INFLUENCING THE SURFACE PROPERTIES OF SINTERED MATERIALS

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The article deals with the influence of known technologies like rolling and shot peening on the surface properties of sintered steels of CrL and CrM. Their influence is in all cases clearly positive. There were no anomalies. The results achieved correspond to the conditions under which the test was carried out.

1 INTRODUCTION

The expansion of powder metallurgy and especially the production of new materials allow their application in specific conditions. It is all about materials that are exposed when using higher stresses. In many cases this is not enough, so the methods of further modifications in order to resolve this issue, or simply increase the service life of the parts. In specific cases, if a stress concentrates itself on the material surface (fatigue, abrasion resistance...) strengthening of the surface often helps. The methods are well known. We divide them into thermochemical, thermal and mechanical. [1] In some cases it is necessary to test the procedures for new materials eventually the unconventional materials, including in some cases, PM materials. Recently, these materials are used in cases of fatigue stress, resp. rolling contact fatigue stress. Mechanical compacting is one of the practices that meet these requirements. There is enough literary references [2-6] confirming this. Mostly the methods of shot peening or deep rolling were used.

The following article describes the two simple methods for their effects on consolidation and structural changes in materials made by PM technology.

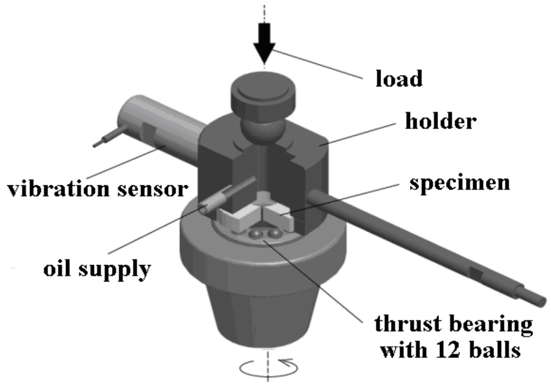
2 EXPERIMENTAL

Samples were prepared from prealloyed steel powders from Höganäs company of Astaloy CrL (Fe - 1,5% Cr - 0,2% Mo) and Astaloy CrM (Fe - 3% Cr - 0,5% Mo) types. Four sets of samples were created by adding graphite powder content of 0.3% and 0.7% wt. for both CrL and CrM. After the addition of HWC type lubricant, samples were compacted under 600 Mpa to form disc specimens of ϕ dimension 30 x 5 mm. Then they were sintered in controlled atmosphere (90% N_2 +10% H_2) at 1120 °C / 60 min. The sintering atmosphere was freezed before sintering - dew point of -57 ° C. Samples were placed into a retort with a mixture of Al_2O_3 with addition of 1% C to avoid possible undesirable oxidation and decarburization of sample surfaces. After sintering the samples were cooled outside the furnace in an inert atmosphere. Subsequently, they were machined so that the outer diameter became ϕ 28 mm. Also a central circular hole with ϕ 10 mm was made. The samples were finally grinded to achieve plan-parallel flatness on both circular areas.

Subsequently, the samples were subjected to surface hardening. In the case of shot peening methods to the surface of the samples were the Metacam device used cast iron granulate of ϕ 0.6 mm. Metacam is operating at a speed of 7000 rev / min, while shot peening took place at an angle of 90 ° to the sample surface. On one side of the set of samples was used 4.5 kg of granulates.

In the case of deep rolling we use an equipment for testing the contact fatigue, Axmat type - Fig. 1, where we exchanged balls for rolls (3 pieces - about 5 mm in diameter and 5 mm in length).

Rollers were placed in a cage. View of tool for deep rolling is at Fig. 2a and schematics of specimen after deep rolling is on Fig. 2b. In addition, it was necessary to change the speed of equipment that has constant 1420 rpm to 220 rpm. That we have reached by the involvement of frequency converter power supply into the circuit of asynchronous induction motor, which spins spindle with roller tool in Axmat device.



