Static and Dynamic Modeling of Piezoelectric Drivers in Drop on Demand Printing

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Overview

- Introduction
- Purpose
- Device Analysis
- Devices Modeled
- Finite Element Analyses
- Results
- Conclusions

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Introduction

- Ink jet printers have evolved in the SOHO market with high resolution and image quality
- Two technologies are used, bubble jet and piezoelectric
- Our focus is on piezoelectric technology for industrial applications that did not advance as the SOHO market
- Industrial applications require higher printing speed, defect free printing for longer times and not very high resolution
- Ink variability is important in order to meet regulations without compromising the performance required

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Purpose

- Use FEM to study the effect of ink variables and print speed on print quality
- Obtain deformations, modes of vibrations and the effect of ink damping
- Couple structural to fluid behavior in order to predict drop formation

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Device Analysis

- Print head performance is affected by device geometry, all material properties including the ink's and by electric pulse applied
- Traditionally devices were analyzed using lumped mechanical models
- There were also few finite element based analyses

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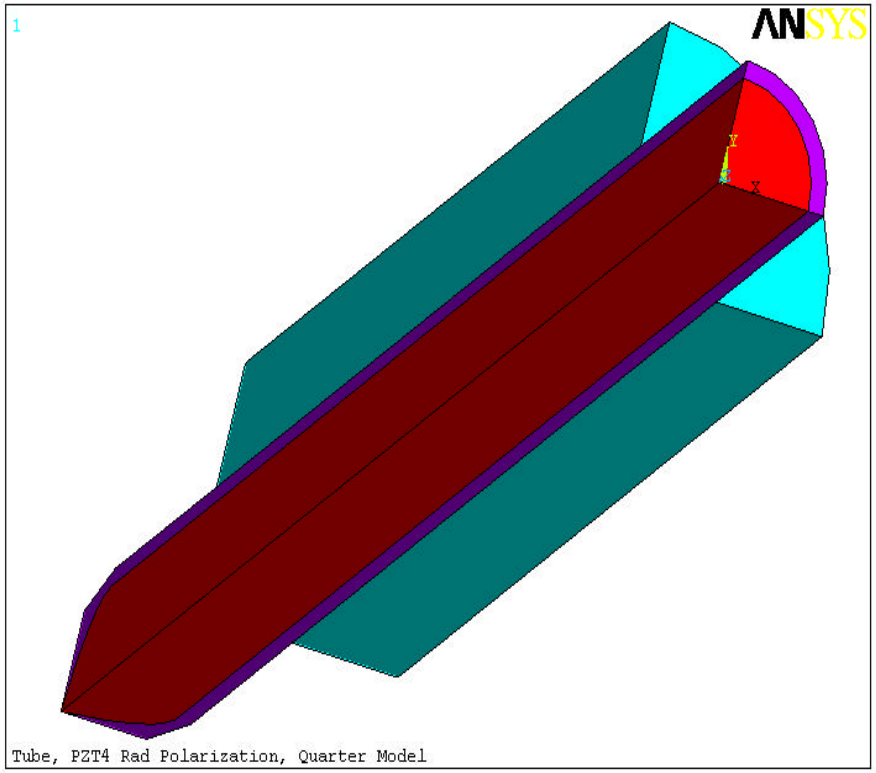
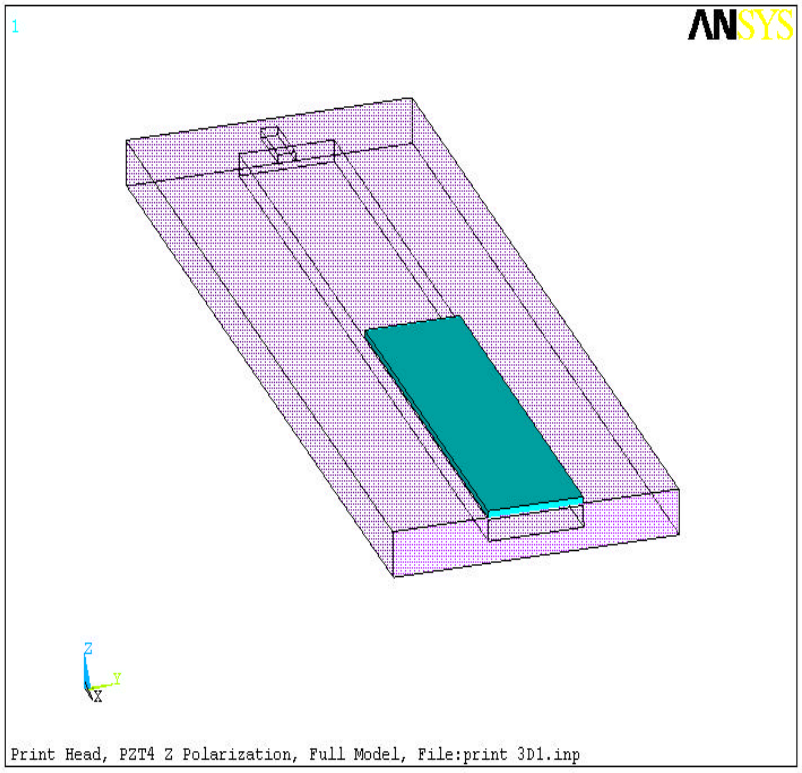
Devices Modeled

