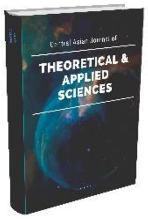


CENTRAL ASIAN JOURNAL OF THEORETICAL AND APPLIED SCIENCES

Volume: 04 Issue: 04 | Apr 2023 ISSN: 2660-5317
https://cajotas.centralasianstudies.org

Mathematical Modeling of the Effect of Titanium (TI) Added as a Modifier on the Wear Resistance of a Low–Alloyed Steel Alloy

Nozimjon Kholmirzaev, Nodir Turakhodjaev
Tashkent State Technical University, Tashkent, Uzbekistan
Uzbek – Japanese Innovation Center of Youth, Tashkent, Uzbekistan

Orzumurod Ermanov, Akmal Ibragimov, Adil Sultonov
JSC Uzbek Metallurgical Plant, Bekabad, Uzbekistan

Anvar Turaev
Tashkent State Technical University, Tashkent, Uzbekistan

Received 11th Feb 2023, Accepted 10th Mar 2023, Online 12th Apr 2023

Abstract: *This article presents a research analysis of the effect of the Ti element as a modifier on the wear resistance of the 35XGCL low – alloyed liquid steel alloy. Based on the obtained results, the increase in the number of crystallization centers of the cast alloy and the formation of a fine granular structure led to a significant increase in the wear resistance property of the cast product.*

Keywords: *modifier, wear resistance, low – alloyed, crystallization centers, Lagrange's interpolation polynomial, Cramer's method.*

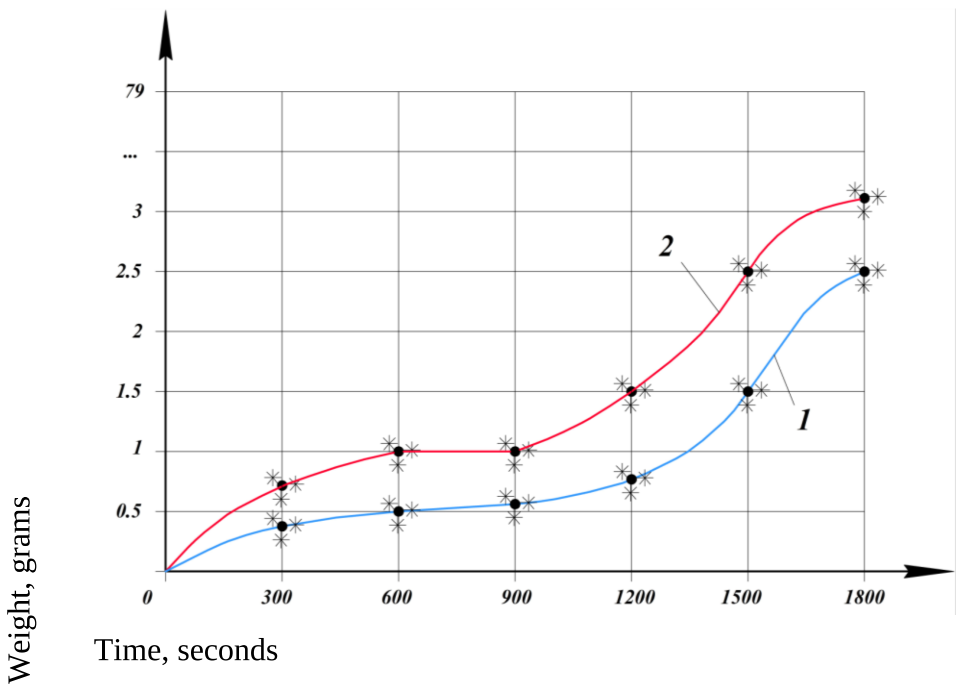
Introduction. Today, the rolling machine shafts used in the stamping shops of production enterprises are the main and very expensive part of the machines for the production of rolled products. They faced various stresses and strains during their work. In addition, the geometric dimensions and material of the shafts must ensure that they can withstand the heaviest loads that occur during the shift sequence. Another important factor related to the service life of the shafts is the wear resistance of its material.

