ISSIQLIK TARQALISH TENGLAMASI UCHUN KOSHI MASALASI

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ANNOTATSIYA

Maqolada issiqlik tenglamasiga qo‘yilgan to‘g‘ri va teskari masalalarning umumlashgan yechimlarining to‘g‘riligi o‘rganilgan.

Kalit so‘zlar: *Uzluksizlik,funksional qator,Fure koeffitsienti,tor tebranish tenglamasi.*

ANNOTATION

The dissertation “Non local boundary conditional direct and inverse problems in an unbounded domain fot the heat propagation in three-dimensional space” is one of the important sections of mathematics. Interest in this field is determined by the theoretical significance if the obtained results and their practical applications.

Kirish

Matematik fizikaning juda ko‘p masalalarini xususiy hosilali tenglamalar ko‘rinishida tavsiflash mumkin. Bunday tavsivlashda unga mos bo‘lgan chegaraviy masalalar yechimini tabiiy aniqlash imkoniyati mavjud va shu bilan birga, ularni yechishga ma’lum usullarni qo‘llash mumkin. Tabiatda uchraydigan jarayonlarni kasr tartibli tenglamalar aniqroq ifoda etadi.

Issiqlik tarqalish tenglamasi.

Koshi masalasi: Tekislikdagi $\Omega = \{(x,t) : 0 < x < l, 0 < t < T\}$ sohada bir jinsli

$$\frac{\partial u}{\partial t} = a^2 \frac{\partial^2 u}{\partial x^2} \quad (a = const) \qquad (1)$$

issiqlik tarqalish tenglamasining

$$u(x,0)=\varphi(x), \quad 0\le x\le l \qquad (2)$$

boshlang'ich va

$$u(0,t)=0,\ u(l,t)=0,\ \ 0\le t<T \qquad (3)$$

bir jinsli chegaraviy shartlarni qanoatlantiruvchi regulyar yechimi topilsin.

Ta'rif: (1) tenglamaning regulyar yoki klassik yechimi deb Ω sohada, tenglamada qatnashuvchi o'zining hosilalari bilan uzluksiz va tenglamani ayniyatga aylantiruvchi *u=u(x,y)* funksiyaga aytiladi.

Aralash masalani o'zgaruvchilarni ajratish (yoki Furye) usuli bilan yechamiz. Bu usulga asosan (1) tenglamaning yechimini

$$u(x,t)=X(x)T(t) \qquad (4)$$

shaklda izlasak, quyidagi

$$X''(x)+\lambda X(x)=0, \qquad (5)$$

$$T'(x)+a^2\lambda T(t)=0 \qquad (6)$$

ikkita oddiy differensial tenglama hosil bo'ladi, bunda λ = const. (4) ifoda va (3) chegaraviy shartlardan (5) tenglama uchun quyidagi

$$X(0)=X(l)=0 \qquad (7)$$

chegaraviy shartlar kelib chiqadi.

(5), (7) masala - xos son va xos funksiyalarni topish xaqidagi Shturm-Liuvill masalasi bo'lib, u tor tebranish tenglamasi uchun aralash masalani yechishda ham qurilgan edi.

Bu masalaning xos sonlari $\lambda_n=\left(\frac{\pi n}{l}\right)^2, (n=1,2,...)$, bu xos sonlarga mos trivial bo'lmagan xos funksiyalari $X_n(x)=\sin\frac{\pi n}{l}x$ ko'rinishda ekanligini aniqlagan edik. $\lambda=\lambda_n$ bo'lganda (6) tenglamaning umumiy yechimi

$$T_n(t)=a_n e^{-(a\pi n/l)^2 t}$$

ko'rinishga ega bo'lib, (1.2.4) tenglikka asosan

$$U_n(x,t) = X_n(x)T_n(t) = a_n e^{-\left(\frac{\pi na}{l}\right)^2 t} \sin\frac{\pi n}{l}x$$

