Thermal Expansion of Tubular Busbars

Article Overview

Tubular busbars expand and contract with temperature changes, generating mechanical stress that must be managed through material selection, geometry, and flexible support design.

Causes of Thermal Expansion

Thermal expansion in busbars occurs when electrical current flows through the conductor, generating heat due to Joule heating and ambient temperature variations. As the busbar heats up, the atomic kinetic energy increases, causing the material to expand; conversely, cooling leads to contraction . The Coefficient of Thermal Expansion (CTE) quantifies this behavior and varies by material: copper expands less and maintains higher mechanical strength, while aluminum expands more and is lighter but requires careful design to prevent stress .

Effects on Tubular Busbars

Tubular busbars, commonly used in substations and switchgear, are subject to mechanical stress at connection points and supports due to expansion and contraction . If the busbar is rigidly fixed, thermal movement can cause plastic deformation, loosening of joints, insulation degradation, and increased electrical resistance, potentially leading to system failures . Repeated thermal cycling can accelerate fatigue and reduce the expected service life of the busbar .

Design Considerations

o Flexible Geometry: U-shaped or bent tubular busbars allow expansion along the curve, reducing stress at fixed points. Simulations show that U-shaped busbars with optimized bend radius and cross-section shape can significantly lower stress and steady-state temperature .

o Support Placement: Proper positioning of sliding supports and fixed points directs thermal expansion along preferred paths, preventing excessive stress accumulation .

o Material Selection: Copper is preferred for high-stability applications due to lower expansion and higher conductivity, while aluminum is used where weight and cost are critical, but requires additional design measures to accommodate expansion .

o Thermal Analysis: Advanced simulations, including CFD and transient thermal modeling, help predict temperature distribution, expansion, and stress under rated and short-circuit currents, guiding design improvements .

Mitigation Strategies

o Flexible joints and weld plates allow controlled movement.

o Sliding supports accommodate longitudinal expansion.

o Optimized cross-section shapes reduce peak temperatures and stress.
o Regular inspection and maintenance ensure connections remain secure despite thermal cycling .

Summary

Thermal expansion and contraction in tubular busbars are critical factors in electrical system reliability. By combining material choice, geometric design, support placement, and thermal analysis, engineers can minimize mechanical stress, maintain electrical performance, and extend the service life of busbar systems .

This paper deal with thermal analysis of various joint configurations of high power busbar system and shows how the temperature

Aluminium tubular busbars offer lighter weight and higher stiffness compared to stranded conductors, enhancing support efficiency.

Aluminium tubular busbars are subject to wind-generated vibration and oscillation. Because of the low self-damping of tubular

That mostly concerns the shape of busbars inside the switchgear and their placement, as it is essential for proper heat distribution.

An approach for the thermal-mechanical design of busbars was developed using ANSYS(TM)-based numerical simulation. Special

The purpose of this work is to analyze the temperature distribution in busbars during rated

2.3 Thermal Stress Copper has a relatively high coefficient of thermal expansion (?17×10?6/K). During long-term

A summary of these conditions can be seen in table 4. Thermal convection as well as radiation boundary conditions are applied to all

Busbars Busbars are used to inter-connect plant and equipment within a substation compound area as detailed in BS EN 61936-1 -

The manuscript presents advanced coupled analysis: Maxwell 3D, Transient Thermal and Fluent CFD, at the time of a

The objective of this work is to compare different laminated aluminum busbars expansion joints in terms of

their

A study by Bedkowski et al., 2016 found that the calculation of convective heat transfer coefficients in thermal

The physics governing busbar thermal behavior centers on three heat transfer mechanisms: conduction through the

In this thesis, the problem of thermal expansion in busbars for implementation in automotive applications are investigated. A busbar

In order to alleviate the contradiction between steady state temperature rise control and compact design of GIS (Gas Insulated

Undersized busbars are one of the leading causes of switchgear failures: they overheat,

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