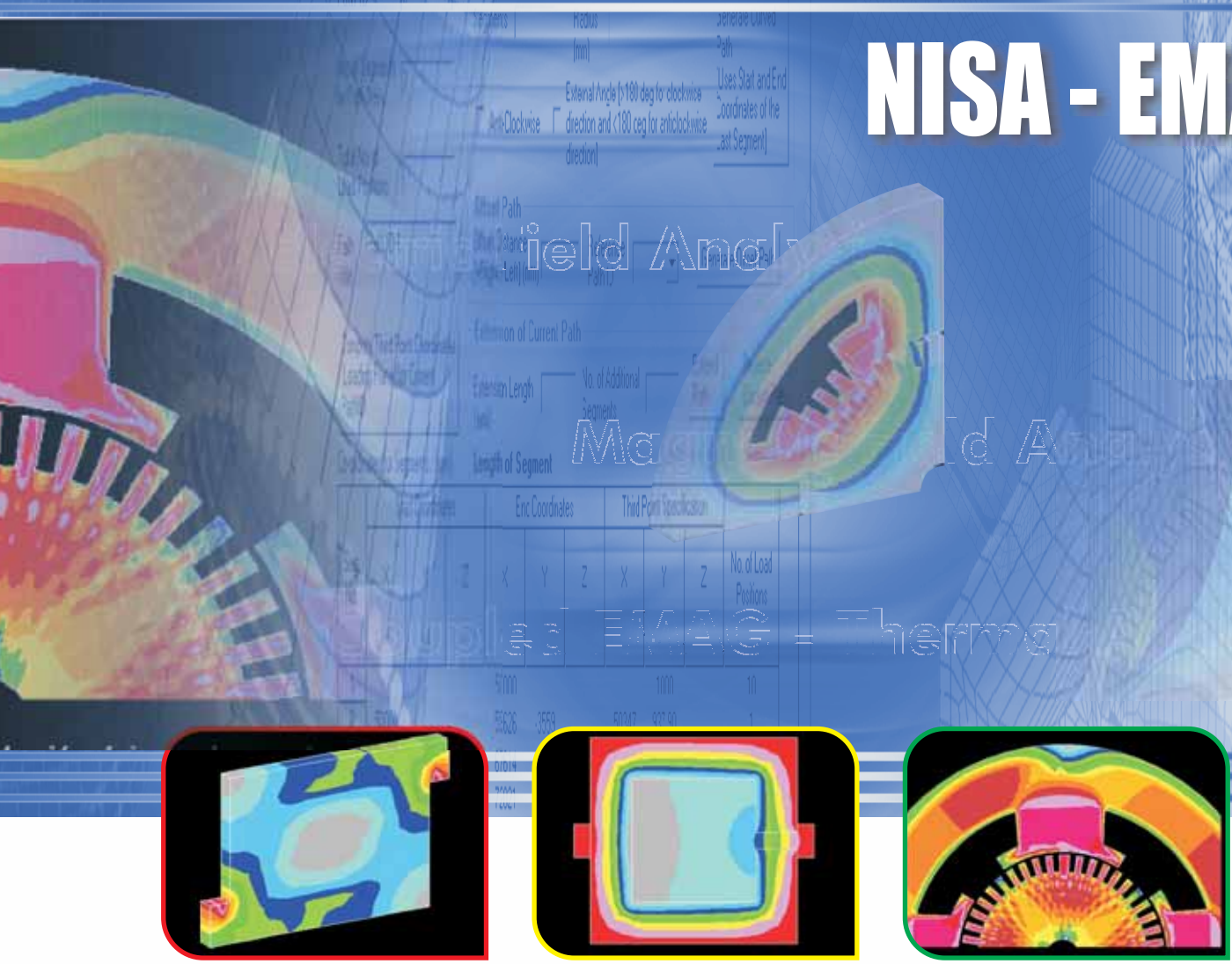
NISA™

NISA - EMAG



EMAG is the electromagnetic module of the family of general purpose finite element based program NISA. It can determine electric and magnetic field distributions in a wide class of electromagnetic devices. EMAG performs electromagnetic analyses by solving the appropriate Maxwell's formulations. It is coupled with NISA/HEAT to enable a coupled analysis of electromagnetic and thermal fields.

