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BINONING TURLI QISMLARIDAGI ISSIQLIK ALMASHISH JARAYONI TENGLAMALARI VA UNING YECHIMLARI

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Annotasiya: *Ushbu maqolada binoda sodir bo'ladigan issiqlik va massa o'zgarishlari keltirilgan. Ko'rilayotgan masala bo'yicha binoning matematik modelini tuzish uchun devorning turli qismlar sistemasi uchun issiqlik balansi tenglamalarini tuzilgan va tajriba natijalari bilan taqqoslangan.*

Kalit so'zlar: *passiv quyosh qurilmalari, tukaturka, quyosh radiasiyasi, issiqlik balansi, solishtirma issilik sig'imi, havo bilan issiqlik almashinish koeffisenti*

c- bino materialining solishtirma issilik sig'imi
ρ-material zichligi
V-bino tegishli qismining hajmi
T_x – bino ichidagi havoning harorati
T_{sh_i} – bino shimoliy qismi ichki sirtining harorati
T_{j_i} – bino janubiy qismi ichki sirtining harorati
T_{s_i} – bino sarqiy qismi ichki sirtining harorati
T_{g_i} – bino g'arbiy qismi ichki sirtining harorati
T_{pot_i} – bino shipti qismi ichki sirtining harorati
T_{p_i} – bino pol qismi ichki sirtining harorati
h_{in} – binoning ichki havo bilan issiqlik almashinish koeffisenti

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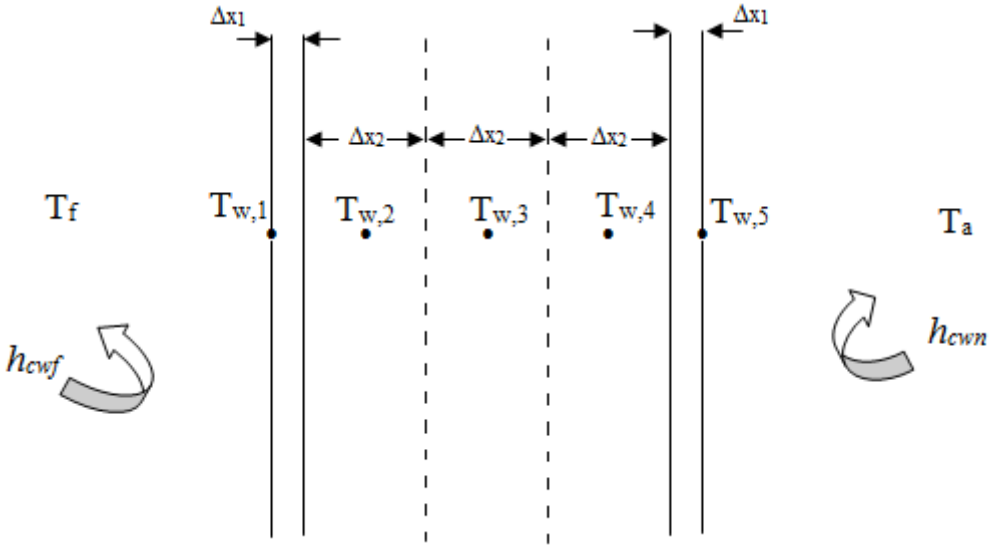
h_{out} – binoning tashqi havo bilan issiqlik almashinish koeffisenti
α - nurlanish koeffisenti
τ – vaqt
F – yuza
I_T- yorug'lik intensivligi
λ_1 – shtukaturkaning issiqlik o'tkazuvchanlik koeffisenti
λ_2 – devorning issiqlik o'tkazuvchanlik koeffisenti
Δx_1- shtukaturka qatlamining qalinligi
Δx_2- devor qatlamining qalinligi

Binoning sharq, g'arb va shimol qismidagi devorlari bir xil material va bir xil konstruksiyaga qurilgan. Ya'ni, ichkaridan bir (Δx_1 qalinlikda) qatlam shtukaturka, o'rta qismida g'isht devor ($3\Delta x_2$ qalinlikda) va binoning tashqori qismidan yana bir (Δx_1 qalinlikda) qatlam shtukaturka deb, undagi balans tenglamalarni ko'rib o'taylik (1 rasm).



1 rasm. Devorning yon tomondan ko'rinishi.

Ko'rilayotgan masala bo'yicha binoning matematik modelini tuzish uchun devorning turli qismlar sistemasi uchun issiqlik balansi tenglamalarini tuzishimiz kerak [2-8].

