# BUILDING QUALITY AND RELIABILITY IN DESIGN AND MANUFACTURE OF

# CG TRANSFORMERS


CG International

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# REQUIREMENTS OF MODERN POWER TRANSFORMERS

- WITHSTAND AGAINST SYSTEM OVERVOLTAGES
- EDDY & STRAY LOSS CONTROL
- STRUCTURAL DESIGN
- THERMAL DESIGN
- SHORT-CIRCUIT WITHSTAND DESIGN

Next

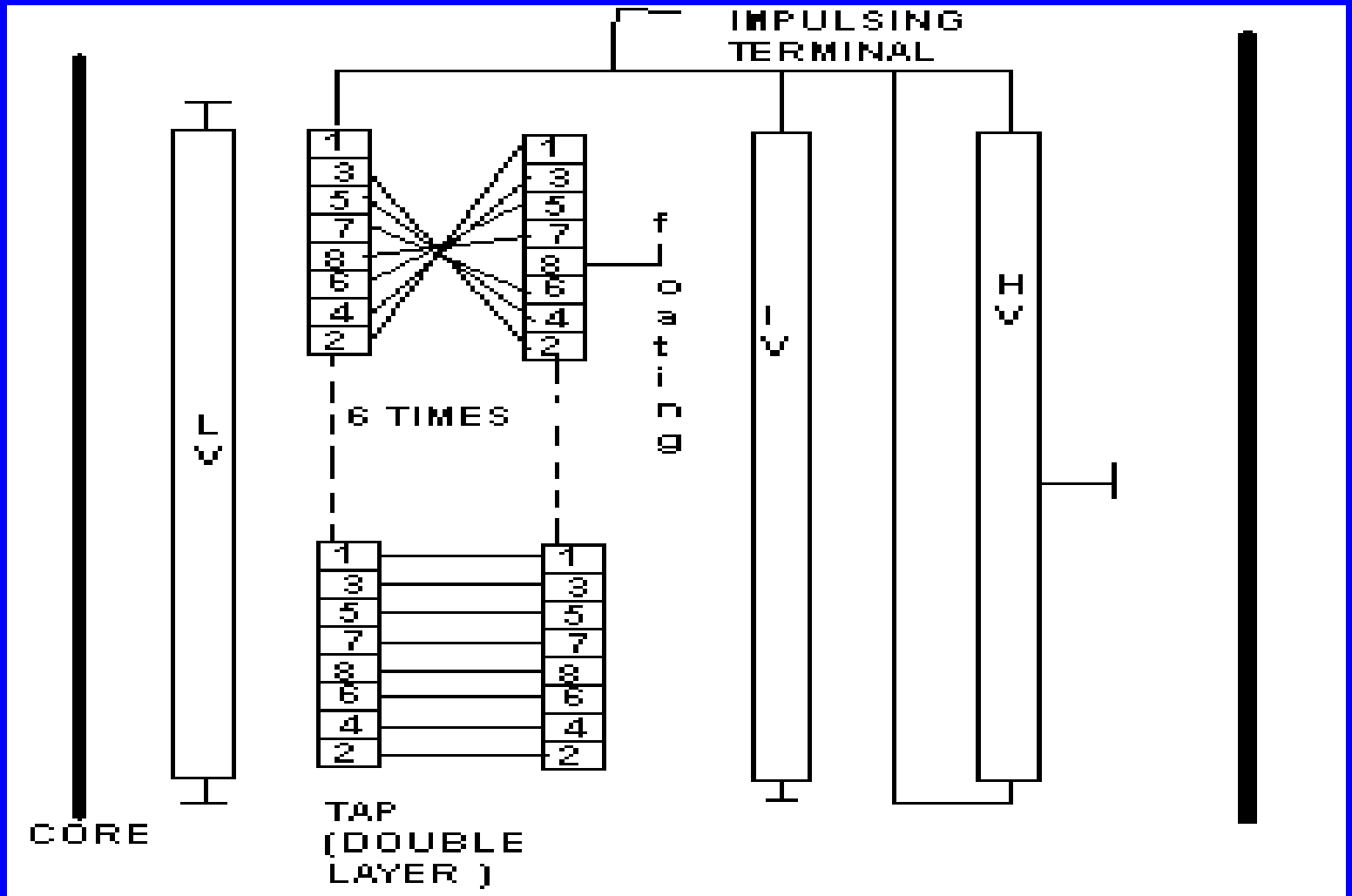
# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## WITHSTAND AGAINST SYSTEM VOLTAGES

- § USE OF L-C-R NETWORK SOFTWARE TO ESTIMATE VOLTAGE LEVELS ALONG WINDING HEIGHT
- § ASSESSMENT OF STRESS LEVELS AT VARIOUS CRITICAL LOCATIONS BY ELABORATE FEM ANALYSIS
- § STRENGTH OF INSULATION BASED ON EXPERIMENTAL DATA
- § USE OF RSG FOR VERIFICATION
- § USE OF SPECIAL INSULATING COMPONENTS

Next

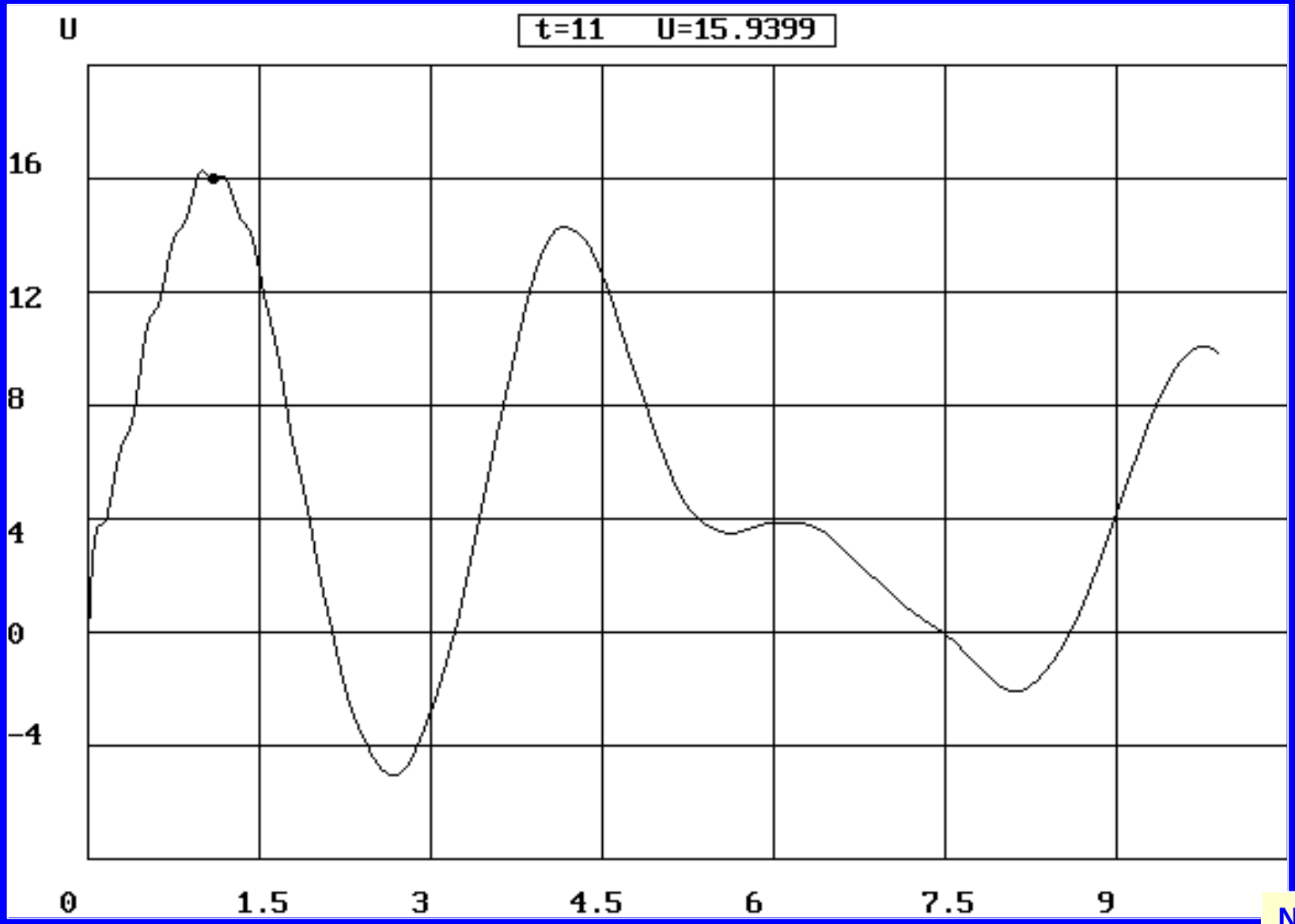
# IMPULSE DISTRIBUTION - WINDING DIAGRAM




TEST SET UP FOR IV IMPULSING FOR CHECKING ACROSS RANGE VOLTAGE OF TAP

Next

# IMPULSE DISTRIBUTION - VOLTAGE AT NODES

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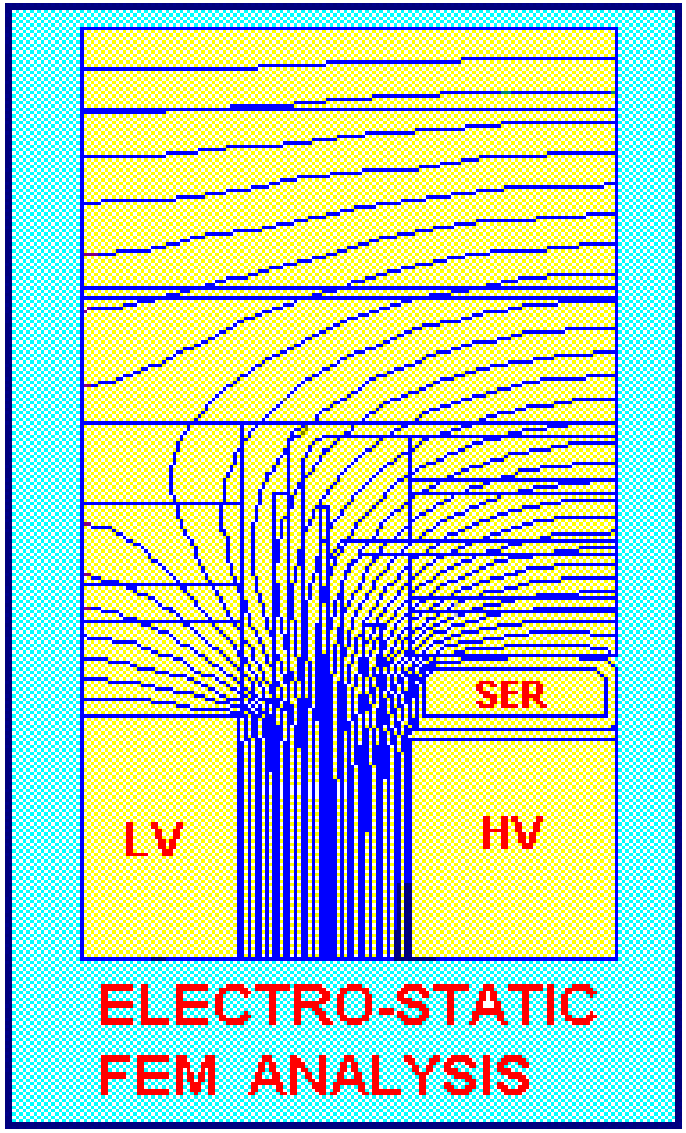
# FEM ANALYSIS FOR END INSULATION DESIGN

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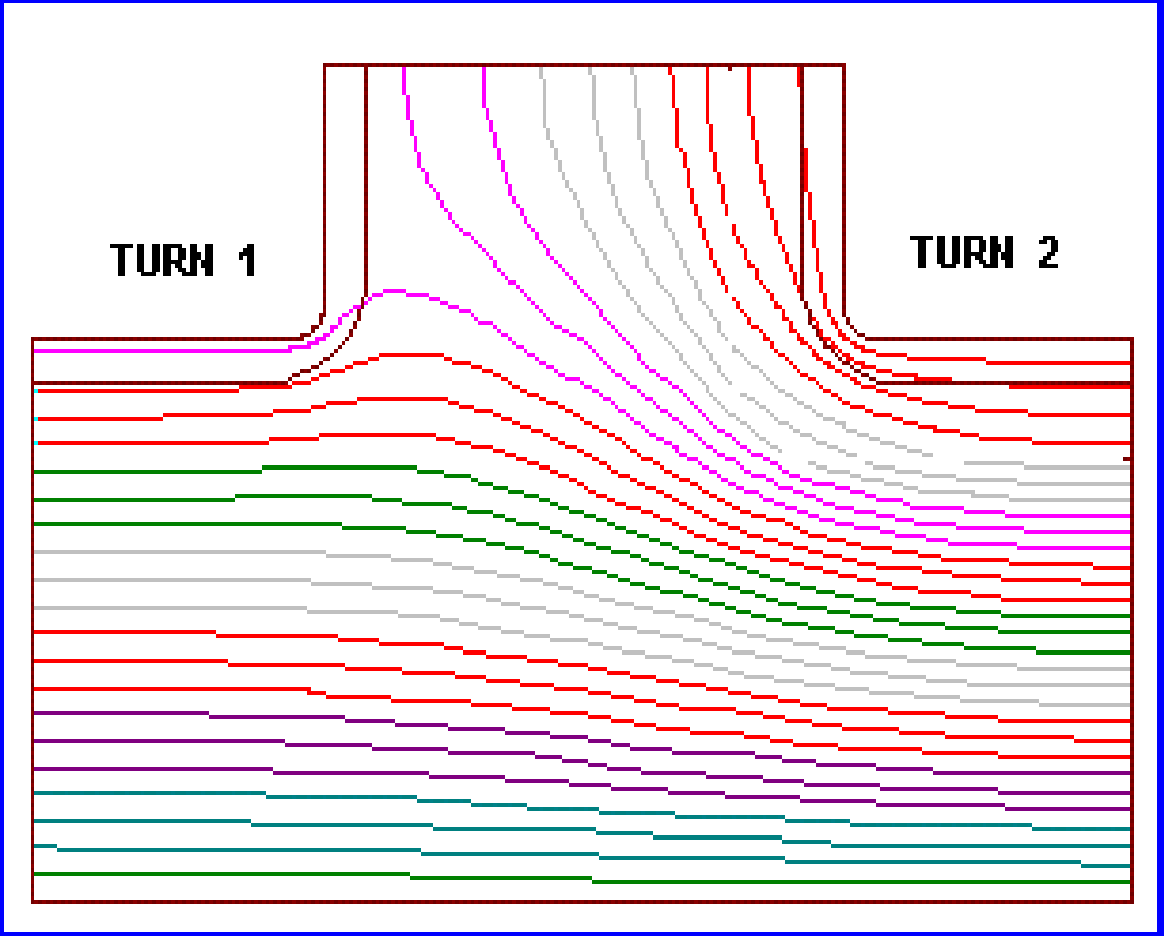
# STRESS ANALYSIS BETWEEN TURNS

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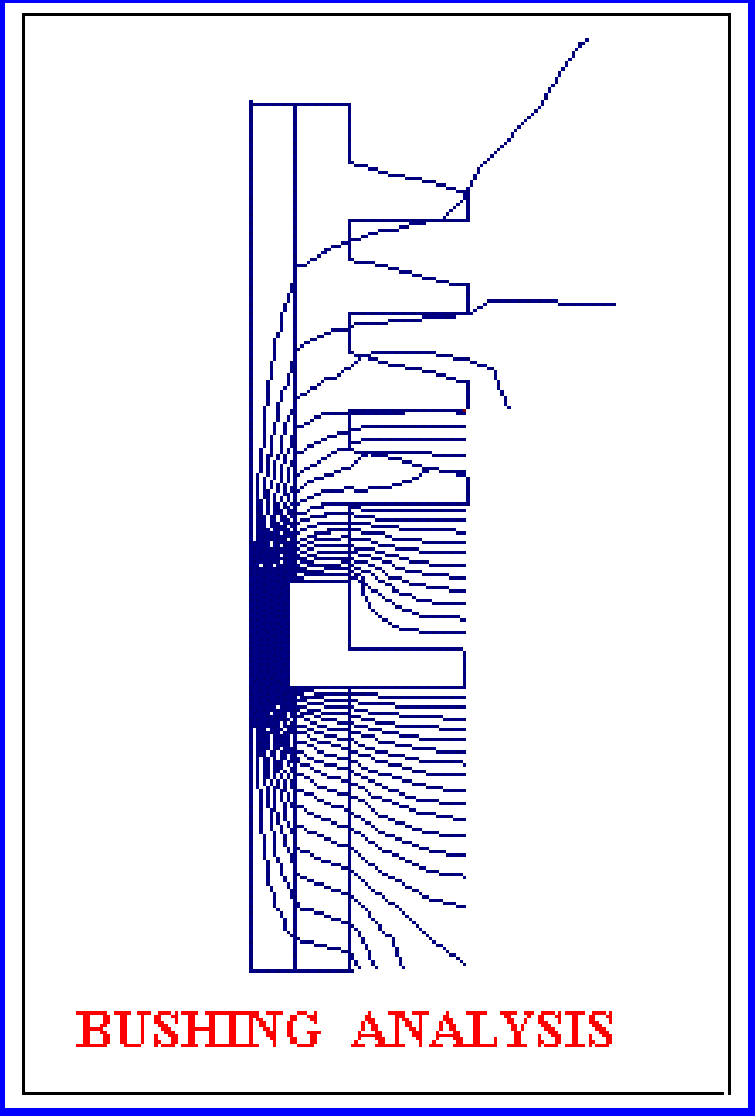
# STRESS ANALYSIS BETWEEN TURNS




