GEORG

GEOTHERMAL RESEARCH GROUP

Deep geothermal wells – Model development and verifications

DRG-H3.2
MECHANICS OF MATERIALS FOR DEEP ROOT EQUIPMENT, FAILURE ANALYSIS AND IMPROVEMENTS IN DESIGN

Introduction

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Deep Geothermal Wells

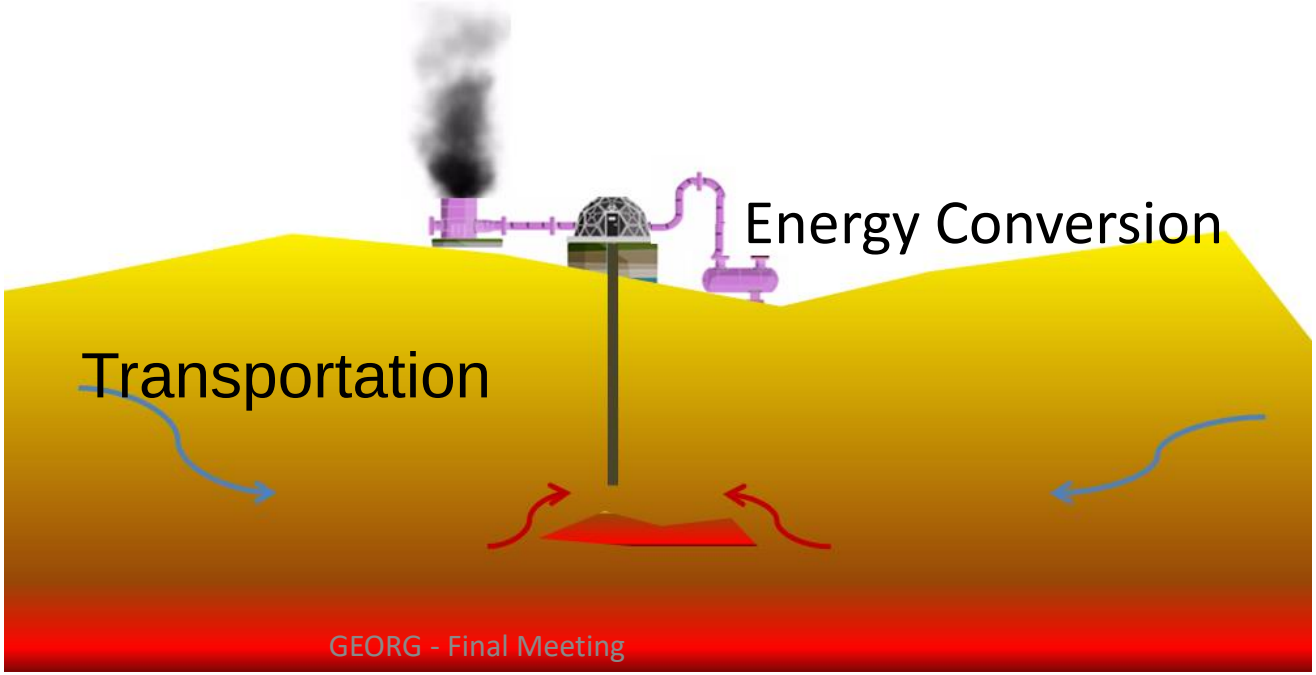
Outline:

- Introduction
- Model Developments
- Verifications
- Root Cause Analysis
- Improvements
- Summary