Bino ichidagi issiqlik balansi

$$c\rho V\frac{dT_x}{d\tau} = h_{in}F_{sh}(T_{sh\_i} - T_x) + h_{in}F_j(T_{j\_i} - T_x) + h_{in}F_s(T_{s\_i} - T_x) + h_{in}F_g(T_{g\_i} - T_x) + h_{in}F_{pot}(T_{pot\_i} - T_x) + h_{in}F_p(T_{p\_i} - T_x) + h_{in}F_d(T_{d\_i} - T_x) + \alpha\tau F_d I_T \quad (1)$$

yechimi:

$$T_x^{\tau+\Delta\tau} = \left[1 - \frac{h_{in}\Delta\tau}{c\rho V}\left(F_{sh} + F_j + F_s + F_g + F_{pot} + F_p + F_d\right)\right]T_x^{\tau} + \frac{h_{in}\Delta\tau}{c\rho V}\left(F_{sh}T_{sh\_i}^{\tau} + FT_{j\_i\,j}^{\tau} + F_sT_{s\_i}^{\tau} + F_gT_{g\_i}^{\tau} + F_{pot}T_{pot\_i}^{\tau} + F_pT_{p\_i}^{\tau} + F_dT_{d\_i}^{\tau}\right) \quad (1.1)$$

Shimoliy devorda issiqlik almashinish jarayoni.

Devorning ichki qismidagi sirtda issiqlik balansi

$$c\rho V\frac{dT_{sh\_i}}{d\tau} = h_{in}F_{sh}(T_x - T_{sh\_i}) + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{sh} - T_{sh\_i})F_{sh} \quad (2)$$

yechimi:

$$T_{sh\_i}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_{sh}}{c\rho V}\left(h_{in} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{sh\_i}^{\tau} + \frac{\Delta\tau F_{sh}}{c\rho V}\left(h_{in} T_x^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_{sh}^{\tau}\right)$$

Devor o'rtasida issiqlik balansi

$$c\rho V \frac{dT_{sh}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{sh\_o} - T_{sh})F_{sh} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{sh\_i} - T_{sh})F_{sh} \quad (2.2)$$

yechimi:

$$T_{sh}^{\tau+\Delta\tau} = \left[1 - \frac{2\Delta\tau F_{sh}}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right] T_{sh}^{\tau} + \frac{\Delta\tau F_{sh}}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{sh\_i}^{\tau} + T_{sh\_o}^{\tau}\right) \quad (2.1)$$

Devorning tashqi qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{sh\_o}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{sh} - T_{sh\_o})F_{sh} + h_{out}F_{sh}(T_h - T_{sh\_o}) \quad (3)$$

yechimi:

$$T_{sh\_o}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_{sh}}{c\rho V}\left(h_{out} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{sh\_o}^{\tau} + \frac{\Delta\tau F_{sh}}{c\rho V}\left(h_{out} T_h^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_{sh}^{\tau}\right) \quad (3.1)$$

Janubiy devorda issiqlik almashinish jarayoni.

Devorning ichki qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{j\_i}}{d\tau} = h_{in}F_j(T_x - T_{j\_i}) + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_j - T_{j\_i})F_j \quad (4)$$

yechimi:

$$T_{j\_i}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_j}{c\rho V}\left(h_{in} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{j\_i}^{\tau} + \frac{\Delta\tau F_j}{c\rho V}\left(h_{in} T_x^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_j^{\tau}\right) \quad (4.1)$$

Devor o'rtasida issiqlik balansi

$$c\rho V \frac{dT_j}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{j\_o} - T_j)F_j + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{j\_i} - T_j)F_j \quad (5)$$

yechimi:

$$T_j^{\tau+\Delta\tau} = \left[1 - \frac{2\Delta\tau F_j}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right] T_j^{\tau} + \frac{\Delta\tau F_j}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{j\_i}^{\tau} + T_{j\_o}^{\tau}\right) \quad (5.1)$$

Devorning tashqi qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{j\_o}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_j - T_{j\_o})F_j + h_{out}F_j(T_h - T_{j\_o}) \quad (6)$$

yechimi:

$$T_{j\_o}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_j}{c\rho V}\left(h_{out} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{j\_o}^{\tau} + \frac{\Delta\tau F_j}{c\rho V}\left(h_{out} T_h^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_j^{\tau}\right) \quad (6.1)$$

Sharqiy devorda issiqlik almashinish jarayoni.