Cylindrical tube and rectangular print head





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Finite Element Analyses

Cylindrical Tube

- 3-D quarter symmetry model. Coupled Field elements for piezoelectric PZT-4. 3-D Solid for Glass and Fluid element for ink using Super-element
- Analysis performed are static to validate material behavior. Modal to capture model shapes and frequencies in open and closed circuit. Transient dynamics under a square pulse that allow capturing tube true behavior

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Finite Element Analyses

Print Head

- 3-D full model. Coupled Field elements for piezoelectric PZT-4. 3-D Solid for substrate and Fluid element for ink using Super-element
- Analysis performed are static to validate material behavior

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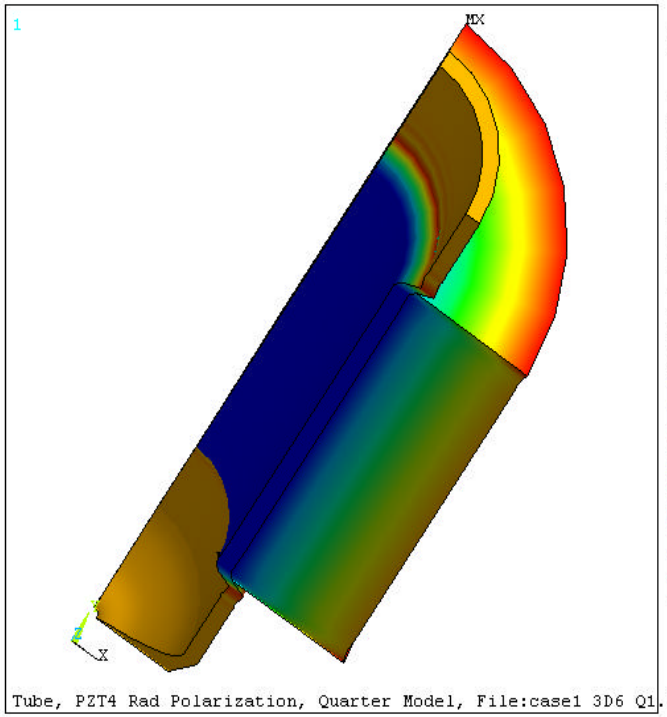
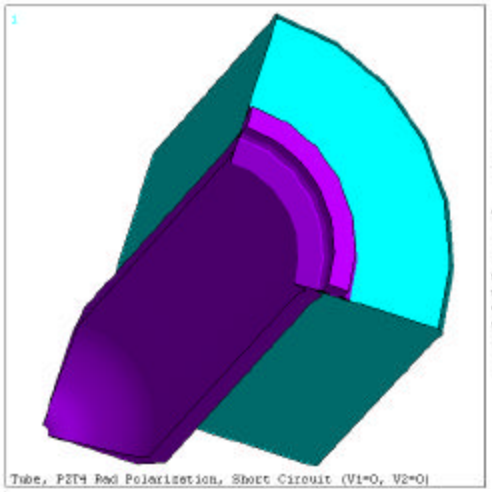
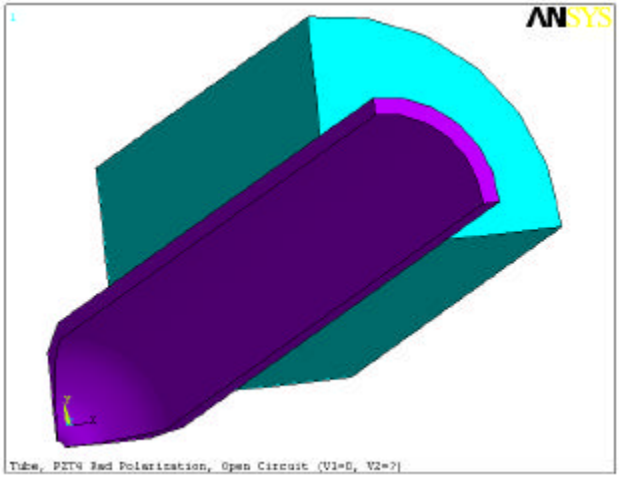
Cylindrical Tube Results

