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SOME ISSUES CONCERNING GEAR WHEELS FABRICATION BY SINTERING

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ABSTRACT

Powder metallurgy appeared in the XVIII century as result of industrial market demand for electric bulbs filaments made of wolfram. Nowadays powder metallurgy is applied in such fields as: automotive industry (cylindrical or conical gear wheels), fine mechanics (components for calculation devices), toys production industry, electrical engineering (field poles for electrical fittings), machine building industry (filters, gear wheels, levers). In this work some applications of metallic powders in the fabrication of gear wheels are presented. As well the possibilities for their utilization in conical gear wheels of precessional planetary transmissions are described.

KEYWORDS: gear wheels, planetary transmissions, sintering

1. Introduction

The following raw materials are utilized in powder metallurgy: native metal, alloys, metallic and non-metallic mixtures. The advantages that have placed powder metallurgy at such a high level are:

- Short-term technological track. The components have the accuracy and quality of surfaces as it is imposed by the drawing (without any further processing);
- The level of utilization of the material is almost 100%;
- The possibility to produce some components from materials with high melting point, which casting is difficult;
- The products are provided with sensitive and uniform composition and high steadfastness of properties;
- Securing of pseudo alloys achieved by powder mixing. Currently it does not make alloys (CU-graphite, Fe-graphite, etc.);
- Components (filters, bearings) with controlled porosity can be obtained;
- Equipment (homogenizers, mills, furnaces, etc.);
- The process of automation is easy to apply in powder metallurgy;
- The qualifications of personnel are reduced.

But along with these advantages, some disadvantages come:

- High cost of powders;
- Restrictions in the geometrical form and dimensions;
- High cost of moulds.

2. Technology for components fabrication

To make a component from metallic powder mixtures are utilised and the following steps are performed:
1) Sorting; 2) heat treating; 3) splitting up of powder sintering; 4) processing of mixtures.

Depending on the destination of components their moulding is carried out by one of the moulding procedures: application of pressure (cold compressing, hot compressing, sinter moulding, isostatical pressing, powder extrusion, powder rolling, etc.) or without application of pressure (plaster mould casting, metallic mould pressing, vibration moulding, etc.).

Fabrication of components from metallic powders is done in several steps which are presented in fig. 1 [2].

3. Compacting of metallic powders (components moulding)

Depending on the component destination its moulding can be done via two big categories of procedures:
I. