465.420 Geothermal Energy, Fall 2009

Mid-term Exam

09:00 - 10:15 14 Oct 2009

* Answers to the questions can be Korean or English.

* Use appropriate units when necessary. Penalty may be imposed on misuse of units.

1. Explain the elements required for geothermal energy. (10)

2. Discuss the advantages and disadvantages of geothermal energy. (10)

3.

Indicate T(true) or F(false) for the following questions. Note that an incorrect answer receives -3 mark while a correct answer receives +3 mark. You may leave the question blank if you wish. (15)

(1) Typical range of thermal conductivity of rock is around 1.5 ~4.0 W/m·K. (T, F)

(2) Specific heat capacity of water is larger than average rock, e.g., unweathered granite. (T, F)

(3) Linear thermal expansion coefficient of rock (for example, sandstone) is in the order of 10^{-5} /°C. (T, F)

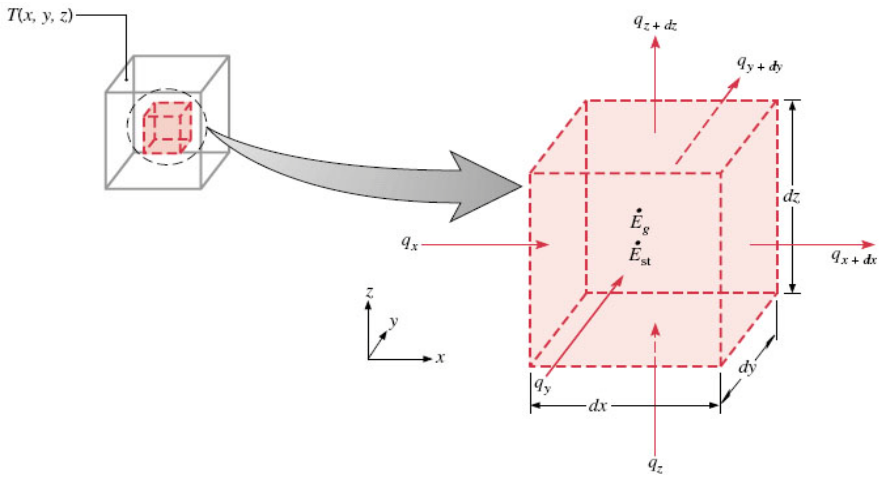
(4) Hydraulic conductivity of shale is typically a few orders larger than that of sandstone (T,F)

(5) Peclet number expresses the transport of energy by bulk fluid motion to the energy transport by conduction.(T, F)

4. List the names of two locations in South Korea where large geothermal projects with boreholes of more than 1km depth were (or are being) carried out. (5)

5. Explain the Darcy's law and Fourier's law with indication of appropriate units. (10)

6. (20)



Differential control volume, dxdydz, are given in Cartesian coordinates as shown above. When conservation of energy is stated as follows,

$\dot{E}_{in} + \dot{E}_g - \dot{E}_{out} = \dot{E}_{st}$

$\dot{E}_{in}$: *energy inflow*

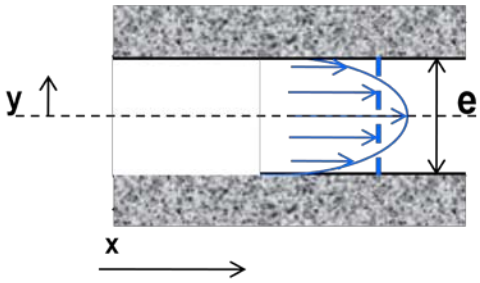
$\dot{E}_{out}$: *energy outflow*

$\dot{E}_g$: *energy generation*

$\dot{E}_{st}$: *energy storage*

derive the heat diffusion equation.

7. (10)



Velocity (v) distribution between parallel plates(shown above) are given as follows;

$$v = -\frac{\rho_w g}{8\mu}\left(e^2 - 4y^2\right)\frac{dh}{dx}$$

where e is aperture of a single fracture, μ is viscosity of water, ρ_w is density of water, g is acceleration of gravity and h is hydraulic head.

Using above expression, derive cubic's law for flow rates through a fracture and give an explanation of the equation.

8. (20)

$$h_0 - h = s = \frac{2.3Q}{4\pi T}\log\frac{2.25Tt}{r^2 S}$$

Above equation is the relationship between drawdown, s, and time, t, in a single well during a pumping test(양수시험). When time-drawdown (s) data collected at a distance (r) of 50.0 m from a well with pumping at a rate of 5.43×10^3 m^3/day (Q) are as plotted in the below,

(1) Calculate the transmissivity (T) and storativity (S) (12).

(2) What are the hydraulic conductivity and specific storage when the thickness of the reservoir is 30 m? (3)

(3) Explain the physical meaning of specific storage. (5)