Introduction

Objective

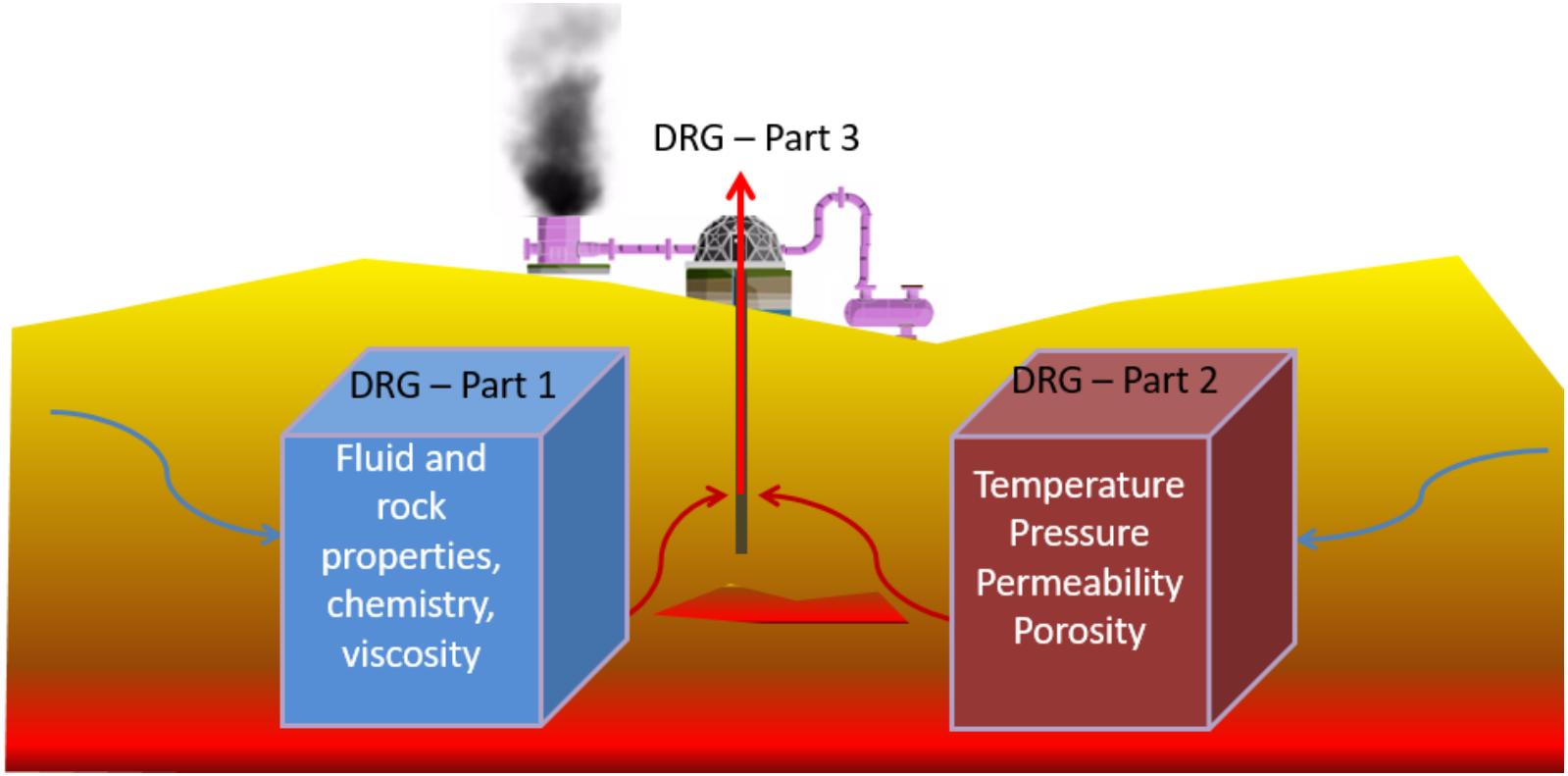
The main goal of this research is to develop a process to utilize the high enthalpy geothermal fluid which comes from drilling into deep geothermal systems.