Devorning ichki qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{s\_i}}{d\tau} = h_{in}F_s(T_x - T_{s\_i}) + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_s - T_{s\_i})F_s \quad (7)$$

yechimi:

$$T_{s\_i}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_s}{c\rho V}\left(h_{in} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{s\_i}^{\tau} + \frac{\Delta\tau F_s}{c\rho V}\left(h_{in} T_x^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_s^{\tau}\right) \quad (7.1)$$

Devor o'rtasida issiqlik balansi

$$c\rho V \frac{dT_s}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{s\_o} - T_s)F_s + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{s\_i} - T_s)F_s \quad (8)$$

yechimi:

$$T_s^{\tau+\Delta\tau} = \left[1 - \frac{2\Delta\tau F_s}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right] T_s^{\tau} + \frac{\Delta\tau F_s}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{s\_i}^{\tau} + T_{s\_o}^{\tau}\right) \quad (8.1)$$

Devorning tashqi qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{s\_o}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_s - T_{s\_o}\right)F_s + h_{out}F_s\left(T_h - T_{s\_o}\right) \quad (9)$$

yechimi:

$$T_{s\_o}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_s}{c\rho V}\left(h_{out} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{s\_o}^{\tau} + \frac{\Delta\tau F_s}{c\rho V}\left(h_{out}T_h^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)T_s^{\tau}\right) \quad (9.1)$$

G'arbiy devorda issiqlik almashinish jarayoni.

Devorning ichki qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{g\_i}}{d\tau} = h_{in}F_g\left(T_x - T_{g\_i}\right) + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_g - T_{g\_i}\right)F_g \quad (10)$$

yechimi:

$$T_{g\_i}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_g}{c\rho V}\left(h_{in} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{g\_i}^{\tau} + \frac{\Delta\tau F_g}{c\rho V}\left(h_{in}T_x^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)T_g^{\tau}\right) \quad (10.1)$$

Devor o'rtasida issiqlik balansi

$$c\rho V \frac{dT_g}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{g\_o} - T_g\right)F_g + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{g\_i} - T_g\right)F_g \quad (11)$$

yechimi:

$$T_g^{\tau+\Delta\tau} = \left[1 - \frac{2\Delta\tau F_g}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right] T_g^{\tau} + \frac{\Delta\tau F_g}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{g\_i}^{\tau} + T_{g\_o}^{\tau}\right) \quad (11.1)$$

Devorning tashqi qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{g\_o}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_g - T_{g\_o}\right)F_g + h_{out}F_g\left(T_h - T_{g\_o}\right) \quad (12)$$

yechimi:

$$T_{g\_o}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_g}{c\rho V}\left(h_{out} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{g\_o}^{\tau} + \frac{\Delta\tau F_g}{c\rho V}\left(h_{out}T_h^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)T_g^{\tau}\right) \quad (12.1)$$

Bino shiptida issiqlik almashinish jarayoni.

Devorning ichki qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{pot\_i}}{d\tau} = h_{in}F_{pot}\left(T_x - T_{pot\_i}\right) + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{pot} - T_{pot\_i}\right)F_{pot} \quad (13)$$

yechimi:

$$T_{pot\_i}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_{pot}}{c\rho V}\left(h_{in} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{pot\_i}^{\tau} + \frac{\Delta\tau F_{pot}}{c\rho V}\left(h_{in}T_x^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)T_{pot}^{\tau}\right) \quad (13.1)$$

Devor o'rtasida issiqlik balansi

$$c\rho V \frac{dT_{pot}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{pot\_o} - T_{pot}\right)F_{pot} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{pot\_i} - T_{pot}\right)F_{pot} \quad (14)$$

yechimi:

$$T_{pot}^{\tau+\Delta\tau} = \left[1 - \frac{2\Delta\tau F_{pot}}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right] T_{pot}^{\tau} + \frac{\Delta\tau F_{pot}}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{pot\_i}^{\tau} + T_{pot\_o}^{\tau}\right) \quad (14.1)$$

Devorning tashqi qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{pot\_o}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{pot} - T_{pot\_o}\right)F_g + h_{out}F_{pot}\left(T_h - T_{pot\_o}\right) \quad (15)$$

yechimi:

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$$T_{pot\_o}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_{pot}}{c\rho V}\left(h_{out} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{pot\_o}^{\tau} + \frac{\Delta\tau F_{pot}}{c\rho V}\left(h_{out} T_h^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_{pot}^{\tau}\right) \quad (15.1)$$

Bino polida issiqlik almashinish jarayoni.