Magnetic Field Analysis

Coupled EMAG - Thermal Analysis

HIGHLIGHTS

- *Integrated with DISPLAY III for easy and effective pre- and post processing*
- *Two dimensional and three dimensional electromagnetic problems*
- *Linear, nonlinear and anisotropic materials*
- *Steady and/or time varying excitations*
- *Ouput of various design parameters critical for design optimisatio*

Steady Current Flow Analysis

Electric field produced in a system of conducting media due to applied voltages.

Inputs:

- *Linear, functional, isotropic or anisotropic material properties: Electrical conductivities of the participating media*
- *Specified voltages at the boundaries*
- *Specified current flow across the problem boundaries, if any*
- *Homogeneous Neumann's boundary for the flow parallel boundaries*
- *Specification of the "open boundary" if any in the problem through infinite elements*

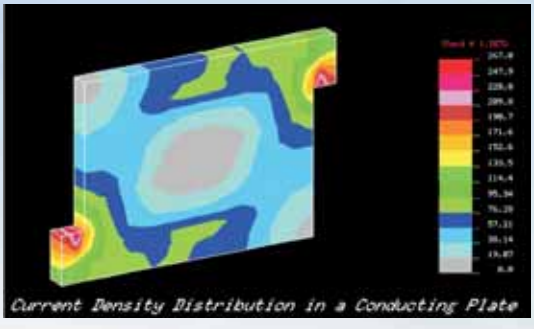
Outputs:

- *Electric potential distribution*
- *Electric field intensity and Current density distributions*
- *Dissipated electric energy for each element*
- *Total dissipated electric energy*
- *Conductance*

For the post processing, potential, electric field intensity and electric current densities are available.

Typical problems that can be analysed using this analysis type are:

- *Resistance of the arbitrary shaped conductors*
- *Particle counter in Tomography*
- *Particle detection in Bio-Medical Engineering*



Current Density Distribution in a Conducting Plate

Magnetic Field Analysis

Analysis of the magnetic field produced by the steady current sources, permanent magnets or time varying current sources and specified boundary conditions. For the case with static sources, either scalar or vector Poisson's equation govern the field. With the time varying sources/boundary conditions, eddy current phenomena prevail and hence the eddy current equation need to be considered. The material nonlinearity play a significant role in governing the magnetic field distributions.

Three distinct categories of the magnetic field analysis are:

- *Magnetostatic analysis*
- *Magnetodynamic analysis*
- *Transient Magnetic field analysis*

MAGNETOSTATIC ANALYSIS:

Magnetic field produced by steady currents and/or permanent magnets. Magnetic material properties are in general nonlinear and can be orthotropic.

Following types of analysis are provided:

- *2D planar and axisymmetric Magnetostatic analysis using vector potential approach (MGSV) - For the 2D problems, vector potential has either z-component (2D planar) or -component (Axisymmetric) only.*
- *3D Magnetostatic analysis using reduced scalar potential approach (MGSS) By employing a reduced scalar potential with Biot-Savart's law, significant reduction in the computational time is achieved. However, nonlinearity and permanent magnets are not included.*
- *3D Magnetostatic anslysis using the magnetic vector potential approach (MGVP) Use of fully magnetic vector potential approach yields accurate results as compared with reduced scalar potential approach.*

Inputs:

- *Linear or nonlinear, isotropic or anisotropic material properties: Magnetic permabilities or reluctivities of the participating media. B-H curve for the nonlinear materials. Specifications of the linear or nonlinear permanent magnets if any.*
- *Specified current density distributions in the media and specified vector/reduced scalar potentials at the boundaries*
- *Specified flux flow along the problem boundaries, if any*
- *Flux tangential boundaries*
- *Specification of the "open boundary" if any in the problem through infinite elements*

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Electric Field Analysis

HIGHLIGHTS

- *Integrated with DISPLAY III for easy and effective pre- and post processing*
- *Two dimensional and three dimensional electromagnetic problems*
- *Linear, nonlinear and anisotropic materials*
- *Steady and/or time varying excitations*
- *Ouput of various design parameters critical for design optimisation*

OUTPUT

- *Color plots of electric field, magnetic field, flux densities, magnetic vector potential, voltage and current distributions*
- *Arrow plots for all vector parameters*
- *Stored electric energy*
- *Stored magnetic energy and coenergy*
- *Power losses*
- *Capacitance, conductance and inductance of the device*
- *Induced eddy currents*
- *Ampers's force in current carrying region*
  Force and torque calculations using either volume integration method and/or displacement method(Virtual work method)
- *Temperature distribution*

Electric Field Analysis (efield)

Analysis of the electric field produced by either static, or quasi-static electric charges and/or voltage distributions. Due to the static or quasi-static nature of the excitations, the governing electromagnetic equations reduce to Poisson's or Laplace's equations. The electrostatic potential commonly called as voltage, remain as the basic unknown field quantity.

