Influence of the Type of Iron Powder on the Tensile Strength of Iron Carbon Powder Materials Alloyed with Cooper

Ivan N. Mitev

***Abstract* — In the present study the influence of the monitored type iron powder, and the process of sintering in the presence of a liquid phase on the tensile strength of the powder metallurgical samples of the system Fe-C-Cu. Research samples are subjected made of three types of iron powders – ASC 100.29, SC 100.26 and NC 100.2. Thereto is added of 0,2 to 0.8% carbon and 2.5% copper. After sintering the measured density of the samples in the range of 6,20 ÷ 7,00g/cm^3. Are presented graphics, amending the tensile strength of the samples depending on their density and the concentration of copper and carbon in the iron matrix.**

***Index Terms* — powder metallurgy; tensile strength; sintering; liquid phase; density; carbon; cooper.**

I. INTRODUCTION

In the most general sense powder metallurgical technology consists of three stages - mixing the starting powders, compression into the desired shape and sintering. [1,5,12,13] Sintering is a kind of heat treatment which undergo extrusion billets to acquire a complex of physical and mechanical properties. Feature of this process is that it is carried out at temperatures of 0,7÷0,9 of the melting point of the most low-melting component in the alloy. Effectiveness of the process is judged by the strength, the ductility, the specific electrical resistivity, density and other properties of sintered workpieces. [5,6,8]Chief thermodynamic factor in the case of sintering of pure metals is striving for minimum surface free energy and in multi-systems further reduction of chemical free energy. Kinetics of hardening of the samples thermally activated and is determined by the existing mechanisms of mass transfer in the sintering workpieces such as volume, surface and boundary diffusion, vapor, condensation and other. [5]Although the process of sintering in powder metallurgy are realized in the solid state, often to increase their effectiveness resort to sintering in the presence of a liquid phase.[8] Sintering in the presence of a liquid phase is carried out when the feedstock has a low-melting component or in the process of sintering to form eutectic. The amount of liquid phase must be substantially less than that of the solid phase. Otherwise possible distortion of the shape of the workpiece during sintering. [2,5,6] Most often as a source of the liquid phase using copper. It is an element that does not apply to conventional steel but has a number of characteristics that favor its use in powder metallurgy. The most important of them are: [3,10,14]

Manuscript Received on April 2015.
Assoc. Prof. Ivan Mitev, Department of Mechanical Engineering, Technical University of Gabrovo, Gabrovo, Bulgaria.

- *can be prepared in powder with different technologies;*
- *resulting copper particles may be of different shapes;*
- *there is easily recoverable oxides;*
- *has high plasticity which makes it easier for pressing;*
- *has a lower melting point than iron which determines the sintering of Fe-Cu pressings in the presence of liquid phase and other.*

Purpose of this study was to determine the influence of the type of iron powders on the values of the tensile strength of the most commonly used in the practice of powder metallurgy two-component system of limited solubility - Fe-C, after sintering in the presence of a liquid phase – Cu.

II. EXPERIMENTAL PART

Basic mechanical characteristics used in practice sintered iron products are directly dependent on the shape and particle size starting powder. Based on literature data on the use and characteristics of the most used in the practice of powder metallurgy iron powders [1,2,12], can be formulated following conclusions:

- The reduction sponge iron powders are mainly used in instances where the device does not require high compressibility- in antifriction products. Their application is required when the final product to be required of high raw strength - friction materials, thin and long details and other;
- Medium density products can be made from spongy powders and from water atomized iron powders Choice of powder in them is made on the basis of the statement of requirements to each case;
- In the manufacture of products with high density using a water atomized iron powders. They possess high compressibility and purity. These powders are used in the production of magnetically soft and hot forged products because they are less impurities.

Based on the conclusions of a study we have selected three types of iron powders manufactured by the company „Höganäs”- Sweden: NC100.24; SC 100.26 и ASC 100.29.

One of the most common practice in powder metallurgy of iron powder prepared by the method of the reduction is NC 100.24. Its compressibility is very good. The particles have a spongy form and determines its high forming. Raw (after compression) and final (after sintering) strength of the details of these powders is very high and the hydrogen concentration therein is low.

Best compressibility of all spongy iron powders produced by the company „Höganäs” by the reducing method has the iron powder SC 100.26. This makes it suitable for working out the

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details with a single press to which has brought demands for higher density. Similarly to previous powders, and these have a high raw strength but somewhat higher densities of these. Recommended in the preparation of details which will subsequently undergo thermochemical treatment.

Iron powder ASC 100.29 is representative of the group water atomized powders. At present it is the highest quality iron powder produced by the company „Höganäs”. It is characterized by a very high purity. Has excellent compressibility. It is a consequence of the fact that its particles are nearly spherical. This makes it possible after a single compression to achieve a high density - 7,20÷7,3g/cm^3. Powders are particularly suitable for making structural parts of high density and also to devices with specific magnetic characteristics.

Maximum size fractions used iron powders, compactability their exertional 420MPa, and the concentration of oxygen and carbon are shown in Table 1.

Basic mechanical properties of structural powder materials in the course of their operation is their tensile strength. In her research used samples with a chemical composition corresponding to the results obtained in a quantitative optimization of the elements of the triple system.[3] The percentage of copper in the samples is 2,5÷2,6%, and the amount of carbon ranges 0,2÷0,8%.

Studied samples were made according to the methodology developed in [5,7]. Pressed with force in the range of 300÷700MPa. This allows, after sintering at 1150°C under an atmosphere of dissociated ammonia, they possess different densities. After mixing of the starting components of the specimen table is set so that after pressing and sintering density is in the range 6,20÷7,00g/cm^3.

Tensile strength is defined according to EN 10045-1. The form of the test samples corresponds to Fig.1.

Table 1. Used iron powders

Type Fe powdert max. size, **µm**	compressibility in **420MPa**		concentration **O_2, %**		concentration **C, %**	
	average	min.	average	max.	average	max.
2	4	5	6	7	8	9
NC 100.24/150	6,45	6,40	0,20	0,30	0,01	0,02
SC 100.26/150	6,65	6,63	0,10	0,15	0,01	0,01
ASC100.29/170	6,82		0,10	0,15	0,01	0,02

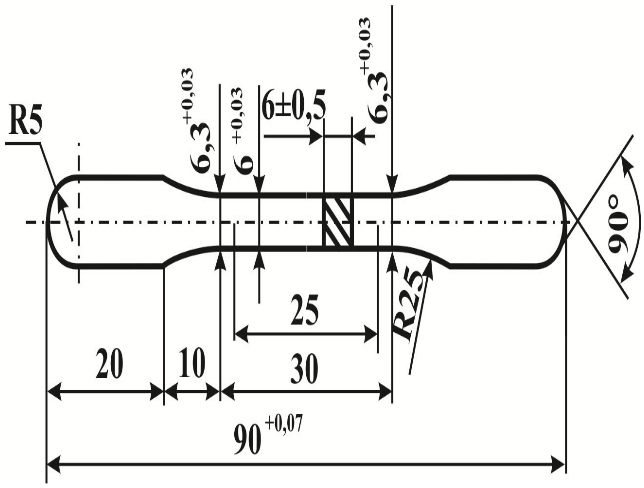

Fig.1. Drawing of a tube of material powder for testing the tensile strength

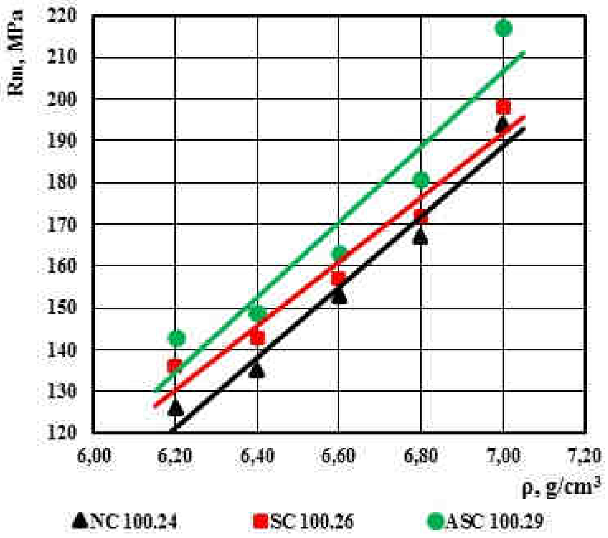

Fig.2. Tensile strength of the iron samples depending on their density

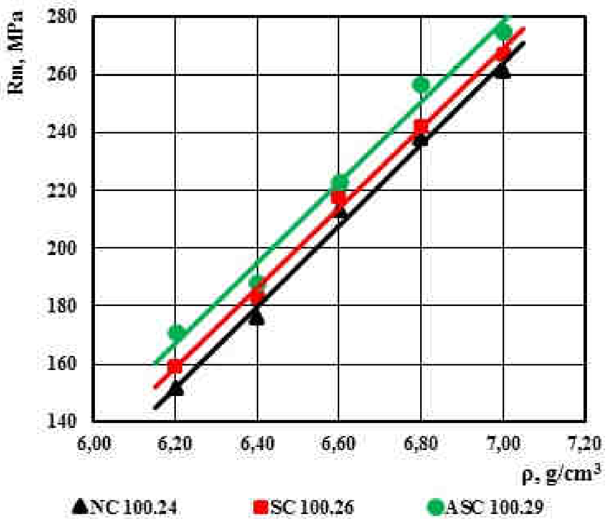

Fig.3. Tensile strength of the iron samples to 0.2%C, depending on the density

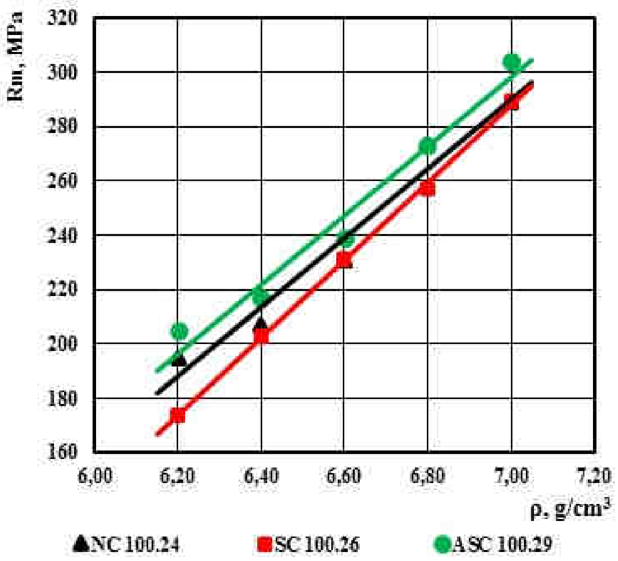

Fig.4.Tensile strength of the iron samples to 0.4%C, depending on the density

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International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249 – 8958, Volume-4 Issue-4, April 2015