Devorning ichki qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{p\_i}}{d\tau} = h_{in} F_p (T_x - T_{p\_i}) + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_p - T_{p\_i}) F_p \quad (16)$$

yechimi:

$$T_{p\_i}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_p}{c\rho V}\left(h_{in} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{p\_i}^{\tau} + \frac{\Delta\tau F_p}{c\rho V}\left(h_{in} T_x^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_p^{\tau}\right) \quad (16.1)$$

Devor o'rtasida issiqlik balansi

$$c\rho V \frac{dT_p}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{p\_o} - T_p) F_p + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_{p\_i} - T_p) F_p \quad (17)$$

yechimi:

$$T_p^{\tau+\Delta\tau} = \left[1 - \frac{2\Delta\tau F_p}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right] T_p^{\tau} + \frac{\Delta\tau F_p}{c\rho V}\left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\left(T_{p\_i}^{\tau} + T_{p\_o}^{\tau}\right) \quad (17.1)$$

Devorning tashqi qismidagi sirtda issiqlik balansi

$$c\rho V \frac{dT_{p\_o}}{d\tau} = \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)(T_p - T_{p\_o}) F_g + h_{out} F_p (T_h - T_{p\_o}) \quad (18)$$

yechimi:

$$T_{p\_o}^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_p}{c\rho V}\left(h_{out} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right)\right)\right] T_{p\_o}^{\tau} + \frac{\Delta\tau F_p}{c\rho V}\left(h_{out} T_h^{\tau} + \left(\frac{\lambda_1}{\Delta x_1} + \frac{2\lambda_2}{\Delta x_2}\right) T_p^{\tau}\right) \quad (18.1)$$

Derezada issiqlik almashinish jarayoni.

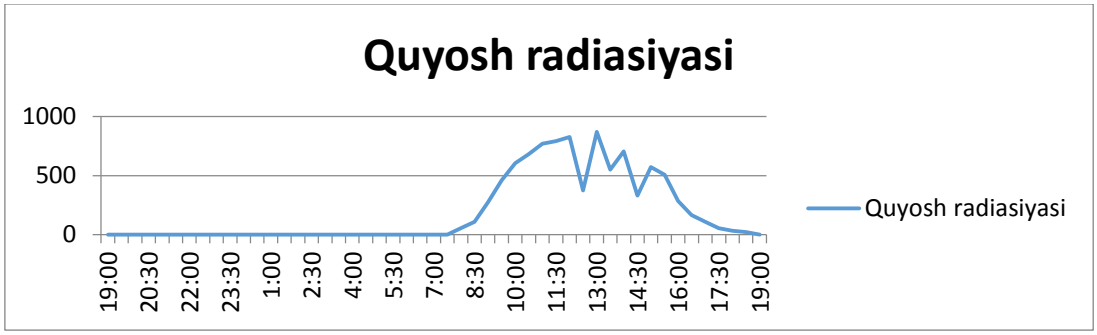
$$c\rho V \frac{dT_d}{d\tau} = h_{in} F_d (T_x - T_d) + h_{out} F_d (T_h - T_{d\_o}) \quad (19)$$

$$T_d^{\tau+\Delta\tau} = \left[1 - \frac{\Delta\tau F_d}{c\rho V}(h_{out} + h_{in})\right] T_d^{\tau} + \frac{\Delta\tau F_d}{c\rho V}(h_{out} T_x + h_{in} T_h) \quad (19.1)$$