Next

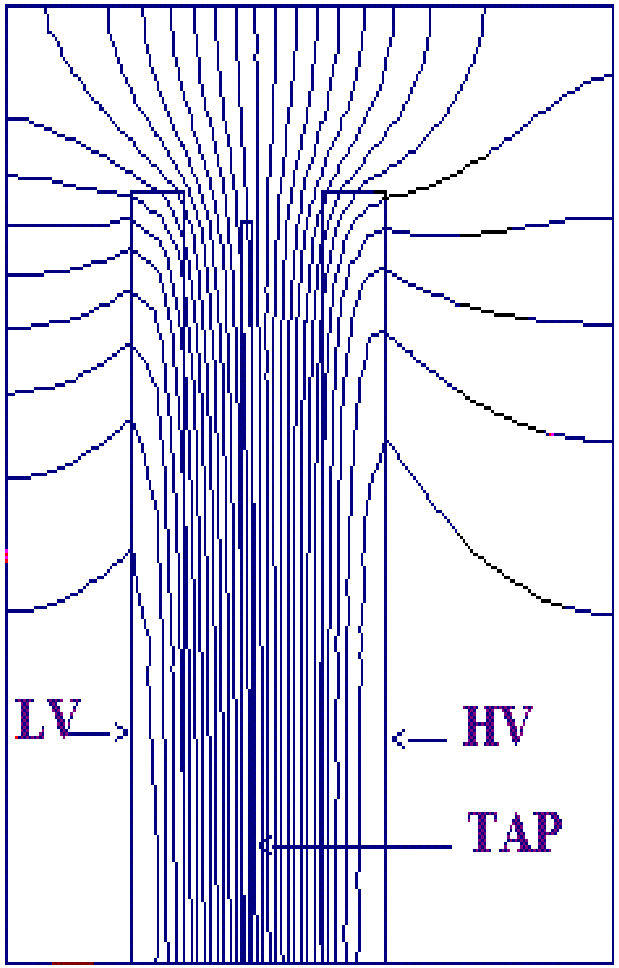
# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## REDUCED LOSSES - EDDY LOSS

- § USE OF 2D FEM TO CALCULATE WDG. EDDY LOSS
- § CHOICE OF PROPER WIDTH & THICKNES TO MINIMIZE EDDY LOSS
- § USE OF CTC FOR HIGHER MVA TRANSFORMERS
- § FEM ANALYSIS FOR CIRCULATING CURRENT LOSS MINIMIZATION

Next

# FEM ANALYSIS FOR WINDING EDDY LOSS




EDDY LOSS ESTIMATION

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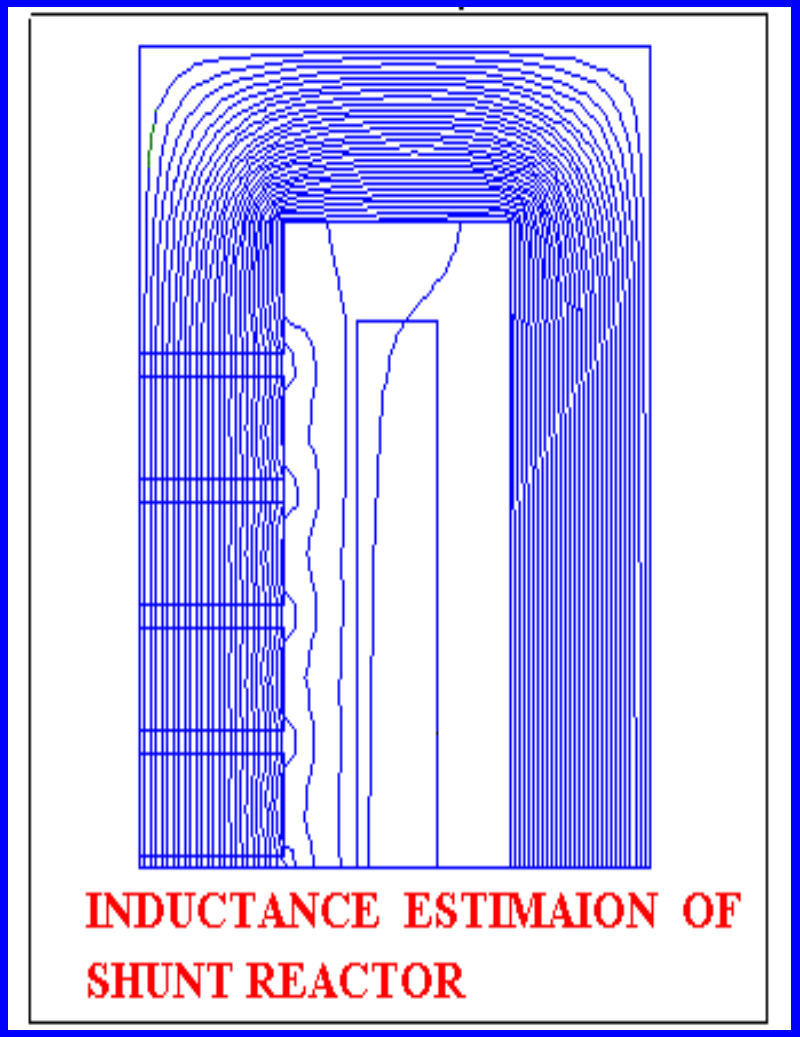
# SHUNT REACTOR ANALYSIS



INDUCTANCE ESTIMAION OF SHUNT REACTOR

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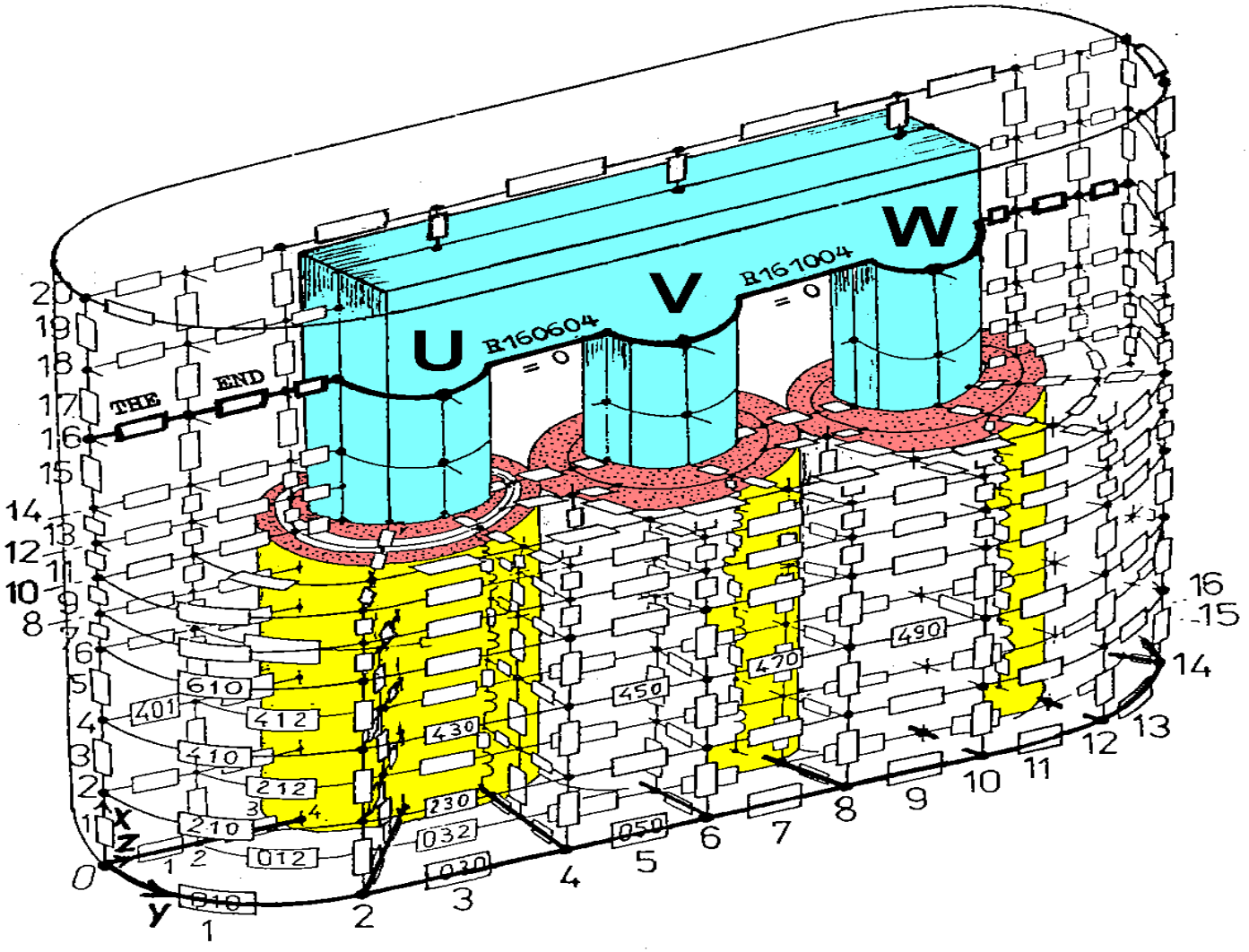
# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## REDUCED LOSSES
## STRAY LOSS