Introduction

DRG – Part 1

DRG – Part 2



Model Developments

Nonlinear FEM Models

Casings and surrounding

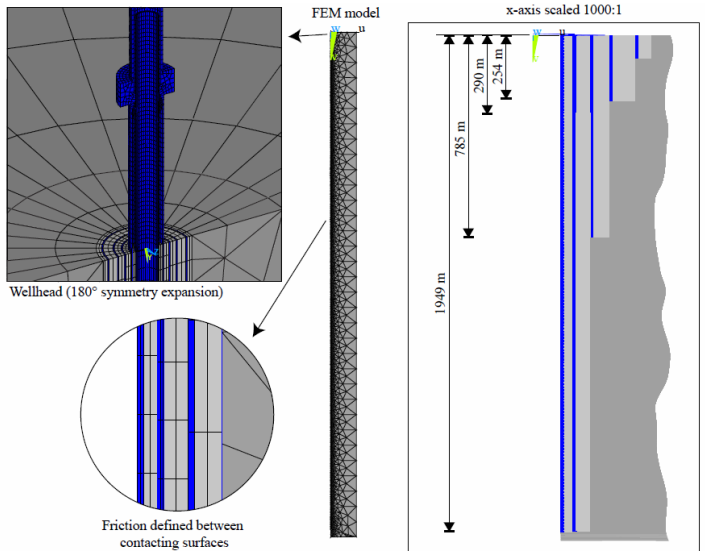
Thermal model: Two dimensional axisymmetric
Transient thermal analysis

Structural model: Two dimensional axisymmetric
Axial and radial deformations

Simplified couplings and wellhead

Nonlinear behaviour:

- Large geometric displacements
- Nonlinear material behaviour
- Connections between surfaces

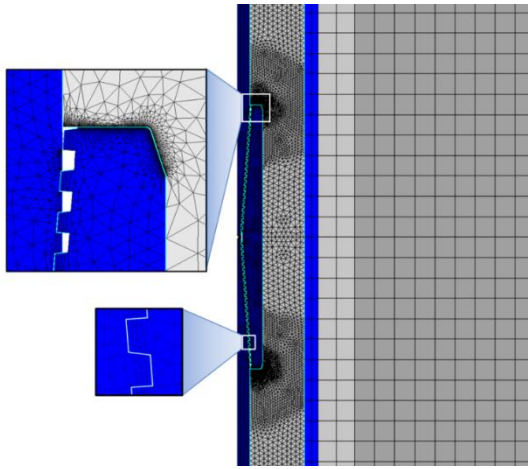


Model Developments

Nonlinear FEM Models

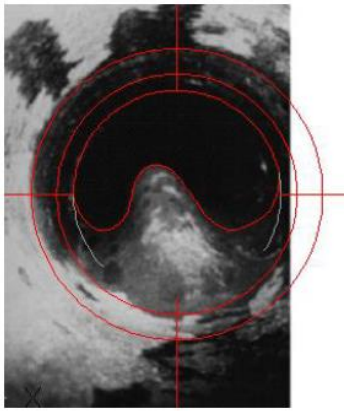
Coupling in concrete

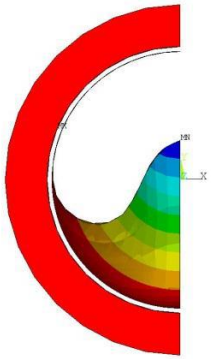
Structural model: Two dimensional axisymmetric

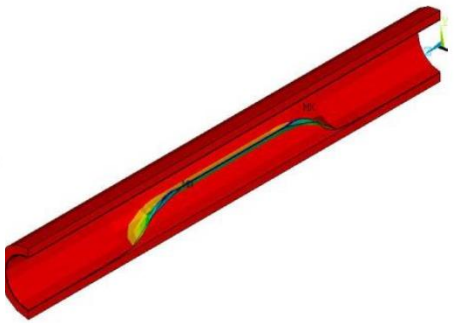


Casing sections

Structural model: Three dimensional



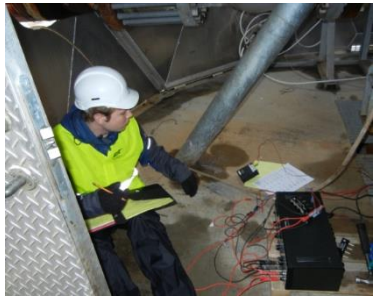


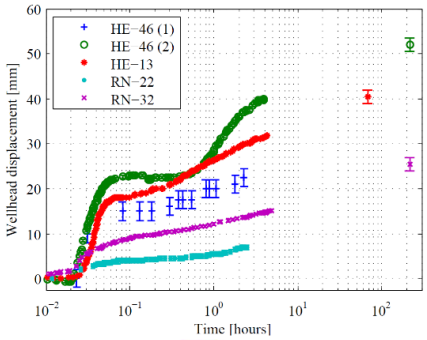


Verifications

Two dimensional thermal and structural model

- The model has been tested against wellhead displacement data of different wells and shows good agreement.

