THERMAL EXPANSION OF SOLIDS

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Annotation.
The article presents the basic assumptions about the thermal expansion of solids and their thermal conductivity. It is shown that the coefficient of linear expansion α is proportional to the heat capacity of the body. In the region of high temperatures, the energy of linearly oscillating particles is equal to E = qD. In the region of low temperatures, α behaves similarly to C_v: it decreases with decreasing temperature and tends to zero as it approaches absolute zero.

Keywords: thawexpansion, thermal conductivity, coefficient of linear expansion, temperature, potential well, Hooke's law, potential energy, particle vibrations.

From the point of view of the harmonic approximation underlying the theory of heat capacity of solids, it turned out to be impossible to explain a number of well-knownных phenomena: the thermal expansion of solids and their thermal conductivity.

Let us turn to the curve of the dependence of the potential energy of interaction of solid body particles on the distance between Them (Fig.At absolute zero, the particless are located at distances $r_o$corresponding to the minimum interaction energyU_0 (at the bottom of the potential яwell we abc). These distances determine the size of the body at absolute zero. As the temperature increases, the particles begin to oscillate around the equilibrium positions O. Let's assume that only particle 2 is oscillating. The oscillating particle has the kinetic energy that reaches the highest value at the moment of passing the equilibrium position O.

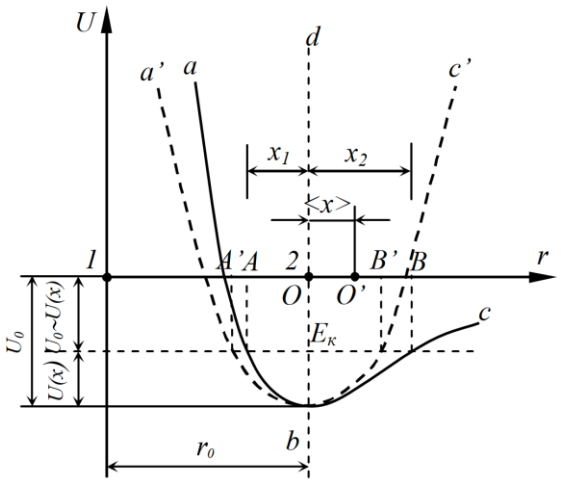

figure 1

In Figure 1, the energy $E_к$ek is deposited from the bottom of the potential well. When particle 2 moves to the left of the equilibrium position, kinetic energy is spent on overcoming the repulsive forces from particle 1 and passes into the potential energy of particle interaction. The deviation to the left occurs until all the kinetic energy of the particle $E_к$ ek is converted into potential energy.

The latter will increase by $U(x) = E_k$ and will be equal to $-(U_0 - U(x))$, and particle 2 will move extremely to the left by a distancex_1. When particle 2 moves to the right of the equilibrium position, kinetic energy is spent on overcoming the forces of attraction to particle 1 and also passes into the potential energy of

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particle interaction. At the point B, which is separated from the equilibrium position by a distance $x_{of\ x2}$, all the kinetic energy E_k passes into the potential energy, as a result of which the latter again increases by the value $U(x) = E_k$ and becomes equal to $-(U_0 - U(x))$.

If particle 2 performed purely harmonic vibrations, then following Hooke's law, the force f(x) that occurs when it deviates from the equilibrium position by a distance x would be strictly proportional to this deviation and directed to the equilibrium position

$$f = -\beta x \qquad (1)$$

The change in the potential energy U (x) of the particle would be described by the parabola a'a'bc' (Fig. 1), the equation of which is

$$U(x) = \beta x^2/2 \qquad (2)$$

This parabola is symmetric with respect to a straight line bdparallel to the U-axis and at adistance r0 from it_0. Therefore, the deviations x_1 and x_2 would be the same in magnitude, and the midpoint of the oscillation range A'B ' would coincide with the equilibrium position 0.Heating the body in this case could not cause its expansion, since with an increase in temperature there would only be an increase in the amplitude of particle vibrations, and the average distances between them would remain unchanged.

In reality, the potential curve abc is, as can be seen from Figure 1, non-symmetric with respect to the line bd. This means that the vibrations of particles in a solid are anharmonic. To take into account the asymmetry of the potential curve, it is necessary (2)to introduce an additional term in equation (2)$-$ gx3/3, which expresses this asymmetry. Then equations (1) and (2) take the form:

$$U(x) = \frac{\beta x^2}{2} - \frac{gx^3}{3} \qquad (3)$$

$$f(x) = -\frac{\partial U}{\partial x} = -\beta x + gx^2 \qquad (4)$$

The unsymmetric nature of the potential curve leads to the fact that the deviations of particle 2 to the right and to the left are not the same (x_{x2}>x_1). As a result, the average position of particle 2 (point O') no longer coincides with the equilibrium position (point O), but is shifted to the right. This corresponds to an increase in the average distance between particles by <x>.

Thus, when heated, the volumetric expansion of the body is explained by an increase in the average distances between particles, and not by an increase in the amplitude of vibrations of particles near their equilibrium positions.

Let us estimate the coefficient of thermal expansion a. The average value of the force that occurs when the particle 2 is displaced from the equilibrium position is written according to (4)(3.19) by the relation

$$< f >= -\beta < x > + g < x^2 >.$$

In free vibrations, <f> = 0, so I $g<^{x2}>$ = β<x>. From here we findдим

$$< x >= \frac{g<x^2>}{\beta} \qquad (5)$$

Up to the second order of smallness, the potential energy of an oscillating particle is determined by the relation (3), and its average value is $< U(x) > \beta \frac{\beta< x^2>}{2}$. Hence we find $< x2^2 > \approx \frac{2<(ux)>\beta}{\beta}$

Substituting this formula in (3.20), we obtain for the value of the average distance between particles the expression: $< x >= \frac{2g < U(x)>}{\beta 2^2}$. In addition to the potential energy U(x), the oscillating particle has a kinetic energy E_k, and $< U(x) >= < E_k >$. The total energy of the particle $E = < E_к ek > + < U(x) >= 2 < U(x) >$. This allows the value <x> to be rewritten as follows : $< x >= gE/\beta 2$.

The relative linear expansion, which is the ratio of the change in the average distance <x> between particles to the normal distance <x> r_o between them, is $\frac{< x>}{r_0} = \frac{g}{\beta^2 r_0} E$, and the coefficient of linear expansion is defined as

$$\alpha = \frac{1}{r_0}\frac{d<x>}{dT} = \frac{g}{\beta^2 r_0}\frac{dE}{dT} = \chi C_V \qquad (5),$$

Where $\chi = \frac{g}{\beta^2 r_0}$, a $C_V = \frac{dE}{dT}$ is the heat capacity assigned to a single particle.

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Thus, the coefficient of linear expansion α is proportional to the heat capacity of the body.

1) In the region of high temperatures, the energy of linearly oscillating particles is equal to E k= Kt, the heat capacity assigned to one particle теплоёмкость With$_V$ = k, so the expansion coefficient of a linear chain of atoms will be equal to

$$\alpha = \chi C_V = \frac{gk}{\beta^2 r_0} \qquad (6)$$

Substituting the numerical values g, k, β, and$_0$ r0 for various solids gives for α a value of the order of^{-4}-10^{-5}10-4-10-5, which is in satisfactory agreement with the experiment. Experience also confirmsthat in the region of high temperatures α is practically independent of temperature.

2) In the region of low temperatures , α behaves similarly to C_v: it decreases with decreasing temperature and tends to zero as it approaches absolute zero. In conclusion, we note that a formula similar to (6) was first proposed for metals by Gruneisen and had the form

$$\alpha = \gamma \cdot \eta \cdot C_v / 3V$$

where ηпкоэis the compressibility coefficient of the metal, V is the atomic volume, and γ is постоянная the Gruneisen constant, which varies from 1.5 to 2.5 for different metals.

References:

1. Zhoroeva, A.M. (2019). On methods of managing the agricultural sector of the economy of the Kyrgyz region. *Economics and Management: Problems, Solutions*,*1*(3), 18-21.
2. Zhoroeva, A.M. (2020). On the state and main directions of horse breeding development in Kyrgyzstan. *Accounting and Control*, (1), 33-38.
3. Zhoroeva, A.M. (2019). On the organization of accounting in horse breeding in accordance with international standards. *Accounting and Control*, (1), 25-28.
4. Zhoroeva, A.M., & Rysbaeva, A. K. (2021). Problems in the development of horse breeding in the Kyrgyz Republic. *Accounting and Control*, (5), 10-17.
5. Raiymbaeva, A. Ch., & ЖороеваZhoroeva, A.M. (2021). Improvement of the management system and cost analysis of economic entities of the Kyrgyz Republic in the context of market transformations. *Accounting and Control*, (9), 8-14.
6. Zhoroeva, A. A.M.(2020). PERCEPTION OF THE CONCEPT «MAN» IN THE KYRGYZ NATIONAL WORLD VIEW. *Proceedings of the National Academy of Sciences of the Kyrgyz Republic*, (1), 174-179.
7. Joroeva, A. M. (2020). QIRGIZ RESPUBLIKASI OTICHILIK KORXONALARINING HOJJIYAT FAOLIYATLARINI ALGARISH SHARTLARI. *Nauka, novye texnologii i innovatsii Kyrgyzstana*.
8. Zhoroeva, A.M. (2019). On the problems of transformation and investment in the economy of the Kyrgyz region. *Economics and Management: Problems, Solutions*,*5*(1), 41-45.
9. Zhoroeva, A.M., & Rysbaeva, A. K. (2021). Problems in the development of horse breeding in the Kyrgyz Republic. *Accounting and Control*, (5), 10-17.
10. Kaxramon, K. (2022). XIX ASR OXIRI VA XX ASR BOSHLARIDA TURKISTONDA XALQ SUDYA (QOZILAR) FAOLIYATIGA KIRITILGAN O ‘ZGARISHLAR. *Yosh Tadqiqotchi Jurnali*, *1*(5), 240-245.
11. Karimov, K. (2023). Turkistonda mustamlaka davri ijtimoiy munosabatlarga oid hujjatlarning tarixiy-huquqiy tadqiqi. *UzA Ilm-fan bo'limi*.
12. Venera, K., & Karimov, K. (2023). Turkistondagi ijtimoiy, siyosiy, iqtisodiy o‘zgarishlar, boshqaruv tizimi, mahalliy aholi vakillarining jamiyat hayotidagi ishtiroki. *Ijobiy maktab psixologiyasi jurnali*, 1213-1218.
13. Karimov, K. (2021). Туркистонда маҳаллий бошқарув тизимида қозилик маҳкамалари фаолияти тарихидан. *FarDU. Ilmiy xabarlar*.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 12 in December-2023
https://www.gejournal.net/index.php/IJSSIR

14. Karimov, K. (2020). Turkistonda tarixan shakllangan qozilik mahkamalari faoliyatiga kiritilgan o ‘zgarishlar. *Qo'qon DPI. Ilmiy xabarlar*.

15. Karimov, K. (2023). XIX ASR OXIRI VA XX ASR BOSHLARIDA TURKISTONDA MUSTAMLAKA HUQUQIY TAKSANOMIYASI TOMONIDAN QOZILAR FAOLIYATIGA KIRITILGAN O’ZGARISHLAR. *Interpretation and researches*, *1*(1).

16. Karimov, K. (2021). Qozilik mahkamalari hujjatlariga oid ayrim mulohazalar. *Sohibqiron yulduzlari*.

17. Karimov, K. (2023). SUDIY MASSASALARNING MASABBIY SHAXSLARI VA ULARNING TASHKIL TARIXI. *Abay nomidagi KazUPU-ning XABARSHYSY, «Yurispredentsiya» seriyasi*.

18. Shermatovna, E. N., & Sodiqjon O’g’li, A. S. (2022). Conditions of inclusive education. Web of Scientist: International Scientific Research Journal, 3, 1-4.

19. Эркабоева, Н. Ш. (2016). FEATURES OF MODERN UZBEK FAMILIES. Ученый XXI века, (4-1 (17)), 36-39.

20. Erkaboeva, N. S., & Kurbanov, M. U. (2022). Scientific Organization and Management of Pedagogical Team Activities. Spanish Journal of Innovation and Integrity, 7, 103-107.

21. Erkaboeva, N., Usmonboeva, M., Irgashova, M., & Khojanazarova, N. (2012). Pedagogical skills: in diagrams and pictures: Methodical manual. Tashkent: TDPU named after Nizami, 14.

22. Эркабоева, Н. Ш. (2016). ОСОБЕННОСТИ СОВРЕМЕННЫХ УЗБЕКСКИХ СЕМЕЙ. Ученый XXI века, (4-1).

23. Erkaboeva, N. S., & Bakhromovna, M. M. (2022). A MODERN APPROACH TO THE FORMATION OF PROFESSIONAL COMPETENCE IN FUTURE DEFECTOLOGISTS. Galaxy International Interdisciplinary Research Journal, 10(12), 1723-1725.

24. Эркабоева, Н., Усмонбоева, М., Иргашова, М., & Хўжаназарова, Н. (2012). Педагогик маҳорат: схема ва расмларда. Т.:“Наврўз.

