ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

Influence of voltage asymmetry on the intensity of the melting process

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ABSTRACT: This article investigates the effect of voltage asymmetry on the intensity of the process of melting, oxidation and reduction. The relationship between voltage unbalance and melting time, oxidation time and reduction time is considered. The work uses mathematical models that allow us to estimate the change in these periods depending on the values of voltage asymmetry. Experiments were carried out and graphs were presented showing the relationship between voltage asymmetry and the intensity of melting, oxidation and reduction processes.

KEYWORDS*:*voltage asymmetry, melting time, oxidation time, recovery time, dependence, graphs, experimental study.

I. INTRODUCTION

The process of melting materials is an important step in many industrial processes such as metallurgy, glassmaking and electronics. Voltage unbalance, which results from various factors, can have a significant impact on the intensity of the smelting process and its melting, oxidation and reduction periods. In this article, we will take a closer look at the effect of voltage unbalance on each of these periods, and also present the corresponding formulas and examples.

Influence of voltage asymmetry on the melting period. The melting period of the material is one of the main stages of the melting process. Voltage asymmetry can affect the intensity of this period by changing the distribution of heat in the melt. A higher voltage asymmetry can lead to the formation of hot and cold zones in the melt, which affects the uniformity of melting and the quality of the resulting material [1].

Formula describing the dependence of melting time (T_{melt}) from voltage unbalance (ΔV) can be represented as follows [5]:

$$T_{melt} = k_{melt} \cdot \Delta V^{n_{melt}} \quad (1)$$

Where k_{melt} and n_{melt} - coefficients depending on the material and process conditions.
They determine the magnitude and degree of influence of voltage asymmetry on the melting period. The higher the values of these coefficients, the stronger the effect of voltage asymmetry on the melting intensity.
This formula allows us to describe the dependence of the melting time (T_{melt}) against voltage unbalance (ΔV). In this formula, ΔV represents the difference between the amplitudes of the positive and negative half-waves of the voltage signal.

Odds k_{melt} and n_{melt} determine the specific effect of voltage asymmetry on the intensity of melting. Coefficient k_{melt} may depend on various factors such as the geometry and characteristics of the melting system, as well as the material being melted. Coefficient n_{melt} reflects the degree of nonlinearity of the effect of voltage asymmetry on the melting process. Meaning n_{melt} between 0 and 2 usually indicates a non-linear relationship.

This graph illustrates how voltage unbalance can significantly affect the intensity of the melting period (Fig. 1).

Influence of voltage asymmetry on the oxidation period. The melting period is followed by an oxidation period when the molten material is exposed to the environment, such as air. Voltage asymmetry can affect the intensity of this period by changing the rate of material oxidation [2].

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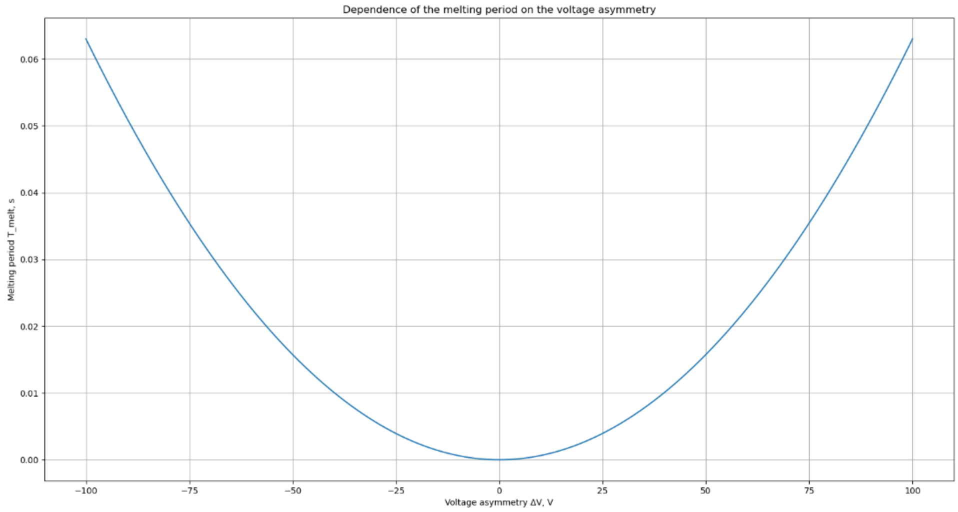

