# Aspects regarding corrosion and mechanical tests for metallic parts obtained by Powder Metallurgy

A Didu<sup>1</sup>, I Pascu<sup>1</sup>, S Gheorghe<sup>1</sup> and C Rotea<sup>1</sup>

<sup>1</sup> Automotive, Transport and Industrial Engineering Department, Faculty of Mechanics, University of Craiova, Calea Bucuresti Str., no.107, Craiova, 200512, Romania

#### ankadidu11@gmail.com

**Abstract.** The researches for this paper were made for knowing the corrosion behavior and mechanical resistance of some metallic powder's specimens obtained by powder metallurgy. This technology was chosen because of the technical and economic advantages, and the obtained parts can be used in all domains. The parts were obtained from iron powders by pressing at different pressures and sintered in an inert atmosphere. The innovation was to obtain metallic composites, having as a matrix an iron powder type Ancorsteel 1000B and as a reinforcement a spring steel wire. The specimens were tested in different solutions and environments and also two mechanical tests. This paper presents a part of tests that were the corrosion in salt spray environment and bending tests, aiming to compare the results for the types of proposed specimens. For the morphological characterization (size, shape, surface) and chemical composition of the material used, SEM electronic microscopy was used using an FEI Inspect S microscope. The sintering was made in a neutral controlled atmosphere (argon) furnace.

#### 1. Introduction

Powder metallurgy is one of the top industrial branches, and it can be said that there is currently no industrial branch where it is not used in advantageous technical - economic conditions powder parts. Thus, in addition to the particle-specific characteristics of the powders, they must be more mechanically and chemically resistant. In this direction, it is necessary to know the resistance to the various types of corrosion of the parts, as they are used in polluting environments.

Due to these obvious technical and economic advantages, powder metallurgy offers multiple possibilities for many types of new materials and products, with special features required by modern technology, especially by the cutting-edge branches. Advantages of Powder Metallurgy have led to the use of this technology in large-scale and mass production, with MP products applying to the automotive and aerospace industries, the medical industry, the manufacture of self-lubricating bearings, the strength parts of the construction industry machines, power contacts, etc.[1-3].

In the contemporary era of intense industrial development, when the consumption of metals and machinery is continuously growing, it seems particularly important, especially for ferrous ones, the concern to protect them against corrosion damage. Costs due to corrosion from raw material and energy consumption are amplified by secondary damage due to activity interruptions, the loss of expensive products (oil, fuel oil), the need for oversize elements, etc.

### 2. Experiments and results

#### 2.1. Obtaining iron powder parts used in researches. Characterization and stages

To obtain both unreinforced and reinforced specimens, with high alloyed steel wires used in the experiments, it was followed the specific stages of powder metallurgy, pressing and sintering. For researches, atomized Fe powder was used, the ANCORSTEEL 1000B sort. The medium size of the particles is 0,125 mm.[8]

For the morphological characterization (size, shape, surface) and chemical composition of the material used, SEM electronic microscopy was used using an FEI Inspect S microscope. For this purpose, a microscope was used to determine the shape of the powder granules with an analyzer - SiLi EDAX Inc detector with a wavelength of  $\pm 0.00000014$  mm.



Figure 1 shows the morphological aspects of the powder used: the chemical composition, respectively, the size, shape, and size of the granules. From the diagram of figure 1b, the chemical composition of the powder used is the same as that presented by the company in the product catalog.

Figure 1a also shows that the shape of the powder granules is very different, with rounded, irregular

shapes, with a significant grain size of around 100 $\mu$ . It was used1% of zinc stearate as a lubricant, blended with 99% iron powder, 1% other elements. The aspect of parallelepiped specimens can be seen in figure 1c. For reinforcement, spring steel wires with a tear resistance of 2300-2500 N / mm2 with diameter  $\Phi$  0.5 mm were used. [5], [6]

*Porosity*. Porosity was calculated after sintering, and the following values were obtained: In figure 2 can be observed that the porosity decreases with increasing compacting pressure.



*Pressing.* The sampled were pressed unilaterally with a surface  $S = 5.5 \text{ cm}^2$  and was performed on a 100-tonne OMCN press. The specimens pressed with compacting pressure of 200 MPa, 300 MPa and 400 MPa were weighed, and their sizes were measured before and after sintering. From the SEM image analysis at 1000X and 5000X magnification of figure 3, it is observed that in the surface area, the iron granules are flattened due to contact with the die or punch.