Two distinct categories arise with electric field analysis:

- *Electrostatic analysis (ESTAT)*
- *Steady current flow analysis (SCFL)*

ELECTROSTATIC ANALYSIS

Electric field produced in a system of dielectric media due to static bulk charges and/or applied voltages.

Inputs:

- *Linear, isotropic or anisotropic material properties: Dielectric permittivities of the participating media*
- *Specified charge distributions in the media and specified voltages at the boundaries*
- *Specified flux flow across the problem boundaries, if any*
- *Homogeneous Neumann's boundary for the flux parallel boundaries*
- *Specification of the "open boundary", if any in the problem, through infinite elements*
- *Specification of the moving object for force/torque calculations*

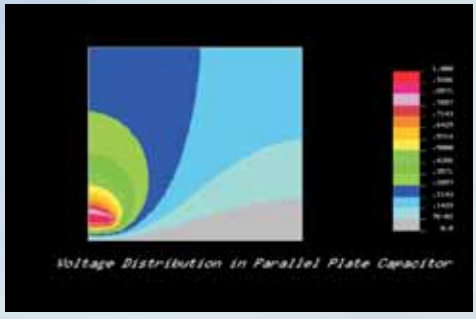
Outputs:

- *Electrostatic potential distribution*
- *Electric field intensity and Electric flux density distributions*
- *Stored electric energy for each element*
- *Total stored electric energy*
- *Capacitance*
- *Force or Torque on the moving object*

For the post processing, potential, electric field intensity and electric flux densities are available.

Typical problems that can be analysed using this analysis type are:

- *Capacitors*
- *Electrostatic precipitators*
- *Transmission lines*
- *Multi-conductor distribution with specified voltages*
- *Transformers and wall bushings for the insulation studies*
- *Outdoor insulators*
- *Supporting insulator blocks*
- *Design of corona shields*
- *Dielectric breakdown studies in High Voltage Engineering problems*



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Coupled EMAG - Thermal Analysis

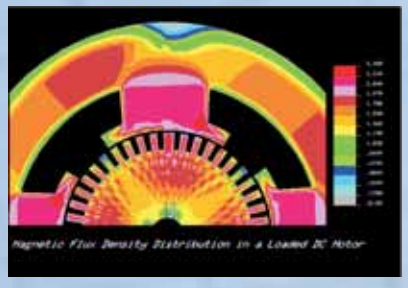
- *Specification of the moving object for force/torque calculations*

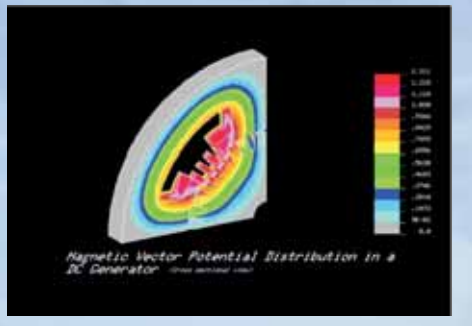
Outputs:

- *Vector/reduced scalar potential distribution*
- *Magnetic field intensity and Magnetic flux density distributions*
- *Stored magnetic energy and coenergy for each element*
- *Total stored magnetic energy and coenergy*
- *Inductance*
- *Force or Torque on the moving object*

For the post processing, potential, magnetic field intensity and magnetic flux densities are available.

- *Typical problems that can be analysed using these analysis types are:*
- *Solenoids & lift magnets*
- *Transmission lines*
- *Transformers*
- *DC & AC rotating electrical machinery*
- *Circuit breakers*
- *Relays*





MAGNETO DYNAMIC ANALYSIS

Magnetic field produced by steadystate sinusoidally varying currents with only linear materials in the problem.

