 2 Flux Density Distribution in Claw Pole Generator.

Fig. 2 illustrates a flux density plot of a claw pole generator. The field lines in the air gap are shown in Fig. 3.

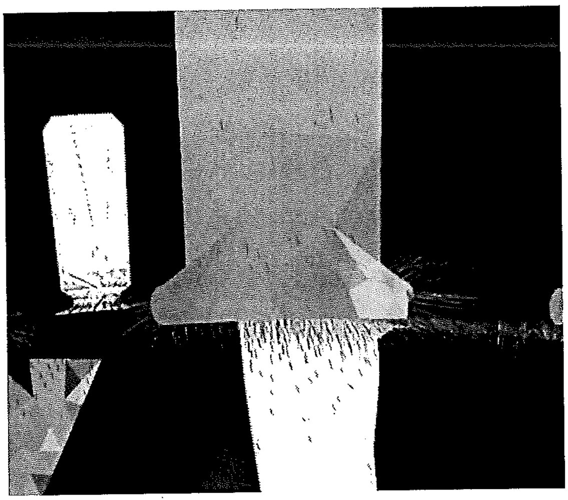

Fig. 3 Field Lines in Air Volume.

This visualisation mechanism can be used to indicate the flux distribution and therefore the flux leakage at every desired position in an simulation model. Combined with Virtual Reality Environments, the flux distribution can be recognised entirely.

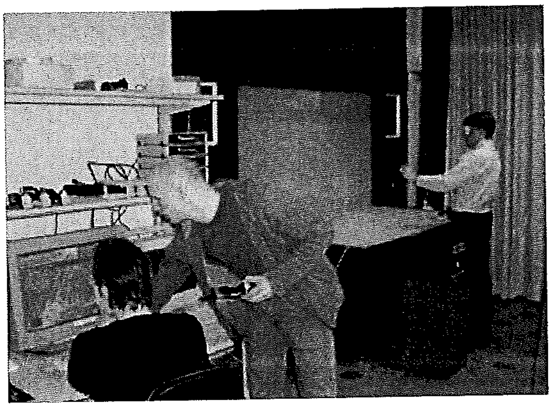

Fig. 4 Holobench.

Fig. 4 shows a typical holobench environment. It offers the possibility to explore simulation results in virtual reality. Combining the holobench with head position tracking and force feedback control, the user can completely dive into the modelled 3D geometrie.

4 Conclusion

Using Virtual Reality Environments allows for a better understanding of the designed machine even for complicated geometries and field distributions. Thereby the iterative design process can be expedited. Furthermore, Virtual Reality can be used for teaching purposes or presentations for non experienced people, giving them a better idea of research objectives.

5 Literature

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[2] T. van Reimersdahl *et al.*, "ViSTA: a multimodal, platform-independent vr-toolkit based on WTK, VTK and MPI," in Fourth International Immersive Projection Technology Workshop (IPT2000), 2000.

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