Researches about wear comportment of sintered parts elaborated from recovered powders

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This paper presents the results of experimental research on the wear behavior of some parts (such as removable plates) made by high speed steel powder (HSS) obtained from chips recovered from sharpening tools used in cutting processes. Chips recovered from high speed steel cutting tools were used to develop metal powders in planetary mills using different grinding regimes. Recovered powders were then compacted unilateral mold were applied to different cycles sintering in argon, and after a heat treatment hardening and tempering. The samples obtained were then used as removable cutting plates in the turning procces of non-ferrous materials.

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1. Introduction

In recent years, with the deepening economic crisis, has imposed the need to implement recycling technologies simultaneously with optimizing modern manufacturing technologies and the appearance of advanced materials obtained with low energy consumption[1][3][4].

Research undertaken in this paper is due now by interest on the need for recycling of materials and especially scarce and expensive. Recovery and recycling of materials is determined both for economic reasons (high costs of materials development, expensive tool execution at the imposed odds and complex technologies processing) because development costs of raw materials decrease and from environmental considerations[5][6].

The purpose of the research undertaken are focused on two directions of work.

- in the first place was studied the technical possibilities of waste processing (sludge) high speed steel resulted from finishing operations of cutting tools used in mechanical processes departments of the enterprises and getting metal powders with reduced manufacturing costs and relatively appropriated property those obtained by classical way.
- in the second place was followed the development of wear resistant sintered parts such as removable cutting plates which replace the classic high speed steel turning tools in monobloc design still widely used today in mechanical processing of various materials in machine construction industry.

2. Experimental research

In order to carry out research goal was set up a technological route for obtaining powders from collected sludge and developed several high speed steel powders with different grains. Were used HSS chips resulted from industrial field, after cutting processing.

To determine the chemical composition of the initial chips and distribution of alloying elements was used electron microscope SEM equipped with EDS spectrometer and analysis software INCA 200. In Fig. 1 is shown the chemical composition of HSS chips.

EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Elem	Wt %	At %	K-Ratio	Z	A	F
C K	2.28	9.52	0.0059	1.2179	0.2131	1.0003
O K	6.20	19.41	0.0300	1.1938	0.4044	1.0024
V K	1.15	1.13	0.0120	0.9950	0.9698	1.0788
CrK	3.88	3.73	0.0432	1.0142	0.9792	1.1224
MnK	0.99	0.90	0.0097	0.9969	0.9849	1.0046
FeK	67.30	60.35	0.6796	1.0167	0.9865	1.0068
W L	18.20	4.96	0.1339	0.7430	0.9905	1.0000
Total	100.00	100.00				

Element	Net Inte.	Backgrd	Inte. Error	P/B
C K	4.72	1.82	4.33	2.60
O K	53.48	2.44	1.01	21.87
V K	7.51	7.45	4.46	1.01
CrK	22.69	6.98	1.89	3.25
MnK	4.22	6.05	6.77	0.70
FeK	239.10	5.55	0.47	43.08
W L	6.82	3.59	3.88	1.90

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kV: 15.01 Tilt: 0.00 Take-off: 35.80 AmpT: 102.4
Det Type:SUTW, Sapphire Res: 130.42 Lsec: 200

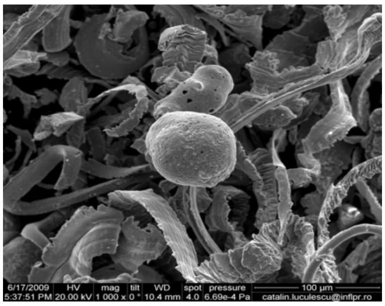
Fig. 1. Parameters and results of EDAX analysis

In order to obtain powders, metallic chips were subjected to mechanical grinding using a Fritsch vario-planetary mill with ball type Pulverisette 4.

