PTE 506 – Geothermal Reservoirs

Instructor: Dr. Fred Aminzadeh: Mork Family Department of Chemical Engr and Materials Science
Course credit: 3 units
Class Hours: Wed 11am – 1:40pm
Class Location:
Office Hours:
TA:

Catalogue Description:
Geothermal reservoirs, heat and mass flow in fracture network, enhanced geothermal systems (EGS), exploration methods, exploitation of hydrothermal and EGS fields, stimulation, forecasting, power generation.

Extended Course Description
This is a graduate course designed to introduce the fundamentals of geothermal energy exploration, production and power generation. The objective of the course is to provide students with the necessary foundations of key elements of geothermal resources. Different requirements for viable conventional (hydrothermal) geothermal reservoirs (heat, fracture system and fluid) will be highlighted. The necessary tools for predicting existence of such conditions such as characterization of fracture network, heat and mass flow, as well as steam generation will be discussed. The enhanced geothermal systems where at least one of the three components that exist in the hydrothermal geothermal is artificially generated, will be introduced. Well simulation, power generation and transportation issues as well as different typical applications of geothermal energy will be covered.

Course Vision and Objectives
This course is intended to provide an opportunity for graduate students in Petroleum Engineers and other engineering disciplines to learn about the technology associated with exploration, drilling, well completion, reservoir engineering and power plant design for various types of geothermal systems. Additionally the course will focus on enhanced geothermal system including issues related to fracturing, pressure maintenance and geophysics-based (eg micro-earthquake / conventional seismic) fracture characterization.

Recommended Preparation: Familiarity with MATLAB is useful but not essential.

Textbook:
Geothermal Reservoir Engineering, Malcolm Alister Grant & Paul F Bixley Elsevier, 2011

Grading:

Homework	20%
Midterm	20%
Term Project	30%
Final	30%

Expectations for Assignments, Exams, and Projects:

Homework assignments will be given on a weekly basis [3-4 hrs/week].

The Midterm and Final will consist of a written exam. Questions will include both qualitative issues to gauge general understanding of the subject matters by the students as well as problems requiring actual calculation based on equations discussed during the class.

The Term project will be a collaborative analysis among team members of an integrated case study, requiring the application of a variety of methods commonly used in geothermal resource exploration and development. The students will be assigned to work on different geothermal field, each having a specific challenges including expansion of the capacity, characterization of the field and design of power plants for optimum utilization of the generated steam from the fields as well development of new "Enhanced Geothermal Systems". The project grade will be based on a report to be submitted by each team member on their individual contributions and a team report submitted at the end of the course. It will also be based on an oral presentation by each team member summarizing the results.

Course Schedule

Week 1

Overview of Geothermal Reservoirs
Reading Chapter 1-2 Textbook
Class Exercise in Energy Modeling
Equivalency of a geothermal power plant with other power generating fuels.

Week 2

Vapor and Liquid Dominated Systems- Chemistry of Geothermal Fluids
Homework 1: Thermodynamic aspects of geothermal systems (due) week 4
Reading: Chapter 3 and Appendix 3
Class Exercise: Liquid dominated Systems with and without influx
Supplemental Reading: Corrosion of Piping Under Insulation in Geothermal Energy Extraction Processes Darrell L. Gallup, NACE paper 03025

Week 3
Exploring for Geothermal Fields-Electromagnetic-Chemical and geophysical methods
Reading: Louise Pellerin et al GEOPHYSICS, VOL. 61, NO. 1 (JANUARY-FEBRUARY 1996); P. 121–130,

Week 4
Hydrothermal Geothermal Systems: Heat, Fluid and Fracture
Reading: Chapter 10

Week 5
Drilling and Production Techniques in Geothermal Reservoirs
Homework 2: Wellbore Design – Casing and Cement (Due Week 6)

Week 6
Down-hole measurement in geothermal wells and their interpretation
Reading: Chapter 4-6
Homework 3: Interpretation of geothermal Logs (Due Week 7)

Week 7
Completion and Testing of Geothermal Wells, Special Tubular, Heat Losses
Homework 4: Well Design for a vapor dominated system (Due Week 8)

Week 8 Midterm Exam

Week 9
Enhanced Geothermal Systems (EGS)
Reading: Chapter 14
Class Discussion: A Coupled Flow-Geomechanics Model For Fluid And Heat Flow For Enhanced Geothermal Reservoirs ARMA 11=213 Case studies.

Week 10
Stimulation of Hydrothermal and EGS reservoirs
Class Discussion: Problems and opportunities
Simulating Complex Fracture Systems In Geothermal Reservoirs Using an Explicitly Coupled Hydro-Geomechanical Model AMA 11-244

Week 11
Characterizing Geothermal Reservoirs with Geological, Geophysical (MEQ/EM and conventional seismic) and Log Data
Homework 5: Interpret data from a liquid dominated system (Due Week 11)
Assignment of Team Term Projects: Design the development plan including drilling, completion and pressure maintenance and power plant for a newly discovered vapor dominated system. Due week 15.

Week 12
Reservoir Engineering aspects of geothermal reservoirs: Field examples from the Geysers,(N. California) and Java (Indonesia)
Reading: Chapter 12-13
Supplemental Reading: Modeling of Geothermal System SPE 13613 (Bodvarson et al)
Class Review: Analysis of Internal Steam Drive in Geothermal Reservoirs, J C Martin, SPE 5382

Week 13
Power production from geothermal fields
Homework 6: Design of flash and a binary cycle. (Due week 14)
Class discussion: Implementation of Efficient Plant Designs in a Time Constrained Market, SPE 121360

Week 14
Management of geothermal reservoirs-Pressure Maintenance-Forecasting
Reading: Chapter 11
Case studies

Week 15 Team Term Project Presentations

Final Exam

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus*, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS