PROPERTIES OF SINTERED PARTS OBTAINED FROM IRON BASED POWDERS PRODUCED BY "DUCTIL IRON POWDER" BUZĂU

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ABSTRACT: The paper presents an experimental study on the characteristics of the iron powders obtained by water atomization, in the "Ductil Iron Powder" - Buzău company and of their sintering capacity. The grain size distribution for the iron powders is centred upon the 80 – 100 μm classes. By analysing the pressability curves of the non-reduced iron based powders produced by "Ductil Iron Powder" – Buzău one notices that DP 200HD and DP200.29 exhibit the best compressibility. The sintered powder DWP 200 presents the best values for the tensile strength, yield strength and elongation.

KEYWORDS: iron-based powder, technological properties, sintered parts

1. INTRODUCTION

The present day material goods manufactured by industry and even the evolution of the industry and its advanced branches, such as aeronautics, astronautics, nuclear science, terrestrial and maritime transportation, etc. are based upon the substitution of classical materials with more modern ones, whose properties reach higher and higher levels. The strength and resistance limits of the traditional materials are often a barrier in their application so that new materials and advanced technologies are more and more often required to satisfy the users needs, still in increase[1].

Powder metallurgy is an important alternative to produce metal products from metal powders (sometimes mixed with non-metallic powders) by pressing and sintering [2, 3].

Powder metallurgy enables the mass production of finite shaped and extremely accurate parts that do not require mechanical processing and losses due to waste. The technology has recently been much improved and the innovation rate in this respect is high as valuable "break-through" still appear quite often. Substantial improvements in the purity level and compressibility of iron powders make possible the manufacturing of high density sintered parts [4].

2. PROPERTIES OF IRON-BASED POWDER PRODUCED BY "Ductil Iron Powder" BUZĂU

As one can see from Table 1, the chemical composition of the iron powders produced by Ductil Iron Powder - Buzău presents a low level of impurities and related elements. As for the oxygen content, it is low in the case of water atomised iron powders (<0.02%), while the carbon, sulphur, phosphorus and manganese content remains the same.

Tabe 1. *Chemichal composition of the iron powders*

Powder Type	Chemical Composition [wt. %]					
	O_2	C	S	P	Mn	Si
DP 200	0.13	0.01	0.01	0.01	0.072	0.019
DP 200.29	0.09	0.01	0.01	0.014	0.079	0.006
DP 200 HD	<0.06	<0.02	<0.012	<0.012	<0.15	<0.05
DWP 200	<0.02	<0.02	<0.015	<0.020	<0.20	<0.05
DWP 200.28	0.1	0.01	0.007	0.008	0.084	0.01

The "DUCTIL IRON POWDER"Buzău powders particle size distribution is presented in Table 2. This shows that: DWP 200, DP 200, DWP 200.28 have similar particle size distributions. Powders DP 200.29 and DP 200HD tend to be finer in particle than DWP 200, DP 200, DWP 200.28. Table 2 also shows the powder fluidity, as better in the case of DP 200.29 and worse for DWP 200.

Table 2. *Powder particle size distribution and fluidity*

POWDER TYPE	PARTICLE SIZE RANGE [%]					FLUIDITY
	63-80 µm	80-100 µm	100-125 µm	125-160 µm	160-200 µm	sec/50g
DP 200	10.1	34.2	19.0	11.0	3.1	29.8
DP 200.29	9.1	36.9	18.2	13.0	3.0	28.2
DP 200 HD	9.9	38.2	25.6	9.9	1.0	29.4
DWP 200	14.4	34.5	18.6	8.8	1.5	32.2
DWP 200.28	16.0	31.0	19.5	9.0	2.5	29.2

The apparent densities of the powders obtained are presented in figure 1. Powder DWP 200 has the lowest apparent density (2.56 g/cm^3), while DP 200.29 (2.9 g/cm^3) is the highest, while the other three sorts have an almost equal apparent density.

