# SUMMARY

The research conducted in the present thesis aims at capturing and showing the value of the different technical posibilities that exist for obtaining metal powders at a reduced fabrication cost and with similar properties as the ones obtained through clasical procedures, from rests derived from the finishing operations of cutting tools.

The research also aimed at creating sinterized pieces that are resistent to usage such as removable cutting plates which would be capable of replacing the clasicall rapid steel knives in a monoblock structure that are still widely used in obtaining and working with different materials in the industry.

To achieve the scope of the research presented above, in the first chapter the following objectives were set:

- Obtaining of different metal powders of different granulations through mechanical division in a vario-planetary mill type Pulverisette and studying their morphology. In this sense, the initial powder was ground at different grinding times as follows: 5, 10, 15 and 20 hours.

  This particular part of the research aimed at evidenciating the correlation between the powder morphology and the grinding times.
- Obtaining different powder compacts with different granulations applying different compacting pressure. This particular area of research focused on obtaining 5 different granulations at two different compacting pressures ( 600 and 800 MPa) and determining their raw density.
- Determining the properties of sinterized compacts opposite the sintering parameters (temperature and maintenance time).

  Here the research was aimed at studying the evolution of the compact characteristics (such as density, contraction, porosity) opposite 3 different sintering temperatures (1150°C, 1200°C, 1250 °C) and 2 maintenance periods (1 hour and 2 hours).
- Studying the evolution of the sinterized compacts hardness.
- Studying the tribological behavior of the removable plates made of recovered steel.

- Analyzing the interdependencies between the morphological characteristics of recovered steels powders, sintering temperature and usage properties (such as resistance to usage and durability) of removable plates.
- Studying the possibility of using compacts obtained from recovered rapid steel as removable plates in the cutting process of different other materials.

  This step in the research focused on determining the behavior of usage and durability of such compacts in the cutting process of different materials.

In **Chapter II** different granulations powders were obtained from the initial chips in the process of grinding the cutting tools.

The rapid steel powders were processed from the chips obtained through rectification through washing, drying and magnetic separation. The powders resulted in this way were ground using a vario-planetary mill Pulverisette 4 (brand Fritsch) during 5 to 20 hours and they were analized through electronic microscopy SEM and X-Ray difraction.

The results of the research concerning the obtaining of Rp recovered powders through mechanical division in planetary mills with balls take us to the following conclusions with regards to their morphology:

- Concerning the shape and the status of the granules, the 5 different powders used have the following characteristics:
  - The shape of the initial chips made of recovered Rp is in most cases acircular and not regular, very few having a spherical shape or dendritic. The surface of the chips is rough.
  - The shape of the granules obtained at shorter period of grinding (5 and 10 hours) is not regular. The surface of the granules is rough and the granulation is not uniform.
  - At longer grinding periods (15 to 20 hours) the surface of the granules becomes more smooth and the powder granulation becomes uniform while their shape tends to become spherical.
- Concerning the size and the distribution of the powder granules we came to the following conclusions:
  - In the initial Rp powders aprox. 30% of the total particles have sizes larger than 200 um and aprox. 60% have sizes between 200-56 um, while 10% of the particles have sizes under 56 um.

- After 5 hours of grinding the powder particles sizes are situated between 0.1 and 150 um and we can observe two classes of granulations (between 01. and 80 um and between 80 and 320 um)
- After 10 hours of grinding the powder particles sizes are situated between 0.1 and 150 um and we can observe 3 classes of granulations ( [0.1-30] um, [50-80 um] and [80-130]um)
- After 15 hours of grinding the powder particles sizes are situated between 0.1 and 45 um and we can observe 2 classes of granulations ( [0.1-5] um, [5-45 um])
- After 20 hours a division time is reached and the particles sizes are between 0.04 and 25 um and we can observe 2 classes of granulation (01.-6 and 6-25 um)

In **Chapter III** we studied the influence of compacting parameters and sintering parameters on obtaining probes out of recovered rapid steel, at different grinding times.

On the basis of this chapter's research we came to the following conclusions:

- The raw densities of rapid steel powder probes are increasing proportionally with the pressing force that we apply to them. The maximum values of the raw densities are obtained at compacting pressure of 800 MPa
- The biggest values of the raw densities correspond to probes made out of powders with finner granulation which were obtained from longer grinding times (aprox. 20 hours). This is justified by the existance in their structure of micronic granules and also nanometric ones which allow for a better compactization than the bigger granules
- The best values for the density of sinterized pieces are obtained when maximum pressure condition and compacting condition are simultaneoulsy achieved and additionally the granulation is as small as possible
- The density of the sinterized probes depends on the compacting pressure, of the granulation of the powder, the sintering temperature and the maintenance time
- In this way, the density of the sinterized probes at 1150°C in case of probes that have been compacted at 600 MPa was situated in the interval of [4,56-5,64]g/cm$^3$ and in case of probes sintered at 800 MPa in an interval of [4,86-5,75]g/cm$^3$ . For probes sintered at 1200°C, the density of the probes compacted at 600 MPa was in the

interval [4,56-6,22]g/cm$^3$ and for the ones compacted at 800 MPa was in the interval [4,89-6,38]g/cm$^3$, while the density for the probes sintered at 1250°C was in the interval [5,01-6,58]g/cm$^3$ for probes compacted at 600MPa and [5,21-6,75]g/cm$^3$ for compacting pressure of 800 MPa. The best values for the density are obtained at a temperature of sintering of 1250°C and the maintenance time is of 2 hours.

