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Study of coatings to be applied on metal appliances for the picking up of agricultural products

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Abstract: The problems of appliances employed for the picking up and the storing of agricultural products are quite complex. In fact,, the stresses acting on the surfaces of the components are different from those that interest mainly the bulk. While the bulk is required to provide suitable structural properties, the surfaces is often exposed to corrosive environments and subjected to wear processes. The paper deals with the possibility to combine different requirements, often opposing each other, by means of surface coatings, obtained with different technologies: thermal spray and PVD.

Keywords: Technological sciences, Architecture, Amorphous materials

1. INTRODUCTION

Surface engineering can be seen as one of the key technologies of the present days, permitting to lengthen the lifetime of the products, simultaneously reducing costs and saving natural resources. The optimal performance of a component is to a great extent determined by the state of the surface, because every work piece is exposed to several strains, namely mechanical, shock, thermal, chemical or electro-chemical, radiation stresses, which often have their maximum in the surface area. Owing to the presence of this complex strain most failures of machine components start within or close to the surface. The high importance of the surface in regard to the lifetime of a component justifies the term “surface engineering”, which combines the knowledge of different scientific disciplines and deals with the design of a composite system which has properties, that cannot be achieved by either the surface layer or the bulk component alone.

The advantages of a chosen bulk-surface system can be related to reduced production costs, failure of the part without damaging the whole machine or even risking human lives, possibility of local repair of damaged machine parts, minimal variation of the original design, energy and resource saving as well as environmental protection.

In this contest the perspective of the coating industry is a very good one. Besides the combination of new or known processes, coating engineering gains interest towards multi-layer coating. The internal layer is responsible for a good adhesion to the substrate, there is a gradually change of the properties with each additional layer so that the outer layers have the optimal properties to fulfil the functions they are designed for.

2. AIMS

The problems of appliances employed for the picking up and the storing of agricultural products are quite complex. In fact, the stresses acting on the surfaces of the components are different from those that interest mainly the bulk. While the bulk is required to provide suitable structural properties, the surfaces is often exposed to corrosive environments and subjected to wear processes. Therefore, it arises the need to combine different needs, often opposing each other.

A strong effort to enhance the properties is provided by the opportunity to coat the surfaces special layers based on metallic materials or ceramic compounds with outstanding resistance to wear or/and corrosion. The coating technologies currently available allow to realise components with different characteristics from surface and core. As the base materials assures mechanical properties, the coating has to inhibit phenomena like wearing or improve chemical or physical phenomena like lubrication arising on surfaces or guarantee corrosion resistance.

Generally speaking, coating processes used to be galvanic. These processes, although maintaining their utility and competitiveness, are always more and more under discussion because of environmental problems. This aspects helped the research of alternative solutions now becoming strategic. They involve both coating chemical processes, as elemental nickel, and high technology coating processes.

The high technology coating processes are divided in two big categories: thin and thick coatings. While the former are films in the range of microns, obtained with physical vapour deposition (PVD) or chemical vapour deposition (CVD), the latter’s often reach hundreds of microns and are powder sprayed with technologies so called “thermal spray”.

Thermal spray process is based on the realisation of a coating from powder from 1 to 500 mm, metal, ceramic or cermets (dispersion of a ceramic phase in a metal matrix) wires or rods. They are heated in a gaseous atmosphere at high temperature (near the melting point) and accelerated with the gas to the substrate where they solidify rapidly. It is possible to obtain structures with layers in the form of lamellae.

CVD and PVD processes, even if more expensive than thermal spray, are, at the moment, the best surface technologies. PVD are always the most important and, because of modern systems, they have a major spread than CVD because the needed temperature is lower (always under 500°C instead of thousand degrees for CVD).

The deposited layers, besides being thin, are extremely adherent to substrates and it is possible to deposit layers of different nature even if they are preferentially based on ceramic materials. Nowadays there are lots of sectors interested in PVD technology, from valves to handle industry, from bath accessories to glasses, watches, pens and biomedical industry.

It is possible to think that this coating can have an important role also in components for the mechanical picking up of fruits and vegetable (mechanical hands) and in surfaces at direct contact with agricultural products like boxes, where the products are collected at the end of the picking up machine.

The research deals with the study and the detecting of suitable coating for mechanical hands and boxes to collect agricultural products;

As function of the base material and of the design characteristics the most suitable coating methods to apply has been studied.

When the thickness of the layer is close to 0.1 mm, the best method is thermal spray whereas when only few microns are sufficient, process like PVD is better and easier to apply.

PVD process nowadays is finding a rapid industrialization because of the possibility of both functional and decorative surface coatings; through its use the environmental impact is reduced if comparing to the other more traditional treatments. It is a perfectly controllable and reproducible technology, more and more sought after in case of corrosion or wearing.

To evaluate and compare the properties of the different coatings the samples were subjected to wear and salt brine chamber corrosion tests, as well as to bending tests. Then, hardness and microhardness tests, Optical Microscopy, SEM with microanalysis were performed on the transverse section of the samples to evaluate the thickness and the characteristics of the different layers.

3. EXPERIMENTAL RESULTS

Thermal spray techniques are a number, however the most employed and developed there are processes based on plasma technology and the High Velocity Oxygen Fuel process (HVOF). While the Plasma based processes are particularly important in the case of ceramic based materials, owing to the highest temperatures reached by plasma, the HVOF process is preferentially applied when spraying metal powders. In figure 1 the microstructure of two different layers, stainless steel and stainless steel added with alumina, are shown. The layers are characterized by the presence of small pores homogeneously distributed, this porosity does not degrade the properties of the layers, even if it is possible to fill the porosity adding PTFE to the powders during the spraying process, in this case the coatings will show lower friction coefficients.