Static under 80 volt. Max def of .02 micron







1st modes for closed and open circuit with frequency of 15Khz

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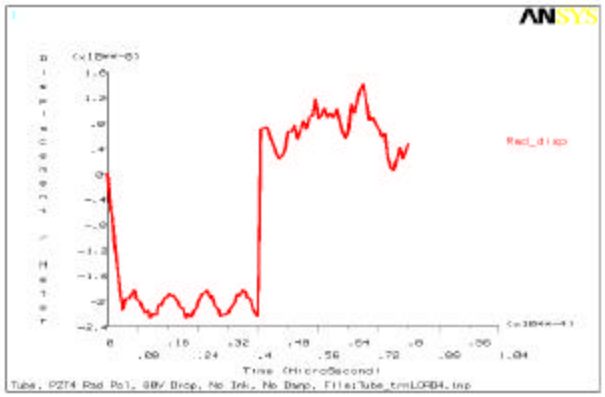
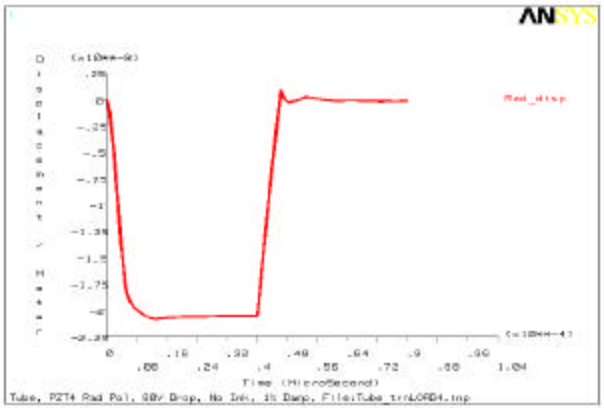
Cylindrical Tube Results

