YuCoMat 2007 - 9th Annual Conference of the Yugoslav Materials Research Society, Herceg Novi, Montenegro, 2007, September 10-14

Superficial Distortion Influence on Characteristics of the Iron-Based Materials

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Aim

- To establish the role of rolling on static and dynamic properties, using specific samples for traction (which are also useful for fatigue testing), obtained as mixtures of cooper and iron powders.
- Main component is iron powder DWP 200.28 from SC Ductil SA (Romania)

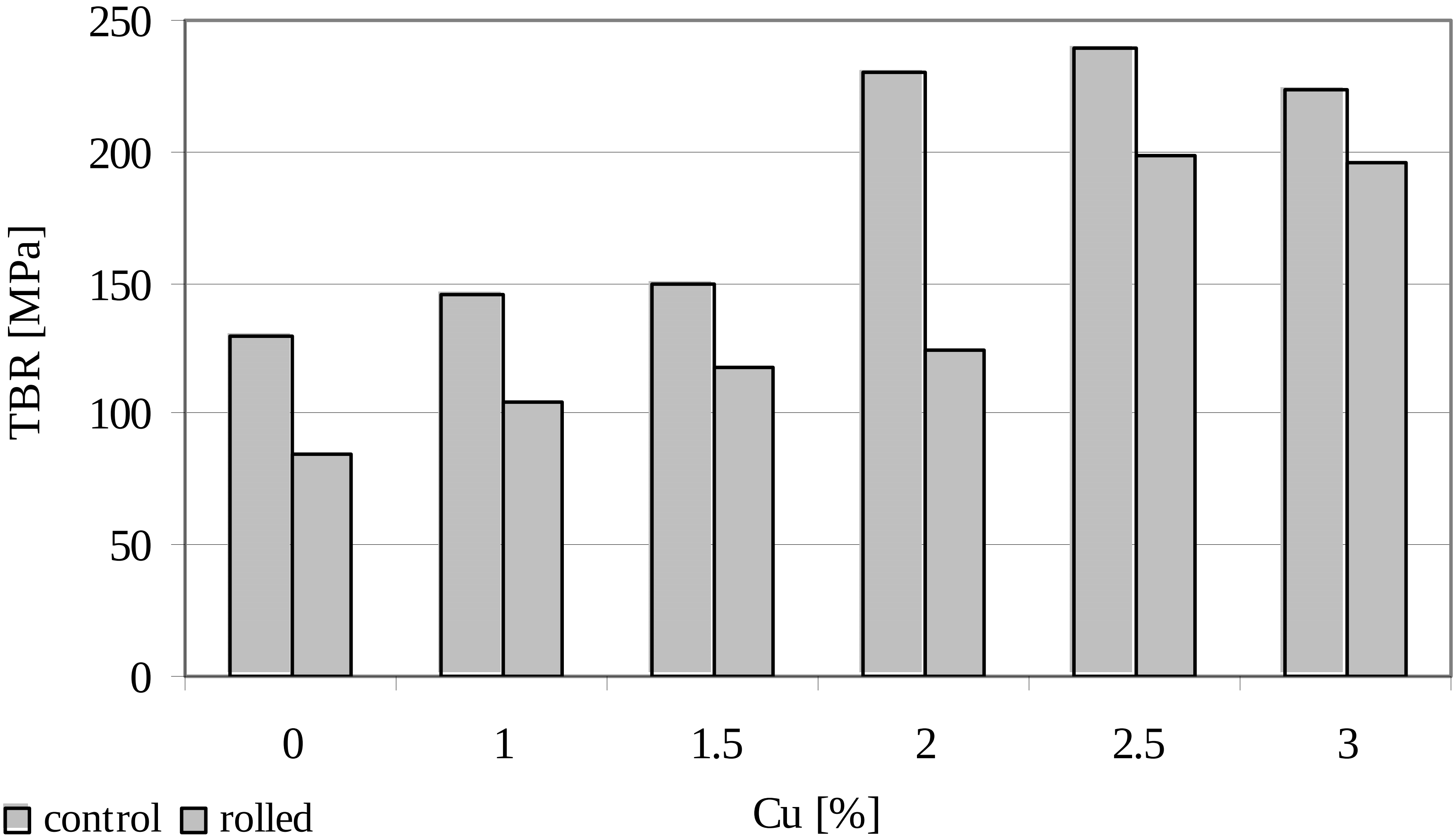
DWP 200.28 iron powder characteristics

Characteristic	Value	M.U.
Particle size distribution (μm)		%
> 160	≤1	
160-100	20-40	
100-63	20-40	
< 63	10-45	
Apparent density	2.7-2.9	g/cm^3
Flowing time	≤33	s/50g
Elemental composition (≠Fe)		%
C,S	≤0.02	
Si	≤0.05	
Mn, O	≤0.20	
P	≤0.015	