Main part. Wear resistance means the ability of a material to resist material loss as a result of some mechanical external influences.

This device can be used to determine the wear resistance of all types of metals. It's easy to use, with the option to control the speed of the diamond disc with automatic power-off at a selected number of revolutions. It is designed to carry out studies of special grinding disk speeds of 400, 525, 650, 775 and 900 revolutions per minute.

Pic 1. General view of a special device with a diamond disc for determining the wear resistance of samples

This graph presents the results of a study conducted to determine the effect of time-dependent corrosion resistance of research samples made from low-alloy steel alloys based on two types of composition [1 – 4].



Pic 2. Wear resistance of research samples made of low – alloyed steel alloys as a function of time.

1 – a sample containing 0.3-0.5% Ti element as a modifier in the composition of the alloy based on the given proposals; 2 – a sample cast from the 35XGCL brand at the production enterprise;

Results. Since the research was carried out on two types of alloys, we will formulate a mathematical expression of the wear resistance of both alloys.

First, we make a mathematical model of the wear resistance of a sample cast from a low – alloyed steel alloy of the 35XGCL brand, which was previously cast at the production plant. For this, time change is taken as a free variable, and we will consider the problem of creating a function that reflects the corrosion of the alloy. In this case, we construct Lagrange's interpolation polynomial, that is, by bringing the problem into the system of algebraic equations, it is possible to express the function of the amount of consumption in the form of a polynomial by determining the unknown coefficients.

m – wear resistance, gram;

t – time, minute;

$m = f(t)$; (1)

$$\begin{cases} 5^6t_1 + 5^5t_2 + \cdots + 5t_6 = 0.7 \\ 10^6t_1 + 10^5t_2 + \cdots + 10t_6 = 1 \\ 15^6t_1 + 15^5t_2 + \cdots + 15t_6 = 1 \\ 20^6t_1 + 20t_2 + \cdots + 20t_6 = 1.5 \\ 25^6t_1 + 25^5t_2 + \cdots + 25t_6 = 2.5 \\ 30^6t_1 + 30^5t_2 + \cdots + 30t_6 = 3.2 \end{cases}; \qquad (2)$$

$t_1 = 1.3*10^{-7}$; $t_3 = 5.3*10^{-4}$; $t_5 = 0.05$;
$t_2 = -1.4*10^{-5}$; $t_4 = -8.5*10^{-3}$; $t_6 = 0.04$;

(2) we can bring the system of equations into the matrix form and find the unknowns using Cramer's method of solving a system of complex linear equations. First, the determinant Δ of the matrix formed using the system of equations is found.

$$\Delta = \begin{vmatrix} 15625 & 3125 & 625 & 125 & 25 & 5 \\ 1000000 & 100000 & 10000 & 1000 & 100 & 10 \\ 11390625 & 759375 & 50625 & 3375 & 225 & 15 \\ 64000000 & 3200000 & 160000 & 8000 & 400 & 20 \\ 244140625 & 9765625 & 390625 & 15325 & 625 & 25 \\ 729000000 & 24300000 & 810000 & 27000 & 900 & 30 \end{vmatrix} =$$

$$= -1.186523437499922e+22 \qquad (3)$$

solving the above matrices, we find the following values of the unknowns,

$$x_1 = \frac{\Delta_1}{\Delta} = \frac{-15820312250000000}{-1.186523437499922e+22} = \frac{823974609375}{617980957031209400};$$

$$x_2 = \frac{\Delta_2}{\Delta} = \frac{166113281249998200}{-1.186523437499922e+22} = -\frac{185394287109373}{13242449079240200000};$$

$$x_3 = \frac{\Delta_3}{\Delta} = \frac{-6288574218749809000}{-1.186523437499922e+22} = \frac{1535296440124465}{2896785736083794000};$$