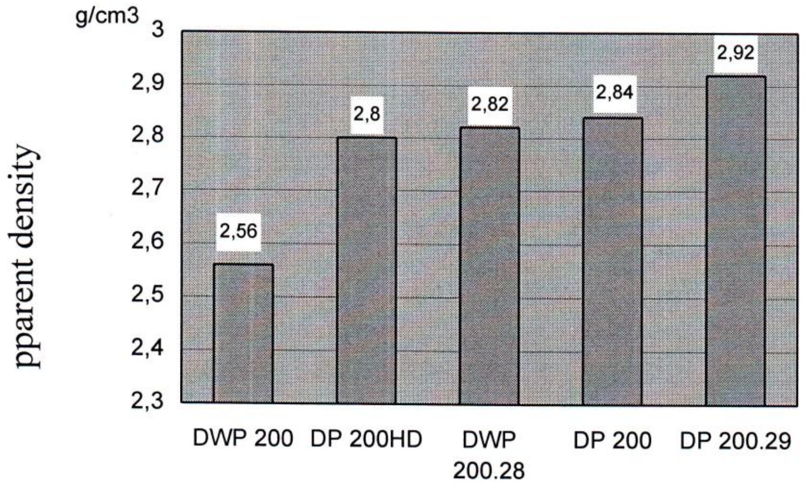

Figure 1. *Influence of the iron powder type (Ductil Iron Powder) upon apparent density*

3. PRESABILITY OF IRON-BASED POWDERS

In order to study the behaviour of powders during pressing, the density variation curves as a function of compacting pressure have been plotted. The cylindrical compacts tablets have been

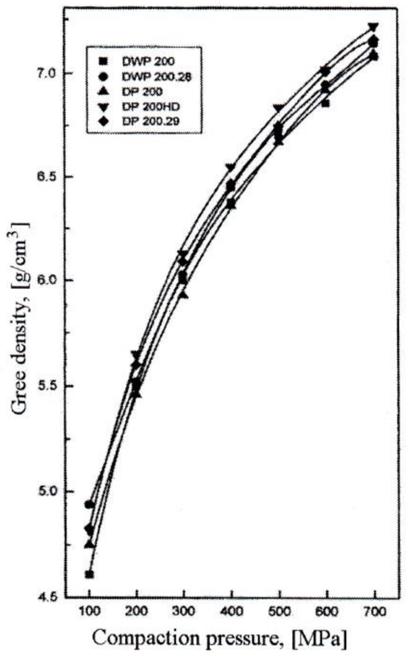

Figure 2*. The presability curves for the "Ductil Iron Powder"*

obtained by pressing at pressures ranging between 100- 700 MPa, on a tensile compression testing machine whose pressure force accuracy was ± 40 daN. As lubricant 0.8% zinc stearate was used.

In order to plot the presability curves, the necessary powder quantities have been modified so that the tablets obtained wight have equal height and diameter, with ±10 % error, according to STAS 9089.

Powders DP 200HD and DP 200.29 exhibited the best compressibility, while the green densities of DWP 200 and DP 200 were lower. At 600MPa compacting pressure, the DP 200HD compacts have 7.02 [g/cm^3] density, i.e. about 90% compactity.

Table 3 presents the results of the edge strength test (M) at 400, 600, 700 MPa compacting pressures. As seen, all the powders satisfy the minimum requirement of M>97%.

Table 3*. Influence of the compacting pressure upon edge strenght test*

	DWP 200			DWP 200.28			DP 200			DP 200HD			DP200.29		
P[MPa]	400	600	700	400	600	700	400	600	700	400	600	700	400	600	700
M[%]	98.1	98.5	99.0	97.6	98.7	98.9	98.3	98.9	99.4	98.1	99.0	99.5	98.1	98.6	99.2

4. THE PROPERTIES OF THE SINTERED COMPACTS

A set of samples have been sintered in hydrogen, at 1000, 1100, 1180^{0}C for 120 minutes. The dimensional shrin kage (d) of sintered samples has been calculated from the ratio between the diameter of the sintered compacts (d_s) and the green compacts diameter (d_c) with the following relation:

$$d = \frac{d_s - d_c}{d_c} \cdot 100[\%]$$

The shrin kage of the samples pressed at various compacting pressures and sintered in hydrogen at various temperatures for 120 minutes are presented in table 4. Small post sintering shrin kages are noticed (less than 1%).