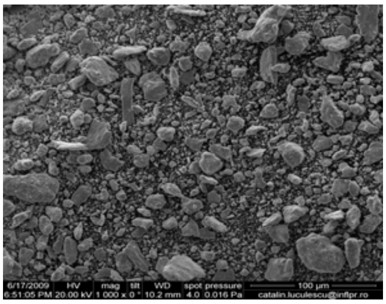
Grinding parameters were: grinding time: 5,10,15,20 hours; bowls speed: 800 rpm; 400 rpm main drive speed; material / balls report: 3/10; volume grinding bowls: 250 ml, diameter balls: 10 mm; bowl material: stainless steel, ball material: stainless steel, grinding atmosphere: argon, type of grinding: dry.

To prevent temperature exceeded 80°C, in the grinding bowl was used a GTM system which monitoring the pressure and temperature inside the grinding bowl.

Influence of milling time on particle morphology of the powders was analyzed by electron microscopy SEM using a JEOL 5600 LV microscope. Fig 2 shows the initial powder morphology and after milling for 10 hours and and 20 hours.



a)



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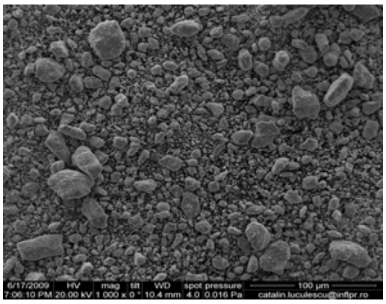


c)

Fig.2 SEM images of the powders: a) initial powder; b) after 10 hours of milling; c) after 20 hours of milling

Original chips are generally rough and irregular shaped needle containing abrasive grains on the surface.

After 10 hours of grinding grain powder is in the range [0.1 to 150] µm and after 20 hours of grinding grain powder is in the range [0.04 to 25] µm

Research focused on the interdependence of powders particle sizes and compaction pressures respectively sintering temperature in order to obtain high wear resistance parts such as removable cutting plates.

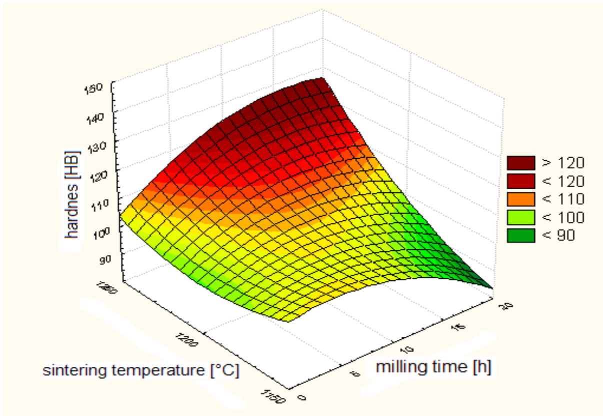
Compacting the obtained powder by grinding was done at two pressing force: 600, respectivily 800 MPa.

Sintering temperature of samples was performed at 1150 °C, 1200 ° C and 1250 ° C in an electric furnace in argon atmosphere, using two holding time at sintering temperature 1 hour and 2 hours.

Correlating density samples with pressing pressure, sintering temperature and holding time was found that the best results were obtained from samples pressed at 800 MPa, sintered at 1250 ° C and holding time 2 hours.

To ensure a good wear resistance for the previously sintered samples from recovered quickly steel chips were subjected at a heat treatment for hardening consisting of quenching at 1280 ° C for 10 min in argon medium and double recovery at 550 ° C for 60 min in air, which led to the transformation of residual austenite into martensite recovery and dispersion hardening under the effect of partial decomposition of martensite and precipitation of finely dispersed carbides.

In the figure 3, 4, are presented the evolution of the hardnes [HB] depending on the sintering teperature [^{0}C] and milling time [h]. The best hardness values for sintered compacts correspond to those milled powders for 20 h, pressed at 800 MPa and sintered at 1250 ° C according Fig. 4b.