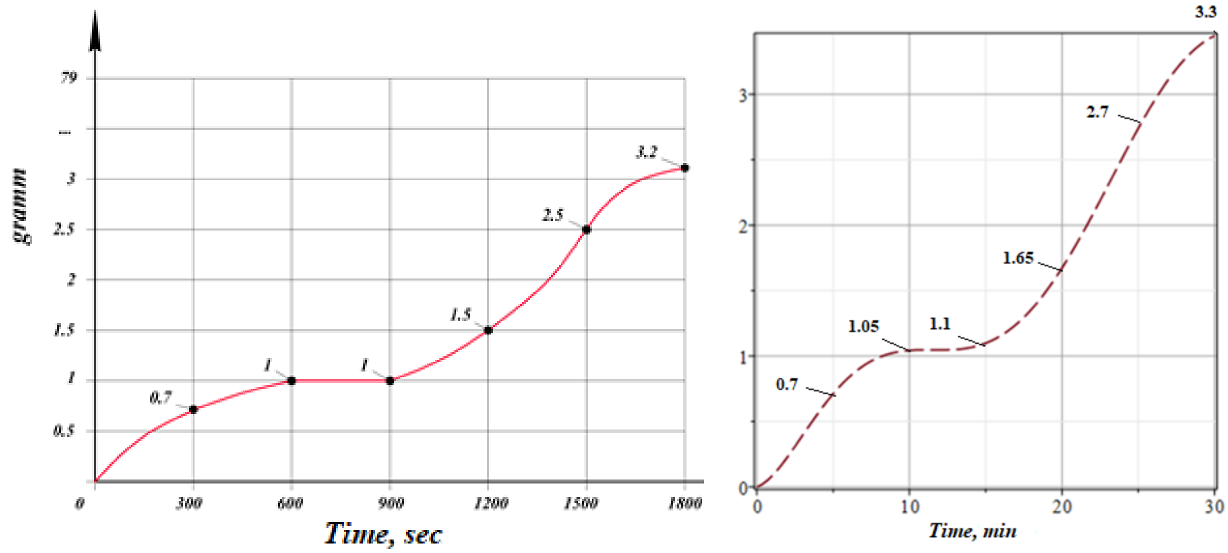
$$x_4 = \frac{\Delta_4}{\Delta} = \frac{101052246093751120000}{-1.186523437499922e+22} = -\frac{128494575619699}{15087425708769760};$$

$$x_5 = \frac{\Delta_5}{\Delta} = \frac{-601171875000039200000}{-1.186523437499922e+22} = \frac{286661088466663}{5657784640788660};$$

$$x_6 = \frac{\Delta_6}{\Delta} = \frac{-494384765624744150000}{-1.186523437499922e+22} = \frac{235741026699421}{5657784640788660};$$

After solving the above equations and determining the unknowns, the function representing the wear resistance of low – alloyed steel alloy 35XGCL as a function of time is as follows:

$m=(1.3*10^{-7})t^6-(1.4*10^{-5})t^5+(5.3*10^{-4})t^4-(8.5*10^{-3})t^3+0.05t^2+0.04t$; (4)



Pic 3. Mathematical model based on research results correspondence to actual results

Next, based on the developed suggestions, we will create a mathematical model of the time dependence of the wear resistance of the sample with 0.3-0.5% Ti element added as a modifier to the alloy composition. For this, time change is taken as a free variable, and we will consider the problem of creating a function that reflects the corrosion of the alloy. In this case, we construct Lagrange's interpolation polynomial, that is, by bringing the problem into the system of algebraic equations, it is possible to express the function of the amount of consumption in the form of a polynomial by determining the unknown coefficients.

m – wear resistance, gram;

t – time, minute;

$m = f(t);$ (5)

$$\begin{cases} 5^6 t_1 + 5^5 t_2 + \cdots + 5 t_6 = 0.3 \\ 10^6 t_1 + 10^5 t_2 + \cdots + 10 t_6 = 0.5 \\ 15^6 t_1 + 15^5 t_2 + \cdots + 15 t_6 = 0.6 \\ 20^6 t_1 + 20 t_2 + \cdots + 20 t_6 = 0.8 \\ 25^6 t_1 + 25^5 t_2 + \cdots + 25 t_6 = 1.5 \\ 30^6 t_1 + 30^5 t_2 + \cdots + 30 t_6 = 2.5 \end{cases}; \qquad (6)$$

