# Chapter 55
# Mitigation of Wear Damage by Laser Surface Alloying Technique

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## ABSTRACT

*Today's increasingly extreme and aggressive production environments require that machine components be made with materials having specific surface properties such as good wear resistance. Unfortunately, nature does not provide such materials, and alloys having these specific properties are usually very expensive and their use drastically increases components and production costs. Moreover, the economic implications of wear, in form of detrimental effects – and waste, are severe. This includes replacement costs, and all downtime costs related to such replacement. Consequently, companies will increasingly need to look to wear reduction as a direct, immediate avenue for maintaining output quotas and for cutting production costs. Laser coating of engineering alloys with wear resistant materials is one efficient and economical means of increasing the wear resistance of these alloys. This work discusses laser coatings for wear prevention. Different wear mechanisms are discussed and the coatings for specific environment are identified. This will provide information for combating wear.*

## INTRODUCTION

Wear is a damage to the surface of a solid as a result of progressive loss (removal) or displacement of material from the surface by the mechanical action of impact, erosion, metal-to-metal contact, abrasion, oxidation, and corrosion, or a combination of these (Camacho et al. 2014). Wear occurs when interaction

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between two surfaces or bounding faces of solids within the working environment produces dimensional loss of one solid, with or without any actual decoupling and loss of material. Wear is the predominant factor that controls the life of any machine part. Metal parts often fail their intended use not because they fracture, but because they wear, which causes them to lose dimension and functionality. Wear damage occurs in twofold. The first is the loss of materials from the surfaces that are in contact which causes reduction in dimension of the components or parts. The implication of this is increase in the dimensional tolerance between the moving parts. Consequently, there will be high vibration, high noise, reduced efficiency and malfunctioning of the system. In situations where dynamic loading is involved, the reduction in component dimension could promote fatigue fracture which can lead to catastrophic failure. Secondly, wear debris (material which detached from worn surface), is harmful and may cause contamination, for example, in a food or beverage processing machine. Moreover, the debris may act as abrasives when trapped inside the contacting surface leading to increased wear rate. The debris may also block valves, critical pipes, oil filters or may accumulate in an electrical contacting point preventing the normal function of a system (wu et al, 2014, Zmitrowicz, 2005, Bayer, 2002).

Wear is affected by: the working environments such as load, speed and temperature; different types of counter-bodies such as solid, liquid or gas also affect wear; and the type of contact which ranges between single phase or multiphase - which may combine liquid with solid particles and gas bubbles. According to Davis (2001), wear causes metallic surfaces to deteriorate progressively which leads to loss of plant efficiency and at worst a shutdown. Although there are four wear mechanism such as: surface fatigue, abrasion, adhesion and tribochemical reaction, most worn parts do not fail from a single mode of wear, but from a combination of modes, such as abrasion and impact. Four main types of wear systems (tribosystems) are identified. These are:

- Relatively smooth solids sliding on other smooth solids.
- Hard, sharp substances sliding on softer surfaces.
- Fatigue of surfaces by repeated stresses (usually compressive).
- Fluids with or without suspended solids in motion with respect to a solid surface

Chand and Fahim, (2000) and Shah (2007) described wear resistance as the ability of a material to withstand mechanical action such as rubbing, scraping, or erosion, which tends to progressively remove material from its surface. Such ability helps to maintain the material's original appearance and structure. Wear is a surface or near surface phenomenon rather than the bulk alloy. Therefore, wear resistance of a component can be improved by providing a surface of different composition and property from the bulk material. The various methods of wear reduction can be categorized into two major types. The first is the application of high wear resistance metals and alloys. These metals and alloys are usually more expensive and the method is thus accompanied by high cost of both materials and labour. The second method is improving the wear resistance of the existing material by addition of wear resistant alloying element to the surface of the material, i. e. surface modification (coating) of the existing metal and alloys. The coating increases wear resistance of the metal/alloy by conferring one or more of the following wear resistant properties: high melting temperature, high density to avoid gas flux through open pores to the substrate, stress free or in a state of compressive stress at the working temperature and good adhesion (Kennedy and Hashmi, 1998). Wear can also be reduced by improvement in working conditions, proper materials selection and appropriate design.

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