2015

Heat and mass transfer during the sump development in a potash solution mine

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Appendix A: Derivation of Rectangular Interior Node

$$\frac{\partial^2 T}{\partial x^2} = \frac{T_2 + T_4 - 2T_0}{a^2}$$

$$\frac{\partial^2 T}{\partial y^2} = \frac{T_1 + T_3 - 2T_0}{b^2}$$

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = \frac{T_2 + T_4 - 2T_0}{a^2} + \frac{T_1 + T_3 - 2T_0}{b^2}$$

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = \frac{b^2\left(T_2 + T_4 - 2T_0\right) + a^2\left(T_1 + T_3 - 2T_0\right)}{b^2 a^2}$$

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = \frac{b^2\left(T_2 + T_4\right) + a^2\left(T_1 + T_3\right) - 2T_0\left(b^2 + a^2\right)}{b^2 a^2}$$

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0 \text{ Therefore;}$$

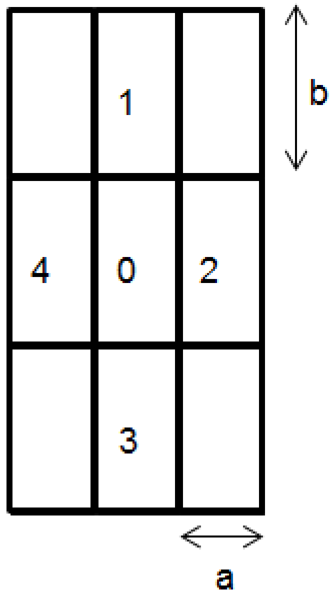
$$b^2\left(T_2 + T_4\right) + a^2\left(T_1 + T_3\right) - 2T_0\left(b^2 + a^2\right) = 0$$

$$T_0 = \frac{b^2\left(T_2 + T_4\right) + a^2\left(T_1 + T_3\right)}{2\left(b^2 + a^2\right)}$$

Appendix B: FDM Equations for Rectangular Nodes

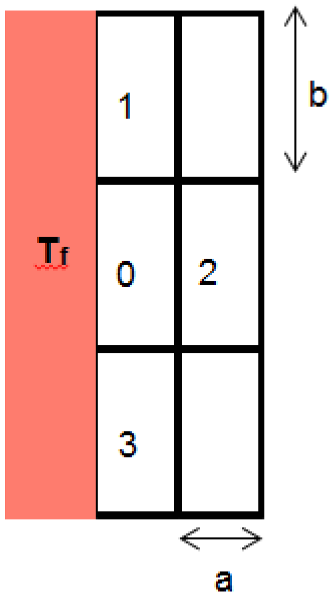
Interior Nodes

$$T_0 = \frac{b^2\left(T_2 + T_4\right) + a^2\left(T_1 + T_3\right)}{2\left(b^2 + a^2\right)}$$



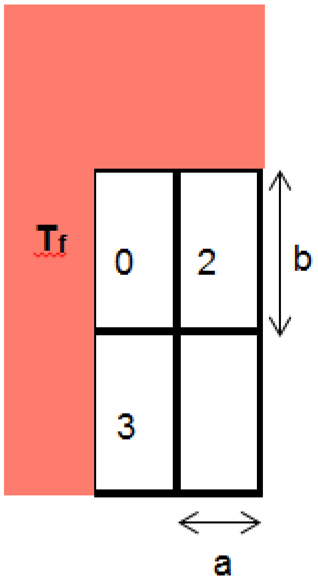
Isothermal Boundary Layer

$$T_0 = \left(\frac{T_1}{2} + T_2 + \frac{T_3}{2} + \frac{ha}{\lambda} T_f\right)\frac{1}{2 + \frac{ha}{\lambda}}$$



External Corner Node

$$T_0 = \left(\frac{T_2}{2} + \frac{T_3}{2} + \frac{ha}{\lambda} T_f \right) \frac{1}{1 + \frac{ha}{\lambda}}$$



Appendix C: Depth Calculation

$$y = 5e\text{-}6x^2 + 0.0031x + 292.67$$

When y= 328

$$328 = 5e\text{-}6x^2 + 0.0031x + 292.67$$

$$0 = 5e\text{-}6x^2 + 0.0031x - 35.33$$

Using the quadratic equation:

$$x = \frac{-0.0031 + \sqrt{(0.0031)^2 - (4 \cdot 5e\text{-}6 \cdot -35.33)}}{2 \cdot 0.0031}$$

$$x = 2366.21 \text{ m}$$

Appendix D: Equating of Heat Transfer Equations

$$\dot{Q} = h \Delta T_{SL} ac$$

$$T_b = T_t - \frac{\dot{Q} \Delta z}{\rho C_p uV} \text{ therefore } \dot{Q} = \frac{\Delta T_{tb} \rho C_p uV}{\Delta z}$$

Equating the two equations gives;

$$\frac{\Delta T_{tb} \rho C_p uV}{\Delta z} = h \Delta T_{SL} ac$$

$$\frac{\Delta T_{tb} \rho C_p uV}{\Delta z hac} = \Delta T_{SL}$$

Appendix E: Fluid Properties

Fluid	**Density (kg/m^3)**	**Prandtl Number**	**Thermal Conductivity (W/mK)**	**Viscosity (pa.s)**	**Specific Heat Capacity (J/kgK)**	**Reference**
Water	1000	9.29	0.59	0.001002	4193	Haywood, 1990
Brine	1076.8	9.29	0.59	0.001002	4193	Haywood,1990 and Lide, 2004
Diesel	820.8	27.74	0.14	0.012	1914.21	Chemical Hazards Response Information System, cited in Zen-Stoves, 1999
Gasoline	704.01	6.68	0.88	0.00041	2055.72	Chemical Hazards Response Information System, cited in Zen-Stoves, 1999
Naphtha	849.94	73.13	0.15	0.0055	2001.29	Chemical Hazards Response Information System, cited in Zen-Stoves, 1999
Kerosene	793.87	17.22	0.13	0.0011	1963.61	Chemical Hazards Response

						Information System, cited in Zen-Stoves, 1999

All properties taken at 20°C and 12% KCl by mass in water.