# BIR O'LCHOVLI HOLATDA MODDANING KO'CHISH TENGLAMASI VA UNI YECHIMI

***T.O.Dzhiyanov, M.H.Turayev.***

Samarkand State University, Samarkand, Uzbekistan

Bir o'lchovli holatda moddaning ko'chish tenglamalari quydagi ko'rinishda yoziladi [8].

$$\rho\frac{\partial S_{al}}{\partial t}+\rho\frac{\partial S_{sl}}{\partial t}+\theta_l\frac{\partial C_l}{\partial t}=\theta_l D_l\frac{\partial^2 C_l}{\partial x^2}-\theta_l v_l\frac{\partial C_l}{\partial x}+\alpha(C_m-C_l), \qquad (3.1.1)$$

$(l=1;2;\ \ m=3-l)$,

Bu yerda $t$ $-$ vaqt, $s$, $x$ $-$ masofa, $m$, $D_l$ $-$ bo'ylama dispersiyasi koeffitsienti, $m^2/s$, $v_l$ $-$ suyuqlik tezligi, $m/s$, $v_1<v_2$, $C_l$ $-$ suyuqlikdagi moddaning miqdori, $S_{al}\ va\ S_{sl}$ $-$ kechiktirilgan moddaning kontsentratsiyasi, $m^3/kg$, $\theta_l$ $-$sohaning g'ovakligi, $m^3/m^3$, $\rho$ $-$muhit zichligi, $kg/m^3$, $\alpha$ $-$sohalar orasidagi massa almashinuvi koeffitsienti, $s^{-1}$.

Har bir soha bo'limida moddalarning cho'kishi kinetik tenglamalarga muvofiq qaytarilish tarzda sodir bo'ladi.

$$\rho\frac{\partial S_{al}}{\partial t}=\theta_l k_{al}C_l-\rho k_{adl}S_{al}, \quad (l=1,2), \qquad (3.1.2)$$

$$\rho\frac{\partial S_{sl}}{\partial t}=\theta_l k_{sl}C_l-\rho k_{sdl}S_{sl}, \quad (l=1,2), \qquad (3.1.3)$$

Bu yerda $k_{al}, k_{sl}$ $-$ suyuqlik fazadan $l$ qattiq fazaga moddaning cho'kish koeffitsientlari, $s^{-1}$, $k_{adl}, k_{sdl}$ $-$ moddaning qattiq fazadan ajralib chiqish va suyuqlikka o'tish koeffitsientlari, $s^{-1}$.

Dastlab sof (moddasiz) suyuqlik bilan to'yingan muhitga vaqtning dastlabki paytidan boshlab suyuqlik $c_0$ moddasining doimiy kontsentratsiyasi bilan to'yingan bo'lsin. Keling, konsentratsiya maydoni muhitning o'ng chegarasiga yetib bormaydigan

$x = \infty$ vaqt davrlarini ko'rib chiqaylik. Belgilangan ma'lumotlarga ko'ra, masalaning boshlang'ich va chegaraviy shartlari quyidagi ko'rinishga ega

$$C_i(0,x)=0,\ S_{al}(0,x)=0,\ S_{sl}(0,x)=0, \tag{3.1.4}$$

$$C_l(t,0)=c_0, \tag{3.1.5}$$

$$\frac{\partial C_l}{\partial x}(t,\infty)=0, \quad l=1,2. \tag{3.1.6}$$

**Sonli yechim va natijalar**. (3.1.1) - (3.1.6) masala chiziqli bo'lsada, analitik yechimni olish qiyin, chunki sohalarning har birida bir vaqtning o'zida uchta maydonni topish kerak. Shuning uchun masalani yechish uchun [9] chekli ayirmalar usulidan foydalanamiz. Ko'rib chiqilayotgan $\Omega = \{(t,x),\ 0 \le t \le T,\ 0 \le x \le \infty\}$ maydonda yo'nalishlar bo'yicha yagona to'r joriy etiladi

$$\bar{\omega}_{\tau h} = \left\{(t_j,\ x_i);\ t_j=\tau j,\ \ x_i=ih,\ \ \tau=\frac{T}{J},\ i=\overline{0,I},\ \ j=\overline{0,\ J}\right\}$$

Bu yerda $I-\ [0,x_I], x_I - ih$ segmenti bo'lishi uchun yetarlicha katta butun son tanlangan, $C_i, S_{ai}$ va $S_{si}$ maydonlarida hisoblangan o'zgarishlar maydonini bir-biriga moslashtiriladi, $h - x$ yo'nalishidagi to'r qadami.