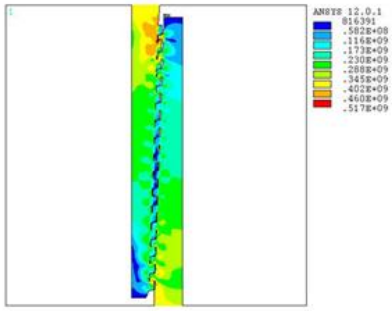




Two dimensional coupling model

Three dimensional sections model

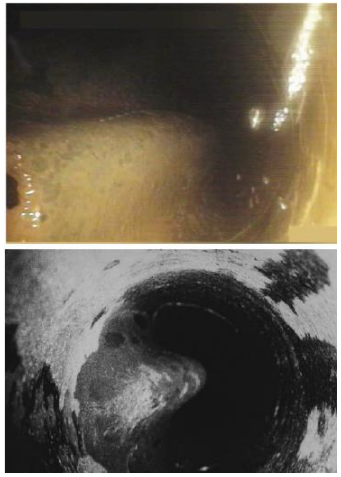
- Comparison with analytical and experimental data show good agreement.

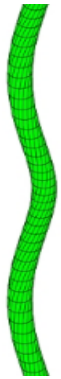


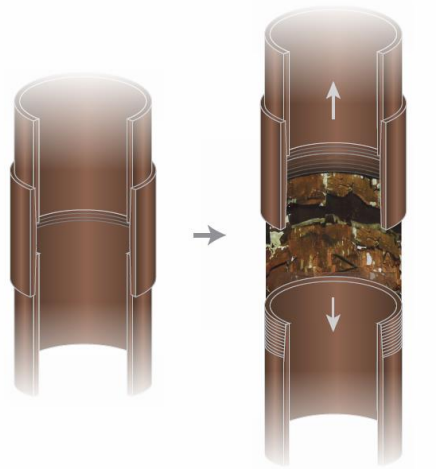
Root Cause Analysis

Failure Analysis

- Erosion and corrosion
- Radial loading
- Axial loading







Root Cause Analysis

Failure Analysis – Radial loading

Radial loadings are applied primarily by internal and external fluid pressures.

Internal Yield – Bursting - Collapse

During installation:

The differential pressures that occur before and during cementing process.

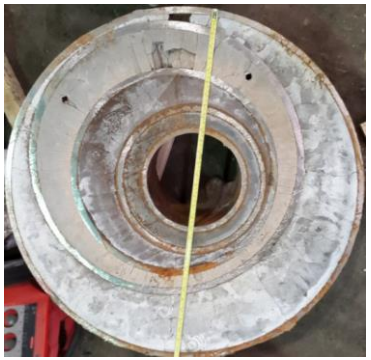
During operation:

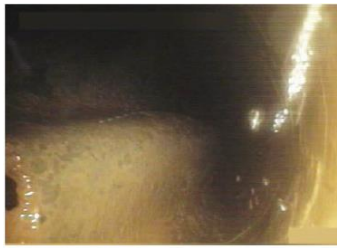
Thermal expansion.

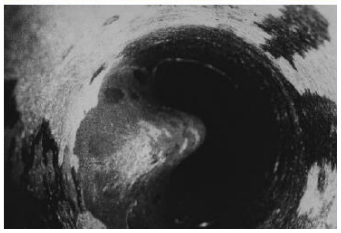
External pressure from entrapped fluid expansion.

Static pressure form a dense liquid column.

Pressure fluctuation during pumping or flashing.







Root Cause Analysis

Failure Analysis – Axial loading

Axial loadings are applied primarily by thermal expansion and self weight.

