ti Current Trends

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Engineering Considerations for Selecting Aluminium Busbars w.r.t Copper Switchgear Terminal.

1. Introduction

In low voltage switchgear assemblies, copper is often the preferred material for terminals due to its superior electrical conductivity and mechanical strength. However, in India aluminium busbars are increasingly used in power distribution systems due to cost advantages and weight savings. This necessitates careful engineering considerations when connecting aluminium busbars to copper switchgear terminals such as Air Circuit Breakers (ACBs), Moulded Case Circuit Breakers (MCCBs), and Contactors.

2. Key Considerations

Material Compatibility and Galvanic Corrosion

When two dissimilar metals such as aluminium and copper are connected, there is a risk of galvanic corrosion, which can compromise the connection's integrity over time. The difference in electrochemical potential between the two metals can lead to corrosion in the presence of moisture or electrolytes.

Mitigation Measures:

- Use bi-metallic connectors or transition plates to prevent direct contact between the aluminium busbar and copper terminal.
- Apply antioxidant compounds or joint grease to inhibit oxidation and reduce the risk of corrosion.
- Periodic maintenance to check for corrosion and joint integrity.

Thermal Expansion Coefficients

Aluminium has a higher coefficient of thermal expansion compared to copper. This means that during operational temperature fluctuations, aluminium busbars will expand and contract more than copper terminals, potentially loosening bolted connections over time.

Mitigation Measures:

- Use spring washers or conical washers to maintain pressure in the joint despite thermal expansion.
- Avoid excessive tightening of connections, as this can lead to mechanical deformation of aluminium.

Electrical Conductivity and Current Carrying Capacity

Aluminium's electrical conductivity is about 61% that of copper. Therefore, for aluminium busbars to carry the same amount of current, they must have a larger cross-sectional area compared to copper busbars.

Implications:

- **Larger Cross-Section:** Aluminium busbars will need to be wider and/or thicker to handle the same current as copper busbars.
- **Terminal Width Mismatch:** The increased width of the aluminium busbar may not correspond with the terminal pad width of copper-based switchgear, resulting in poor contact or overheating.

3. Terminal Width Compatibility

Most switchgear devices, such as ACBs, MCCBs, and MCBs, are designed with copper terminals that have specific pad widths and hole patterns. For the system to operate efficiently, the aluminium busbar needs to be sized and aligned with the terminal to ensure proper electrical contact and mechanical integrity.

Key Considerations for Terminal Width Compatibility:

- Ensure that the **width** and **thickness** of the aluminium busbar match the copper terminal's requirements for mechanical clamping and electrical contact.
- Use **bi-metallic connectors** or **transition lugs** to connect aluminium busbars to copper terminals, ensuring a secure connection.
- **Current Density:** Adjust the busbar size to maintain a consistent current density within the specified limits of the switchgear terminal.

4. Formula for Busbar Current Rating

The busbar current rating is a critical parameter when selecting the appropriate size of aluminium busbars. The formula used to calculate the current rating of a busbar is:

K = Derating Factor **{Busbar Current Rating} = K x W x t x J x n**

Where:

- (considering environmental and operational factors)
- **W** = Width of Busbar (mm)
- **t** = Thickness of Busbar (mm)
- **n** = Number of runs
- **J** = Current Density of conductor (A/mm^2)

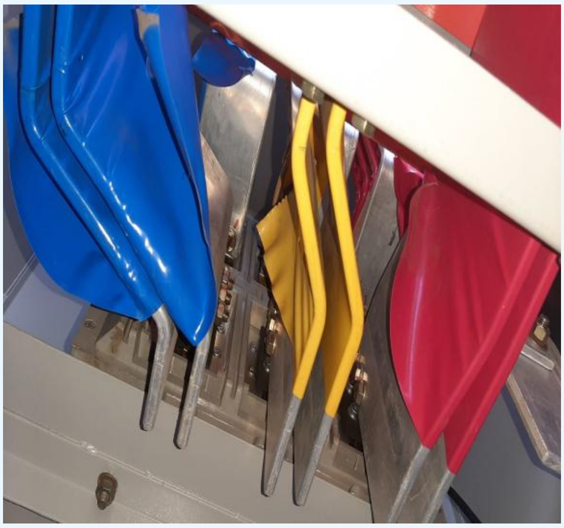
5. Derating Factors

The derating factors (K) account for various environmental and operational conditions that influence the performance of the busbar. These include:

- **K1:** Altitude Derating Factor — Adjusts for the effect of altitude on cooling efficiency.
- **K2:** Ambient Temperature & Busbar Operating Temperature Derating Factor — Adjusts for the impact of ambient temperature on the busbar’s performance.
- **K3:** Installation Media Derating Factor — Accounts for whether the busbar is installed in air, enclosed, or in an insulated medium.
- **K4:** Position Derating Factor — Affects the performance depending on whether the busbar is positioned in a horizontal, vertical, or confined space.
- **K5:** Insulating Material Derating Factor — Adjusts for the impact of insulating materials surrounding the busbar.
- **K6:** Artificial Derating Factor — Applies when artificial cooling or specific design features affect the busbar’s capacity.
- **K7:** Enclosure Derating Factor — Adjusts for the type and dimensions of the enclosure housing the busbar.
- **K8:** Proximity Derating Factor — Adjusts for the proximity of other electrical conductors that may impact the busbar’s current carrying capacity.

Junction Heating Due to Incorrect Busbar Selection

Scenario:



- Air Circuit Breaker (ACB) Rating: 1600A
- Busbar Specification: 200 mm width x 10 mm thickness, 2 runs
- Contact Area Width: 50 mm (ACB terminal)

Cause of Junction Heating:

- Mismatch in Contact Area: The terminal's contact width of 50 mm is too small compared to the busbar's width (200 mm). This causes the current to concentrate in a small area, increasing the current density and leading to excessive heating at the junction.
- Current Density Calculation: With a 1600A current and a contact area of 500 mm^2 (50 mm x 10 mm), the current density is 3.2 A/mm^2, which is higher than recommended for both copper and aluminium, leading to heat buildup.

Solutions:

- Increase Contact Area: Ensure the busbar matches or exceeds the terminal's contact width.
- Proper Sizing: Size the busbar to handle the full current with acceptable current density.
- Secure Fit: Ensure a proper, secure fit to minimize contact resistance and prevent overheating.

Conclusion: While aluminium busbars offer economic and logistical advantages, connecting them directly to copper switchgear terminals requires thorough planning. Factors such as electrical conductivity, mechanical compatibility, galvanic reaction, and thermal expansion must be addressed through careful selection of materials, joint hardware, and interface design. By adhering to these engineering considerations, the long-term reliability, safety, and performance of the power distribution system can be ensured, optimizing the system's efficiency while maintaining safety standards.

Inadequate sizing and poor fit between the busbar and terminal cause junction heating. Proper design **and material selection are crucial to prevent damage and ensure safe operation.**