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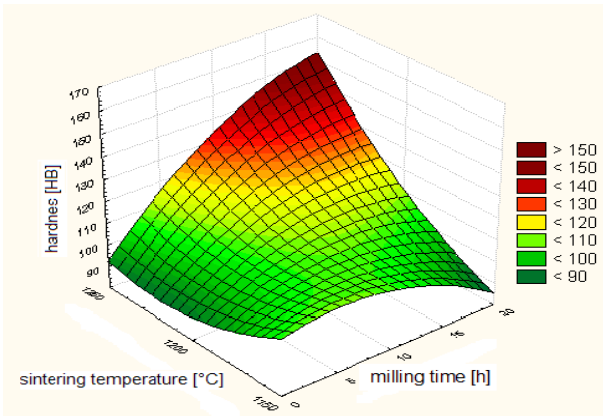
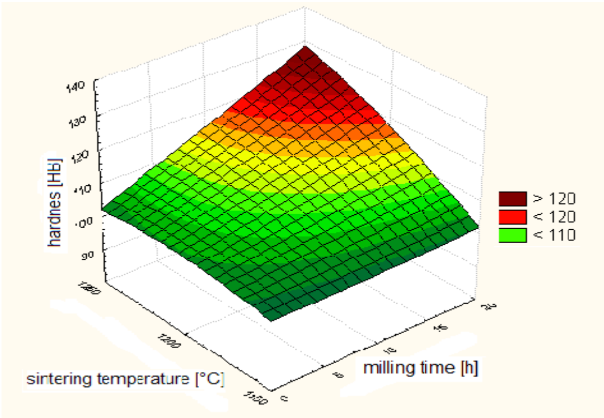


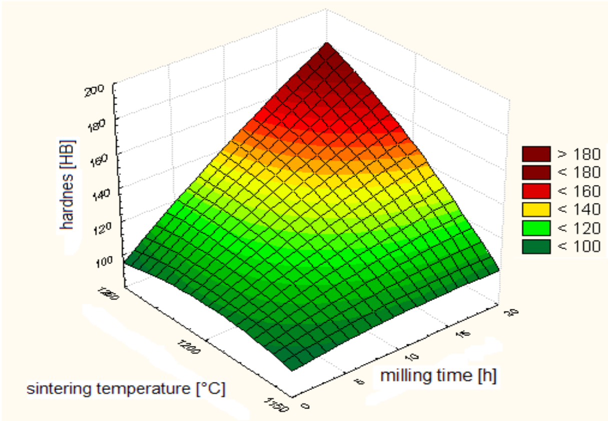
b

Fig.3 Evolution of hardness for samples compacted at 600 Mpa and sintering teperature maintained at: a)1hour and b)2 hours.

Further research were focused on the posibility to use sintered compact as removable plates in the cutting process. After then were analyzed the causes and the forms of wear as well as the influence of basic factors of cutting faces on cutting tool durability. Were followed the evolution of wear on the settlement and clearance faces and also analytical determination of the size of wear.



a



b

Fig.4 Evolution of hardness for samples compacted at 800 Mpa and sintering teperature maintained at: a)1hour and b)2 hours.

Active part of cutting tool wear is influenced by the workpiece, cutting tool type and cutting conditions, which correspond to different physico-chemical processes.

Experimental studies on processing of cutting and sustainability were performed on lathe parallel, using a knife specially designed for this purpose, according Fig. 5.

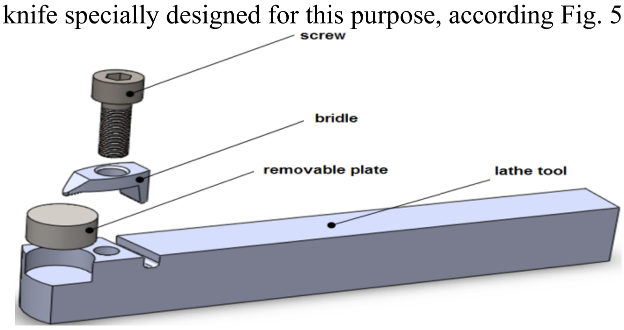


Fig.5 Turning knife with removable plates obtained from recovered powders

Shape and position of the removable plate were made so that after mounting it on the knife to achieve a negative rake angle γ = -10 °, an inclination α = 10 ° and an angle of inclination of edge λ = - 5°. This is presented in Fig. 6

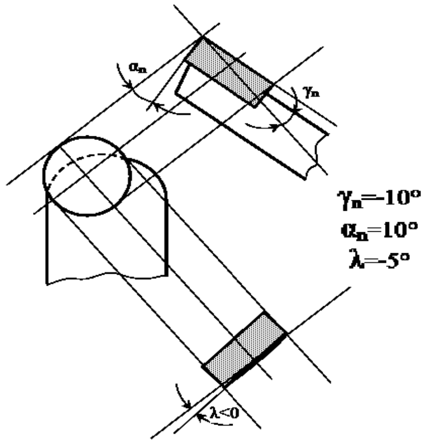


Fig.6 Cutting tool geometry.