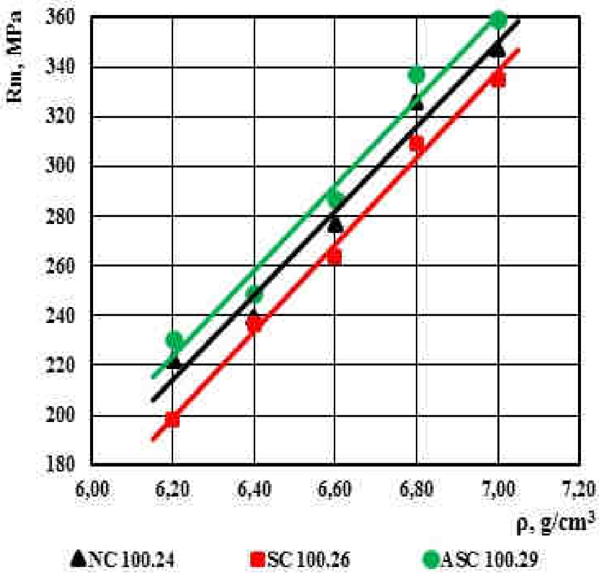

Fig.5. Tensile strength of the iron samples to 0.6%C, depending on the density

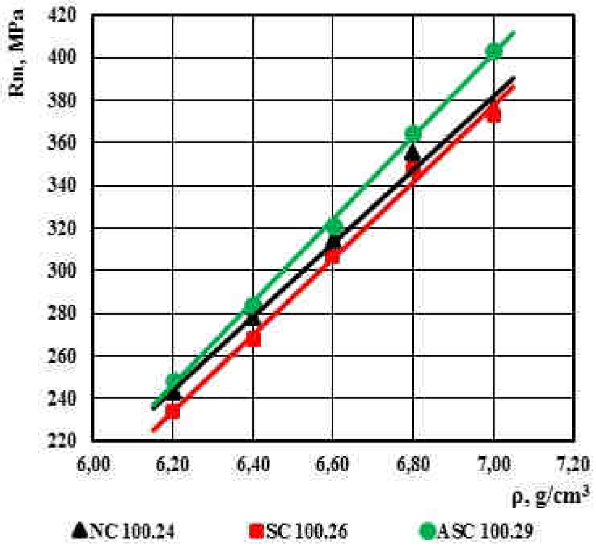

Fig.6. Tensile strength of the iron samples to 0.8%C, depending on the density

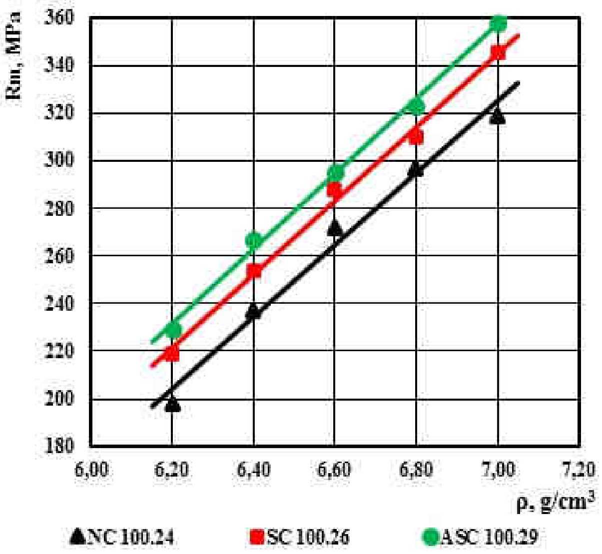

Fig.7. Tensile strength of the iron samples to 0.2% C and 2.5% Cu, depending on their density

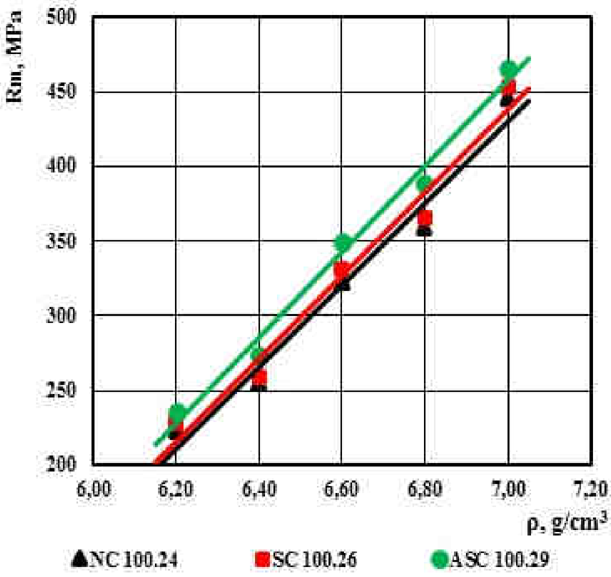

Fig.8. Tensile strength of the iron samples to 0.4% C and 2.5% Cu, depending on their density