Transient analysis results under 80 volt 40 microsecond square pulse

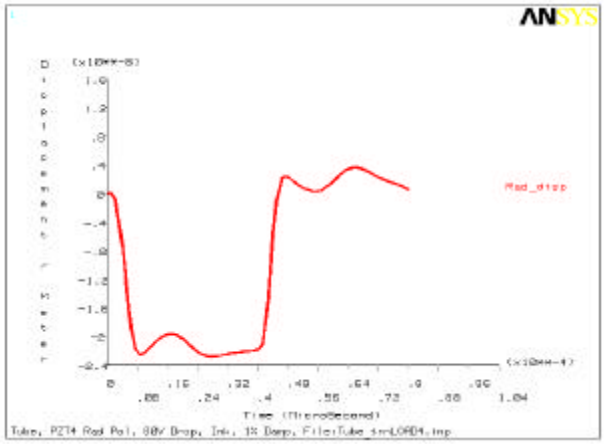
No ink
no damp



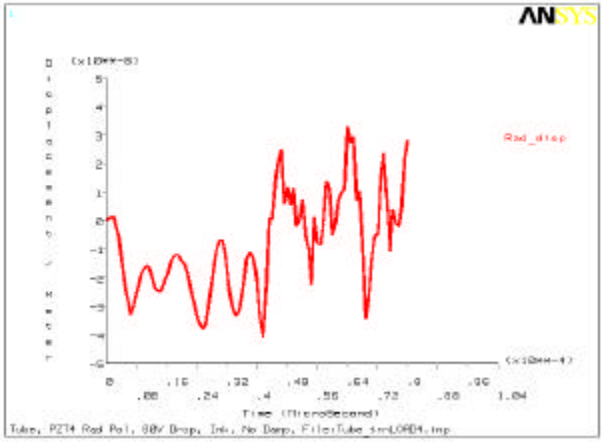
No ink
damp



Ink damp



Ink
no damp



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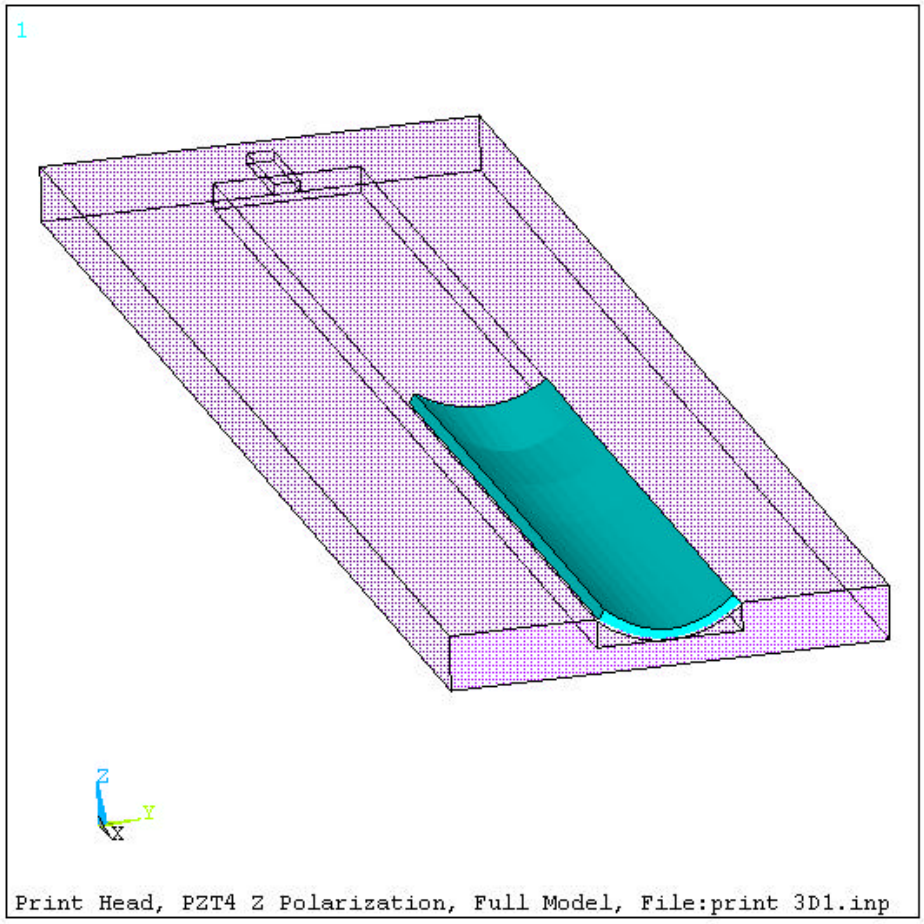
Print Head Results

Static def under 80 volt. Max def is 0.22 micron



ANSYS 5.6
MAY 1 2000
17:15:10
DISPLACEMENT
STEP=1
SUB =1
TIME=1
RSYS=0
DMX =.222E-06

*DSCA=500
XV =.905691
YV =-.255947
ZV =.337958
*DIST=.001639
*XF =.001759
*YF =-.295E-03
*ZF =.418E-03
A-ZS=-83.344
CAPPED Z-BUFFER
EDGE

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Conclusions

- FEM can be used to study the dynamic response of piezoelectric ink jet devices
- Modeling illustrates the effect of materials, device geometry and ink variables on final drop formation
- Ink damping, mass and bulk modulus affect device response
- Piezoelectric material properties should be validated in terms of values and orientation
- Future work will incorporate the ink's surface tension in order to predict drop formation. This requires better structural – fluid coupling

