Chapter 11
Surface Engineering of Materials Through Weld-Based Technologies:
An Overview

Magdaline N. Muigai
Dedan Kimathi University of Technology, Kenya

Fredrick M. Mwema
https://orcid.org/0000-0001-6116-5587
Centrer for Nanomaterials and Nanoscience Research (CNSR), Dedan Kimathi University of Technology, Kenya & University of Johannesburg, South Africa

Esther T. Akinlabi
Pan African University for Life and Earth Sciences Institute (PAULESI), Nigeria

Japheth O. Obiko
Jomo Kenyatta University of Agriculture and Technology, Kenya

ABSTRACT

In this chapter, an overview of welding as a technology for surface engineering is explored. According to literature, all types of welding techniques are appropriate for coating applications. However, as a result of process characteristics, some welding processes stand out. The most used welding techniques in the metal coating are arc welding (MIG, TIG, and PAW) and oxyacetylene welding. In the coating of metals using welding techniques, the coatings produced usually have a thickness that ranges between 1 and 6 millimeters. Applications of surface coating have been studied extensively. Such applications include aeronautic industry, sports, transport industries, petroleum and chemical industries, mining, food, and in the electronic industry. Plasma MIG welding is an advanced plasma process that combines the advantages of both MIG and plasma welding. Applications of plasma MIG welding in the surface coating of metals are expected to be explored extensively in the future.

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BACKGROUND

Surface Engineering refers to a multidisciplinary activity aimed at tailoring the surface properties of engineering components to improve their serviceability and functional properties. In other words, surface engineering is the modification of the surface of a material or a component to achieve excellent properties (Mishra, 2002). Some properties which are improved by surface engineering of metallic materials are wear resistance, corrosion, oxidation resistance, fatigue, toughness, electrical properties, thermal insulation, and aesthetics. Historically, methods of surface engineering have included solvent swelling, mechanical abrasion, solvent wiping to remove contaminants on the surface, application of coatings, and wet chemical etching (Kutz, 2010).

This chapter explores coating as a method of surface engineering and in particular welding as a possible method of surface engineering. There are various metal coating techniques including Physical Vapor Deposition(PVD)coating, Chemical Vapor Deposition(CVD) coating, Micro Arc Oxidation (MAO) coating, Plasma Spray Coating, Thermal Spray coating, Sol-gel coating, Welding coating, and among others (Fotovvati et al., 2019). Welding is used to applying a coating to a metallic substrate through partially or fully molting the coating material. The process is related to the laser cladding technique for additive manufacturing. Since welding is used as an additive manufacturing process, it can be used as a technique for protecting or repairing surfaces. It is due to this motivation is considered as a surface engineering method in this paper. In this case, the coating material and the substrate are melted to create a bond between the two materials. When compared to other types of additive manufacturing/coating techniques, wielding produces coatings/clads with higher adhesion and thickness properties (Gebert & Bouaifi, 2006). It is also possible to coat larger samples compared to other techniques. These types of coatings are appropriate particularly for applications of in areas of high wear conditions. These coatings also exhibit great edge strength. Generally, all types of welding techniques are appropriate for additive manufacturing/coating applications. The most used welding techniques in the metal coating are arc welding and oxyacetylene welding (Holmberg & Matthews, 2009. In Oxyacetylene welding, coating material and substrate are placed close to each other and the touching parts are melted using an Oxyacetylene flame (Hazledine, 2019). Arc welding uses an electric arc to produce heat which is used in the coating of metals. Examples of arc welding techniques include; Plasma arc welding (PAW), Tungsten inert gas welding (TIG), and Metal inert gas welding (MIG).

The coating of metals by welding is used on a small scale as well as in large scale applications. The coatings achieved usually resist surface attacks such as wear, corrosion, or a combination of both wear and corrosion (Gebert & Bouaifi, 2006). To attain the part strength desired, a suitable identification of the substrate material is necessary. Sometimes, the substrate is heat-treated before the coating takes place. Because of the potential of these technologies there has been a lot of interest in their applications in surface engineering. As such, a lot of literature on this subject is available. Applications of a surface coating by welding have been studied extensively. Such applications are in the aeronautic industry, sports, transport industries, petroleum and chemical industries, mining, food, and in the electronic industry. Through surface coating, problems that cause engineering failures such as wear, corrosion, and friction are solved (Kennedy et.al, 2005). Surface coating of metals by welding, is also used in areas experiencing issues of surface refinement to enhance resistance to thermal shock and corrosion, as well as fatigue strength and impact. These methods also repair damaged tools and components. In industries, metal coatings are not applied to nonferrous materials with melting points less than 1100°C. The coating materials normally used are carbides, tungsten, boron, or chromium spread in a matrix of nickel, iron, or

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