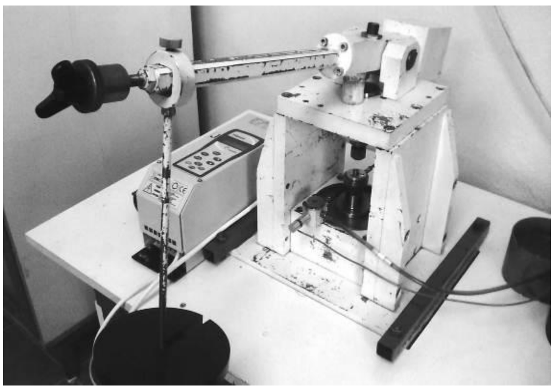
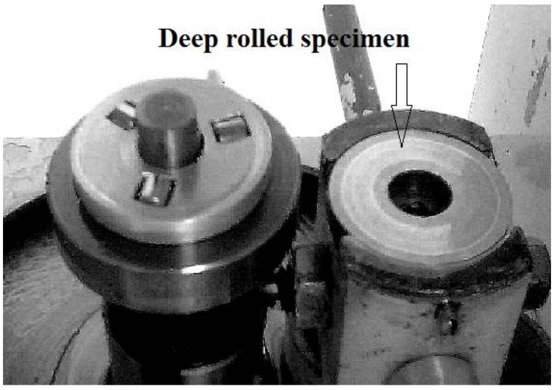


Fig.1a,b Principle of Axmat and overall view of Axmat device transformed into device for deep rolling

The frequency of the electrical network during the rolling was set to 8 Hz, which after calculation using the familiar relation n_s = (60.f) / p, (where n_s means revolutions count of stator, f – current frequency, p - number of engine pole pieces) gives the resulting speed of 230 rpm. They are naturally less due to the slippage of asynchronous induction motor. Complete assembly of equipment with a frequency converter is shown in Fig. 1b. Deep rolling was performed with a constant force of 1100 N (time varies) to achieve the same value of surface roughness R_a.

The samples after tests were subjected to metallographic-microscopic analysis, hardness and micro-hardness measurement. Hardness values were obtained by conventional tests such as the Vickers or micro Vickers hardness measurements.



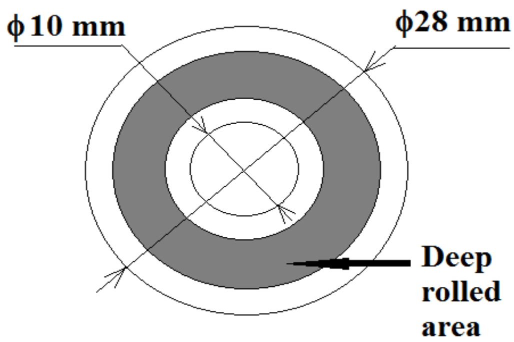


Fig.2a, b View of tool for deep rolling and specimen with deep rolled track

3 RESULTS AND DISCUSSION

Shot peening technology is quite old and currently is used almost everywhere. Mainly, however, where at low cost can be achieved increasing values, which determine the lifetime of the device. Sintered materials that are currently already used in the fabrication of structural components, could also be subjected to this technology. Practically for the same benefits achieved when used by the compact material. Sintered materials based on iron powder CrL and CrM type are currently mainly used in the manufacture of parts in the automotive industry [7-8]. Samples of these materials used - 4 sample variants see Tab. 1 after pressing and sintering have certain mechanical properties primarily characterized by the hardness, as well as other properties as seen from example of Tab. 2. As seen from Table 1, the first conclusion is that the hardness after shot peening in such conditions has increased in all four variants. Logically, this increase was by softener material of CrL + 0.3% C type, where the hardness increased by about 15%. The other three options are practically the same value increases about 8-9%.

The real influence of shot peening on the material can be found out from measuring its microhardness in cross-section. The results obtained are presented in Fig. 3. The values of microhardness show that hardness increased on the surface for all material variants. The highest slope is visible for the material with the lowest initial hardness, and this roughly linear trend is retained also for the material with the highest hardness value. This increase represents 185 HVM 0.05 for the softener material and 90 HVM 0.05 for the hardest material. From the diagram in Fig. 2 it is possible to subtract the approximate depth of the deformation strengthening, which varies up to the values of ~150 - 200 μm.

