



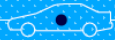
MSC.Marc SIMULATION  
of  
Proposed Fluid Cooled Catheter Design  
for  
In-Stent Restenosis

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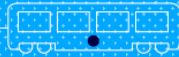
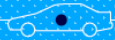
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# Summary

Arteries that are obstructed by plaque may reduce or prevent blood flow, producing strokes or cardiac arrest. If the stenosis is severe, invasive coronary bypass surgery may be required, but balloon angioplasty, often followed by a drug coated stent insertion, is the less invasive, preferred current treatment method. Unfortunately, experience has shown that approximately 65% of cardiovascular stents suffer in-stent restenosis – i.e. become significantly blocked, within six months of the angioplasty procedure.



# Design Objective

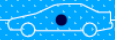
The design of a catheter mounted device able to deliver controlled energy sufficient to prevent the formation of stenotic tissue, without damaging artery walls or surrounding tissue, would therefore be of significant benefit.



# MSC.Marc Application

Due to their small dimensions, direct measurement of stress levels, temperature distributions and flow characteristics within such a device is not feasible. Hence, FEA modeling, carefully correlated with bench test results, may provide an advantageous design tool.

The present work discusses the influence of MSC.Marc FEA simulation with respect to evaluation and modification of a proposed fluid cooled catheter design for in-stent restenosis applications.



# Model Objectives

Design Considerations:

Evaluate Preliminary Design Geometry

Evaluate Proposed Material Properties

Evaluate Proposed Coolant Flow Parameters

Proposed Temperature and Power Distribution

Study effects on Blood and Tissue



# FEA Model Parameters

2-Dimensional Axi-Symmetric Element

(QUAD 4, TYPE 10, SOLID)

