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Corrosion effects on mechanical properties of sintered stainless steels

C. Barile[a,*], C. Casavola[a], C. Pappalettere[a]

[a]*Dipartimento di Meccanica, Matematica e Management, Politecnico di Bari, viale Japigia 182, 70126 Bari, Italy*

Abstract

This paper aims to analyse the effects of corrosion atmosphere on sintered stainless-steel specimens. In particular, it is intended to assess a relation existing between weight and corrosion resistance, density and corrosion resistance, tensile properties and corrosion resistance. Three groups of sintered stainless steels were studied. They differ, one from each other, for the laser power and for the speed scanning. For each group, nine specimens were made up. For all of them, measurements of both weight and density were carried out. One specimen of them was tested, as received, according to the tensile standard for metallic materials. Eight specimens for each class were placed in corrosive atmosphere in conducting the neutral salt spray (NSS) tests for assessment of the corrosion resistance of metallic materials. Four different periods of exposure were defined. At the end of each test period, two specimens were removed from the cabinet. Visual observations, measurements of mass loss, density variations and tensile tests was carried out on all the specimens referring to the specific exposure time, in order to evaluate and record all the changes referring to the specific conditions they were subjected to.

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1. Introduction

High corrosion resistance, good visual aspect and good formability favored the use of stainless steels in several engineering fields, not only in mechanical industry but also in the building one (Bellezze et al. 2005). In particular, stainless steel powder metallurgy process has numerous advantages to fabricate small pieces of complex shapes,

* Corresponding author. Tel.: +39-080-5962812; fax: +39-080-5962777.
E-mail address: claudia.barile@poliba.it

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because it allows energy and material savings as well as dimensional accuracy. Sintered stainless steels have a wide range of applications, mainly related to the automotive industry but also related to biomedical field (Raza et al. 2017). However, they present lower properties than their wrought counter-parts in terms of corrosion and wear resistance. The main reason for this lower performance is the presence of porosity that could change the performance of material especially if exposed to corrosive environments. Many studies are carried out on corrosion behavior of such materials but all of them referring to immersion of components in corrosive solution and successively drying in air (Vera Cruz et al. 1998). Scientific literature investigates this problem but only in studying the relation existing between corrosion resistance of stainless steels and their surface finishing (Burstein and Pistorius 1995, Coates 1990), the combined action due to the presence of atmosphere contaminants as Cl and SO_2 ions (Johnson 1982, Rosenfeld 1972, Ambler 1970) and the role played by the presence of non-metallic inclusions (Asami and Haschimoto 1979, Manning 1979). Commonly corrosion resistance is related to roughness; more specifically, with a lower roughness the stainless steel shows a higher pitting potential (Burstein and Pistorius 1995, Coates 1990). A stainless steel characterized by a good surface finishing in terms of low roughness of material, could be considered as a steel with good corrosion behavior too. Indeed, the roughness is not always a guarantee of high resistance, since, in some cases, it can be verified that steels with the same roughness gives deep differences in corrosion response (Nishimura 1997).

This paper studies the effects of corrosive atmosphere on mechanical properties of powder metallurgy 316L stainless steel sintered by selective laser melting. Many different criteria for the evaluation of the test results may be applied to meet specific requirements. The aim of this work is to evaluate changing in terms of tensile properties, appearance after corrosion exposure, mass loss, and changing in density. Three groups of sintered stainless steels have been analysed. They differ, one from each other, for the laser power and for the speed scanning. For each class, 9 specimens were made up. For all of them, measurements of both weight and density were carried out. One specimen of them was tested, *as received*, according to the tensile standard for metallic materials (ASTM E 8M 2004). Eight specimens for each class were placed in corrosive atmosphere in conducting the neutral salt spray (NSS) tests for assessment of the corrosion resistance of metallic materials.

Four different periods of exposure were defined, choosing among the recommended standard periods: 24 h, 96 h, 168 h and 240 h (DIN EN ISO 9227 2006). A periodic visual examination of specimens under tests for a predetermined period was made, but the surfaces under test was not disturbed, and the period for which the cabinet is open was the minimum necessary to observe and record any visible changes. At the end of each test period, two specimens were removed from the cabinet. The test specimens removed were leaved at environmental conditions to allow them to dry for 0,5 h to 1 h before cleaning, in order to reduce the risk of removing corrosion products. Before they were examined, the residues of spray solution from their surfaces were carefully removed.

Visual observations, measurements of mass loss, density variations and tensile tests were carried out on all the specimens belonging to the specific exposure time, in order to evaluate and record all the changes referring to the specific conditions they were subjected to.

2. Material and methods

Twenty-seven specimens were made up by using selective laser melting technique on 316L stainless steel powder metallurgy. They were divided into three groups having different values of laser power and speed scanning. Table 1 reports the sintered process parameters for each group.

Table 1. Sintered process parameters.

# Group	Laser Power [W]	Speed Scanning [mm/sec]
1	100	200
2	56,5	200
3	85	300

Visual aspect observation of specimens didn't show great differences between group 1 and group 3; group 2 seems to have more defects on surface probably due to the combination of lowest laser power and lowest speed scanning.

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