funksiyalar (a_n-ixtiyoriy, o‘zgarmas sonlar) (1) tenglamani va (3) chegaraviy shartni qanoatlantiradi. Tenglama bir jinsli bo‘lgani uchun bu yechimlar yig‘indisi yana yechim bo‘ladi. Shuning uchun (1) tenglamaning (2), (3) shartlarni qanoatlantiruvchi yechimini

$$u(x,t) = \sum_{n=1}^{\infty} a_n e^{-\left(\frac{\pi na}{l}\right)^2 t} \sin\frac{\pi n}{l}x \qquad (8)$$

qator ko‘rinishida izlaymiz. Agar (8) Funksional qator va uning t bo‘yicha birinchi, x bo‘yicha ikkinchi tartibli hosilalari tekis yaqinlashuvchi bo‘lsa, u holda bum qator yig‘indisi (1) tenglamani va (3) chegaraviy shartlarni qanoatlantiradi. Boshlang‘ich shartni ham qanoatlantirishini talab qilsak,

$$u(x,0) = \varphi(x) = \sum_{n=1}^{\infty} a_n \sin\frac{\pi n}{l}x$$

tenglikka ega bo‘lamiz. Bu tenglikni $\varphi(x)$ funksiyaning $(0,l)$ oraliqdagi sinuslar bo‘yicha Fure qatoriga yoyilmasi desak, u holda a_n Fure koeffitsienti bo‘lib,

$$a_n = \frac{2}{l}\int_0^l \varphi(x)\sin\frac{\pi n}{l}x dx \qquad (9)$$

formula bo‘yicha topiladi.

(9) tenglikka asosan (1)-(3) masalaning (8) yechimini quyidagi ko‘rinishda yozish mumkin

$$u(x,t) = \int_0^l G(x,y,t)\varphi(y)dy, \qquad (10)$$

bu yerda

$$G(x,y,t) = \frac{2}{l}\sum_{n=1}^{\infty} e^{-\left(\frac{\pi na}{l}\right)^2 t} \sin\frac{\pi n}{l}x \sin\frac{\pi n}{l}y.$$

Bu funksiya oniy manbaning ta’sir funksiyasi deyiladi.

1- Teorema. Agar [0,l] kesmada φ(x) funksiya

1. uzluksiz;
2. bo‘lakli-uzluksiz hosilaga ega va
3. φ(0)=φ(l)=0

shartni qanoatlantirsa, u holda (8) qator aralash masalaning $\overline{\Omega}$ da uzluksiz va cheksiz differensiallanuvchi yechimi bo‘ladi.

(2) funksiya aralash masalaning yechimi bo‘lishi uchun, (2) boshlang‘ich shartda berilgan *φ(x)* funksiya uzluksiz, bo‘lakli silliq va boshlang‘ich hamda chegaraviy shartlarning moslashganlik shartiga *(φ(0)=φ(l)=0)* bo‘ysunishi kerak. Lekin *φ(x)* funksiyaning uzluksizligi va moslashganlik shartini qanoatlantirishi amaliyot uchun og‘ir shartdir.

Masalan, $U_0 = const$ temperaturagacha isitilgan va chetlarida nol temperaturaga ega bo‘lgan, soviyotgan sterjenda issiqlik tarqalish masalasida, boshlang‘ich va chegaraviy shartlarning moslashganlik sharti bajarilmaydi, ya’ni $\varphi(0)= \varphi(l)=0=U_0 \neq 0$. Bu holda quyidagi teorema o‘rinlidir.

2- Teorema. Agar [0,l] kesmada φ(x) funksiya bo‘lakli-uzluksiz (I - tur uzilishlarga ega) bo‘lsa, u xolda (10) funksiya:

1) Ω sohada (1) tenglamasining yechimi bo‘ladi;
2) $\overline{\Omega} = \{(x,t): 0 \le x \le l, 0 \le t \le T\}$ sohada chegaralangan;
3) (3) chegaraviy shartlarni qanoatlantiradi;
4) t=0 da φ(x) funksiyaning uzluksiz nuqtalarida uzluksiz va u(x,0)=φ(x) bo‘ladi.

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