Solution – fully coupled fluid-thermal-solid

Large Displacement

Transient Thermal with Initial Conditions

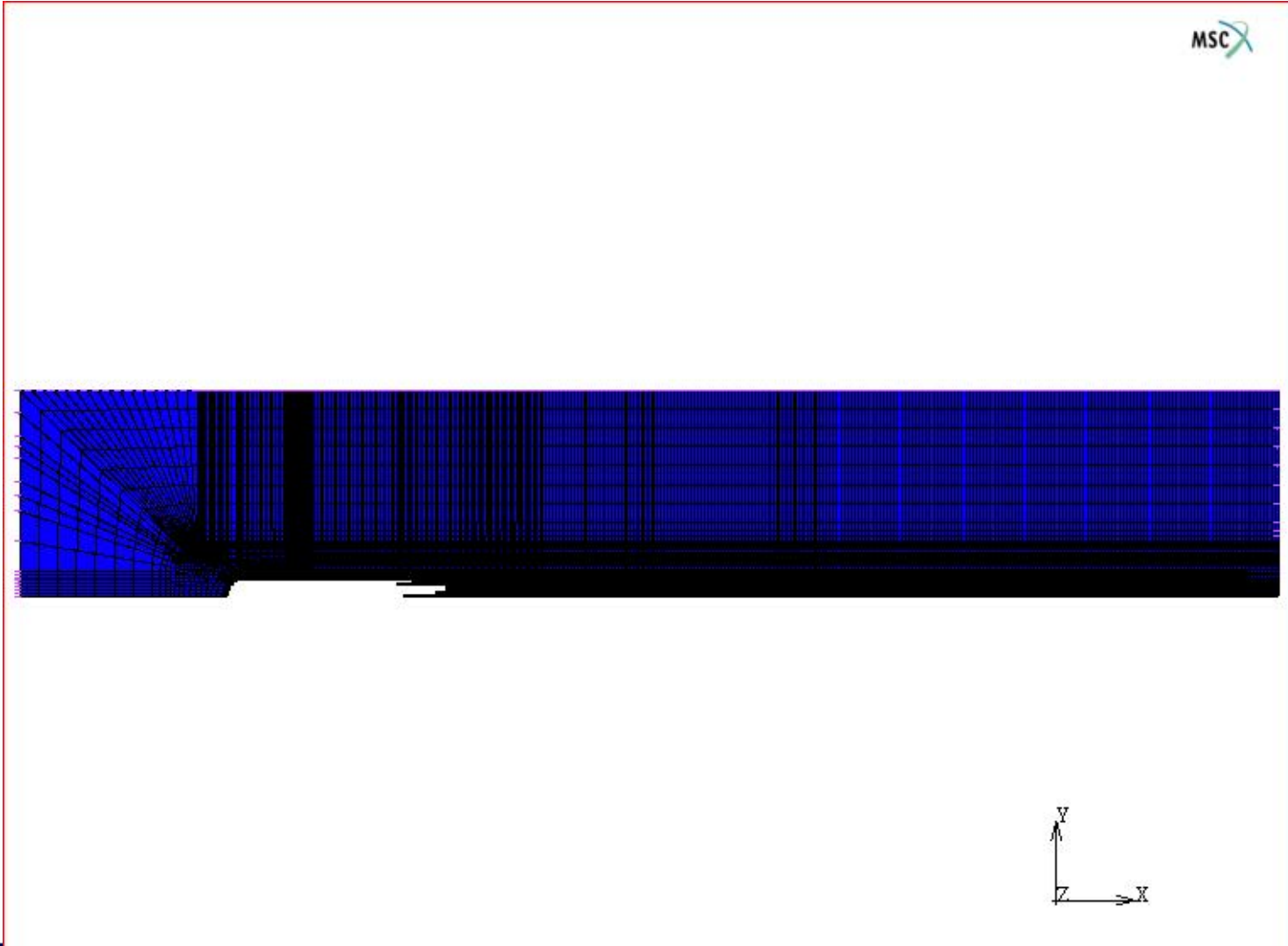
Newtonian Fluid

Linear & Non-Linear Materials

Boundary Conditions



# FEA Model Geometry





# Material Properties

## □ Mechanical

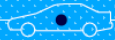
- Modulus, Poisson's, Mass Density

## □ Thermal

- Conductivity, Specific Heat, Mass Density

## □ Fluid

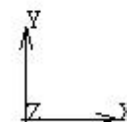
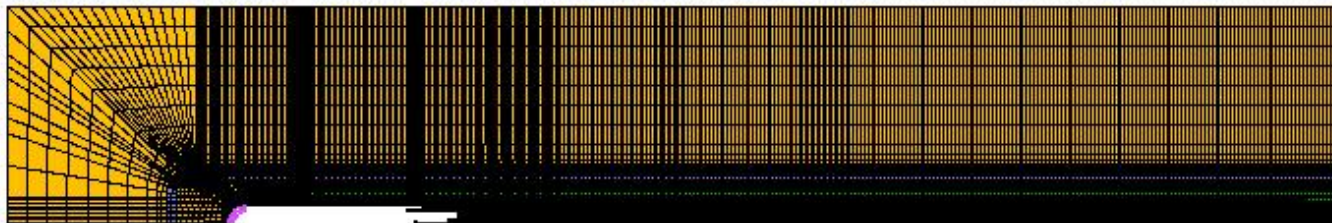
- Newtonian, Viscosity, Mass Density