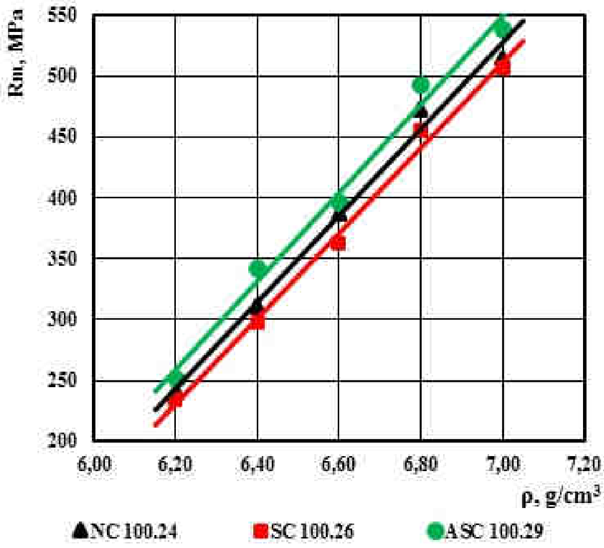

Fig.9. Tensile strength of the iron samples to 0.6% C and 2.5% Cu, depending on their density

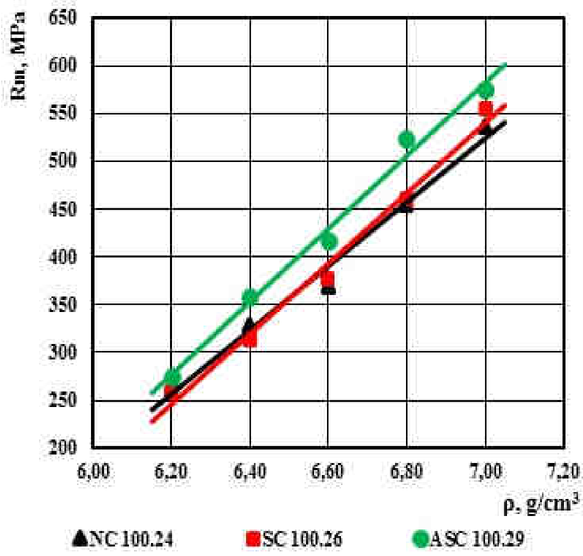

Fig.10. Tensile strength of the iron samples to 0.8% C and 2.5% Cu, depending on their density

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To remove the influence of the porosity on the final outcome in the studies used three sample values of the figures are arithmetic averages obtained for each type of samples.

On specimens of pure iron experimental results are presented in Fig.2.

From the figure it can be seen that with increasing the density of the samples increased and the values for tensile strength, for samples of the iron powders NC100.24 and SC 100.26 , the increase is of the order of 60÷70MPa, while that of ASC 100.29 is 70÷80MPa. In this case the change in the values for tensile strength are due only to reduced porosity, and increased surface contact between the iron particles in sintering. In all investigated densities results for the tensile strength of samples of iron powder ASC 100.29 are higher by an average of 20MPa compared with those obtained when samples of the powders NC100.24 and SC 100.26. Results confirm that the powders of spherical shape have better compactibility compared to sponge. This allows the tensile strength in compacted with spherical particles of iron powder is higher by an average of 10%.

Addition of 0.2% carbon results in increased values for tensile strength. For the three types of tested by us iron molds this increase ranges 30÷60MPa, and is a function of their density – fig. 3. Lower values are registered in samples with lower density and higher in samples with density 7,0g/cm^3. These results can be explained by the fact that the denser sample is increased contact between the iron and carbon particles. This facilitates the diffusion of carbon in ferrite at the sintering and the formation of pearlite structure in the tested samples.

With the increase of the carbon concentration of 0,2 to 0,8%, the values for tensile strength increased in the range of 70÷120MPa. As in the previous case the higher increase of 11÷125MPa. registered in samples with lower porosity and a correspondingly higher density - Fig. 3÷6.

The highest values of tensile strength were measured in samples alloy with 2.5% Cu. In parts containing 0.2% carbon by increasing the density of 6,20 to 7,00g/cm^3 values for the tensile strength increased in the range of 200÷360MPa - fig.2.7. This is an increase of about 25÷30%. To increase the concentration of carbon in the samples from 0.2 to 0.8% and increased values for the tensile strength of the samples from the triple system - fig.7÷10.

For samples containing 0,8% C, the tensile strength varies in the range of 260÷560MPa - fig.2.10. Analogously to the samples with 0.2% C, and in this case the larger the differences in the values are registered in the samples examined by us the maximum density – 7,0g/cm^3.