Thus, all cutting plates used in the tests had the same geometry so that it can not be considered a influencing factor.

Influencing factors for wear and durability removable cutting plates were:

- technological factors, namely cutting regime parameters;
- geometrical parameters of the active part - mechanical properties of semi-processed material;
- cooling- oiling conditions of the blade.

Preliminary experiments made by longitudinal turning, took into account the realized material behavior as removable plates used in various processing of metallic and nonmetallic materials. Material that attempts were made are: aluminum alloy (AlMgSi1);

Were used removable plate made from HSS recovered powder with fine-grained and following sintering parameters: t_{sint} = 1250°C and t_{men} = 2 hours, quenched and tempered.

Parameters of cutting regime were: f = 0.125 mm / rot, cutting depth a_p= 0.5mm, cutting speed v_a= 55m/min without cooling.

The behavior and development of the cutting process was investigate by closely monitoring the formation of the chips, their appearance and surface roughness generated as well as the wear evolution and sustainability of the cutting tool.

During the experiments were collected the chips samples to study their deformation and their influence on the resulted roughness.

Micro-roughness of the semi-products processed by turning were analyzed on a NIKON microscope using 150x magnification. Status plates after processing was analyzed with digital microscope DigiMicro 2.0 Scale connected to a portable PC.

Figures 7,8,9 are shown micro-roughness of the AlMgSi1 bar after 30 minutes of processing.

Because of small feed 0.125 mm / rot, small step of tread pattern is observed. You can see the appearance of uneven ribs and tears on their route.

Fig.7 Lathed surface image of AlMgSi1 after 30 min

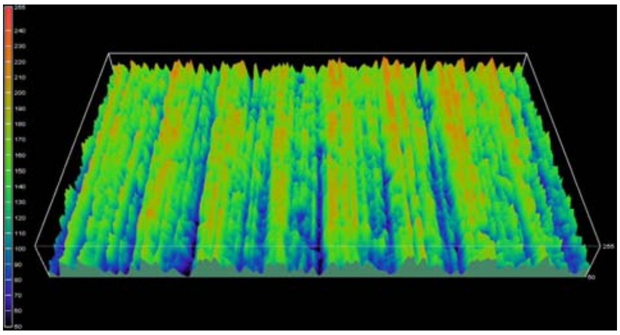


Fig.8 3D image of the machined surface after 30 min AlMgSi1

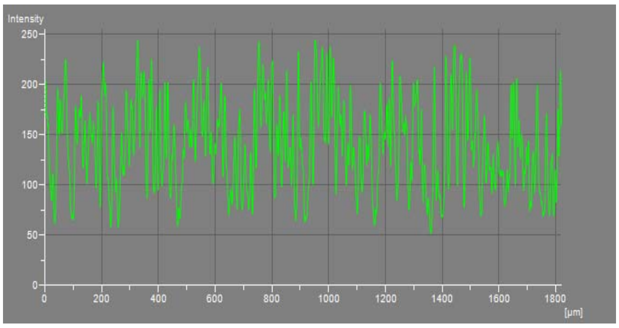


Fig.9 Profile diagram machined surface after 30 min of AlMgSi1

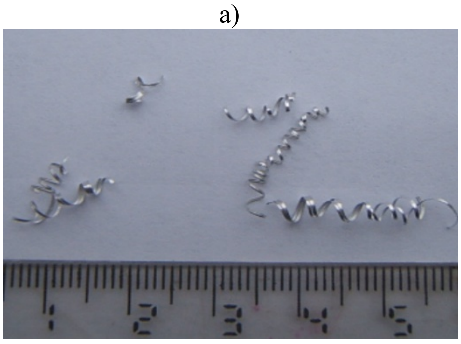
With the same removable plate was turning the same material during the two time periods, respectively 30 and 90 minutes using different areas marked on the surface. The shapes of processing chips were also studied, and it was observed that they are generally in a helicoidal shape with one or two turns while some of them have Archimedean spiral. chips thickness are fairly uniform. These things are presented in Fig. 10.