*Sintering.* It was made in a neutral controlled atmosphere (argon) furnace. The sintering of the compacted samples was performed in an LL207 / 220 V-type resistive laboratory furnace using a specially designed enclosure to maintain an inert atmosphere to prevent the oxidation of the specimens as inert medium, argon was used, providing a flow rate of 2.51 / hr. The sintering was made at  $1150^{\circ}$  C, step by step.

By analyzing the SEM images, it is observed that in the surface area, the iron powder granules are flattened due to contact with the mold or the punch (figure 4a) and are not flattened in the rupture zone. Spectral analysis showed a chemical composition similar to that before sintering(figure 4b).



## 2.2. Salt spray corrosion

The experimental tests were performed using a 5% NaCl solution (according to the salt spray corrosion standard SR EN ISO 9227/2007), [4] the temperature was maintained at about 28 ° C for the first set of specimens made of iron powders. The specimens were introduced into the salt spray chamber. The first check was made after approximately 3 hours, and the first corrosion points were observed on the uncovered specimens. After approximately 45 hours for standard samples, the corrosion process is becoming stronger, as seen in Figure 5.

The below images show that the iron powder, pressed and sintered pieces exhibit relative resistance in saline medium, with changing the appearance over the whole surface, due to the formation of layers composed of corrosion compounds of iron. Due to the low corrosion resistance of the used material, in the following researches methods of corrosion protection are searched and tested [7].



For the morphology of the sample surface at a compaction pressure of 400 MPa, a relative uniformity and relative porosity are observed. The EDS spectrum (Figure 6b) refers to a high proportion of iron and other elements as impurities. The difference between the non-corroded sample (Figure 6a) and the corroded sample (Figure 6c) is highlighted by the compact appearance and uniformity of the surface layer due to more or fewer iron compounds that can form from the oxidation processes.

### 2.3. Bending test

The bending test is more important in the case of cast iron and sintered powders which are sometimes required to determine the capacity to take up this type of request.

From the analysis of the force-deflection diagrams obtained, it was observed that the bending breaking strength is directly proportional to the density of the parts (implicitly with the compaction pressure) [4,5]. It is also clear that bending strength is higher for reinforced parts than for unreinforced ones for standard specimens.



From curve analysis in figure 7, it can be seen that the bending resistance decreases for salt spray corroded parts subjected to stress. It is also noticed that the reinforced pieces have bending strength higher than those unreinforced with yarns.

## 3. Conclusions

The salt spray corrosion resistance of metallic powder parts is relatively low; metallic coating is needed to improve the properties.

The corrosion process affects both the surface and the interior of the specimens, as well as the reinforcement yarn; the highest corrosion resistance in both salt spray and other studied environments corresponds to pressed pieces at 400 MPa.

After corrosion in salt spray chamber, SEM images and EDS spectra showed that at a compacting pressure of 400 MPa, a relative uniformity and porosity were observed.

Tensile strength by bending is directly proportional to the density of the parts (implicit with compacting pressure).

The tensile strength at bending is higher for the reinforced pieces than for the unreinforced ones.

The tensile bending strength of standard (not covered) corroded parts in the salt spray is lower than those not corroded.

#### References

- [1] Aderhold J., Davydov V. Yu., Fedler F., Klausing H., Mistele D., Rotter T., Semchinova O., Stemmer J., and Graul J. 2001 J. Cryst. Growth of **222**.
- [2] Bautista A., Velasco F., Guzman S., De la Fuente D., Cayuela F., and Morcillo M., Rev. Metal Madrid 2006 42 175
- [3] Shankar J., Upadhyaya A. and Balasubramaniam R., Corros. Sci.200446 487
- [4] Didu A., Dumitru V., Stanescu G., and Ploscaru C, Appl. Mech.s and Mater. 2017 880 291-296
- [5] Didu A., Studies on corrosion behavior in a pollutant environment of iron-based composites reinforced with high resistant steel yarns Ph.D. thesis, 2013
- [6] VlasaA., Varvara S., Pop A., Bulea C., and Muresan M., J. Appl. Electrochem. 2010 40 1519-1527
- [7] Didu M., Gruionu L, Radu S., and Ghermec C. Mater. Sci. Forum., 2011 672 327-330
- [8] Mureșan R., Powder Metallurgy (Metalurgia pulberilor), Ed. U.T. PRES 2005 Cluj-Napoca