Tab. 1

	CRL+0.3C		CRL+0.7C		CRM+0.3C		CRM+0.7C	
	HV10	%	HV10	%	HV10	%	HV10	%
Sintered state	109	100	170	100	200	100	235	100
Deep rolling	156	143	182	135	218	125	269	121
Shot peening	125	115	190	109	245	108	260	109

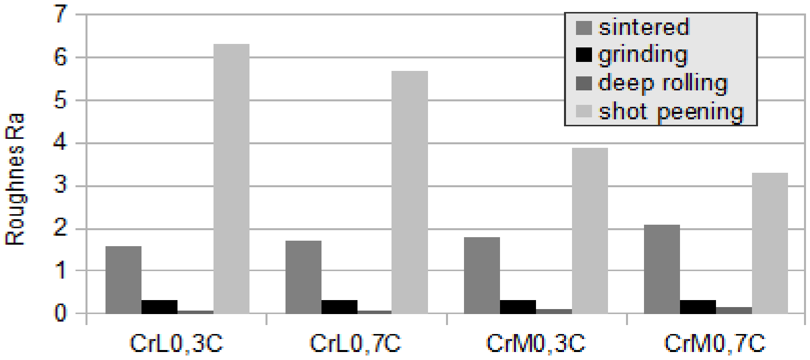


Fig. 3 Graphical interpretation of microhardness for used surface treatment

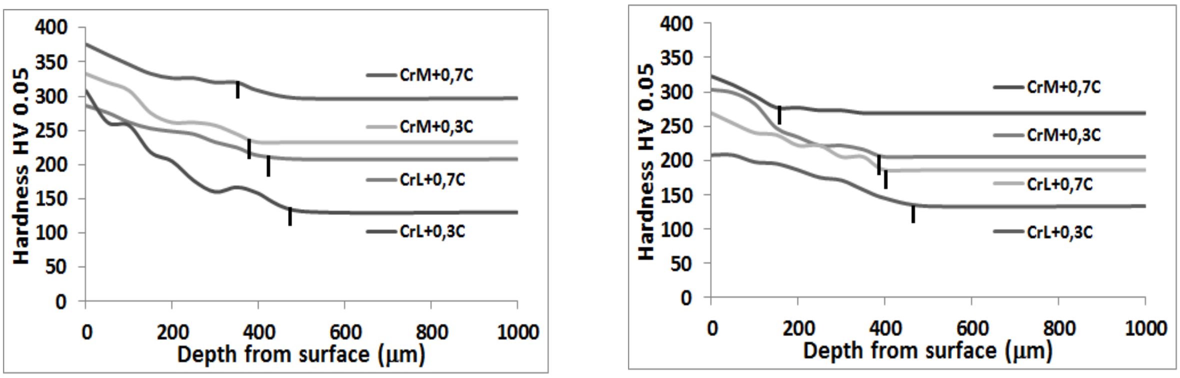
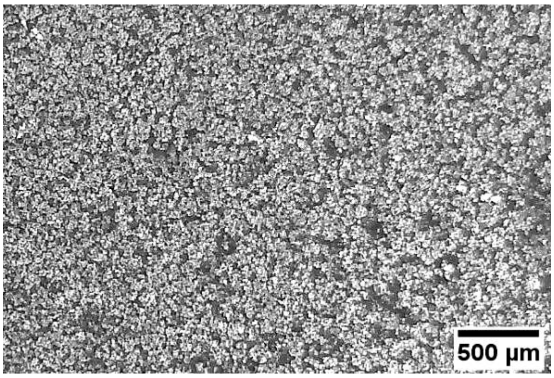


Fig. 4 a, b The course of micro-hardness of samples with different surface treatment