- USE OF 3D RELUCTANCE NETWORK METHOD TO ESTIMATE TANK LOSS
- PROPER CHOICE OF FLITCH PLATE MATERIAL (MS / SS / LAMINATED) AND TYPE ( WITH SLOTS / WITHOUT SLOTS)
- JUDICIOUS USE OF MAGNETIC / NONMAGNETIC SHIELDING
- FEM (2D OR 3D) SIMULATION FOR STRAY LOSS CONTROL IN HIGH CURRENT TERMINATIONS

Next

# Stray Loss Calculation
# by 3-D Leakage Field Estimation

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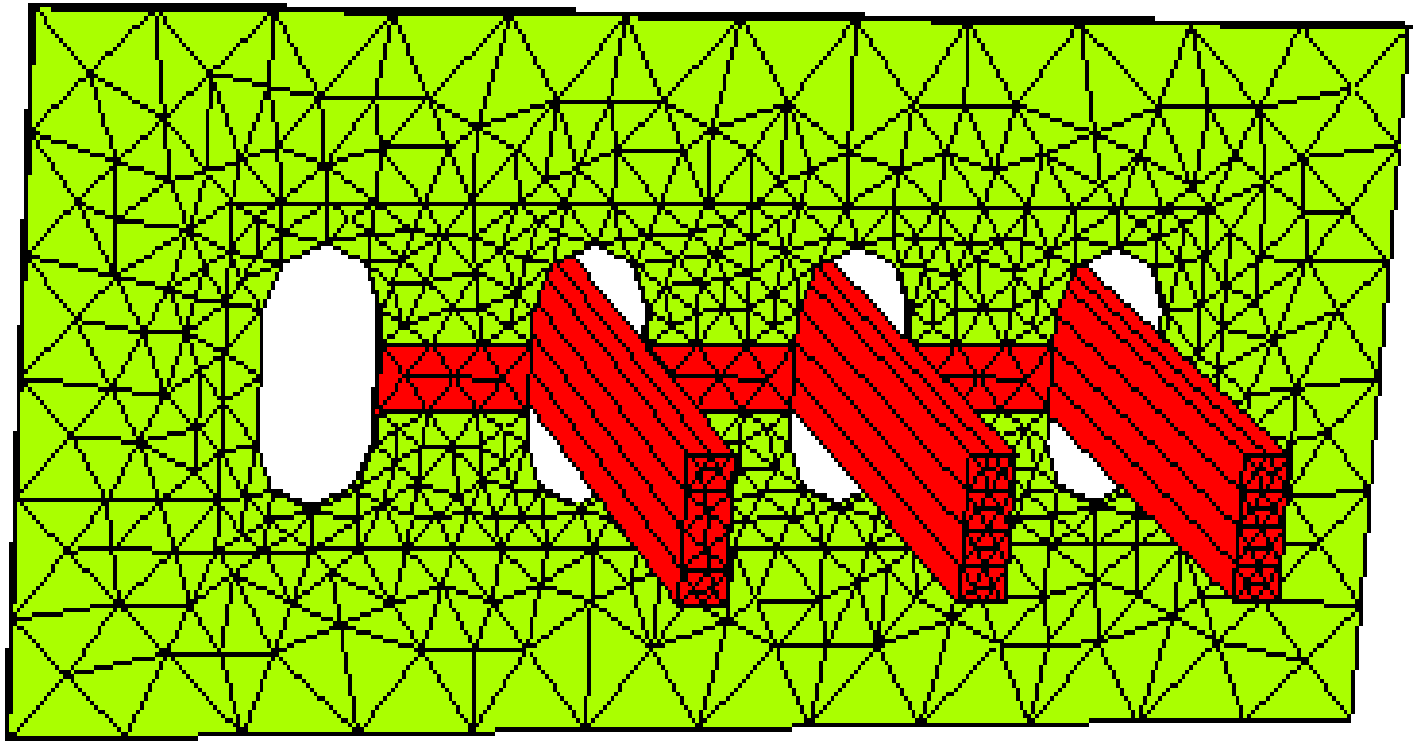
# Eddy Loss Analysis in Bushing Mounting Plate by 3D FEM Analysis



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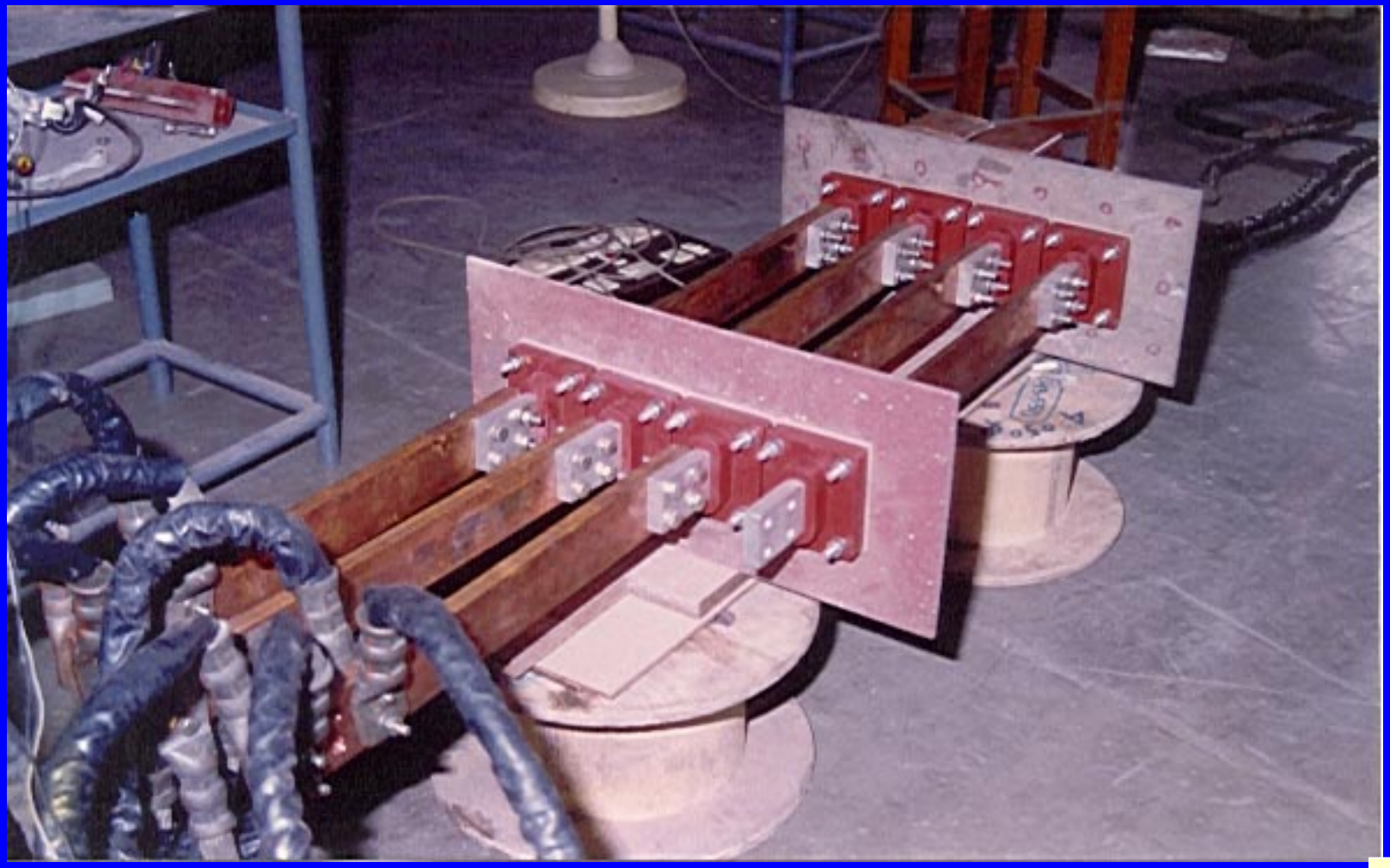
# Experimental Verification of Eddy Loss Calculation in Bushing Mounting Plate