Inputs:

- *Linear isotropic material properties: Magnetic reluctivities of the participating media. Conductivities for the massive conductors i.e. where the eddy currents are expected to be significant.*
- *Specified current density distributions with their phases in the media and specified vector potentials at the boundaries*
- *Flux tangential boundaries*
- *Specification of the "open boundary" if any in the problem through infinite elements*

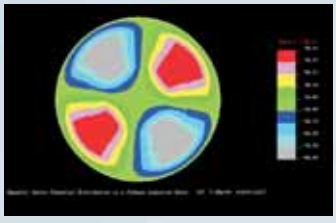
Outputs:

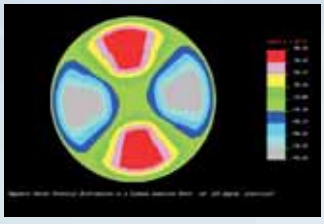
- *Magnetic vector potential distribution*
- *Magnetic field intensity and Magnetic flux density distributions*
- *Eddy current density distribution*
- *Total current density distribution*
- *Induced electric field distribution*
- *Total electric field distribution*
- *Power loss density distribution*
- *Stored magnetic energy for each element*
- *Total stored magnetic energy*
- *Total power loss*
- *Inductance*
- *Resistance*

For the post processing, magnetic vector potential, magnetic field intensity and magnetic flux densities, eddy current density, induced electric field, total current density and total electric field are available. Results are also available for different instants or angles. With the elegant movie option of the DISPLAY III, results corresponding to different instants can be viewed in dynamic mode.

Typical problems that can be analysed using this analysis type are:

- *Solenoids & lift magnets*
- *Transmission lines and Bus bars*
- *Transformers*
- *Induction machines*
- *Synchronous machines*





NISA - EMAG

Electric Field Analysis

TRANSIENT MAGNETIC FIELD ANALYSIS

Magnetic field produced by arbitrarily time varying currents and steady permanent Magnets. Materials involved in general can be nonlinear.

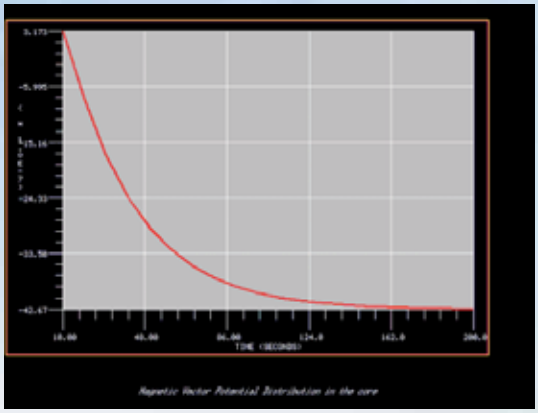
Inputs:

- Linear or nonlinear material properties: Magnetic reluctivities of the participating media. B-H curve specification for the nonlinear materials.
- Specifications of the linear or nonlinear permanent magnets, if any. Specify conductivities for the massive conductors i.e. for the conducting regions where the eddy currents are expected to be significant
- Specified current density distributions and their time variations and specified vector potentials at the boundaries
- Flux tangential boundaries
- Specification of the "open boundary" if any in the problem through infinite elements

Outputs:

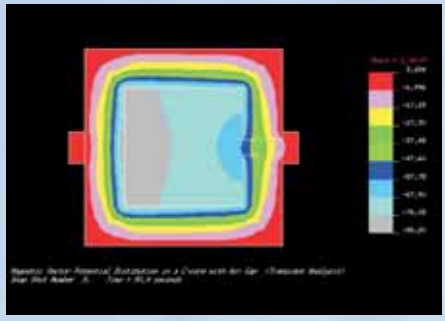
- Magnetic vector potential distribution
- Magnetic field intensity and Magnetic flux density distributions
- Eddy current density distribution
- Induced electric field distribution
- Power loss density distribution
- Stored magnetic energy and coenergy for each element
- Total stored magnetic energy

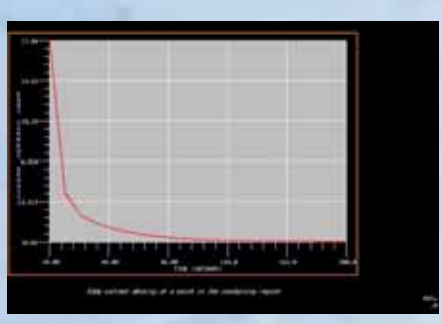
For the post processing, magnetic vector potential, magnetic field intensity and magnetic flux densities are available. Results are also available for different time Instants. With the elegant movie option of the DISPLAY III, results corresponding to different instants can be viewed in dynamic mode.