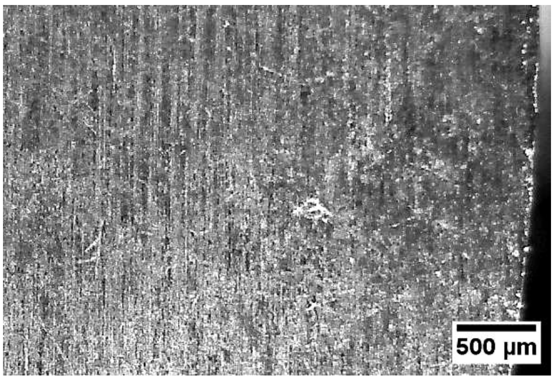
The disadvantage of shot peening is increase in surface roughness. As shown in Tab. 2 samples after sintering showed roughness values, we measured by the value of Ra. As you can see the roughness is just over 6 µm. The sensitivity of this method is best illustrated by the fact, that roughness decrease with the increase of hardness. Although this difference is small, has a similar character as decrease the density of sintered samples, also the toughness of the material during pressing. After shot peening, the surface roughness is high. Again, it is obvious fact decrease the roughness of the material toughness. The surface morphology of the samples after different surface treatments is on fig. 5 a, b, c, d.

Tab. 2

Drsnosť (µm)	CrL+0.3c		CrL+0.7c		CrM+0.3c		CrM+0.7c	
	Ra	%	Ra	%	Ra	%	Ra	%
Sintered state	1.57	100	1.71	100	1.82	100	2.09	100
Grinding	0.33	21	0.33	19	0.32	17.6	0.31	15
Deep rolling	0.06	3.8	0.09	5.3	0.12	6.6	0.16	7.7
Shot peening	6.34	404	5.69	333	3.9	214	3.29	157



(a)



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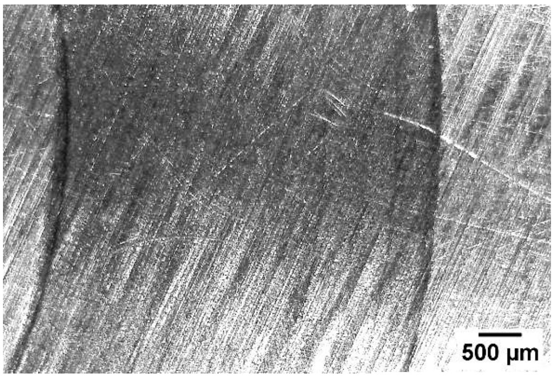

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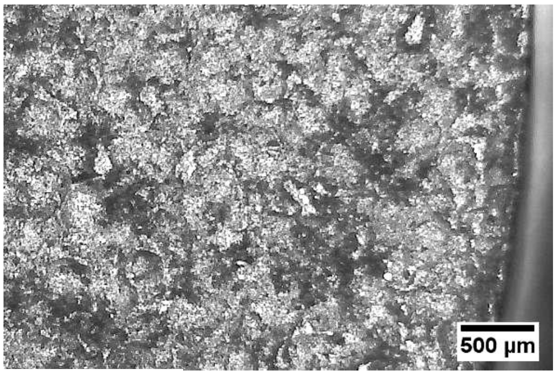

(d)

Fig. 5 a – sintered state , b – grinded surface, c – deep rolled surface, d – shot peened surface

Deep rolling was used to monitor its effect to the surface roughness. This measurement is actually a side observation, because we needed to verify certain facts in addressing another research problem. These materials will be referred to the research on the impact of PVD coating type, studied for their resistance to contact fatigue. Because the coatings are thick, only about 1-3 μm, polished surface is required. In any case, it is necessary that the surface roughness Ra value expressed, was less than 1 μm. To eliminate this factor in determining the contacts-fatigue life and the need to use such parameters roller to whatever hardness of materials was the same roughness. The results, which led us to the intended target are shown in Fig. 3 and Fig. 4. Fig. 3 shows the effect of time of deep rolling with constant pressure to increase hardness compared to sintered state. Logarithmic course proof the fact that with the increase in hardness of the material with a roller, it is necessary for the same contact force, causing each longer time to achieve the desired surface roughness. The length of the operation is then given by the functional dependence. In contrast to the time dependence, which had logarithmic course, on fig. 6 can be seen that the depth of the pressure dependence of hardness on deformation of samples is based almost linear. Its results are indicated in Tab. 2. Ra values are below 1 μm. From fig. 6 we can see that the constant rolling for force and increasing the time of its application, we value Ra reached the level better than required.