# FEA Model Geometry

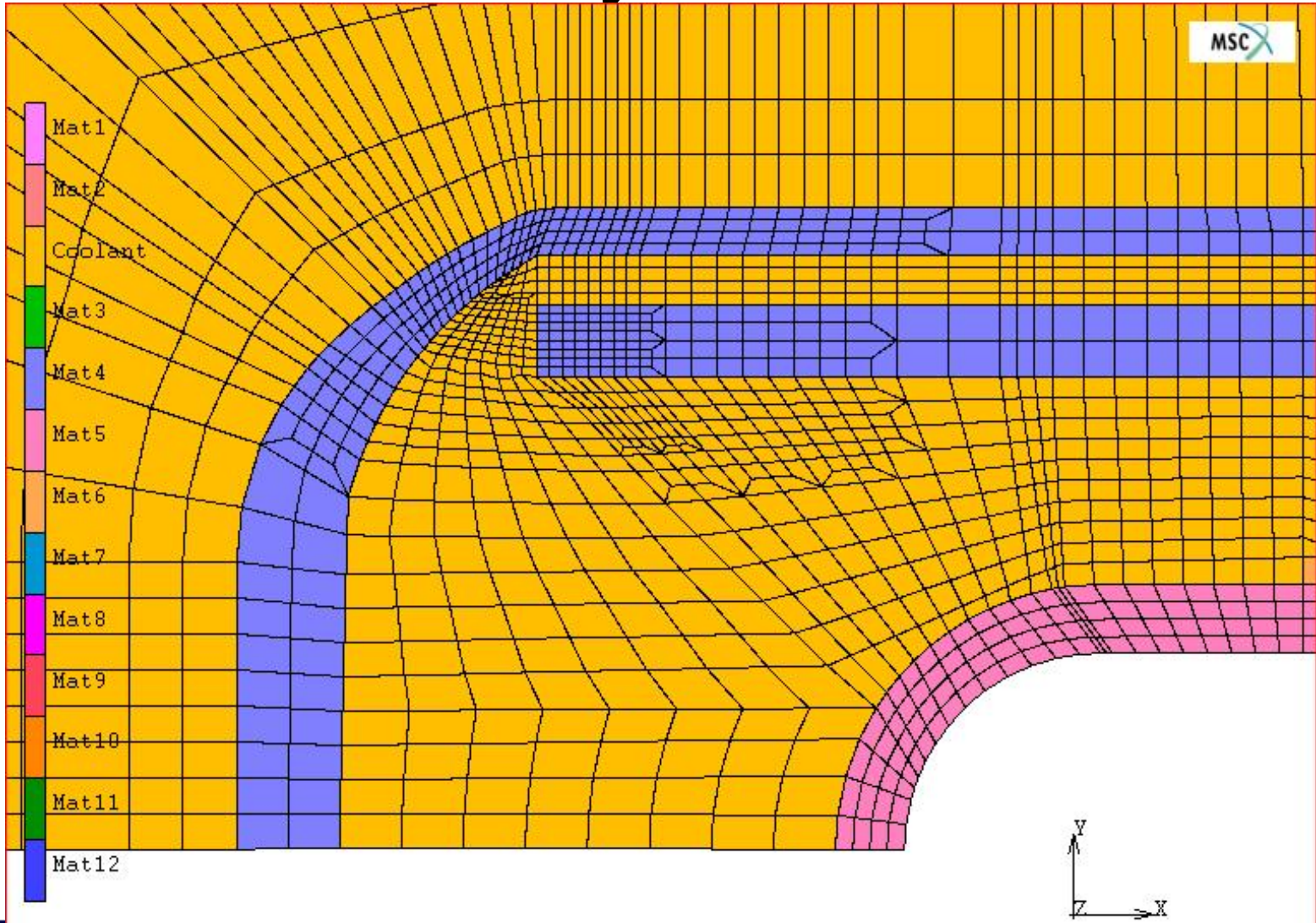


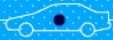
- Mat1
- Mat2
- Coolant
- Mat3
- Mat4
- Mat5
- Mat6
- Mat7
- Mat8
- Mat9
- Mat10
- Mat11
- Mat12





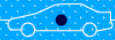
# FEA Model Geometry





# Coolant Fluid Parameters

- Channel Geometry
- Flow Direction
- Localized Turbulence
- Viscosity
- Inlet Temperature
- Inlet Velocity



