"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2015
Brasov, 28-30 May 2015

CHARACTERISTICS OF SLUDGE RESULTED FROM BALL-BEARINGS RECTIFICATION

Ion Dinescu

*Faculty of Aeronautical Management, "Henri Coandă" Air Force Academy, Brasov, Romania

Abstract: *The paper is presenting some of the researches made on sludge resulted after a processing of ball bearings, by grinding. Due to the high quantity of sludge, it must be considered the power which can result, because it is already there. The power from ball-bearing steel is compared with powders produced by famous companies from the world.*

Keywords: *sludge, powder, ball-bearing, rectification.*

1. INTRODUCTION

As a result of processing of the component parts from a ball-bearing, there is resulting an important amount of sludge. This sludge is containing particles detached from the rectified piece and also granules from the abrasive disk.

Nearby these components, which are in solid state, the sludge is containing also a fluid component coming from the cooling fluid. But the most important component is from ball-bearings steel, which is a medium alloyed steel containing a high level of carbon.

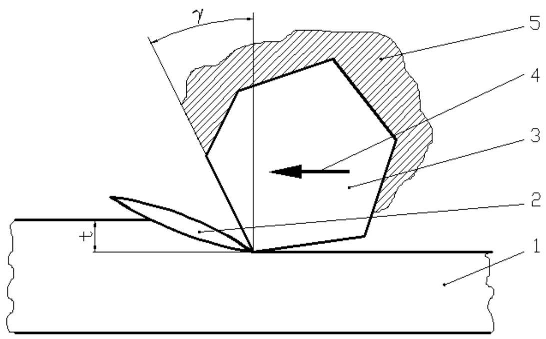
Missile aeromechanics technologies have benefits that include enhanced flight performance, reduced weight, increased Mach number, reduced cost, higher reliability, and reduced observables [6].

In the following passages there are presented some characteristics of the sludge resulted from working processes

2. HOW TO OBTAIN THE POWDER

The studies sludge is obtained during the grinding of the components from the ball-bearings. Grinding is a technological proceeding where the surfaces of features are treated with the help of grinding stones, with the purpose of obtaining a precise dimension and higher quality of the surface.

Grinding stock is eliminated through very fine splinters. Fineness is depending on: grinding regime, cutting oil, working material, and the characteristics of grinding stones (hardness, binding matter, and granulation). During rectification, the grinding stones are working as the milling cutter. The difference between these two is that according to the tooth of milling cutter, hard grains are dispersed in an arbitrary manner, and this working with very different departure angle [1]. This can be observed in figure 1.



1 – feature; 2 – splinter; 3 – grain; 4 – binding matter; 5 – direction of cutting;
γ – departure angle; t – cutting depth.
Fig. 1. The geometry of cutting with abrasive grains

Because most of grains are cutting with different departure angles, in the cut surfaces we will find plastically deformations which will influence the sludge quality. For this study it was used a sludge resulted from rough-grinding and roughing.

The sludge is containing the following elements: [2, 4]

- *particles from the grinding stone*; these particles are SiO_2, carbides, and are very hard; these there are influencing, in a certain way, the characteristics of the powder obtained from the sludge;
- *grinding compound*; this fluid, normally, is containing a water emulsion and has the role of preventing the overheating of the feature, evacuation of falling splinters and grains, and decreasing of friction;
- *splinters from the piece*, in fact splinters from steel for ball-bearings.

Ball-bearing steels are alloyed steels, with a high percentage of carbon. The chemical composition of ball-bearing steel (RUL) are presented in Table 1.

Table 1. The chemical composition of ball-bearing steels (RUL) according to STAS

Steel	**Chemical composition**, [%]							
	C	**Mn**	**Si**	**Cr**	**S** [max.]	**P** [max.]	**Ni** [max.]	**Cu** [max.]
RUL 1	0.95-1.10	2.20-0.45	0.17-0.37	1.30-1.65	0.20	0.027	0.30	0.25
RUL 2	0.95-1.10	0.90-1.20	0.40-0.65	1.30-1.65	0.20	0.027	0.30	0.25

3. THE CHEMICAL COMPOSITION OF THE POWDER

The chemical composition and the purity of powders are depending on working material and the technological processes for fabrication [3]. The obtained powder of the sludge from ball-bearings is containing impurities like:

- hard grains from the grinding stone;
- textile residues, thrown by the workers on the gathering belt;
- film around the splinter, film which is coming from the cooling-fluid;
- particles coming from the bounding material used when the abrasive disk was made .

The impurities can generate different influences:

- *a negative one*: modifies pressability, is griping matrix, is providing deformations during sinterisation, there are resulting chemical reactions during sinterisation; these are diminishing the final properties of features;
- *a positive one*: less often by increasing the hardness of features.

The percentage of impurities in sludge is about 14-16% depending on the type of working, smoothing, grinding, finish grinding.

The chemical composition of the sludge is depending on working material (ball-bearing steel) grinding regime. At the smoothing grinding the percentage of hard abrasive particles is higher as with finish-grinding, but it is also depending on the processing where the sludge is transformed in powder.