Table 4. *The effect of the compaction pressure and sintering temperature on the shrin kange of the compacts sintered from iron powder*

Sintering temperature [^{0}C]	Shrin kange, d [%]														
	DWP 200			**DWP 200.28**			**DP 200**			**DP 200 HD**			**DP 200.29**		
	P [MPa]			P [MPa]			P [MPa]			P [MPa]			P [MPa]		
	400	600	700	400	600	700	400	600	700	400	600	700	400	600	700
1000	-0.64	-0.25	-0.24	-0.62	-0.15	-0.15	-0.43	-0.25	-0.29	-0.12	-0.40	-0.27	-0.25	-0.51	-0.41
1100	-0.12	0	-0.14	-0.25	-0.27	-0.30	-0.38	-0.14	-0.42	-0.13	-0.25	-0.26	-0.13	-0.42	-0.23
1180	-0.23	-0.59	-0.26	-0.34	-0.66	-0.39	-0.12	-0.61	-0.5	-0.38	-0.41	-0.26	-0.5	-0.13	-0.14

Other tests are referred to the tensile strength, to the yield strength and to the total elongation. For this purpose, the samples have been pressed on both sides in a steel die according to SR ISO 2740-1999. The sinterizability has been assessed through the strength tensile and hardness of the sintered samples, function of the parameters of the sintering process (sintering temperature, length of maintenance, protective atmosphere, see table 5)

Table 5. *Variation of mechanical properties function of the powder type and sintered parameter*

Type powder	Sintering temperature [°C]	Tensile strength [N/mm^2]	Yield strength [N/mm^2]	Elongation [%]
DWP 200.28	1000	15.2	7.1	7.0
	1100	18.2	8.5	8.3
	1180	18.0	7.5	7.9
DP 200	1000	13.9	7.1	5.4
	1100	15.9	7.9	5.3
	1180	17.5	7.3	7.3
DP 200.29	1000	13.3	6.4	6.0
	1100	16.1	6.9	6.1
	1180	17.5	7.2	8.1
DP 200HD	1000	14.8	7.5	6.1
	1100	13.9	6.1	5.3
	1180	15.6	7.6	5.5
DWP 200	1000	16.1	7.2	6.4
	1100	19.6	7.9	9.0
	1180	18.4	7.5	8.8

The presability curves raised for the compacts have been used for the correct dosage of the pressing material. The die surface was measured by means of planimetry. The compacting pressure was 600 MPa and the force reading accuracy was ± 200 daN.

The highest values of the tensile strength, yield strenght, and elongation belong to the DWP 200 powder sintered parts. This is due, probably, to the initially lower oxygen content (<0.02%) as compared to other sorts and to the significantly higher carbon and manganese content, whose positive effects upon the mechanical characteristics is known. As 0.1% C alters the tensile strength by 5 – 8 [daN/mm^2] and 0.1% O_2 in the powder can decarburize 0.075%C, the discrepancy between the values for the resistance is normal.

5. CONCLUSIONS

The iron based powders produced by "Ductil Iron Powder" – Buzău present a lower than 0.02% oxygen content, similar to powders made by other manufacturers. The carbon content has a nearby value in all powders, the same being valid for the sulphur, phosphorus and manganese contents. The grain size distribution for the iron powders is centred upon the 80 – 100 μm classes. The most fluid powder is DWP 200, whose apparent density is, however, small (2.56 g/cm^3). The apparent density is the highest with the DP 200.29 powder (2.9 g/cm^3).

By analysing the pressability curves of the non-reduced iron based powders produced by "Ductil Iron Powder" – Buzău one notices that DP 200HD and DP200.29 exhibit the best compressibility.

The mechanical characteristics increase with the temperature and sintering time. The sintered powder DWP 200 presents the best values for the tensile strength, yield strength and elongation.

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