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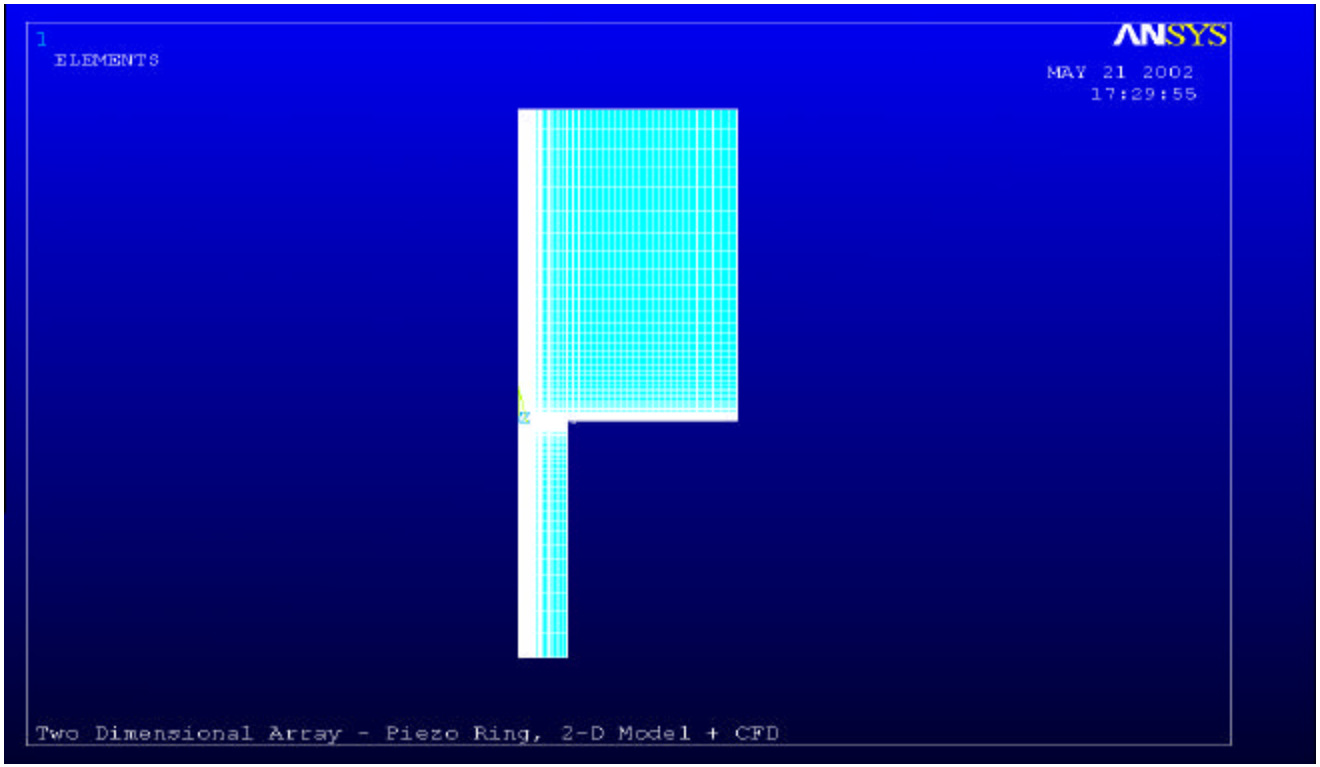
Conclusions

- Current work incorporates FSI between piezoelectric model and ink model



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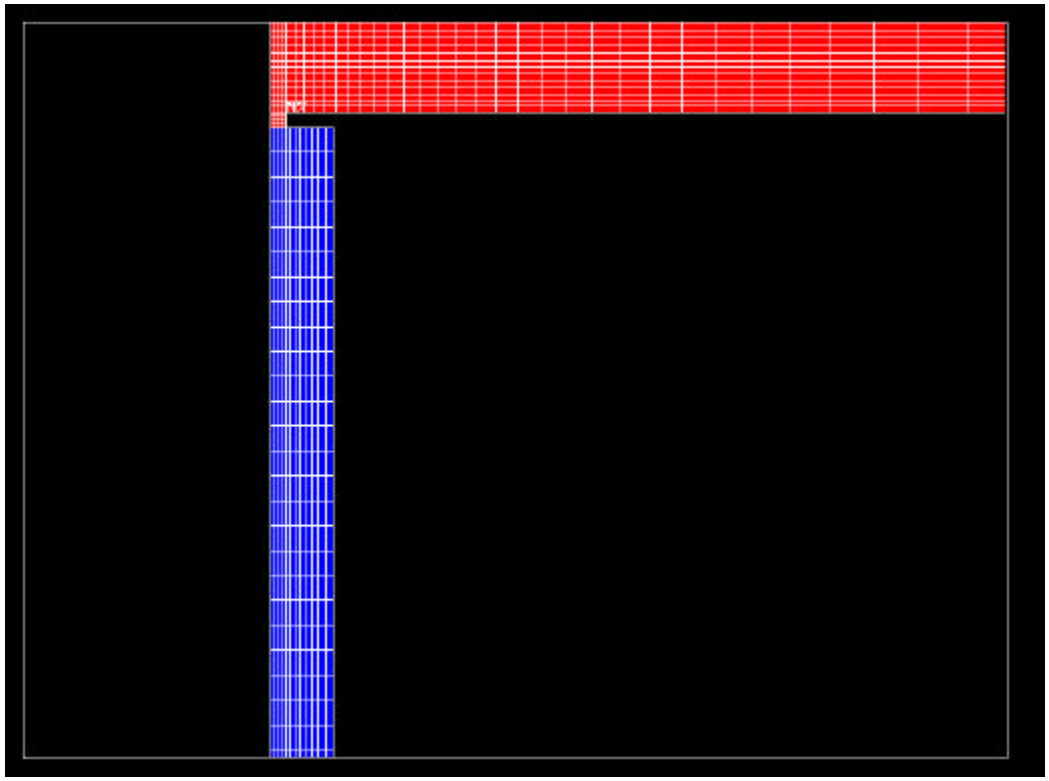
Conclusions

- Current work incorporates FSI between piezoelectric model and ink model – drop formation



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