Experimental

- Through cooper adding were intended that at sintering procedures to form a liquid faze which to lead to the transformation of the pores as sphere or even closing them in the material structure. In the same time, copper addition can lead to obtaining of constituents such as: ferrite, copper-alloyed ferrite, alloyed ferrite associated with copper alloyed with iron, copper alloyed with iron, and unalloyed copper. Obtaining of these components is given, in high measure, by copper content, temperature and time of sintering.
- Homogenizing of components was done for 30 minutes, and after that a two-side pressuring with 600 MPa were applied. From these mixtures were taken samples for experimental determinations. The samples were sintering at 1120°C for 30 minutes in dissociated ammonia. Obtained samples were processed through superficial plastic deformation and rolling, on both sides simultaneously, with an applied force of 50 Kgf and a number of 104 cycles, using a special device developed for this purpose. After preparation procedure, on the obtained materials the following measurements were done: breaking traction resistance, elongation at breaking, elasticity modulus, hardness, and number of cycles until breaking through plane flexing alternative symmetrically.

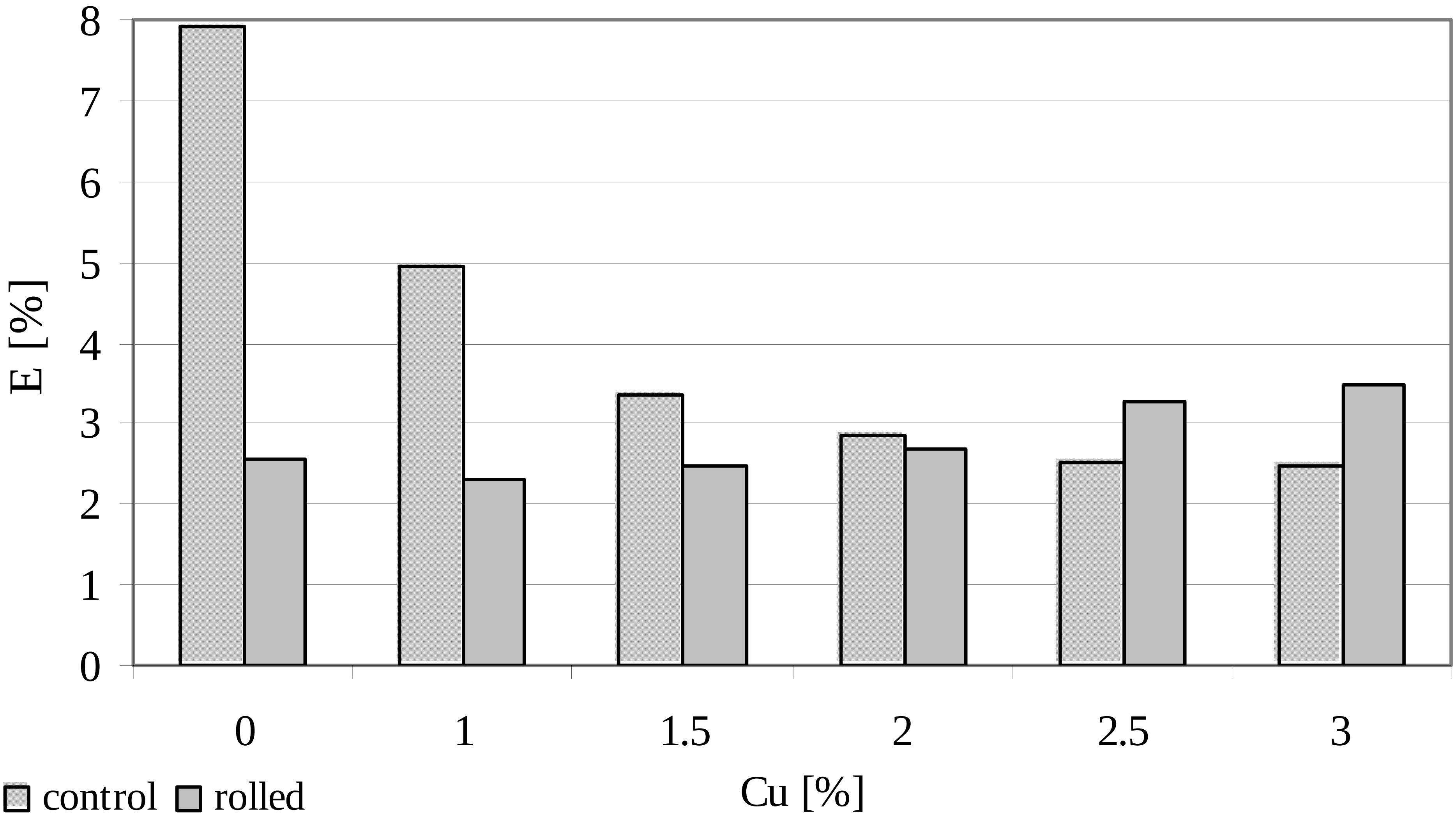
Results - Cooper content and rolling influence on traction breaking resistance