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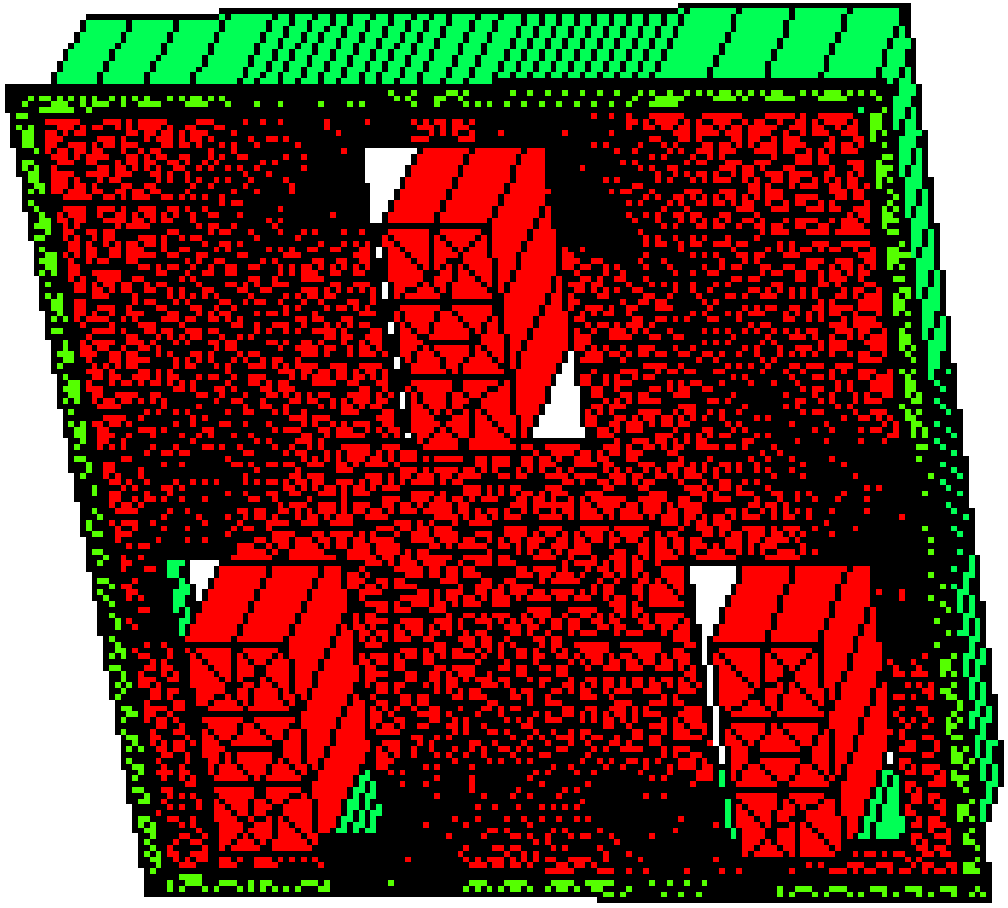
# 3D FEM Electromagnetic Analysis of Large Furnace Transformer Lead Termination



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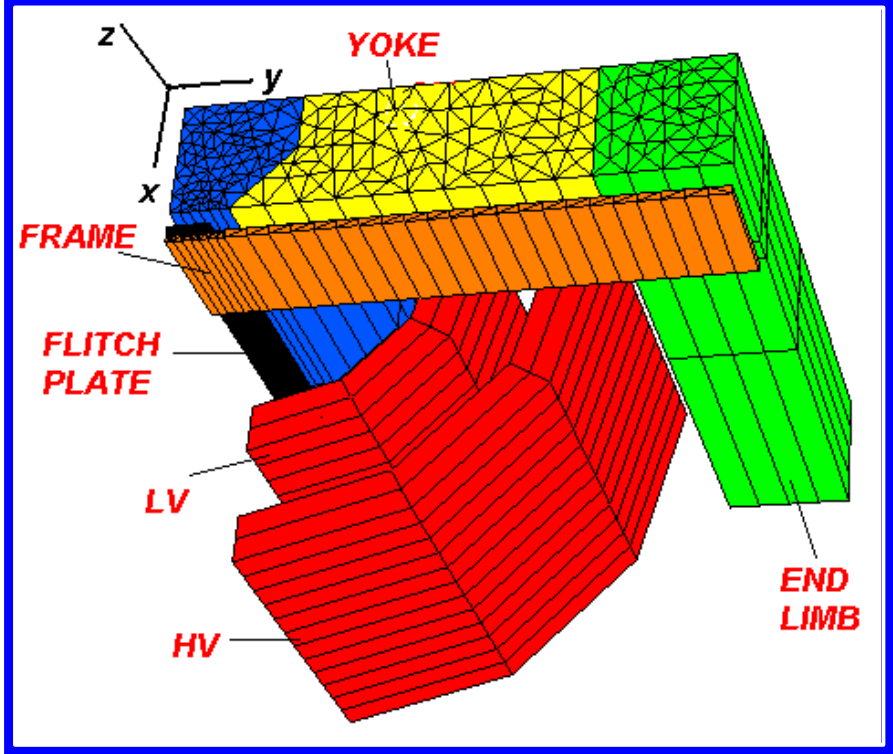
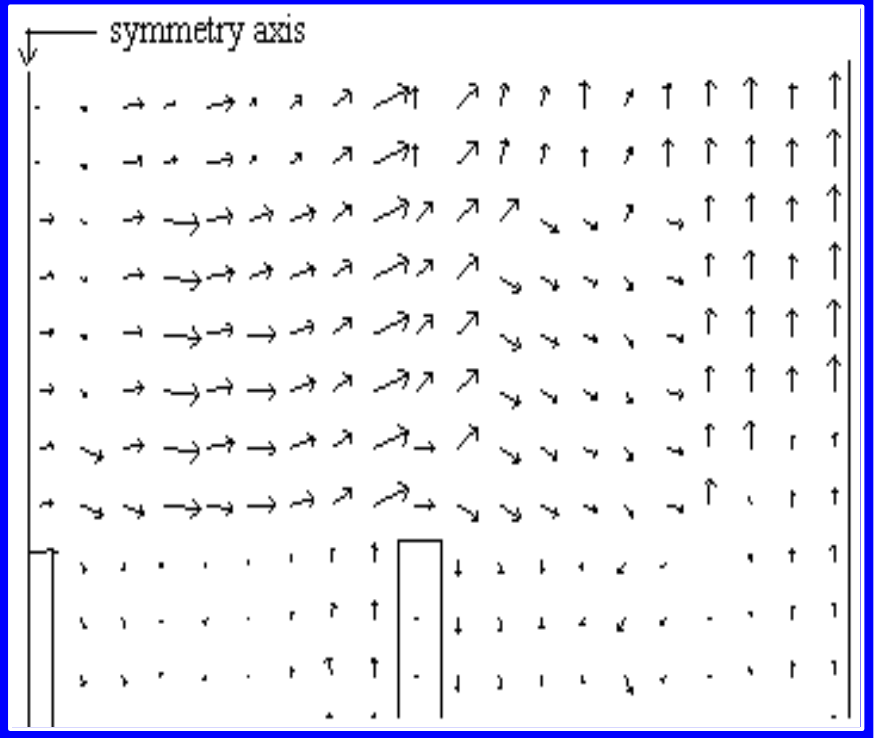
# 3D FEM Analysis of Eddy Loss in Structural Part - Flitch Plate