The sludge obtained with ball-bearings processing is containing a series of elements. These are presented in Table 2. [1, 3, 5]

Table 2. Chemical composition of sludge

The type of sludge	**Chemical composition**, [%]									
	C	**Mn**	**Cr**	**Ni**	**Cu**	**Al**	**Si**	**P**	**S**	**Loss of mass in H_2**
From smoothing grinding	0.90	0.33	1.74	0.21	0.76	2.64	1.90	0.03	0.03	6.98
Finishing grinding	0.72	0.33	1.74	0.21	0.66	2.62	1.70	0.03	0.03	4.33

This percentage presented in Table 2 can be explained like this:

- smoothing grinding is leading to a higher quantity of impurities, which, at their turn, are increasing the percentage of carbon, silicon, aluminum, cooper;
- in the case of finishing grinding impurities can be found in a lower degree;
- when, from the sludge, there are separated abrasive particles, then the percentage of carbon is decreasing till 0.40%-0.60% and silicon it's almost reaching the normal limits of RUL steel, and aluminum it is also substantially decreasing till 1%.

Researches on sludge were made with spectral-chemical analysis, with the help of Spectrograph Q24 – with a prism, produced by Carl Zeiss Company – Germany.

4. THE POWDER HUMIDITY

An important characteristic for further processing of sludge is humidity.

This was determined as following:

- 100g of sludge (m_0=100g) was weight with analytical balance;
- the sludge was dried in oven at temperature of 170ºC;
- the dry sludge was weight (m_1) and calculated the humidity (u) with the relation 1.1. [5]

$$u = \frac{m_0 - m_1}{m_0} \times 100,\ [\%] \qquad (1.1)$$

The sludge humidity has got the values between 42% and 48% (u=42-48%) and in is depending on different factors, for example:

- the place where sludge is collected, collecting band or filtrate;
- the nature of cooling fluid used for grinding.

The humidity isn't influencing the chemical composition, the chemical properties or other characteristics of powder, because at the high temperature of soaking, the possible oil residue what remains, will be burned out.

5. THE CHEMICAL COMPOSITION OF THE POWDER

To be able to use the powder incorporated in the sludges, this must come to a technological process. The powder chemical composition depends, evidently, on the sludge's composition. The sludge processing will result in a changing of percentage for a few elements.

The results of the chemical analysis are presented in the Table 3.

Unseparated powder is representing the powder from where impurities were not separated, and separated powder is representing the powder from where impurities were cleaned [4, 5].

Table 3. Chemical composition of powder

Powder	**C**	**Cr**	**Ni**	**Mn**	**Al**	**Cu**	**Si**	**P**	**S**	**O_2**
	[%]									
Unseparated	0.57	1.74	0.21	0.33	2.32	0.50	1.60	0.027	0.01	0.36
Separated	0.40	1.74	0.20	0.31	1.84	0.45	1.40	0.014	0.001	0.20

As a comparison between powders produced by prestigious companies from all over the world and the chemical composition of these powders obtained from the sludge resulted from ball-bearings, there is presented in Table 4 [2, 5].

Table 4. Chemical composition from different powders

Different powders	C	Cr	Ni	Mn	Al	Cu	Si	P	S	O_2
	[%]									
RUL Separated	0.40	1.74	0.20	0.31	1.84	0.45	1.40	0.014	0.001	0.20
FREM 400-24	0.05	-	-	0.40	-	-	0.35	0.02	0.02	0.50
ULTRPACA	0.02	-	1.75	0.20	-	1.50	0.05	0.02	0.01	0.22
NC 100-24	0.02	-	-	-	-	-	0.25	-	-	0.30
ATOMET 4601	0.003	0.05	1.8	0.20	-	0.02	0.003	0.01	0.01	0.10
SUMIRON 4100 S	0.008	0.93	-	0.69	-	-	0.002	-	-	0.08
RZ 400	0.03	-	-	0.25	-	-	0.10	0.03	0.02	0.35

As we can observe it from Table 4, RUL powder separated is similar from chemical point of view with powders produced by famous companies from the world. [2, 3, 5]

6. CONCLUSIONS & ACKNOWLEDGMENT

With grinding of ball-bearings there is resulting an important amount of sludge. This sludge is mostly containing splinters from the rectified part, and also some impurities.

By detaching these impurities there can be obtained a powder, from ball-bearing steel, which from chemical point of view is similar to powders produced by famous companies in the world.

REFERENCES

1. Dinescu, I. *Investigations about the determination of the powder's physical properties which result from the processing bearings*, Bulletin of the Transylvania University of Brasov, Romania, Series A, Vol. XXXII, 1990.
2. Dinescu, I., Maniu, Al. *Investigations about the pressability of the powder result from the processing bearings*, Bulletin of the Transylvania University of Brasov, Romania, Series A, Vol. XXXII, 1990.
3. Dinescu, I. *Researches on the powders resulting from ball-bearing rectification*, Proceedings First International Conference on Materials and Manufacturing Technologies, MATEHN '94, Technical University of Cluj-Napoca, Romania, 18-20 May, 1994, p. 385-390.
4. Dinescu, I., s.a. *Theoretical and Practical Researcher concerning New Recycling Technologies for Steel Powder from the Sludge Obtained after Rectifing Bearing Elements*, Second International Conference on The Recycling of Metals, Organized by the European of ASM International Europe and its Recycling Division, Amsterdam, Nederland, 19-21 October, 1994, p. 295-304.
5. Dinescu, I. *Characteristics of powder resulted from ball-bearing steel processing*, Proceedings of the International Conference on Powder Metallurgy, RoPM '96, Technical University of Cluj-Napoca, Romania, 4-7 July, 1996, ISBN 973-97485-5-4, p. 205-208.
6. Prisacariu V., *The aerodynamic analysis of the profiles for flying wings,* Journal of Defense Resources Management, vol.4 Issue 1(6)/2013, ISSN:2068-9403, eISSN: 2247-6466, ISSN-L:2247-6466, p.211-218.