In Fig. 11 we can see that the surface deposit the clearance height is 0.82 mm and its width is 1.92 mm after cutting for 90 minutes.

It was found that there were no wear of removable plate of seating surface while on the clearance surface appeared deposit of materials that were proportional to the time of cutting.

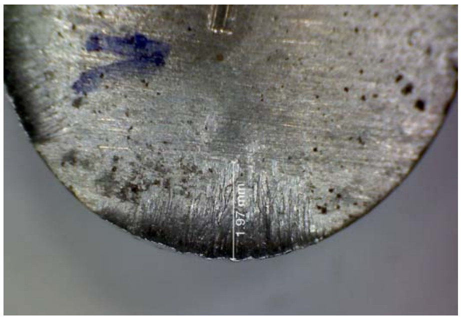
Absence of wear on the clearance surface is due by deposition of Al alloy which took over from the cutting edge.

a)



b)

Fig.10 Aspects of removable plate and chips form at AlMgSi1 turning; a - plate aspect; b -form chips.



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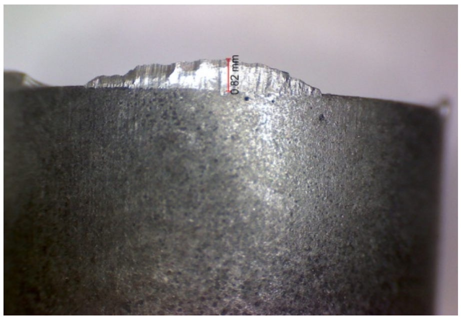

b)

Fig11 Aspects of the submission on the turning edge AlMgSi1: a - Detail of plate to measure the clearance of deposit size b- Detail of plate to measure size of deposit on the settlement

Figs. 12,13,14 are shown micro-roughness of the AlMgSi1 bar after 90 minutes of processing. Is observed between the tread pattern a step higher due to higher deposit on the surface clearance. It appears that the ribs are fairly uniform and appear little break on their way.

Fig.12 The image of turned area on 5.14 AlMgSi1 after 90 min

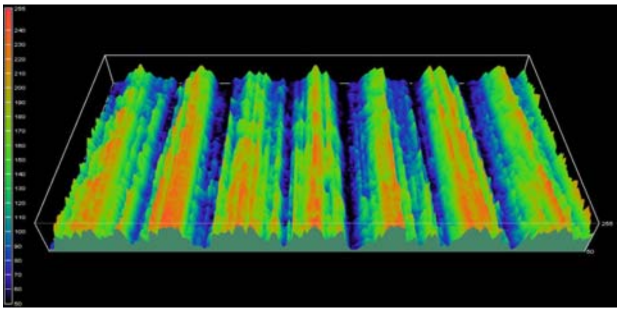

Fig.13 3D surface image of AlMgSi1 processed for 90 min

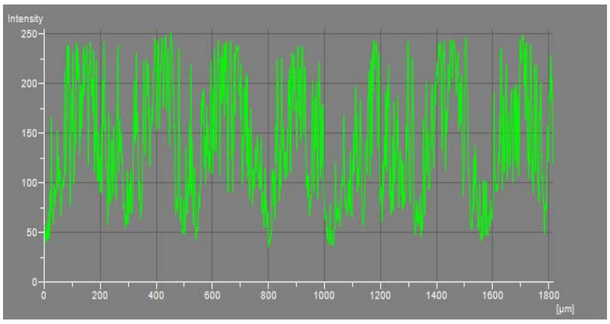

Fig.14 Profile diagram on machined surface of AlMgSi1 after 90 min

3. Results

The experiments consisted in using the same type of removable plates for cutting aluminum alloy of a different time and monitor their wear values. Measured values with the portable microscope on the settlement surfaces of the cutting removable plates depending on cutting time and speed, are given by table 1 and fig. 15.