Discussion

- From Figure it results that on both plastic deformed and control ones the resistance on braking by traction vary in same way with copper concentration. At the beginning the resistance increase slowly till 1-2 % Cu, value which it correspond to cooper solubility limit in iron, and after the resistance increases more rapidly, because of copper precipitates allied with iron forming, and even because of liquid phase forming at sintering, with implications on pores sphere shapes. At bigger than 2.5%, Cu content the resistance decrease, probably because of the presence in bigger quantity of free copper and of forming of large pores through diffusion of copper in the material.

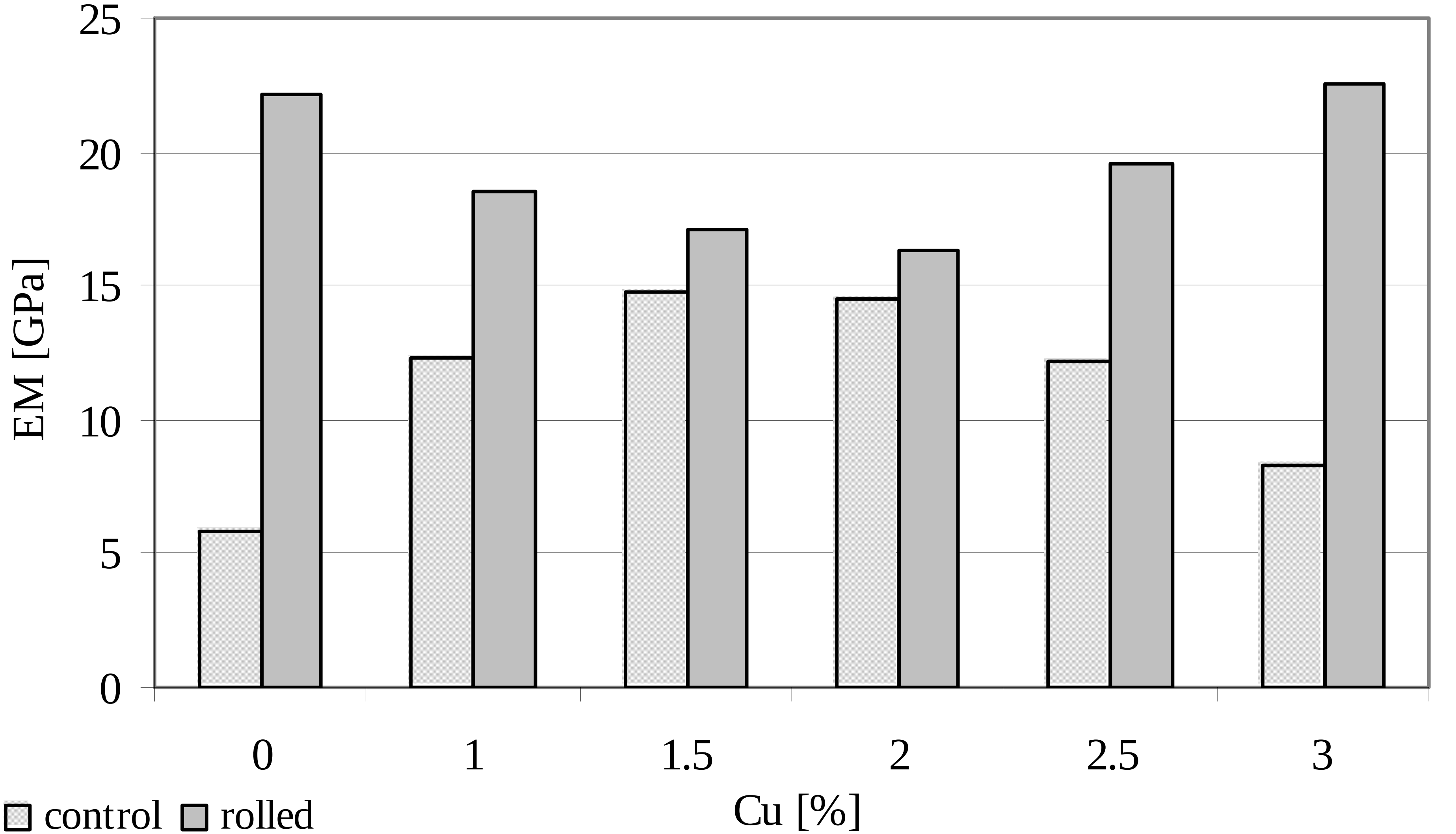
Cooper content and rolling influence on elongation of sintered materials