$t_1 = -7.11*10^{-8};$ $t_3 = -1.38*10^{-4};$ $t_5 = -0.01;$
$t_2 = 5.33*10^{-6};$ $t_4 = 1.6*10^{-3};$ $t_6 = 0.087;$

(6) we can bring the system of equations into the matrix form and find the unknowns using Cramer's method of solving a system of complex linear equations. First, the determinant Δ of the matrix formed using the system of equations is found.

$$\Delta=\begin{vmatrix} 15625 & 3125 & 625 & 125 & 25 & 5 \\ 1000000 & 100000 & 10000 & 1000 & 100 & 10 \\ 11390625 & 759375 & 50625 & 3375 & 225 & 15 \\ 64000000 & 3200000 & 160000 & 8000 & 400 & 20 \\ 244140625 & 9765625 & 390625 & 15325 & 625 & 25 \\ 729000000 & 24300000 & 810000 & 27000 & 900 & 30 \end{vmatrix}=$$

$$=-1.18652343749992\mathrm{e}+22 \qquad (7)$$

solving the above matrices, we find the following values of the unknowns,

$$x_1=\frac{\Delta_1}{\Delta}=\frac{843750000000000}{-1.18652343749992e{+}22}=-\frac{164794921875}{2317428588867035000};$$

$$x_2=\frac{\Delta_2}{\Delta}=\frac{-63281249999999940}{-1.18652343749992e{+}22}=\frac{988769531249999}{185394287109362800000};$$

$$x_3=\frac{\Delta_3}{\Delta}=\frac{1634765625000033300}{-1.18652343749992e{+}22}=-\frac{159645080566409 5}{1158714294433517 6000};$$

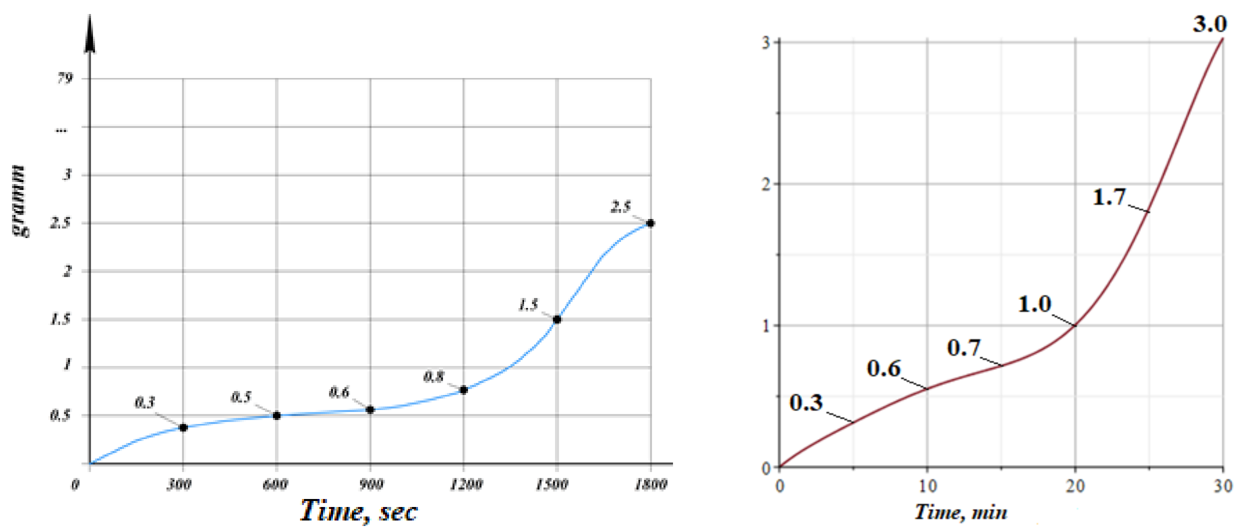
$$x_4=\frac{\Delta_4}{\Delta}=\frac{-1898437500000233000}{-1.18652343749992e{+}22}=\frac{48279762268067}{301748514175395 20};$$

$$x_5=\frac{\Delta_5}{\Delta}=\frac{1247167968749955 30000}{-1.18652343749992e{+}22}=-\frac{237878412008277}{22631138563154640};$$

$$x_6=\frac{\Delta_6}{\Delta}=\frac{-1.02832031249993 35e{+}21}{-1.18652343749992e{+}22}=\frac{1961365342140071}{22631138563154640};$$