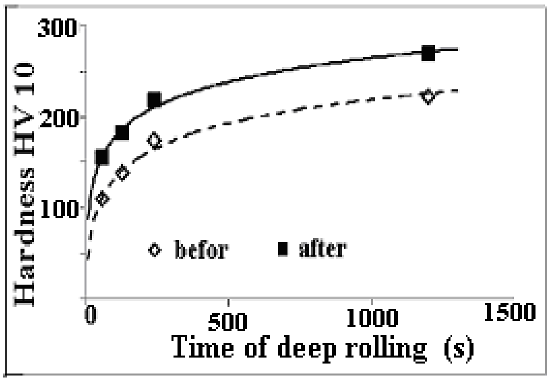

Fig. 5 Dependence of Hardness versus Time of deep rolling

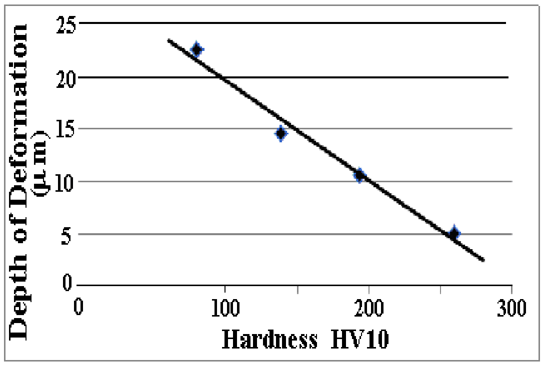

Fig. 6 Dependence of Depth of Deformation versus Hardness

Both technologies have one thing in common. There occurs increase in the surface hardness and also to the formation of favorable compressive stresses. Hardness and behavior of tensions with the penetration depth decreases. Previously, however, booth values firstly growth, which has been associated with Hertzian stress and after reaching the peak, decrease follows. What is interesting is the fact that in both cases there is some maximum that cannot overcome the increased load. These aspects are generally already well developed, and can be described on the basis of the graph in Fig. 6 and 7 - according to [1].

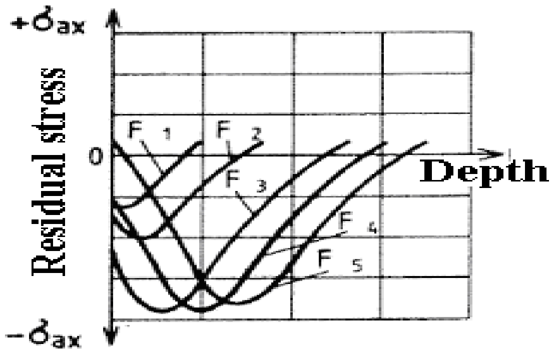

Fig.7 Dependence of residual stress on Depth

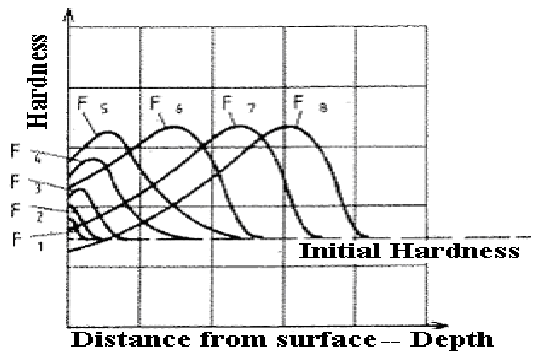

Fig.8 Dependence of Hardness on Depth

In the case of deep rolling we are also subtracted depth of influence from the graph in fig. 4. Here too we see a clear difference between the softest and hardest material. Maximal hardness and the depth of influence reached are lower for deep rolling than for shot peening.

4 CONCLUSION

Tests carried out have shown that there is no significant qualitative difference in the impact of both technologies used, with sintered materials. Quantitatively technologies differ in the change of surface roughness, which could be without proper treatment in some cases unfavorable. Low values of pressure deformation in both cases showed the phenomenon of surface compaction. This means that on the surface was not created layer with reduced porosity. The main factor for use these technologies are still deformational strain hardening and also reduce the surface roughness in the case of deep rolling.

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