Comparing the results obtained for the tensile strength of samples of systems Fe-C and Fe-C-Cu, can conclude that the addition of 2.5% copper increases the experimental results with 50÷150MRa, with higher rates reported in samples with higher density - 7, 0g/cm^3.

In samples containing carbon, as well as those doped with 2.5% Cu is observed and the effect of the type of iron matrix the values for tensile strength. At all concentrations tested values for tensile strength in the iron matrix of the powders NC 100.24 and SC 100.26 are with 10-20MPa lower than those measured in samples whose matrix is from iron powder ASC 100.29.

III. CONCLUSION

Of the examination and received at these results can be formulated following important conclusions:

- It is confirmed that the samples of pure iron with increasing density from 6,20 to 7,0g/cm^3, the values for tensile strength increased by 60÷70MPa and independent of the type of iron powder
- It was shown that addition of 0.2%C to the iron matrix increases the values for tensile strength with 30÷60MPa. this increase is a function of their density. denser samples with greater strength as a result of increased contact between particulates and processes of koalistsentsiya in sintering.
- It was shown that addition of 2.5%Cu increases the values of the tensile strength of the iron-carbon powder materials with 50÷150MPa. as larger differences are recorded in the samples with higher density - 7, 0g/cm^3. In this case the increased strength characteristics are a result of the intensification of the process of sintering in the presence of liquid phase sintering in the samples.
- It is confirmed that the samples made from powders of spherical shape - ASC 100.29, they have higher values for the tensile strength compared with those made from sponge iron powders - NC 100.24 and SC 100.26. Difference in values of the order of 10÷20MPa. This is a result of better compacting of the powders of spherical shape as compared to those whose particles have a spongy or dendrite shape.

REFERENCES

[1] Balshin, M., C. Kiparisov, Fundamentals of Powder Metallurgy, Metallurgy, Moscow, 1988, p.171.
[2] Dorfeev, U., L.Marinenko, V.Ustimenko. Structure Powder Materials and Products,. Metallurgy, Moscow, 1986, p.144.
[3] May, I., L. Schetky, Cooper in iron and steel, John Wiley and sons. Toronto, 1988, p.307, ISBN 0-471-05913-7
[4] Mitev,I., R.Maimarev, Optimizing Strength Characteristics of Powder Workpieses of Fe-C-Cu System, IJETCAS, ISSUE 5, vol.1, 2013, p.1÷6, ISSN (online) 2279-0055, ISSN (print) 2279-0047,
[5] Mitev, I., Powder Metallurgy – part I, UP”V.Aprilov”, Gabrovo, 2004, ISBN 954-4683-233-2
[6] Митев, И., Powder Metallurgy – part II, UP”V.Aprilov”, Gabrovo,, 2004, ISBN 954-4683-234-0.
[7] Mitev, I., Structural Analysis, EKC-PREC, Gabrovo, 2013, ISBN 978-954-490-363-3
[8] Mitev, I., R.Maimarev, Sintering the Binary Powdere Materials in the Presence of a Liquid Phase, Manufacturing and Machine, vol.№17, 2012, p.70÷73, ISSN 1312-8612
[9] Mitev,I., I. Vinev, Influence of the Type of Iron Powder on the Mechanical Properties of Powders Manganese Steels, „AMTECH'07” Gabrovo, 2007, vol 1, p. 121÷126
[10] Nichiporenko, O., A. Pomosov, S. Naboichenko, Powders of Copper and its Alloys, Metallurgy, Moscow, 1988, p.202. ISBN 5-229-00163-1
[11] Todorov, R., I.Mitev, Powder Metallurgy – Technology of the Present and Future, LSP Conference, Gabrovo, 2000, p.225÷230.
[12] Todopov, R., A. Mechkov, H. Angelov. Materials and Equipment for Powder Metallurgy Construction Products. BAS, Sofia, 1988, p.191.
[13] Todorov,R., A.Mechkov, J.Pulov. Ceramic Structural Metal Products. Sofia, Technology, 1981, p.254.
[14] Fedorichenko, I. and other, Powder Metallurgy – materials, technologies, properties, application areas, Scientific Thought, Kiev, 1985, p.255.

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