Discussion

- Through plastic deformation, the breaking on traction resistance of studied materials decreases because the material ecruises and become fragile in a certain degree. Fragility of the material is better evidenced at elongation (Figure).
- Elongation of materials obtained from copper and iron powders decreases continuously, at beginning in a pronounced manner and later (over 1.5% Cu) slower. This fact shows that together with copper-alloyed ferrite formation and appearing of copper precipitates the plasticity of the material decreases. In same time, at a higher copper content, which creates the bigger pores, the elongation it should decrease more rapidly. This fact did not occur because of spherical pores forming, and, as consequence, the factor of local tension accumulation decreases.

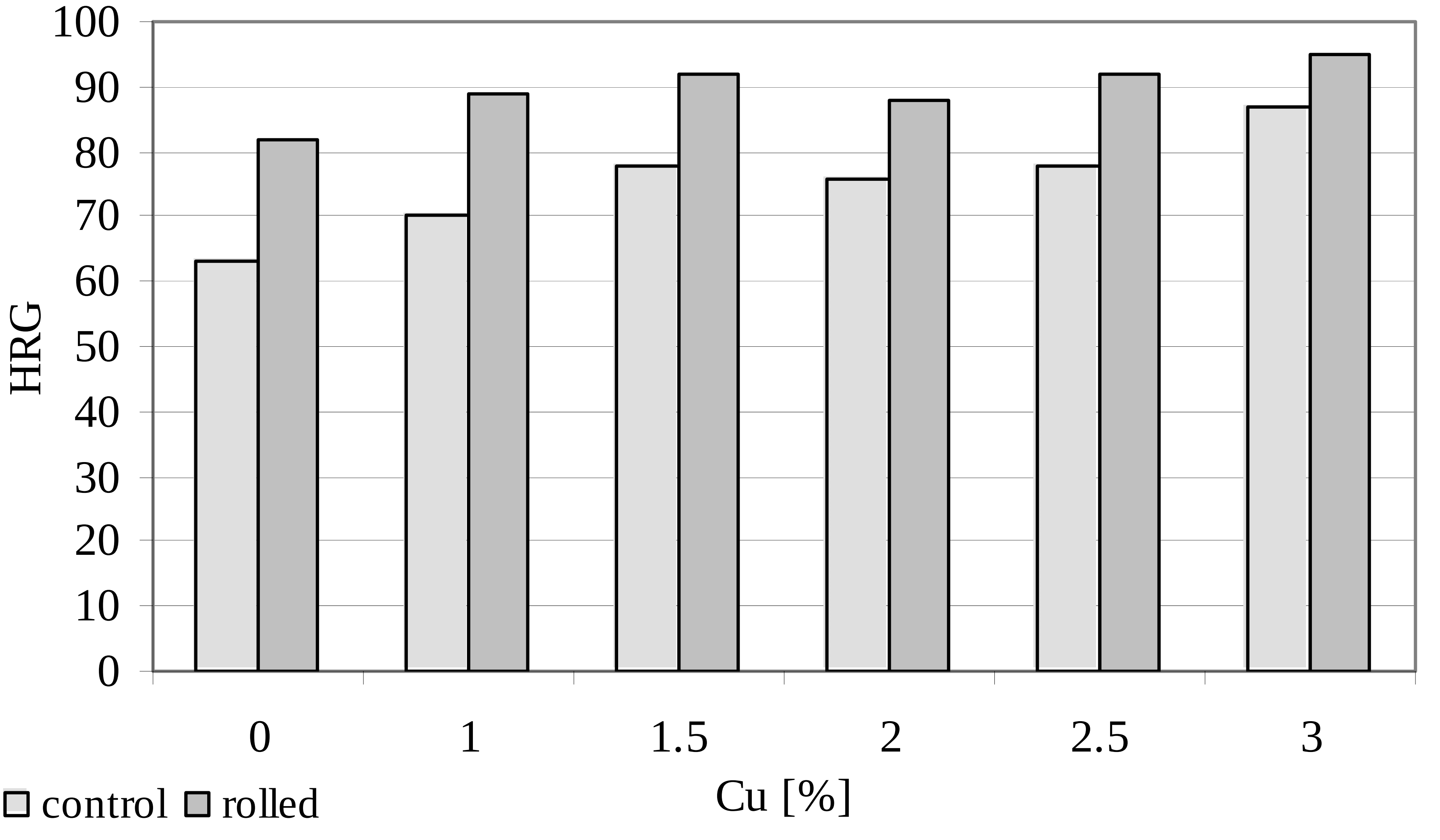
Cooper content and rolling influence on elongation modulus