25. Shermatovna, E. N., & Kizi, Y. M. I. (2022). STAGES OF FORMATION AND DEVELOPMENT OF MEDIAMADANIATIN. Galaxy International Interdisciplinary Research Journal, 10(12), 272-274.

26. Erkaboyeva, N. S. (2016). FEATURES OF MODERN UZBEK FAMILIES. Ученый XXI века, (4-1), 36-39.

27. Erkaboyeva, N. S., & Ugli, A. S. S. (2022). Nclusive education and inclusive society. Asian Journal of Multidimensional Research, 11(11), 10-14.

28. Эркабоева, Н. (2005). Янгиланган фикрларнинг моҳияти ва унинг устувор йўналишлари. Халқ таълими, 19-20.

29. Erkaboeva, N. S., & Rahimberdiyeva, M. M. (2022). Features of Pedagogical Thoughts at a New Stage of Development of Uzbekistan. Spanish Journal of Innovation and Integrity, 7, 53-58.

30. Erkaboeva, N. S., & Musaeva, D. A. K. (2022). FACTORS OF DEVELOPING THE PROFESSIONAL COMPETENCE OF A TEACHER OF A SPECIAL EDUCATION INSTITUTION. Open Access Repository, 8(12), 109-111.

31. Shermatovna, E. N., & Sodiqjon O’g’li, A. S. (2022). Conditions of inclusive education. Web of Scientist: International Scientific Research Journal, 3, 1-4.

32. Fatima, I., & Erkaboyeva, N. S. (2023). WAYS TO FORM THE QUALIFICATIONS OF THE SPECIAL EDUCATION INSTITUTION IN THE PRIMARY SCHOOL STUDENTS OF SOCIAL STANDARDS. Galaxy International Interdisciplinary Research Journal, 11(2), 529-531.

33. Erkaboyeva, N. S., & Elmurodova, O. E. Q. (2023). YOSHLARNI YANGI O ‘ZBEKISTON SHAROITIDA IJTIMOIY FAOLLIGINI OSHIRISH ZAMONAVIY PEDAGOGIKA VA PSIXOLOGIYANING DOLZARB MUAMMOSI SIFATIDA. Academic research in educational sciences, 5(NUU conference 3), 218-222.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 12 in December-2023
https://www.gejournal.net/index.php/IJSSIR

34. Erkaboyeva, N. S. (2023). INSON KAPITALI–IJTIMOIY DAVLATNING ASOSI SIFATIDA. Academic research in educational sciences, 4(KSPI Conference 1), 31-37.

35. Erkaboeva, N. S., & Turdaliyeva, M. I. K. (2022). THEORETICAL PRINCIPLES OF EDUCATION OF NATIONAL ETHICS SKILLS IN EDUCATIONAL INSTITUTION STUDENTS. Open Access Repository, 8(12), 352-354.

36. Shermatovna, E. N., & Azamovna, R. G. (2022). USE OF VIRTUAL ENVIRONMENT AND 3D MULTIMEDIA ELECTRONIC TEXTBOOKS IN HIGHER EDUCATION. International Journal of Early Childhood Special Education, 14(7).

37. УЗБЕКИСТАН, О. Р. (2021). TA'LIM TIZIMIDA INNOVATSIYA, INTEGRATSIYA VA YANGI TEXNOLOGIYALAR ИННОВАЦИЯ, ИНТЕГРАЦИЯ И НОВЫЕ ТЕХНОЛОГИИ В СИСТЕМЕ ОБРАЗОВАНИЯ INNOVATION, INTEGRATION AND NEW.

38. ГУЛОМИДДИНОВА, Д., РАСУЛОВА, Д., & ЭРКАБОЕВА, Н. (2014). ПОДГОТОВКА МОЛОДЁЖИ К СОЦИАЛЬНОЙ ЖИЗНИ. In Будущее науки-2014 (pp. 37-39).

39. ЭРКАБОЕВА, Н. НАЦИОНАЛЬНЫЕ ОСОБЕННОСТИ ОБРАЗОВАНИЯ В УЗБЕКИСТАНЕ. К ЧИТАТЕЛЯМ, 618.

40. Norquzieva, D. S., & Abdullaeva, N. R. (2019). PSYCHOLOGICAL ANALYSIS OF AGGRESSIVE BEHIVIOR IN ADOLESCENCE. Scientific and Technical Journal of Namangan Institute of Engineering and Technology, 1(6), 490-495.