3D Model




Eddy Currents

Next

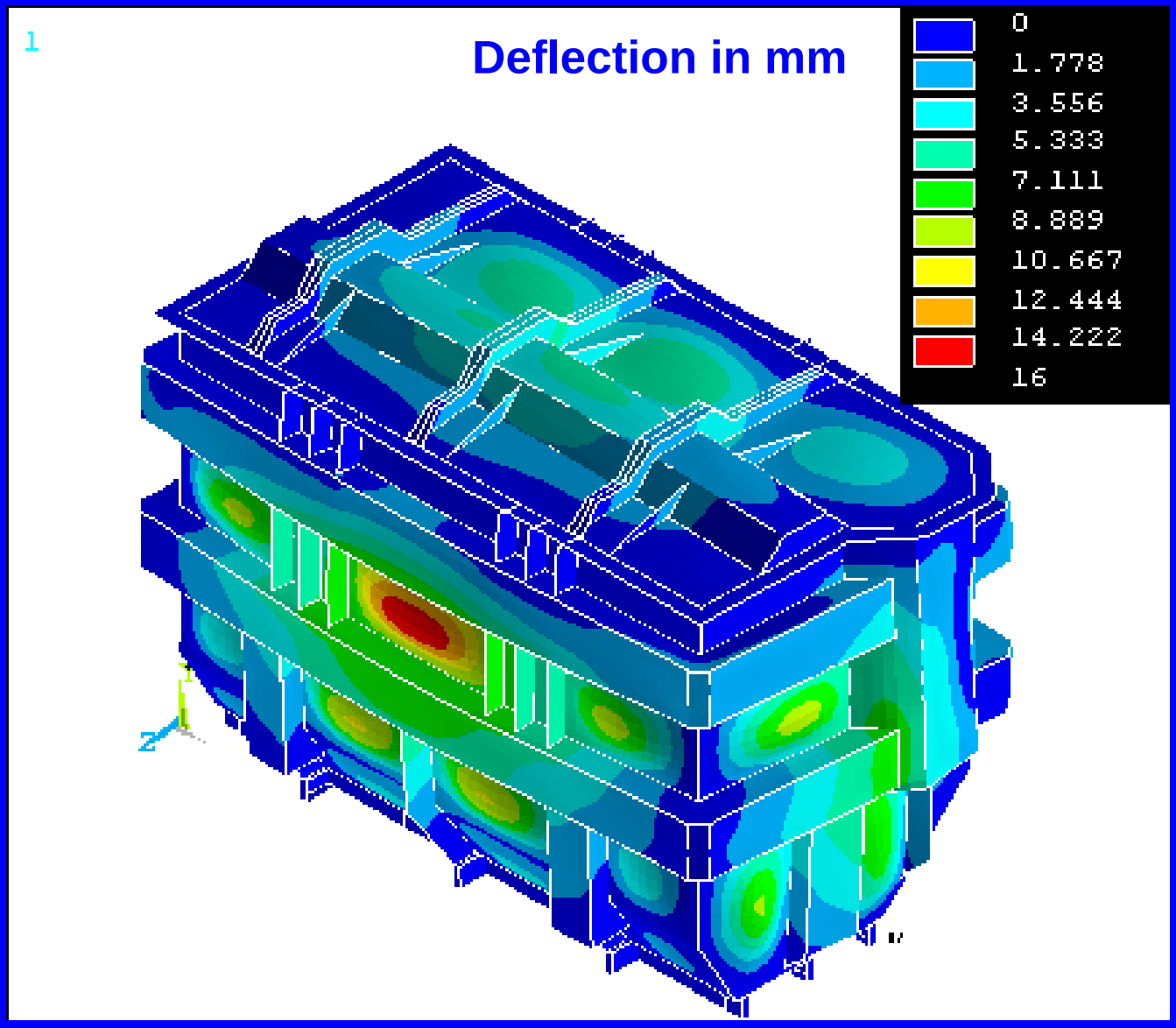
# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## STRUCTURAL DESIGN

- § USE OF 3D FEM TO CHECK VACUUM / PRESSURE WITHSTAND
- § ADEQUATE STIFFENING FOR VARIOUS TYPES OF LOADS ( LIFTING, JACKING, ETC. )
- § SEISMIC ANALYSIS ( ANALYTICAL AND 3D FEM )

Next

# Deflection Plot under Pressure Loading

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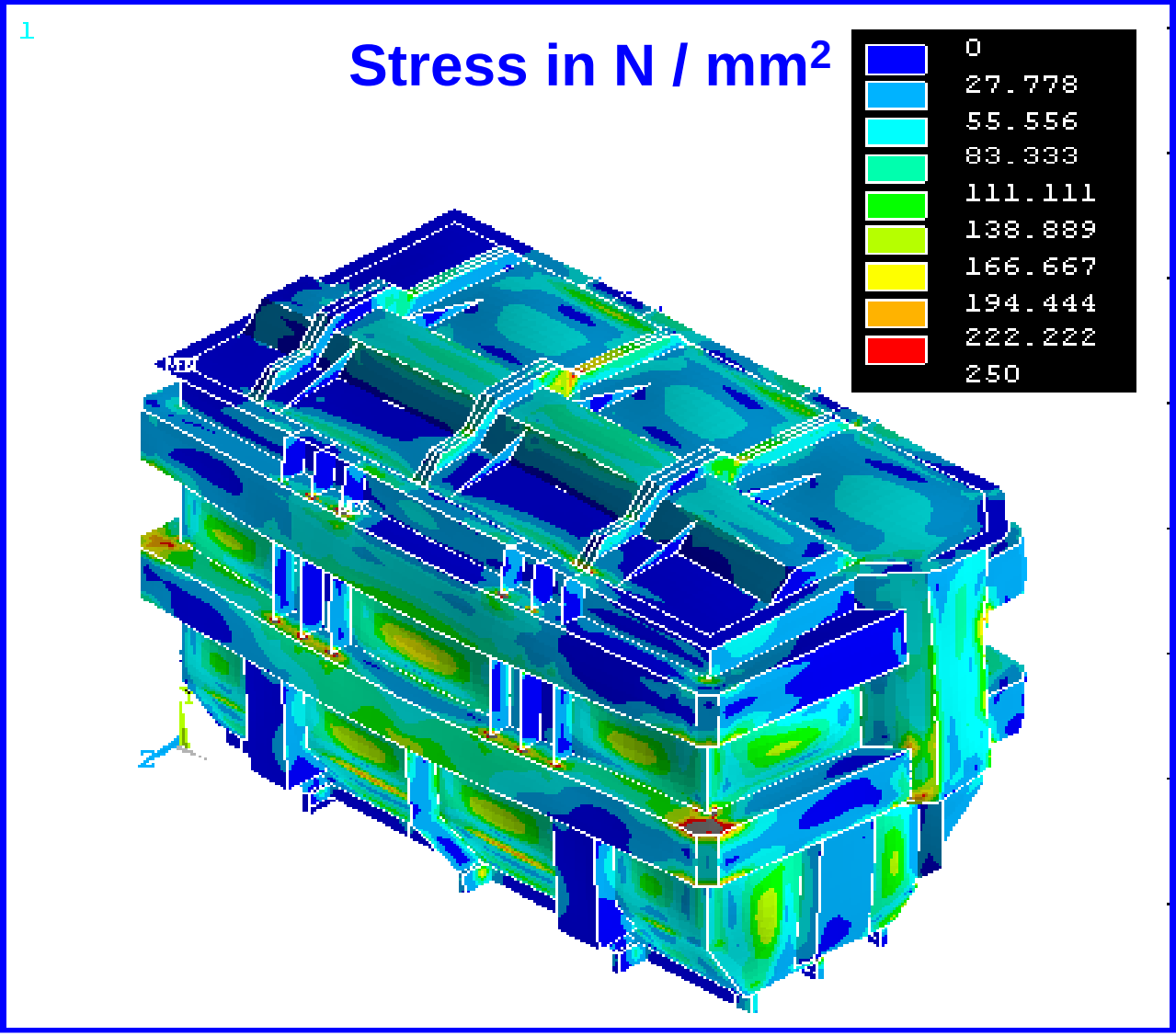
# Stress Plot under Pressure Loading

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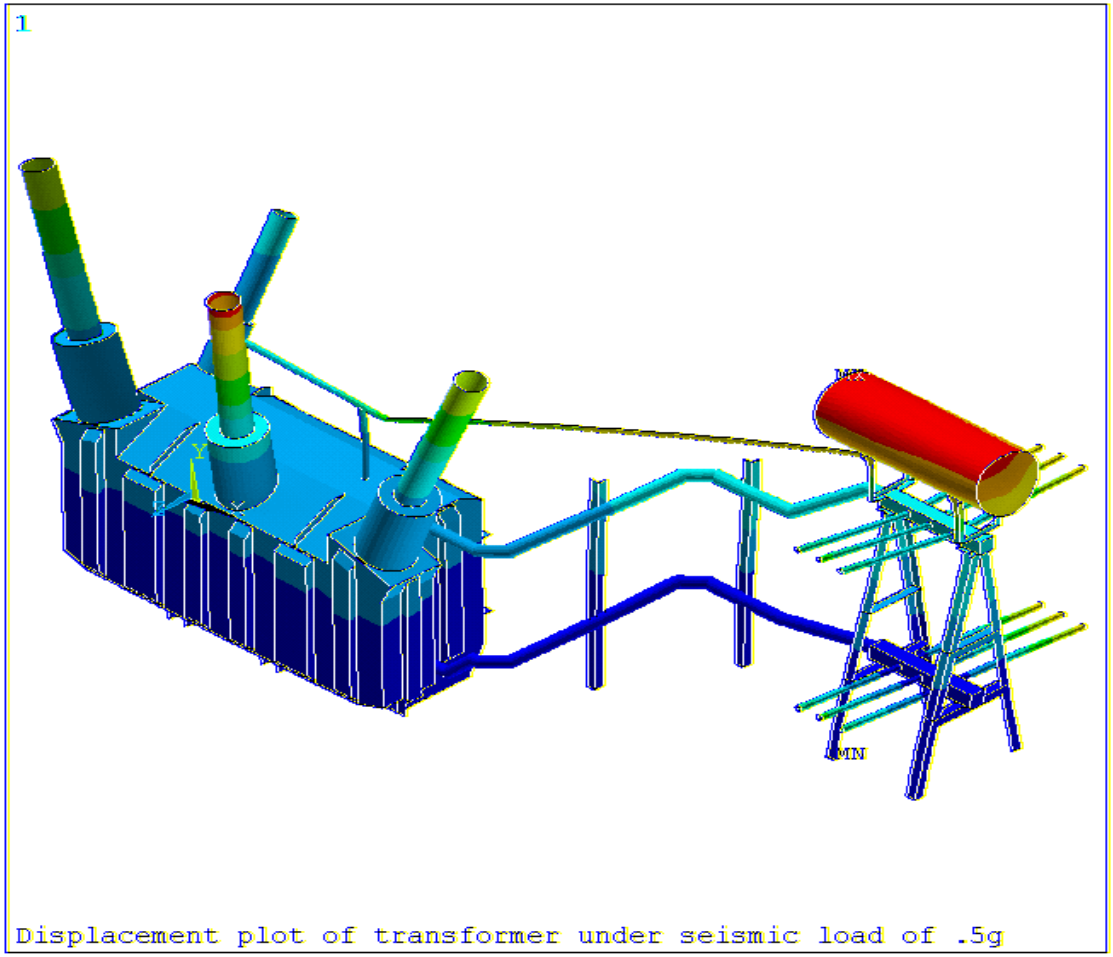