Table 1. Values of wear on the seating face opposite speed and the turning duration.

Speed V_1=62m/min		Speed V_2=93m/min		Speed V_3=120m/min	
Cutting time [min]	wear [mm]	Cutting time [min]	wear [mm]	Cutting time [min]	wear [mm]
2	0,31	2	0,56	1	0,86
5	0,39	5	0,71	2	0.94
8	0,46	8	1,21	3	1,27
12	0,79	12	1.36	4	1,42

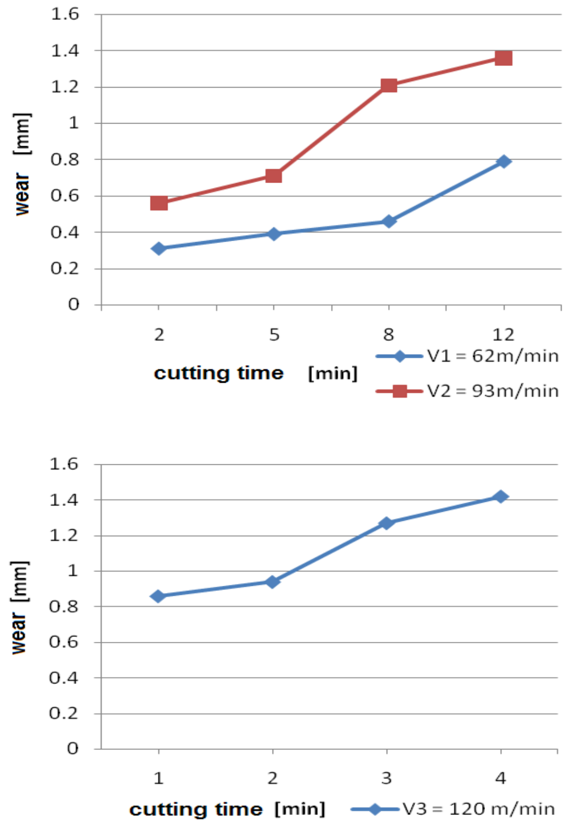

Fig.15. Wear variation depending on the time at speeds cutting

The research shows that the wear increases with cutting speed. At high speed cutting (v_3 = 120 m/min) could not be cutting than short durations of 1-4 minutes due to excessive heating of the processed materials and its adherence to the removable plate.

After material processing by removable cutting plates from recovered powders was evaluated the roughness of resulted surfaces.

Surface roughness is a result of the deformation of the system machine-tools–device-piece, the tool geometry and cutting regime used.

Roughness measurement was performed with a portable profilometer Surtronic 25.

Concepts that define geometric surface condition are presented in EN ISO 4287-2003 and ISO 4287/A-2003. The most important parameters for appreciations of appropriate standard roughness are:

- Rz - maximum height of the profile
- Ra - arithmetical mean deviation of the evaluated profile
- Rq - standard deviation of the evaluated profile
- RS_m - average width of profile elements

Profilometry allows tracing Abbott-Firestone curve capacity that is used to study the wear of metallic and nonmetallic surfaces in tightness or lift appreciation of the pressed assemblies.

Fig. 16 are given roughness and capacity curves for processed material in research.