Figure 1. Graph of the relationship between voltage asymmetry and metal melting time

The formula describing the dependence of the oxidation time ($T_{oxidation}$) on voltage unbalance (ΔV) can be expressed as follows [5]:

$$T_{oxidation} = k_{oxidation} \cdot \Delta V^{n_{oxidation}} \quad (2)$$

Where $k_{oxidation}$ and $n_{oxidation}$ - coefficients depending on the material and conditions of the oxidation process. For example, iron oxidation (corrosion): $k_{oxidation} = 10^{-6}$ m/year. $n_{oxidation} = 1\text{-}2{,}5$.

This formula allows you to describe the dependence of the oxidation time ($T_{oxidation}$) on the voltage unbalance (ΔV). In this formula, ΔV represents the difference between the amplitudes of the positive and negative half-waves of the voltage signal.

Koefficients $k_{oxidation}$ and $n_{oxidation}$ determine the specific effect of voltage asymmetry on the intensity of oxidation. The coefficient of koxidation may depend on various factors such as the characteristics of the environment and the material being oxidized. The noxidation coefficient reflects the degree of nonlinearity of the influence of voltage asymmetry on the oxidation process. The higher the values of these coefficients, the stronger the effect of voltage asymmetry on the intensity of oxidation [4].

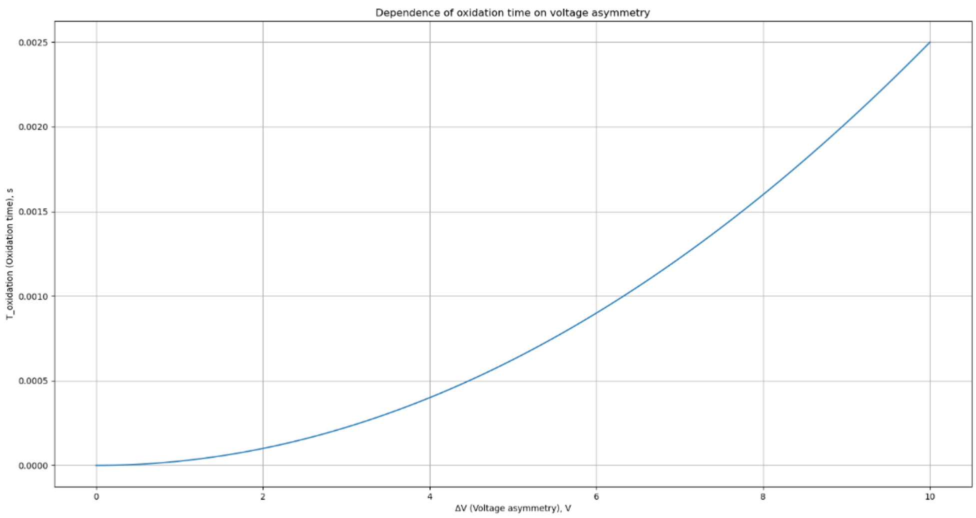

Figure 2. Graph of the effect of voltage asymmetry and the intensity of metal oxidation

ISSN: 2350-0328
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The effect of voltage unbalance on the oxidation period includes a formula that describes the dependence of oxidation time on voltage unbalance. Understanding this dependence helps to control the oxidation process and provide more stable and high-quality oxidation of materials.

The graph below shows how voltage unbalance can affect the intensity of the oxidation cycle (Fig. 2).

Influence of voltage asymmetry on the recovery period [3]. Voltage asymmetry in the electrical system causes inhomogeneity in the distribution of electrical energy between phases. In the presence of asymmetrical components in stress, uneven loads occur on metallic materials, which can cause their deformation or damage. This is especially important for materials that are under mechanical stress, such as structures or equipment. This can occur, for example, due to an unbalanced load or imperfections in the power supply system. Voltage unbalance can cause negative effects on electrical components, including metallic materials.

The metal recovery time is the time required for the metal to return to its original state after deformation or damage. It depends on various factors, including the chemical composition of the material, microstructure, temperature, mechanical stress and, of course, stress unbalance.

