CORPUS PUBLISHERS

Journal of Mineral and Material Science (JMMS)

ISSN: 2833-3616

Volume 6 Issue 1, 2025

Article Information

Received date : January 21, 2025

Published date: February 07, 2025

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DOI: 10.54026/JMMS/1106

Opinion

Increasing the Reliability of Welded Joints of Steam Pipelines Under Creep and Fatigue Conditions

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Opinion

The metal of welded joints of steam pipelines made of steel 12X1MΦ and 15X1M1Φ, which operate for a long time at operating parameters - temperature 545-565 °C and steam pressure 25.5 MPa, under variable loads, is damaged by creep and fatigue mechanisms. It is advisable to consider the features of damage, which is necessary to understand in order to prevent its formation and inhibit it when creating new, more heat-resistant steels. It should be noted that the damage of the metal of welded joints occurs more quickly than the damage of the base metal of steam pipelines, which has not undergone welding heating. Such acceleration is due to the presence of the corresponding structural, chemical and mechanical heterogeneity. In general, damageability is caused by physicochemical processes that occur in the metal of welded joints and, accordingly, ensure the passage of structural and phase changes. The purpose of the work is to generalize the features of providing stability to the metal structure of welded joints in terms of reducing their damageability under creep and fatigue conditions. The generalization of the above features is part of the research for the development of new, more heat-resistant steels. Structural and phase transformations were studied in welded joints made of steels 12X1MΦ and 15X1M1Φ.

During the long-term operation of welded joints, physicochemical processes occur in their metal [1]; self-diffusion of alloying elements Cr, Mo and V; coagulation of carbides M_7C_3 and $M_{23}C_6$; carbide reactions $M_3C \rightarrow M_7C_3 \rightarrow M_{23}C_6$; formation of new carbides VC and Mo_2C; the chemical composition of carbide $M_{23}C_6$ changes; dislocations move by creep and sliding. The above processes ensure the formation of a new component in the structure of welded joints - a ferrite-carbide mixture, the presence of which contributes to their accelerated damageability. Therefore, when developing new steels of the P91/P92/P911 type [2] and 10X9K3B1M1ΦБР [3] type for operation at a temperature of 580-650 °C and a pressure of 340 MPa, the peculiarities of the course of physicochemical processes were insufficiently taken into account. The trostitomartensitic structure formed in steels P91, P92, P911 after their heat treatment gives them high creep resistance. However, after tempering, according to the reactions $M_3C \rightarrow M_2C \rightarrow M_{23}C_6$ and $M_3C \rightarrow M_7C_3 \rightarrow M_{23}C_6$, carbide $M_{23}C_6$ is formed. In the metal of welded joints from steels 12X1MΦ and 15X1M1Φ, coagulation of carbides, by coalescence, occurs mainly along the grain boundaries. And the formation of creep nucleation pores occurs at the contact boundary of grains with coagulating carbides $M_{23}C_6$.

In the structures of the metal of welded joints, coagulation of $M_{23}C_6$ carbides occurs, mainly those located at the grain boundaries of the α-phase. The reaction $M_7C_3 \rightarrow M_{23}C_6$ under creep conditions occurs by restructuring the Me_7C_3 lattice into the $M_{23}C_6$ lattice. Such restructuring is facilitated by the presence of segregation layers along the grain boundaries of the α-phase. In the structure of the metal of welded joints, in the presence of layers, carbides $M_{23}C_6$ are mainly located at the grain boundaries, and M_7C_3 and $M_{23}C_6$ along their body. It is advisable to establish the manifestation of the segregation effect in the metal of welded joints of the proposed steels, including in steel 10X9K3B1M1ΦБР. Elimination of the presence of segregations will prevent the reaction $M_7C_3 \rightarrow M_{23}C_6$, as well as the coagulation of $M_{23}C_6$ carbides, which will enhance the stability of the structure of welded joints under creep conditions and ensure a reduction in their damage.

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