Discussion

- Elasticity modulus of plastic deformed materials is bigger than of control samples (Figure). As consequence, together with ecruising of the material, decreasing of traction breaking resistance and elongation, it increases elasticity modulus. It can be observed that for studied materials, it exist a correlation between properties. Most significant increase of elasticity modulus seems to be at lower and upper bounds of copper content from studied interval.
- Significant increases of elasticity modulus at lower level of copper content are explained by the higher plasticity of ferrite weak allied with copper when the material ecruises and plasticity it decrease. With copper content increasing, the effect of rolling on elasticity modulus decreases as elongation. At about 2% Cu the effect of plastic deformation on elasticity modulus is not significant.

Copper and rolling influence on sintered materials hardness



Discussion

- From obtained hardness results of rolled sintered materials (Figure) it results that the most important improving of this quality are until 1.5% Cu. This phenomenon is explained by the fact that the solid solution of copper-alloyed ferrite has a bigger plasticity than a structure composed form solid solution and copper precipitates. As consequence, these materials are deformed and ecruises more pronounced through rolling, fact, which provoke the increasing of the hardness. Together with copper content increases the capacity of metal deformation decreases, which lead to less pronounced increase of the hardness. This fact makes that the effect of superficial plastic deformation on hardness increasing to decrease, such that at 3% Cu the hardness of rolled and control materials to be not significant different.

Copper content

- In order to appreciate the copper content influence on mechanical properties, a clusterization procedure was applied on the data from Figures. The rescaled distance cluster combined dendrogram using average linkage (between groups) are given in the following Table.
- The data from Table reveals that the copper adding (from 1% to 2.5%) determines a change into mechanical properties of the material. Note that adding of 3% Cu is grouped with 0% Cu at similarity distance of 3, which suggest that a quantity of Cu over 2.5% make obsolete the advantage of copper adding.

Copper content influence cluster dendrogram [ref]

Cu	**Combined similarity distance**			
[%]	**1**	**3**	**5**	**25**
1.5	A		D	E
2.0	A		D	E
1.0	B		D	E
2.5	B		D	E
0.0		C		E
3.0		C		E

Discussion

- The fact that 1.5% and 2.0% Cu adding are grouped at similarity distance of 1 and 1.0% and 2.5% are also grouped at similarity distance of 1 shows that this interval (from 1.5% to 2%) produces different (and looking at Fig. 1-4 it result better) mechanical properties than (from 0.5% to 1.0%) and (from 2.5% to 3.0%) intervals. Grouping at similarity distance of 5 of all copper contents from 1% to 2.5% shows once again that any copper adding from 1% to 2.5% generates a different mechanical behavior of the material. All copper concentrations are grouped at similarity distance of 25 (five times bigger than the previous group), which prove the difference in mechanical behavior of materials with copper content from 1% to 2.5% relative to no copper content and copper content equal (or over to) 3.0%.

Conclusion

- The effect of rolling on materials properties differs. This type of processing lead to decreasing of traction resistance and elongation, and to increasing of hardness, elasticity modulus and fatigue resistance. The way through rolling gives the materials properties depends on both copper content and its microstructure.

Reference on dendrograms:

- S.D. Bolboacă and L. Jäntschi: *Data Mining on Structure-Activity/Property Relationships Models*, 11th Electronic Computational Chemistry Conference, online, Monmouth University, New Jersey, USA, www, Internet, April 2-30, 2007, presentation #29.

Thank you for you attention!

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