Reducing Electrical Contact Resistance at Highly Loaded Copper Conductor using Nickel and Silver Coating

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Abstract— Electric motor used in an electrical vehicle commonly operated under high direct current of several hundred amperes. In such condition conductor contacts are very critical. Bad contacts may result in losses, overheating and disturb the operation of the motor. The improvement of contact can be achieved by reducing the contact resistance. This paper reports investigation results on the effects of silver and nickel coating on the contact surface in improving the contact performance in copper conductors. The effect of the pressure on the contact was also investigated. The current used in the investigation is direct current with magnitude of up to 350 A. The measured parameter was contact resistance. Contact resistance was measured using micro ohmmeter. The investigation results indicated significant improvement of conductor contact performance by applying the silver and nickel coating on the contact surfaces. The contact resistance reduced from 10.6 \( \mu \Omega \) for uncoated contact to 9.5 \( \mu \Omega \) for nickel coated and to 5 \( \mu \Omega \) for silver coated contact.

Keywords— contact resistance, silver, nickel, coating, contact resistivity

I. INTRODUCTION

Conductor connection (joint) is a component which has an important role in the efficiency of electricity distribution. The main function of a joint is to flow the electrical current from one contact element to another contact with minimum losses. The connection system must have integrity, both electrically and mechanically [1].

A good joint system must be mechanically strong and have a small contact resistance. The greater contact resistance on the joint will lead to the greater voltage drop \( V_d \) and power losses \( P' \). The power loss is not only determined by resistance of the line conductor, but also determined by value of the contact resistance at each connection and the amount of current flowing in the line [2].

The contact resistance of conductor joints is not constant, but tends to increase along with the time of operation [3]. This could occur because the bad initial installation, the relaxation of the contact during the operation, and the effect of the environmental conditions. If the joint resistance increases during the lifetime, the power loss and the temperature can rise up to a critical level and the joints might fail [4]. Figure 1 is the example of the overheating on the connection between one phase conductor with circuit breaker due to poor contact performance.

Stable and low contact resistance of the conductor joints reduces the need of maintenance and decrease overall downtime of equipment, low maintenance costs and reduce greatly the risk of catastrophic failures [5].

This paper discusses reducing electrical contact resistance at highly loaded copper conductor using nickel and silver coating. The effects of contact pressure and plating materials on the initial value of contact resistance at three samples of conductor joints are observed. Three samples used in the experiments are copper conductor joint without plating, copper conductor joint with nickel plating, and copper conductor joint with silver plating. Connection type used in the experiments is overlapping bolted joints.

II. CONDUCTOR JOINTS

A. Overlooping Bolted Joint

The overlapping bolted joints as shown in Figure 1 are the most commonly used in substations components. They are versatile, dependable, simple design and fabrication, easy installation, and easy maintenance.