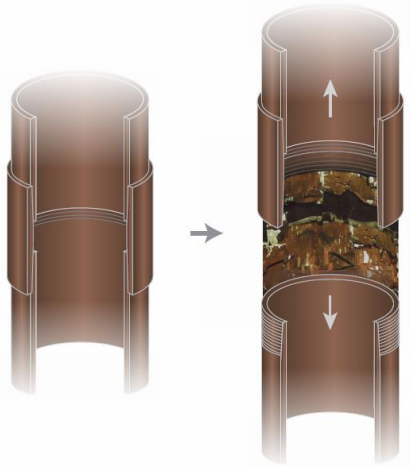
Buckling - Rupture

During installation:

Axial tension due to casing weight

During operation:

Thermal expansion during quenching and cooling.



Improvements

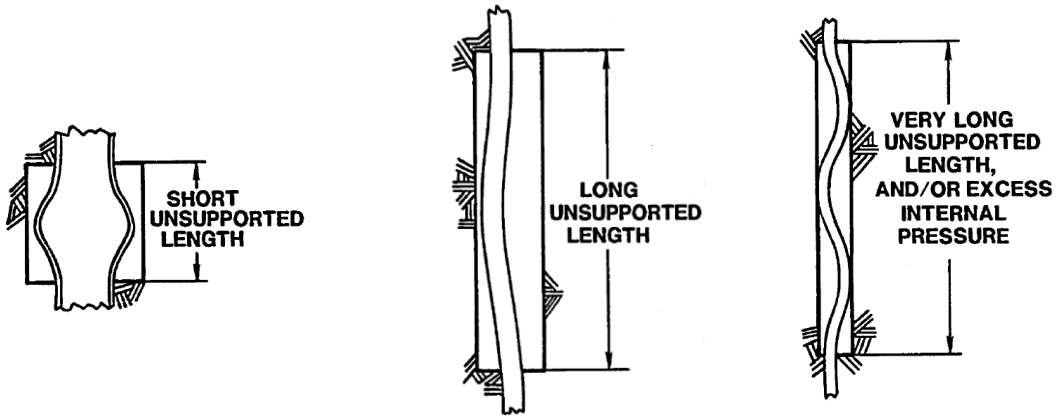
Improvements for radial loading:

- Improve the cementing process
- Chose the right material based on,
  - corrosion resistance,
  - thermal expansion,
  - yield stress,
  - young modulus.
- Chose the right dimensions according to
  - diameter,
  - thickness,
  - ovality.

Improvements

Improvements for axial loading:

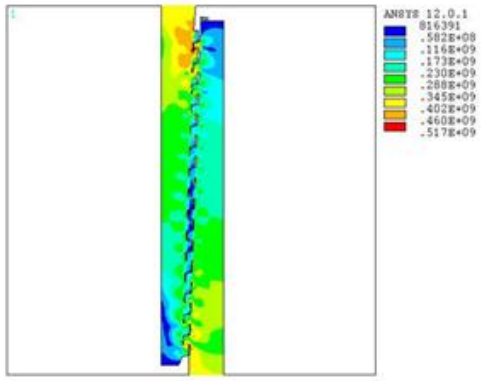
- Improve the cementing process
- Improve the quenching and cooling program
- Chose the right couplings

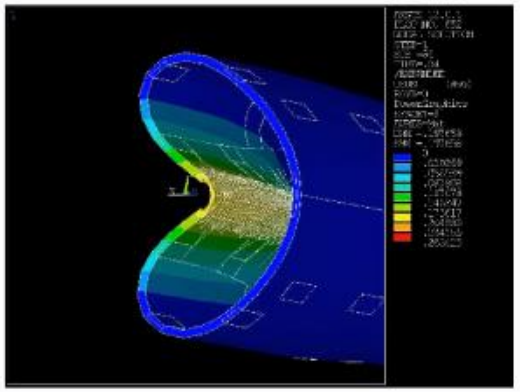


Summary

Summary:

- Introduction
- Material research
- Model development
- Verification
- Root cause analysis
- Improvements
- Conclusion





Summary

Questions ?