- The porosity of compacts is complementary to density and we observe that the density of the compacts is lower as the density of compacts is higher, the lowest values is of 13.46% is registered for probes with the code 8432 which corresponsd to sintering temperatures of 1250°C and maintenance time of 2 hours.
- The evolution of the sintered pieces is influenced both by the sintering parameters (temperature and maintenance time) as well as the compacting pressure and the granulation of the powders. Therefore, the probes obtained from powders that have been ground for 20 hours, pressed at 800 MPa and sintered at 1250 $^{o}$C with a maintenance time of 2 hours we obtained superior values for hardness (181 HB) comparing with the compacted probes at 600 MPa and sintered in the same conditions (165 HB).
- The probes made of recovered Rp powder from the initial chips have a pore density much bigger than the grinded powders.
- The granulation of sintered samples from the initial powder is big and not homogenous and the sizes of the crystal grains are very big due to the large sizes of the powder particles from recovered powder.
- The granulation increases with the increase of temperature and the maintenance time for sintering which is normal due to the intensification of the diffusion processes.
- In order to obtain materials from recovered powders with a high density it is necessary to use very fine powders (grinded 10 hours) and compacted at high pressure (800 MPa) and sinterized at high temperatures

In **Chapter IV** research was conducted with regards to thermic treatment of kneeling –and reverse procedure applied to recovered rapid steel probes.

We achieved first a kneeling through heating up the probes in an argon environment at a temperature of 1280 $^{o}$C maintaining this for 10 minutes and then cooling this down at a kneeling temperature with water and oil, followed by 2 successive heating up to 550 $^{o}$C and maintaining this for about 60 minutes and cooling them in the air. In this way we analyzed the evolution of the probes hardness and their tribological behavior.

It was observed that superior values of the hardness have been obtained in the case of probes obtained from powders with a fine granulation, compacted at 800 MPa and sintered at 1250 $^{o}$C.

Data regarding the tribological behavior of sintered compacts from recovered Rp powder obtained during experiments and presented in the present paper reflect that the value of the friction coefficient depends on the compacting pressure, of the powder granulation and of the technological parameters of the sintering process (temperature and maintenance time) as follows:

- from the point of view of the compacting pressure, we can observe that the values of the friction coefficients are lower when the pressure increases for the probes that are made out of powders with the same granulation
- from the point of view of the powders granulation, the best values of the friction coefficient were obtained for the probes that were made out of powders with a superior granulation and obtained through mechanical division in 20 hours
- from the point of view of the sintering parameters we could observe that both the raise in the sintering temperature and the maintenance duration led to lower values for the friction coefficients the best values being obtained for the sintering temperature of 1250°C and maintenance time of 2 hours

**Chapter V** encompasses studies with regards to the behavior the cutting of the removable plates made out of recovered rapid steel powder.

The experiments were conducted on a parallel lathe type SNA 400, using a special knife which utilizes as cutting plates probes obtained from recovered rapid steel powder.

The materials on which we conducted the cutting were: aluminum alloy ($AlMgSi_1$), textolit, high density polietilen and teflon.

Based on the experiments conducted we can draw the following conclusions:

- When working with aluminum alloy we observe that during the cutting we will obtain some deposits of materials on the knife’s surface. In these conditions there will be no usage noticed on the releasing surfaces of the removable plates
- At shorter times for turning, the resulting chips are in general fragmented, while at longer durations these become helicoidally in shape due to the large deposit of material on the release surface

- The quality of the surfaces that we worked on in the case of the aluminum alloy is very good and the roughness has the value $R_a$ = 1,68 µm;
- When working with textolit we observe as well that there is no usage present on release surfaces of the removable plates. The chips resulted during turning are fragmented and are small in size;
- The roughness has the value of $R_a$ = 4,68 µm for textolit;
- When we work with teflon materials, there are as well no usage signs present
- The chips resulting from turning have helicoidally shape and are irregularly deformed;
- The roughness measured is in value of $R_a$ = 3,63 µm;

In **Chapter VI** the conclusions and the personal contributions are presented out of which the most remarcable are the following:

- The usage of recovered chips for sharpening the cutting tools for an enterprise in order to obtain rapid steel powders of different granulations is possible and the production cost as well as the properties of these will be very similar with the same materials obtained through classical procedures
- The method of obtaining metal powders through mechanical division of chips of small size is the only viable procedure of recovering these, as by melting a total burning of these would occur
- The production of sintered compacts which were utilized afterwards as removable plates for cutting of certain non-metal, non-ferric materials