After solving the above equations and determining the unknowns, based on the proposals developed, the function representing the wear resistance of the alloy with 0.3-0.5% Ti as a modifier is as follows [5 – 12]:

$m=-(7.11*10^{-8})t^6+(5.33*10^{-6})t^5-(1.38*10)t^4+(1.6*10^{-3})t^3+0.01t^2+0.087t$; (8)



Pic 4. Mathematical model based on research results correspondence to actual results

Conclusions. Based on the results of the research, it was found that the corrosion resistance was significantly improved under the influence of the titanium element added as a modifier to the alloy composition in the amount of 0.3 - 0.5%. The results obtained based on the results of practical research were compared with the results obtained based on mathematical models. The results are confirmed to be compatible.

References

1. Electric Arc Furnace Steelmaking. Miroslaw Karbowniczek. First edition published 2022 by CRC Press 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742
2. Turakhodjaev, N., Kholmirzaev, N., Saidkhodjaeva, S., & Kasimov, B. (2021). Quality improvement of the steel melting technology in an electric arc furnace. ACADEMICIA: An International Multidisciplinary Research Journal, 11(7), 48-54.
3. Nodir, T., Nosir, S., Shokhista, S., & Furkat, O. (2021). Development of 280X29Nl alloy liquefaction technology to increase the hardness and corrosion resistance of cast products. International Journal of Mechatronics and Applied Mechanics, (10), 154-159.
4. Nosir, S., Nodir, T., Kamol, A., Nozimjon, K., & Nuritdin, T. (2022). DEVELOPMENT OF QUALITY STEEL ALLOY LIQUIDATION TECHNOLOGY. American Journal of Interdisciplinary Research and Development, 7, 74-83.
5. Nodir, T., Sarvar, T., Andrey, J., & Yahyojon, M. (2022). Mathematical model for calculating heat exchange. In International Conference on Reliable Systems Engineering (ICoRSE)-2021 (pp. 243-249). Springer International Publishing.
6. Turakhodjaev, N. (2022). Technology for Cleaning Non–Metallic Inclusions and Gaseous Pores in the Process of Liquefaction of Steels in an Electric Arc Furnace. European Multidisciplinary Journal of Modern Science, 4, 77-82.
7. Kholmirzaev, N., Kasimov, B., Abdullayev, B., Sunnatillo, A., & Farrux, A. Increasing the Lifetime of Tillage Machine of Plowshares Made Stell Made by Foundry Technologies. JournalNX, 7(11), 55-59.
8. Turakhodjaev, N., Saidmakhamadov, N., Turakhujaeva, S., Akramov, M., Turakhujaeva, A., & Turakhodjaeva, F. (2020). EFFECT OF METAL CRYSTALLATION PERIOD ON PRODUCT QUALITY. Theoretical & Applied Science, (11), 23-31.
9. Karimov, K., Turakhodjaev, N., Akhmedov, A., & Tashbulatov, S. (2021). A mathematical model of the technology of extraction of copper from industrial slags. In E3S Web of Conferences (Vol. 264, p. 04077). EDP Sciences.
10. Nosir, S., Kamol, D. A., Bahodirjon, T. A., & Akhrorjon, K. (2022). Development of technology for obtaining quality castings from steel alloys. Eurasian Journal of Engineering and Technology, 5, 135-138.
11. Nodir, T., Nosir, S., Shirinkhon, T., Erkin, K., Azizakhon, T., & Mukhammadali, A. (2021). Development Of Technology To Increase Resistance Of High Chromium Cast Iron. The American Journal of Engineering and Technology, 3(03), 85-92.
12. Turakhujaeva, S., Karimov, K., Turakhodjaev, N., & Akhmedov, A. (2023). Mathematical modeling of quantitative changes in hydrogen and oxide inclusions in aluminum alloy. In E3S Web of Conferences (Vol. 365, p. 05016). EDP Sciences.