# Displacement plot of a transformer under seismic load of 0.5 g

Next

# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## WITHSTAND AGAINST SHORT CIRCUIT FORCES

§ USE OF METHOD OF IMAGES TO CALCULATE FLUX DENSITIES ( AXIAL & RADIAL ) - Westinghouse Program

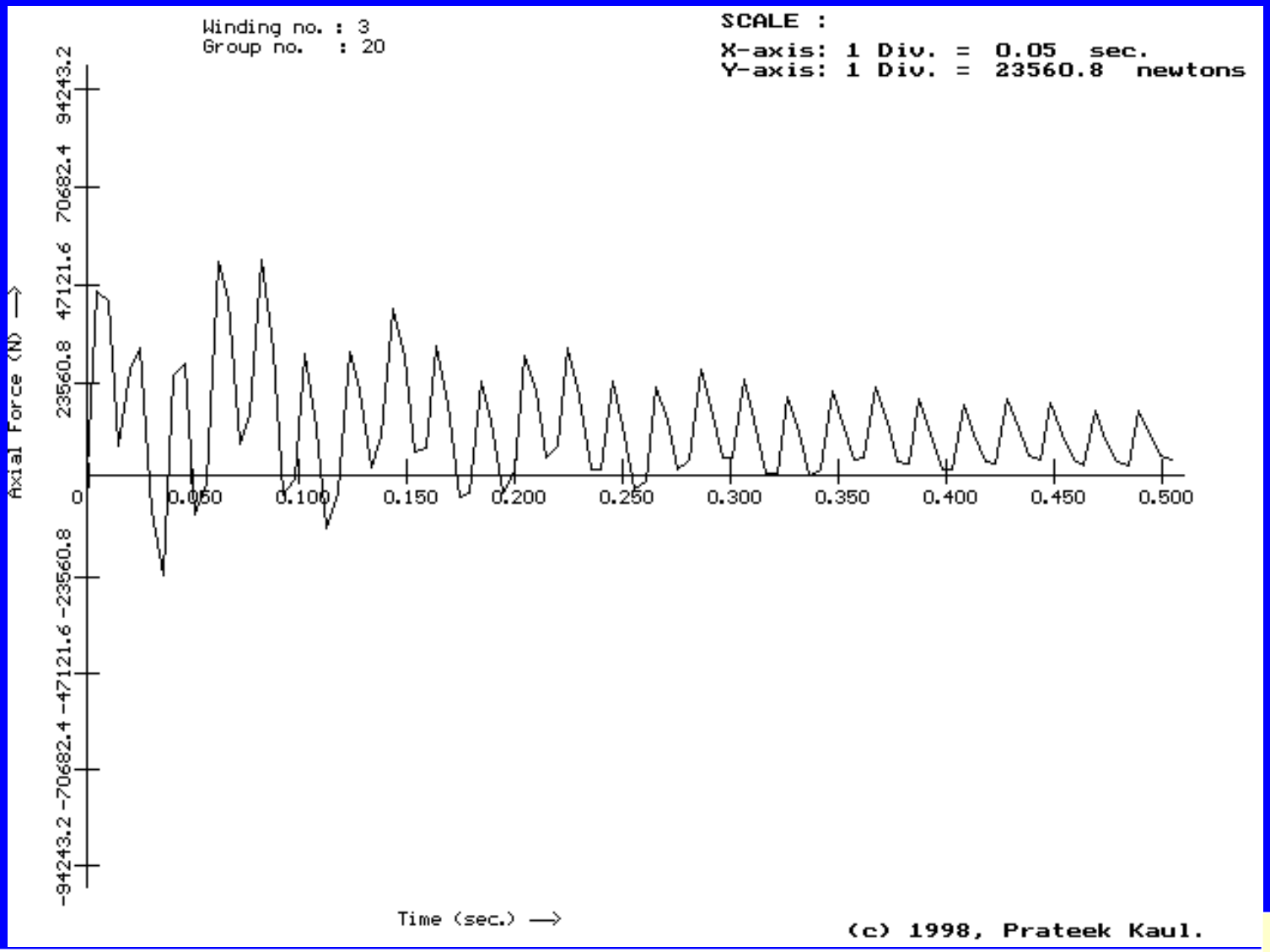
§ INTEGRATION OF FORCES ALONG THE WINDING

§ DYNAMIC SHORT CIRCUIT ANALYSIS : CALCULATION OF NATURAL FREQUENCIES FOR SPRING-MASS MODEL AND AVOID RESONANCE - UNDER DEVELOPMENT

§ USE OF GLUED CTC CONDUCTORS FOR HIGH CURRENT GENERATOR TRANSFORMERS.

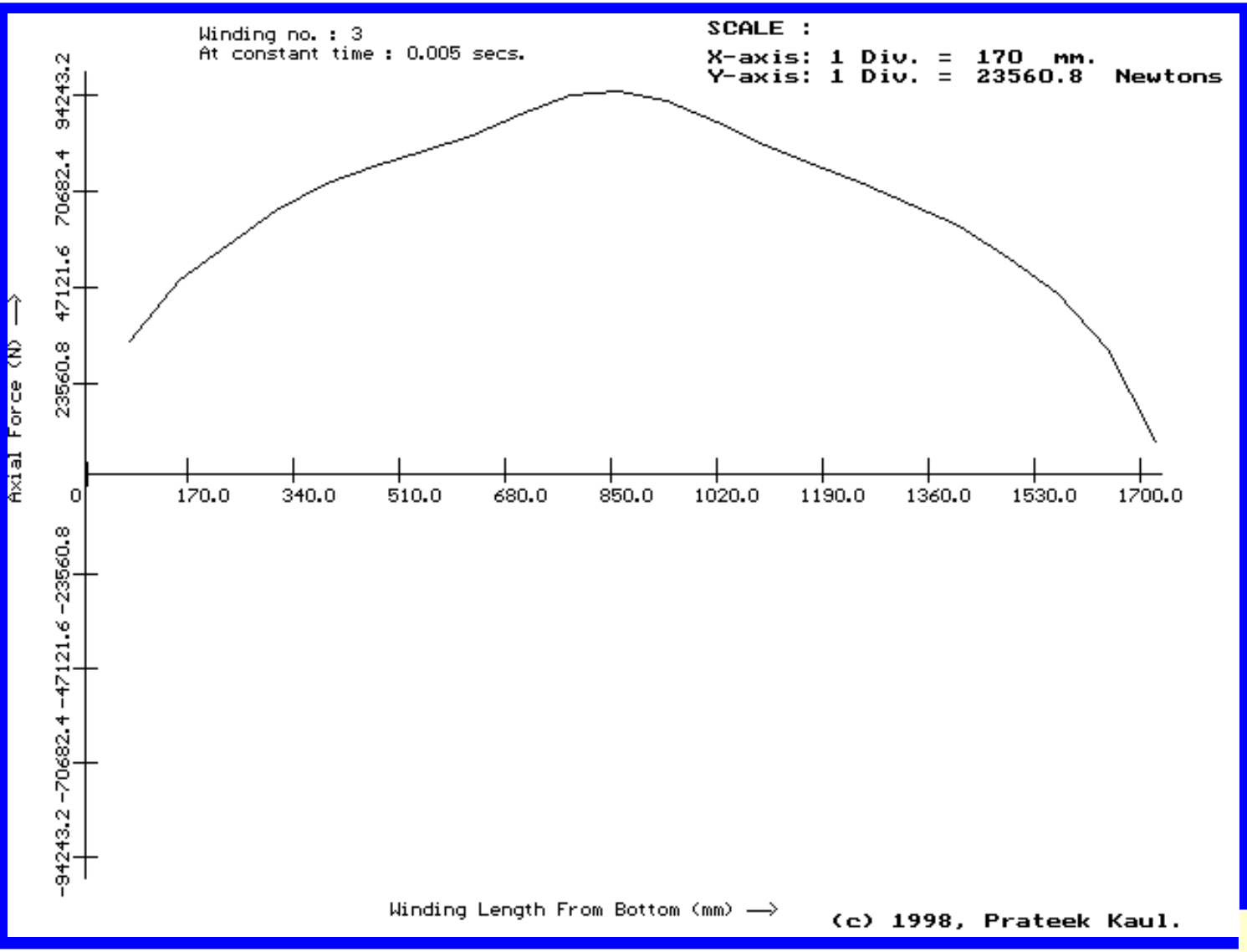
Next

# Force Pattern at a location




Next

# Force along winding at a time instant

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# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## THERMAL DESIGN