Oshkor to'r sohasida

$$\omega_{\tau h} = \left\{(t_j,\ x_i);\ t_j=\tau j,\ \ x_i=ih,\ \ \tau=\frac{T}{J},\ \ j=\overline{1,\ J},\quad i=\overline{1, I-1},\ \right\}$$

(1), (2), (3) tenglamalar quyidagicha approksimatsiya qilinadi

$$\rho\frac{(S_{al})_i^{j+1}-(S_{al})_i^j}{\tau}+\rho\frac{(S_{sl})_i^{j+1}-(S_{sl})_i^j}{\tau}+\theta_l\frac{(C_l)_i^{j+1}-(C_l)_i^j}{\tau}=$$
$$=\theta_l D_l\frac{(C_l)_{i-1}^{j+1}-2(C_l)_i^{j+1}+(C_l)_{i+1}^{j+1}}{h^2}-\theta_l v_l\frac{(C_l)_i^{j+1}-(C_l)_{i-1}^{j+1}}{h}+\alpha(C_m)_i^j-\alpha(C_l)_i^j, \tag{3.1.7}$$

$(l=1,2;\ \ m=2,1)$,

$$\rho\frac{(S_{al})_i^{j+1}-(S_{al})_i^j}{\tau}=\theta_l k_{al}(C_l)_i^j-\rho k_{adl}(S_{al})_i^{j+1},\quad (l=1,2), \tag{3.1.8}$$

$$\rho\frac{(S_{sl})_i^{j+1}-(S_{sl})_i^j}{\tau}=\theta_l k_{sl}(C_l)_i^j-\rho k_{sdl}(S_{sl})_i^{j+1}, \quad (l=1,2), \tag{3.1.9}$$

Bu yerda $(C_l)_i^j$, $(S_{al})_i^j$, $(S_{sl})_i^j - C_l(t,x)$, $S_{al}(t,x)$, $S_{sl}(t,x)$ ,$(l=1,2)$ funktsiyalarning $(t_j, x_i)$ nuqtadagi to'r qiymatlari.

Aniq to'r (3.1.8), (3.1.9) tenglamalaridan, $(S_{al})_i^{j+1}$, $(S_{sl})_i^{j+1}$ ni aniqlaymiz

$$(S_{al})_i^{j+1}=p_{1l}(S_{al})_i^j+p_{2l}, \quad (l=1;\ 2), \tag{3.1.10}$$

$$(S_{sl})_i^{j+1}=q_{1l}(S_{sl})_i^j+q_{2l}, \quad (l=1;\ 2), \tag{3.1.11}$$

Bu yerda

$$p_{1l}=\frac{1}{1+\tau k_{adl}}, \quad p_{2l}=\frac{\tau\theta_l k_{al}}{\rho+\rho\tau k_{adl}}(C_l)_i^j, \quad (l=1;2),$$

$$q_{1l}=\frac{1}{1+\tau k_{sdl}}, \quad q_{2l}=\frac{\tau\theta_l k_{sl}}{\rho+\rho\tau k_{sdl}}(C_l)_i^j, \quad (l=1;\ 2).$$

To'r tenglamalari (3.1.7) ko'rinishga keltiriladi

$$A_l(C_l)_{i-1}^{j+1}-B_l(C_l)_i^{j+1}+E_l(C_l)_{i+1}^{j+1}=-(F_l)_i^j, \quad (l=1,2), \tag{3.1.12}$$

Bu yerda

$$A_l=\frac{\theta_l D_l\tau}{h^2}+\frac{\theta_l v_l\tau}{h},$$

$$B_l=\theta_l+\frac{2\theta_l D_l\tau}{h^2}+\frac{\theta_l v_l\tau}{h},$$

$$E_l=\frac{\theta_l D_l\tau}{h^2},$$

$$(F_l)_i^j=(\theta_l-\alpha\tau)(C_l)_i^j+\alpha\tau(C_m)_i^j-\rho((S_{al})_i^{j+1}-(S_{al})_i^j)-\rho((S_{sl})_i^{j+1}-(S_{sl})_i^j),$$

$$(l=1,2;\ m=2,1).$$

Yechimlarni quyidagicha tartibda hisoblaymiz. (3.1.10), (3.1.11) ga ko'ra $(S_{al})_i^{j+1}$, $(S_{sl})_i^{j+1}$ aniqlanadi, so'ngra $(C_l)_i^{j+1}$, $(l=1,2)$ – (3.1.12) chiziqli tenglamalar tizimini progonka usuli bilan yechiladi. Chunki $p_{1l}$, $q_{1l}<1$ sxemalar uchun (3.10), (3.1.11) barqaror va (3.1.12) uchun progonka usulining barqarorlik shartlari bajariladi.

Hisoblashda dastlabki parametrlarning quyidagi qiymatlaridan foydalanilgan:

$v_1 = 10^{-4}$ m/s, $v_2 = 10^{-5}$ m/s, $D_1 = v_1 \cdot \alpha_l$, $D_2 = v_2 \cdot \alpha_l$, $\theta_1 = 0{,}1$, $\theta_2 = 0{,}4$

$k_{a1} = 3 \cdot 10^{-4} s^{-1}$, $k_{ad1} = 2{,}5 \cdot 10^{-4} s^{-1}$, $k_{s1} = 4 \cdot 10^{-4} s^{-1}$, $k_{sd1} = 2 \cdot 10^{-4} s^{-1}$, $\rho = 1800\ kg/m^3$,

$k_{a2} = 4 \cdot 10^{-4} s^{-1}$, $k_{ad2} = 2 \cdot 10^{-4} s^{-1}$, $k_{s2} = 5 \cdot 10^{-4} s^{-1}$, $k_{sd2} = 10^{-4} s^{-1}$, $\alpha_l = 0{,}005$ m.

## Foydalanilgan adabiyotlar ro'yxati

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