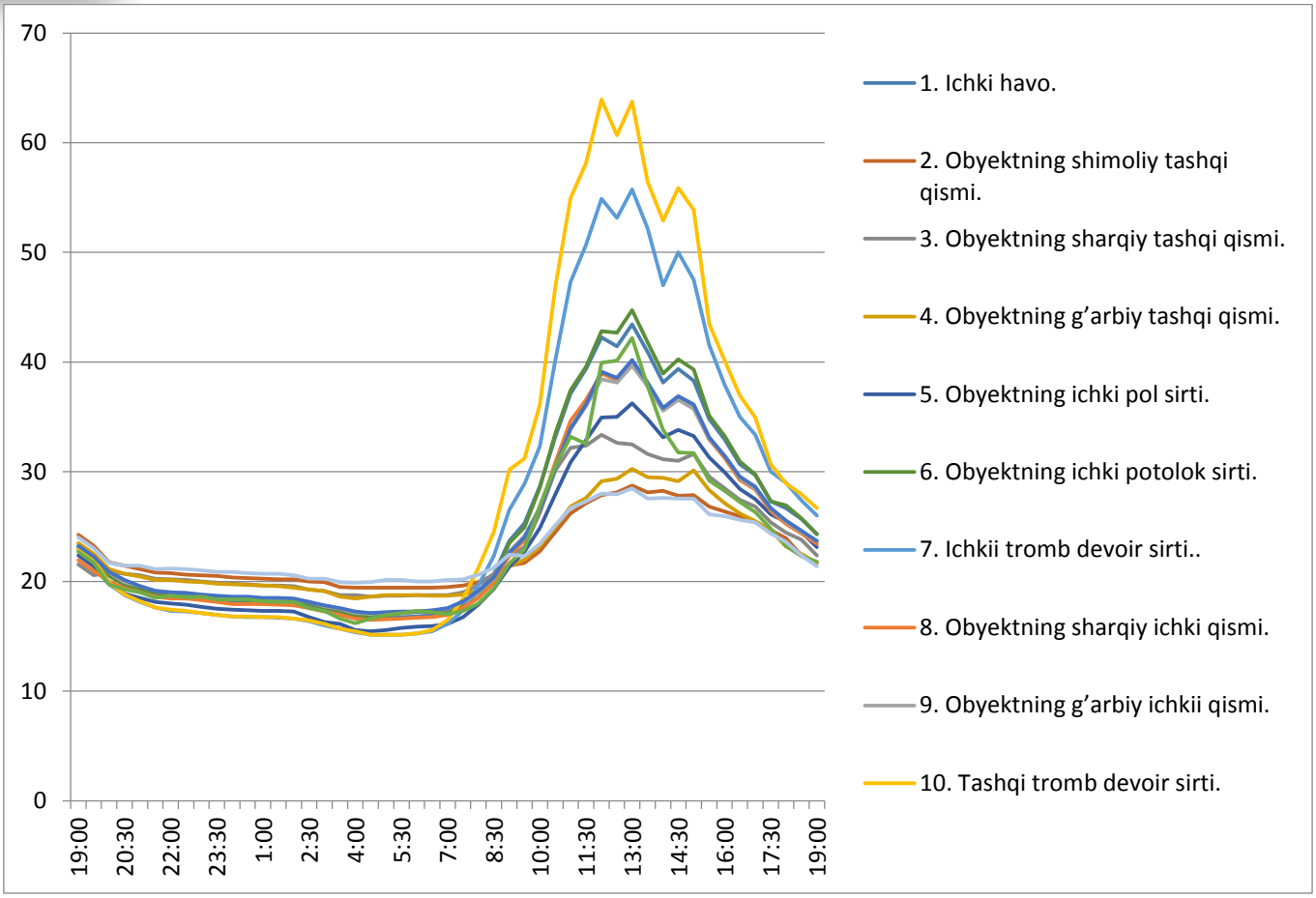
Ushbu tenglamalar asosida mathCAD15 dasturlash tilidan foydalanib dastur tuzildi va yechildi.

Kichik o'lchamli maketda tajriba o'tkazilib, olingan natijalar asosida grafiklar tuzildi va tenglamalardan olingan natijalar bilan solishtirildi.

Tajribadan 2022 yii 31 mart – 1 aprel kunlarida olingan natijalar quyidagi grafiklarda keltirilgan.



2 rasm. Mos vaqtlarga quyosh radiatsiyasining miqdori.



3 rasm. Ob'ektning turli qismlarida temperaturalarning vaqtga bog'lanish grafigi.

Xulosa:

Kichik o'xshash ob'yektda tajriba o'tkazildi va tajriba natijasiga ko'ra quyosh radiatsiyasining o'zgarish natijasida ob'yektning turli qismlarida temperaturalar mos ravishda o'zgarib borishi kuzatildi. Tenglamalar asosida mathCAD15 dasturlash tilidan foydalanib dastur tuzildi va yechildi. Kichik o'lchamli maketda tajriba o'tkazilib, olingan natijalar asosida grafiklar tuzildi va tenglamalardan olingan natijalar bilan solishtirildi.

Foydalanilgan adabiyotlar ro'yxati:

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