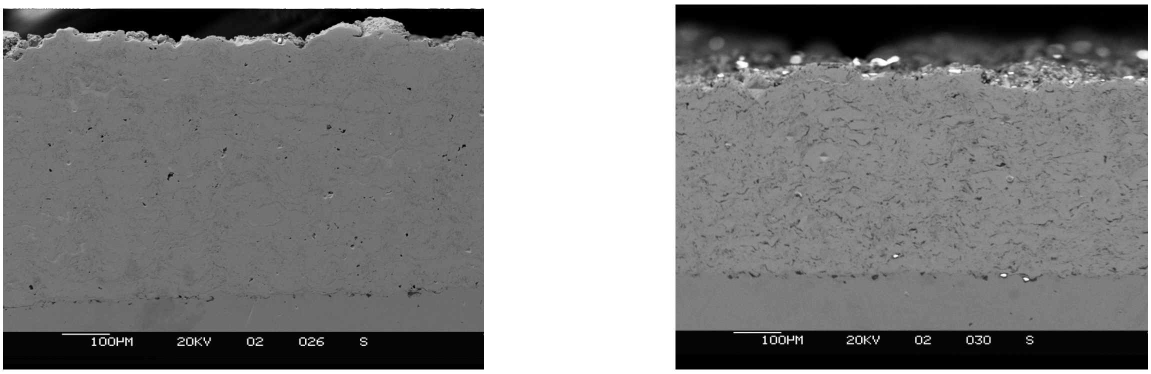


Figure 1: Microstructure features of AISI 316L (left) and of AISI 316L+Alumina (right) layers deposited by High Velocity Oxygen Fuel (HVOF) process on plain carbon steel substrate.

The PVD technology offers the possibility to deposit different types of coatings, able to help the design of surface properties focused to highlight performances and resistances of the coated parts. Among the different compounds that can be deposited, chromium nitride, has been here taken into consideration owing to its colour, hardness and wear resistance, coupled with good anti-corrosion properties in different environments.

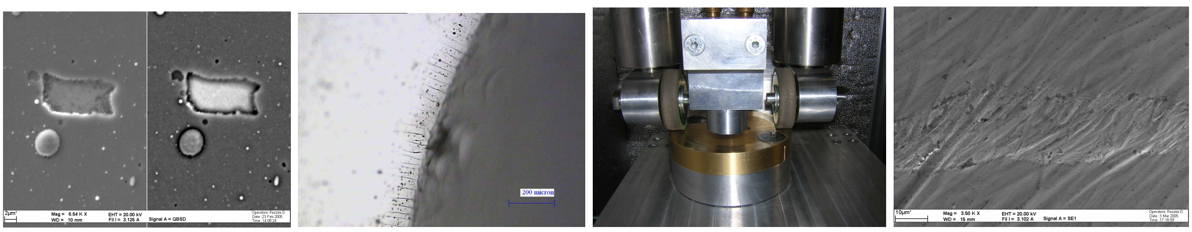
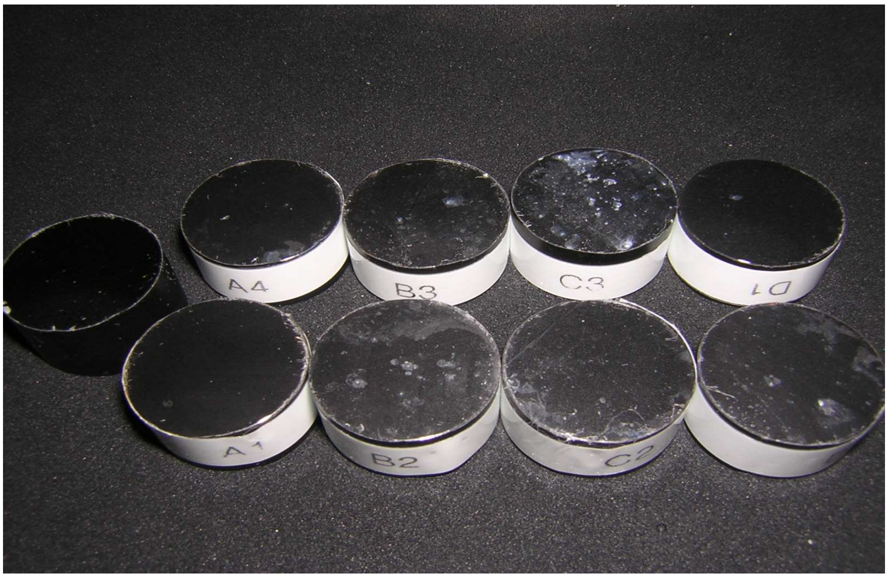


Figure 2. From the left to the right, aspect of common surface defects of the PVD layer, the HRC penetration to test the high adhesion properties. The Taber wear test machine and the aspect of the coating surface after the wear test.

The CrN has been deposited on brass alloy, in order to obtain suitable surface for the deposition the samples have been previously Ni and Cr coated, the thickness of the deposited nitride layer was few microns, the properties of the coated samples were compared with those of samples Cr coated as in the traditional way.

The properties of the coating layers are strongly dependent upon the adopted coating parameters. The pictures in figures n. 2 and 3 illustrate the main characteristics of the obtained CrN coatings. In particular, the influence of process parameters is highlighted by the corrosion test in the salt brine chamber (figure 3), only the optimised parameters are able to guarantee a satisfactory corrosion resistance.

In particular the dominant parameters are the pressure of the deposition chamber, ranging between 50 and 200 mbar and the gas flow, approximately 0.005 sccm (Standard Cubic Centimeter per Minute). In fact in figure 3 the samples showing the highest corrosion resistance after 350 h in salt brine chamber are the types A1 and D1, they are compared with a sample galvanic coated by pure Cr, the first one on the left.



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