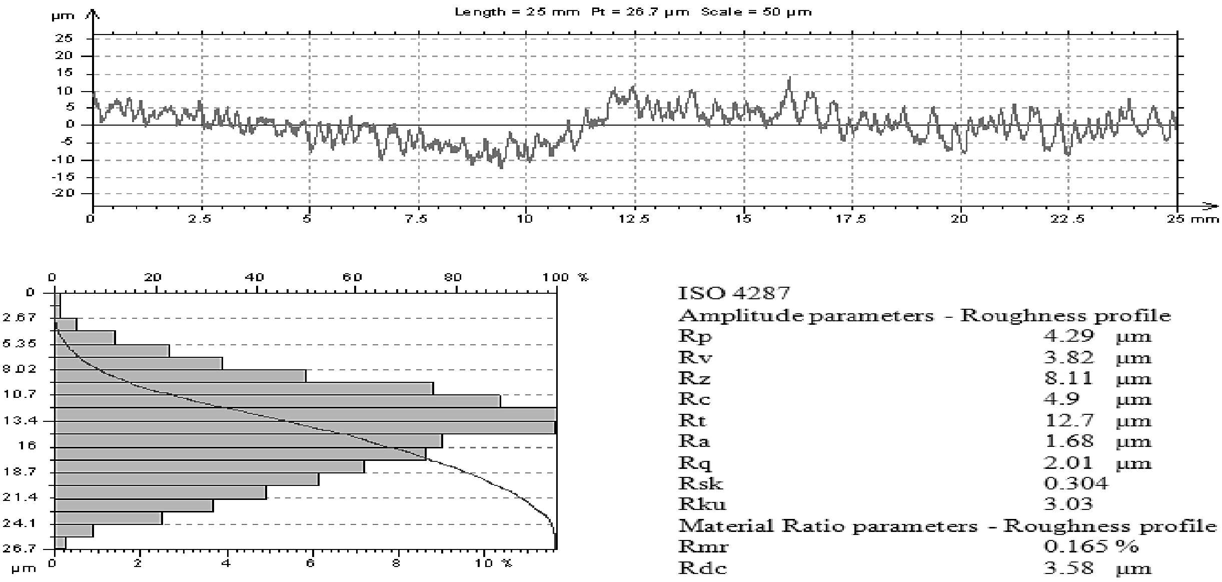

Fig. 16 Roughness and capacity curve at the AlMgSi1 processing

4. Discussions

Regarding on the wear behavior of sintered and annealed samples:

- in terms of grain powder, the lowest values of the wear coefficient were obtained for samples made from powders with fine grain, obtained by mechanical division for 20 hours;
- in terms of the parameters of sintering was found that the increase in sintering temperature and duration of maintenance led to increased hardness (and thus lower wear) sintered HSS components recovered. The best values being obtained for the 800 MPa pressed and sintered at a temperature of 1250 ° C while maintaining 2 hours.

Regarding on plates cutting capacity developed based on research:

- at processing of aluminum alloy it was found that during process cutting deposits occur on surface clearance of the cutting edge which makes that this takes over the role surface clearance. Under these conditions no wear occurs on the surfaces of clearance and settlement of removable plates;
- shorter turning times process that the resulting chips are typically fragmented, while at larger time intervals they become helicoidal due to the massive deposit of material on the clearence surface;
- processed surface quality for aluminum alloy AlMgSi1 is very good, measure of the value roughness is Ra = 1.68 µm;

5. Conclusions

Undertaken research led to the following conclusions:

- recovered high speed steel chips from regrinding operations of cutting tools used in machining enterprises can be used to obtain metal powders , with low manufacturing costs and relatively appropriated propertys as those obtained by classical technologies;
- the method of obtaining metallic powders by mechanical splitting of small chips is the only viable process to recover them, as if melting would take place this would lead to their complete combustion;
- method of obtaining metallic powders by mechanical splitting of small chip is the only viable process to recover them, because if melting would take place result a complete combustion;
- of powder obtained from HSS chips can be obtained sintered compacts, which were subsequently used as removable plate cutting process for metallic and nonmetallic materials.

References

[1] C.E. Costa, W. C. Parucker, M. L. Parucker, J. Mater. Proc. Tech. **143-144**, 138 (2003).

[2] Y. Trudel, Metal Powder Production and Characterization, Powder Metal Technologies and Application. Ch. 2, ASM International, USA (1998).

[3] A. Sverdlin, T. Loumacheva, A. Melnikov, K. Sarbaeva, A. Kirillova, ASM Proceedings. **2**, 1024 (2000)

[4] B. I. Jody, Recovering Recyclable Materials from Shredder Residue, JOAM February, p.40 (1994)

[5] J. Kers, P. Kulu, D. Goljandin, M. Kaasik, T. Ventsel, K. Vilsaar, V. Mikli, Materials Science **14**(4), 296 (2008).

[6] The Powder Metallurgy Industry Worldwide 2007-2012, Materials Technology Publications; PM Steels, p.441(2003)

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