- § TRANSFORMER LIFE CLOSELY RELATED WITH TEMPERATURE OF INSULATION AND PAPER COVERING
- § HENCE NECESSARY TO ESTIMATE ACTUAL HOT-SPOT TEMPERATURE AND ITS LOCATION IN THE WINDING
- § CONVENTIONAL TEMPERATURE RISE MEASUREMENTS ARE AVERAGE OIL AND WINDING RISES
- § PRESENT METHOD: HOT-SPOT=TOR+1.1*AV WDG GRADIENT (50+1.1*15)=66.5 DEG.
- § ON LARGE JOBS ACTUAL HOT SPOT WAS MEASURED BY FIBRE-OPTIC PROBE AROUND 69.5 DEG = 50+1.3*15
- § HENCE THE NEED FOR DIRECT HOT-SPOT MEASUREMENT

Next

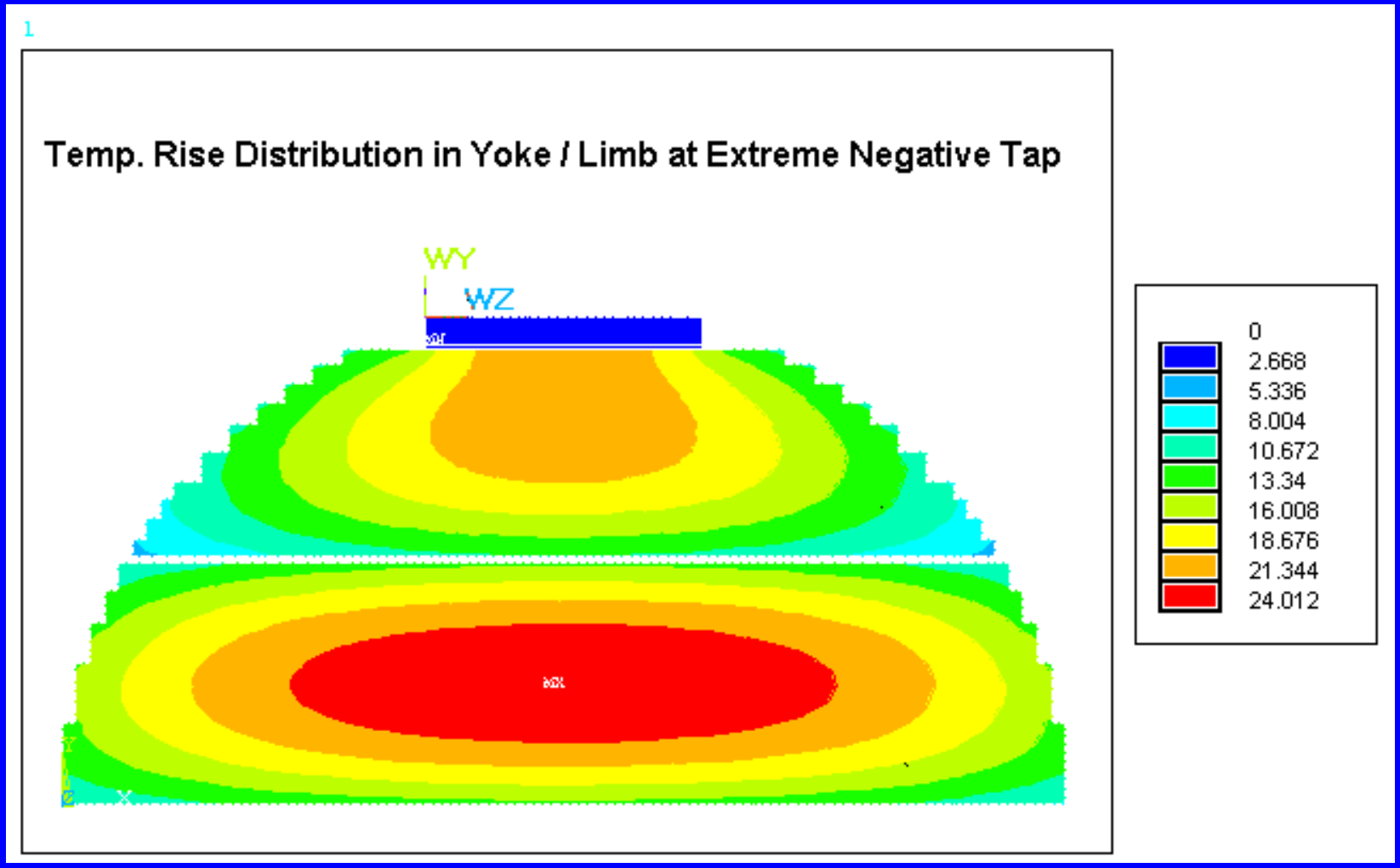
# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## THERMAL DESIGN

- § ACCURATE ESTIMATION OF WATTS PER UNIT AREA FROM DC RESISTANCE LOSS & EDDY LOSS
- § LIKELY HOT SPOT LOCATION: TOP DISCS (DUE TO HIGHER EDDY LOSS ON ACCOUNT OF FRINGING OF FIELD) AND HIGHER OIL TEMPERATURE
- § DIRECT HOT SPOT MEASUREMENT - PART OF ON-LINE MONITORING SYSTEM IN COMING YEARS

Next

# 3D FEM Thermal Analysis of Core

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# LOW NOISE TRANSFORMER

- MEASURES FOR UPTO 10 dB REUCTION
  - REDUCTION OF FLUX DENSITY
  - USE OF HI-B MATERIAL
  - RESI-GLASS BANDING OF THE CORE
  - ANTI-VIBRATION MOUNTS
  - LOW NOISE FANS

- MEASURES FOR MORE THAN 10 dB REUCTION
  - SANDWICH PANELS
  - DOUBLE TANK DESIGN
  - CONCRETE ENCLOSURES
  - ACTIVE NOISE CANCELLATION

- ACHIEVED 60 dB ON 90 MVA TRANSFORMER, WORKING FOR 50 dB FOR TRANSFORMERS UPO 50 MVA

Next

# Transformer Integrated Design Package

- Takes customer specification as input
- Provision to change the standard values
- Strong user interface - interactive design
- Checks impulse, thermal, short-circuit performance
- Optimization to either get minimum material cost or minimum total capitalized cost (material cost + loss cost)
- Gives output as design data sheet and electrical specification for manufacturing
- Integration with total CAD

Next

# State of the Art Software

2D and 3D FEM analysis

- Electromagnetics - MAGNET
- Structural - ANSYS, IDEAS
- Thermal- IN-HOUSE DEVELOPED
- Electrostatics - IN-HOUSE DEVELOPED
- Seismic - ANSYS

Next

# REQUIREMENTS OF MODERN POWER TRANSFORMERS

## EMERGING NEEDS

- § LOW NOISE TRANSFORMERS ( ACHIEVED 60 dB ON 90 MVA rating )
- § DIRECT HOT SPOT MEASUREMENT FIBRE OPTIC SENSORS
- § GEARED UP TO DESIGN & MFR. TRANSFORMERS UPTO 500 kV, 500 MVA )
- § ENERGY EFFICIENT TRANSFORMERS (DEVELOPMENT OF 1600
- § KVA AMORPHOUS CORE TRANSFORMER)

Next

# TECHNOLOGY MANAGEMENT

- TECHNOLOGY SCAN
- CONTINUOUS TRAINING IN STATE OF THE ART TOOLS
- TECHNOLOGY ACQUISITION
- TECHNOLOGY FORECASTING
- FRONTIER LEVEL APPLICATION ORIENTTED RESEARCH

Next

# INTERNATIONAL PUBLICATIONS IN LAST 3 YEARS

| | |
|---|---|
| IEEE (USA) | 3 |
| IEE (UK) | 2 |
| TOTAL QUALITY MGMT (UK) | 1 |
| ISEF (GREECE) | 1 |
| ISH (CANADA) | 1 |
| INTL. JOURNAL OF POWER & ENERGY SYSTEMS (UK) | 1 |
| AACE (USA) | 1 |
| SAVE INTERNATIONAL (USA) | 1 |

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