Typical problems that can be analysed using this analysis type are:

- Solenoids & lift magnets
- Induction furnaces
- Transformers
- Induction machines
- Synchronous machines





Coupled Emag-thermal Analysis

Coupled Heat transfer analysis in electromagnetic devices due to the power losses produced by the presence of applied and induced currents in these devices. This analysis can be carried out coupled with steady state current flow analysis, transient magnetic field and manetodynamic analysis. Material properties can be a function of temperature.

Inputs:

- *The inputs for the electromagnetic part follow the corresponding analysis as described earlier*
- *For the thermal part:*
  - *– Linear or nonlinear/functional, isotropic or anisotropic material properties*
  - *– Specification of the flux tangential (adiabatic), specified temperature, convention heat loss boundary conditions*

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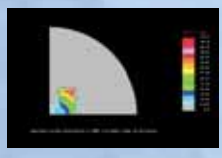
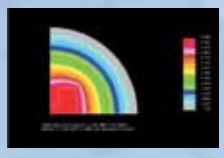
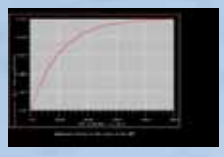
Electric Field Analysis

Outputs:

- *Ouput from the electrical analysis is same as discussed under corresponding sections*
- *From the thermal run:*
  - *Temperature distribution at all specified print interval (Animation of the temperature distribution has been provided)*
  - *Boundary heat flux rates*







For the post processing, temperature distribution at specified time intervals and nodal response graphs for the pre-specified nodes, are available. Also, the temperature distributions over time can be animated.

Typical problems that can be analysed using this analysis type are:

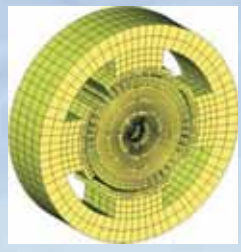
- *Solenoids & lift magnets*
- *Induction furnaces*
- *Transformers*
- *Induction machines*
- *Synchronous machines*

PRE AND POST PROCESSING FEATURES

NISA/EMAG interfaces directly with NISA/DISPLAY for Pre- and Post-Processing. DISPLAY is an Interactive, User-Friendly and Powerful Graphics Environment for modeling, animation, and result interpretation.

Creating the Model

- Extensive capabilities to model complex geometries using arcs, surfaces, solids and NURBS curves and surfaces
- CAD interface, directly or through IGES. Supports I-DEAS, Pro/ENGINEER, AutoCAD, SolidWorks, Solid Edge, ACIS, etc
- Extensive MACROs for parametric modeling and database queries.



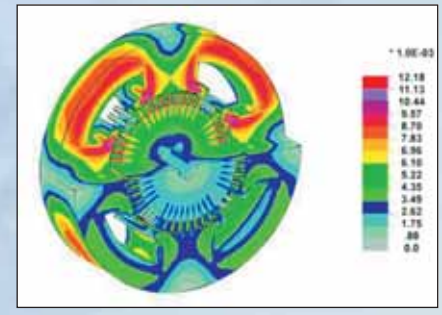
Mesh of a three-dimensional DC Generator (Pre-processing)

Meshing the Model

- Automatic and mapped mesh generation for 2D and 3D geometries, using planar and solid elements.
- Graphical representation of loads and boundary conditions.
- Extensive mesh verification facilities, boundary, normal, duplicate and distortion checks.
- Extensive plotting options including boundary and hidden line plots for selected elements or regions.

POST-PROCESSING THE NISA/EMAG RESULTS

- Color contour plotting of electric field, magnetic field, flux density, magnetic vector potential, voltage, and current distribution.
- Vector contour plotting of all vector quantities.
- Time history plots for transient magnetic field analysis.



Magnetic flux density distribution of a three-dimensional DC generator (post-processing)

About us

Cranes Software International Limited is a leading provider of Computer Aided Engineering (CAE) services to the Automotive, Aerospace, Energy & Power, Civil, Electronics and Sporting Goods industries. Over 70 dedicated scientists, technology architects and software engineers providing NISA based solutions have helped major engineering companies reduce analysis turnaround time, improve user productivity, and ensure faster return on investments. The Company has its presence in 33 countries across the world and has a user base of more than 350,000.

With a mission statement to provide its customers the best in scientific technology and to enable its customers to define new limits, Cranes is setting new standards in the scientific and engineering field. *For more information, please visit www.nisasoftware.com Email: nisa@cranessoftware.com*

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