# Power, Temperature & Velocities

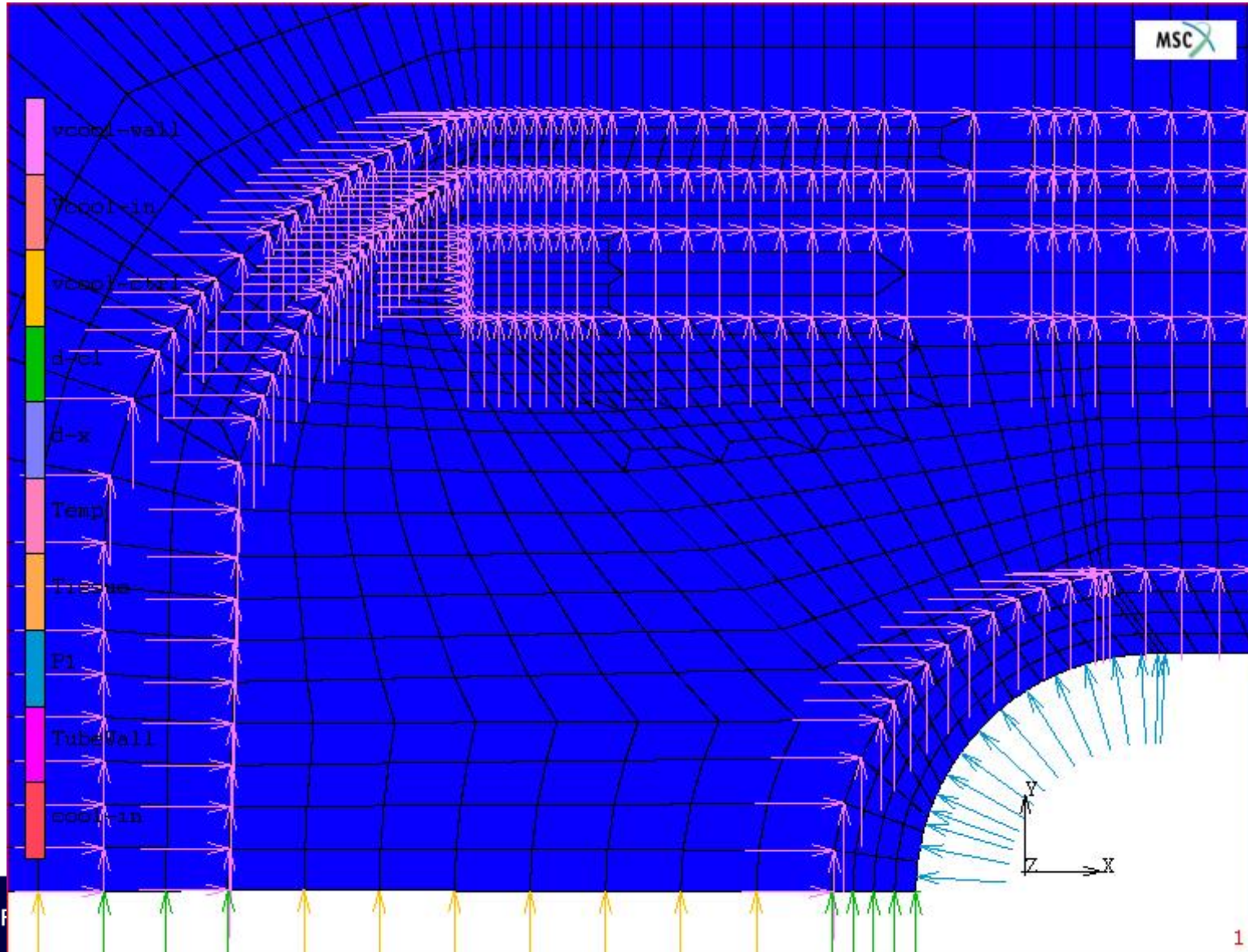
Surface Temperature Distribution

Surface Power Distribution

Wall Velocities



# Model Boundary Conditions





# Study Results

Model used to predict effects of:

Coolant and Component Temperature Distributions

Material Selection Effects on Temperature Distributions

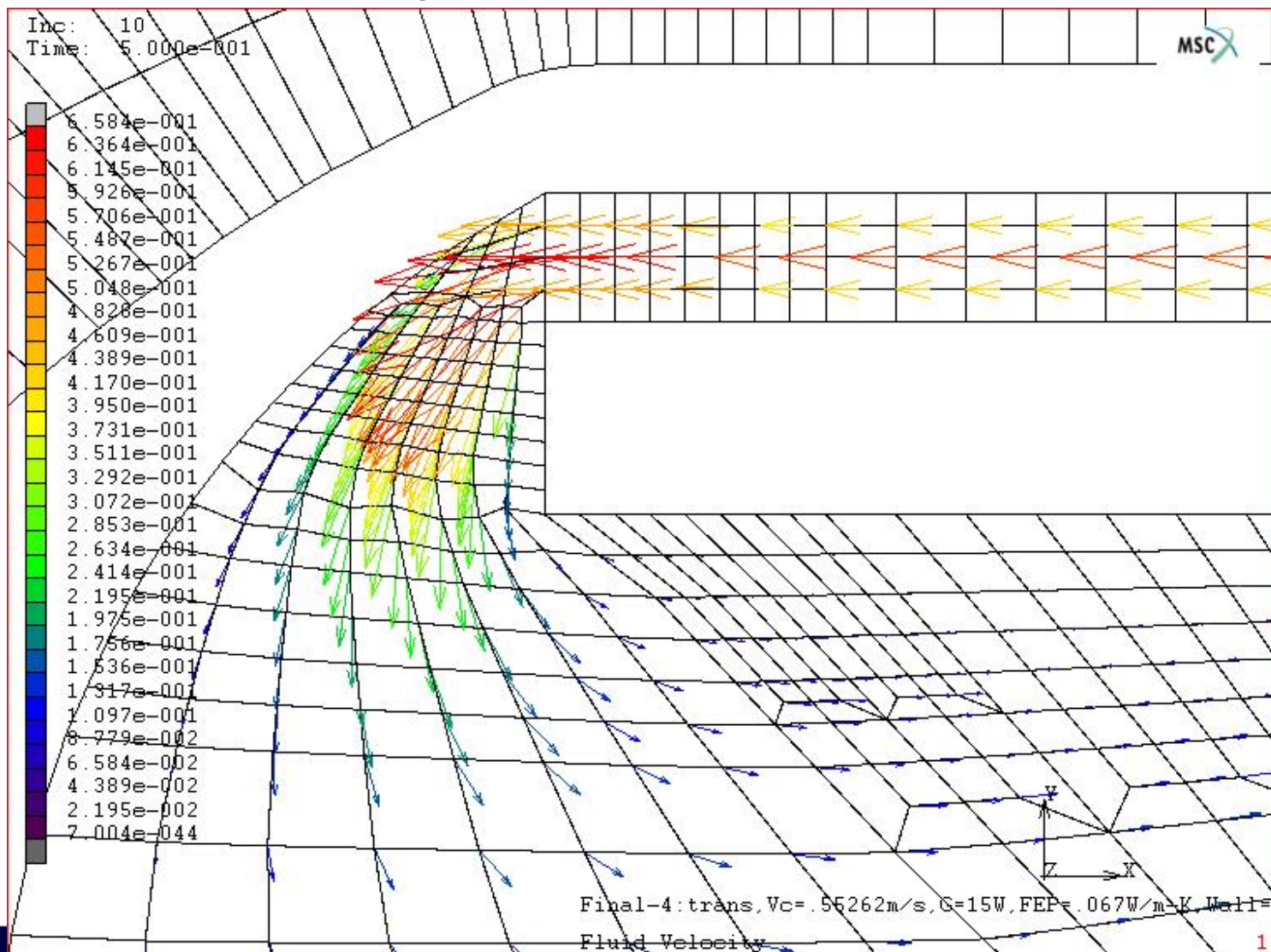
System Temperature Distributions due to Variations in  
Coolant Inlet Velocity & Temperature

Temperature vs. Time Characteristics

Dimensional Changes vs. Temperature



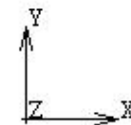
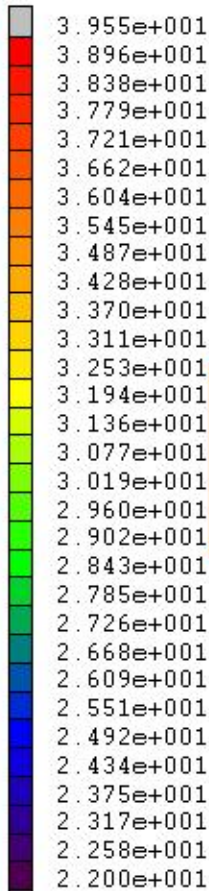
# Coolant Velocity Vectors





