NanoPeening® by Winoa

WINOA, formerly Wheelabrator Allevard, is a world leader in abrasion and cutting technologies for the metal and stone industries. Innovation is a guiding principle for Winoa and the company is marketing their new process called NanoPeening® that is of special interest to the shot peening industry.

NanoPeening® is a surface enhancement technology developed and patented by Winoa. It enables the surface transformation of metals by reducing grain size down to a nanometric scale. According to Winoa, NanoPeening® can achieve improvements in hardness, abrasive wear, fatigue life and corrosion resistance that aren't possible with a conventional shot peening operation. NanoPeening®, however, is a mechanical process that doesn't use chemicals or nanometric particles and it is done at room temperature. The equipment to perform NanoPeening® looks like a conventional shot peening machine from the outside. The difference is in the way the treatment is carried out, employing a precise combination of parameters that are accurately controlled and adjusted to both the material and shape of the component being treated.

Winoa has investigated industrial applications for the new process and has qualified:

- Tools - forging dies, casting dies, plastic molds, rolls
- Mechanical parts - automotive and aerospace gears and pinions
- Stainless steel hardening - tubes, dosing pumps

The benefits of NanoPeening® include:

- Reduces costs
- Increases performance
- Allows the downsizing of mechanical parts
- Replaces thermochemical treatments when anti-corrosion or treatment times are an issue
- Surface hardness increased by 200%
- Stable microstructure up to 600˚ C (1112˚ F) in steady regime
- Up to 200 µm transformed thickness
- Progressive transition from surface to core structure

Constance Morel, a Research and Development Process Engineer for Winoa, and Mario Guagliano, a Professor with the Department of Mechanical Engineering at Politecnico di Milano (MECC), have been working together to apply the modeling competences of MECC to the NanoPeening® process. They have prepared a report on some of their work for the readers of *The Shot Peener*. The paper's Introduction has been reprinted here and the complete paper is available for download in the library at www.shotpeener.com (paper number 2014001).

Surface Nanostructuring through a Technique Derived from Shot-Peening: Recent Advances

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INTRODUCTION

Over the past decades, ultrafine-grained materials have attracted considerable scientific interests, especially nanocrystalline materials, whose grain size inferior to 100 nm conveys superior mechanical, physical, and chemical properties compared to conventional coarse-grained materials. It is well known that most of failures of engineering materials (such as fatigue fracture, fretting fatigue, wear, corrosion, etc.) are very sensitive to the structure and properties of material surface, and in most cases material failures occur on the surface. As a consequence, a material exhibiting a nanostructured surface is expected to be much less likely to undergo such damages without changing the chemical compositions.

Many techniques have been developed to achieve surface nanocrystallization. Referred to as Severe Plastic Deformation (SPD) techniques, they all rely on the plasticity of metals and lead to a mechanically induced nanostructuration of the surface. Some of them can be referred to as "bulk treatments" as they aim at transforming the whole volume of a part They include ECAP (Equal Channel Angular Pressing), HPT (High Pressure Torsion) or drilling. On the other hand, some techniques focus on the surface: SMAT (Surface Mechanical Attrition Treatment) or USSP (Ultrasonic Shot Peenng), ball milling, sliding wear.

While those processes were developed at laboratory scale and are hardly compatible with up-scaling for application to mass-production, Severe Plastic Deformation and the resulting surface nanostructuring can also be achieved through a technique derived from Shot-Peening called NanoPeening®. In most cases, Shot-Peening carried out longer or stronger than usually leads to "over-peening", which is detrimental to the material, inducing cracks and surface degradation without any change in the microstructure. In the last few years it was discovered that it is possible, under specific conditions, to pass over these effects and reach a nanocrystallised state of the surface. NanoPeening®-type treatments thus allow for the fast generation of a thick layer (several tens of micrometers) characterized by a gradient in grain size from a nanocrystalline microstructure at the surface to the conventional core structure. Like all SPD techniques, the nanostructured layer is produced "in-situ", i.e. without any external addition like a coating, but this new treatment differs from the processes mentioned earlier in that it offers a real potential in industrial applications with high productivity, reliability and reproducibility. It is also very flexible, as a large range of shapes, sizes and steel grades can be treated.

This article aims at giving a description of NanoPeening® process, including the modeling works carried out with Pr. Guagliano's team from Politecnico di Milano: using a Finite Elements method, they developed a program that allows for an estimation of the nanostructured layer created by the treatment, for a given set of process parameters.

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