41. Khamidovna, M. I., Sheralievna, N. D., & Okhunovna, M. D. (2022). CONFLICT MANAGEMENT AND TYPES OF CONFLICTS AMONG MINORS. International Journal of Early Childhood Special Education, 14(7).

42. Sheralievna, N. D. (2021). DYNAMICS OF CONSTRUCTIVE BEHAVIOR FORMATION IN PRIMARY SCHOOL STUDENTS. Galaxy International Interdisciplinary Research Journal, 9(10), 666-669.

43. Sheralievna, N. D. (2022). FORMATION OF CONSTRUCTIVE BEHAVIOR AS A FACTOR IN THE EFFECTIVENESS OF SCHOOLCHILDREN'S EDUCATION. Galaxy International Interdisciplinary Research Journal, 10(12), 1212-1216.

44. Norqo'Ziyeva, D. S. (2021). ILK O'SPIRINLARNI KASBGA YO'NALTIRISHNING AYRIM PSIXOLOGIK MASALALARI. Scientific progress, 1(6), 1188-1192.

45. Buronovich, U. B. (2022). THE PLACE OF MODERN PROFESSIONAL QUALITIES OF VIRTUAL TECHNOLOGIES IN TEACHERS OF FUTURE TECHNOLOGICAL EDUCATION IN HIGHER EDUCATIONAL INSTITUTIONS. Open Access Repository, 9(11), 37-43.

46. Buronovich, U. B., & Ashirovich, B. T. A. (2022). Examples Of Drawing Up Tests From Drawing And Engineering Graphics. Journal of Positive School Psychology, 6(11), 3128-3132.

47. Boronovich, U. B. (2022). THE CONTENT OF THE FORMATION OF MODERN PROFESSIONAL QUALITIES IN FUTURE TEACHERS OF TECHNOLOGICAL EDUCATION IN HIGHER EDUCATIONAL INSTITUTIONS. Open Access Repository, 9(11), 16-22.

48. Umrzaqov, B. B. (2023). PEDAGOGICAL NEED FOR THE FORMATION OF MODERN PROFESSIONAL QUALITIES THROUGH VIRTUAL TECHNOLOGIES IN TEACHERS OF FUTURE TECHNOLOGICAL EDUCATION IN HIGHER EDUCATIONAL INSTITUTIONS. INTERNATIONAL JOURNAL OF SOCIAL SCIENCE & INTERDISCIPLINARY RESEARCH ISSN: 2277-3630 Impact factor: 7.429, 12(11), 89-93.

49. Umrzaqov, B. B. (2023). MODERN PROFESSIONAL QUALITIES IN FUTURE TECHNOLOGICAL EDUCATION TEACHERS AND THEIR OWN RANGE OF VIRTUAL TECHNOLOGIES. INTERNATIONAL JOURNAL OF SOCIAL SCIENCE & INTERDISCIPLINARY RESEARCH ISSN: 2277-3630 Impact factor: 7.429, 12(11), 101-105.

50. Bo'ronovich, U. B. (2022). TECHNOLOGY OF INCREASING WORK PRODUCTIVITY IN TECHNOLOGICAL EDUCATION CLASSES.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 12 in December-2023
https://www.gejournal.net/index.php/IJSSIR

51. Umrzakov, B. B. (2022). ORGANIZATION OF EDUCATIONAL PROCESS IN TECHNOLOGICAL EDUCATION CLASSES.

52. Madumarov, T., & Ogli, G. O. R. (2023). FIGHT AGAINST CORRUPTION IN THE REPUBLIC OF UZBEKISTAN (ON THE EXAMPLE OF THE EDUCATION SYSTEM). *Educational sacrifices*, 02-05.

53. Abdullaev, A. N. (2020). THE SOCIAL PHILOSOPHICAL ESSENCE OF THE COEVOLUTION OF SOCIETY AND FAMILY. *Theoretical & Applied Science*, (2), 733-736.

54. Xalimjanovna, A. M. (2022). MANIFESTATIONS OF STRESS IN PROFESSIONAL ACTIVITY AND WAYS TO ELIMINATE IT. *Galaxy International Interdisciplinary Research Journal*, *10*(11), 841-844.

55. Makhmudova, N. (2023). THE CONTENT OF THE DEVELOPMENT OF INDEPENDENT COGNITIVE ACTIVITY IN STUDENTS THROUGH SELF-ASSESSMENT. *International Bulletin of Applied Science and Technology*, *3*(3), 215-221.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 12 in December-2023
https://www.gejournal.net/index.php/IJSSIR