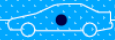
# Coolant Temperature Distribution

Inc: 10  
Time: 5.000e-001

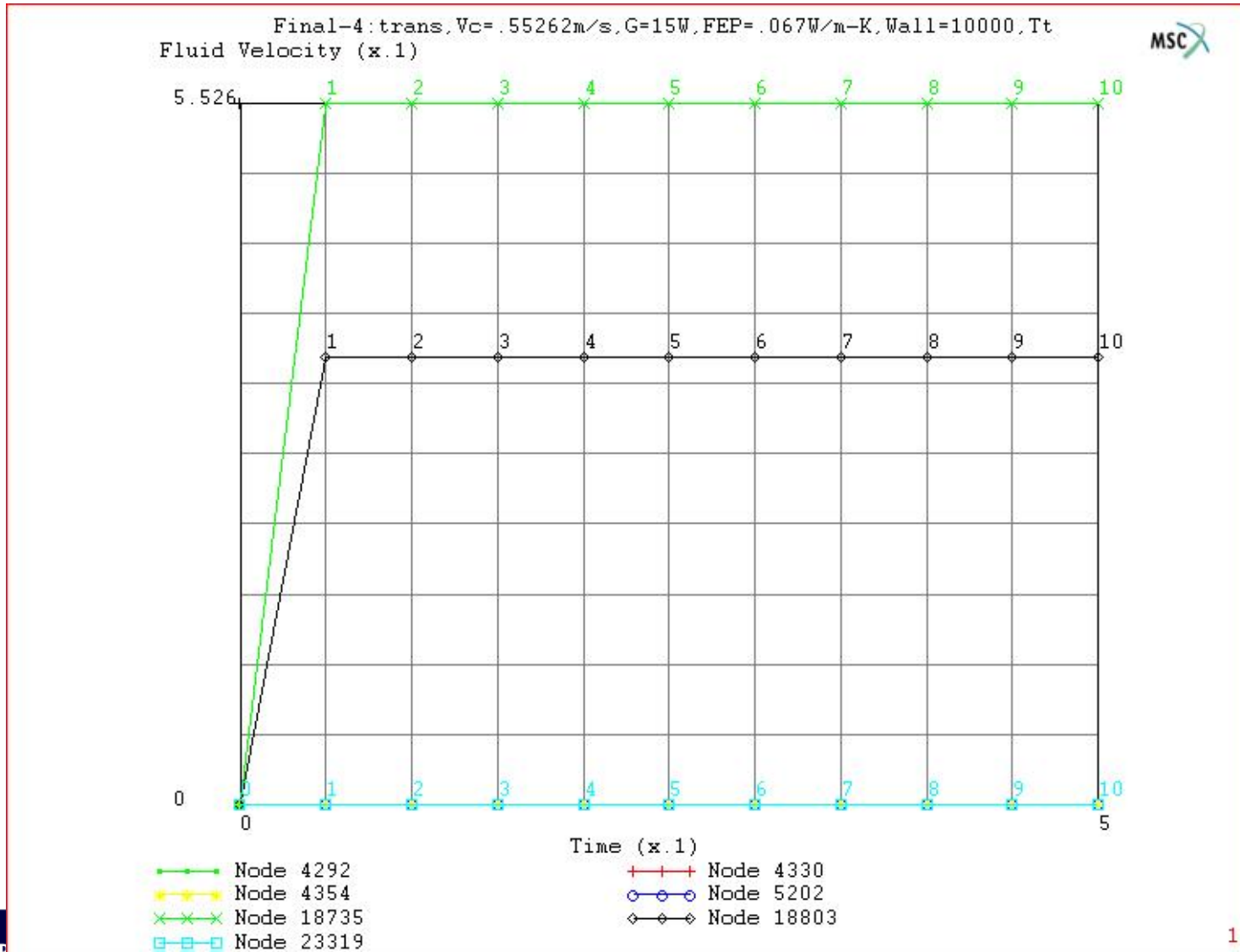


Final-4:trans,Vc=.55262m/s,G=15W,FEP=.067W/m-K,Wall=1

Temperature



# Time History Plots





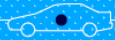
# Model vs. Bench Test Data Correlation

Macro Heat Transfer Bench Test Data Showed Good Correlation with FEA Model Results

Model Correctly Predicted Potential Problem Areas as Verified by Bench Testing

Model Correctly Predicted Effects Due Changes in Insulation Material Thickness

Model Correctly Predicted Radial High Voltage Breakdown Effects



# Model vs. Bench Test Correlation

Model Allowed Rapid, Low Cost Evaluation of Effects Due to Using Unusual Materials and Thermal Properties

Model Successfully Used to Evaluate Effects of Proposed Geometry Design Changes

Model Results Reduced Time and Costs for Fabrication Method Development

Model Correctly Predicts Energy Effects on Surrounding Tissue