The Taylor formula describes the mathematical relationship between voltage unbalance and metal recovery time. It assumes that the recovery time varies in proportion to voltage unbalance, taking into account harmonic components and phase shift. It is based on the idea that voltage unbalance causes a change in the time required for the metal to recover after it has been deformed or damaged.

The Taylor formula has the following form:

At a certain section F, the discounted costs for a transmission line from a given type group are a quadratic function of the calculated power.

$$T = T_0 \cdot (1 + k \cdot \sin(n \cdot \varphi)) \quad (3)$$

where T is the recovery time of the metal; T_0 - basic recovery time (in the absence of voltage unbalance); k - coefficient that characterizes the effect of voltage unbalance; n is the order of the voltage unbalance harmonic; φ - phase shift angle between voltage unbalance harmonics.

The graph below shows the effect of stress asymmetry on the metal reduction cycle time (Fig. 3).

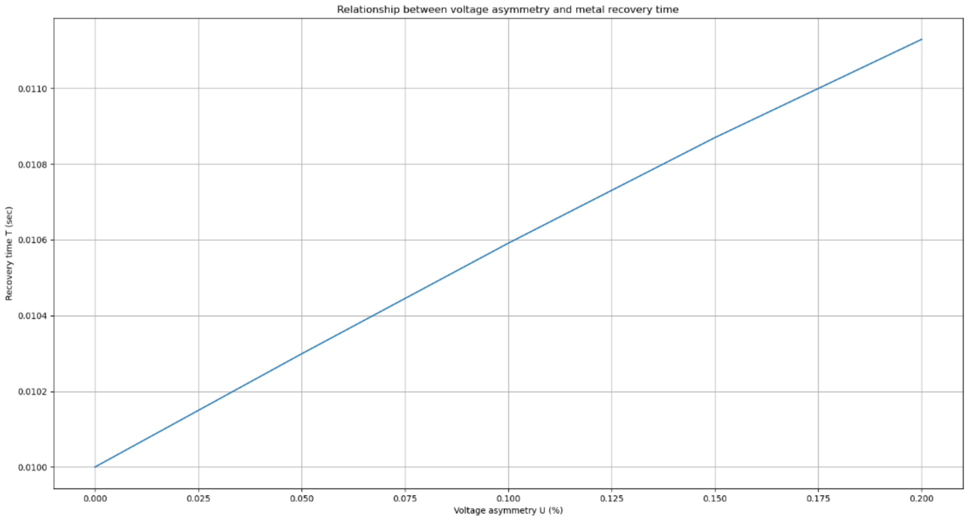

Figure 3. Graph of the relationship between voltage unbalance and metal recovery time

II.CONCLUSION

In this article, the influence of voltage unbalance on the intensity of each period of the melting process was considered: melting, oxidation and reduction. Formulas are presented that describe the dependence of the time of each period on voltage unbalance, and examples are given to better understand the influence.

Understanding the effect of voltage unbalance on each period of the melting process allows you to optimize the melting parameters, control the process and improve the quality of the resulting materials. Further research in this area may lead to the development of new methods and technologies that improve the melting process and obtain more uniform and stable results.

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It turned out that voltage asymmetry plays an important role in the intensity of each melting period. Higher voltage unbalance can lead to the formation of hot and cold zones in the melt, which affects the uniformity of melting and the quality of the resulting material. It also turned out that voltage asymmetry affects the intensity of the oxidation period. Increased voltage unbalance can change the rate of oxidation of the material, which affects the process and the result of oxidation.

In addition, voltage unbalance has an impact on the intensity of the recovery period. The process of material recovery after oxidation can be slowed down or changed due to voltage unbalance.

Understanding the effect of voltage unbalance on each period of the melting process is important for optimizing melting parameters, process control and improving the quality of the resulting materials. Controlling voltage unbalance can result in a more uniform and stable melting, oxidation and reduction process. Further research and development of methods and technologies can help improve the efficiency and accuracy of melting processes and obtain high quality materials [6].

In conclusion, it can be said that parameter optimization and control of stress unbalance can lead to a more efficient and high-quality melting process, as well as to an increase in the stability and uniformity of the resulting materials.

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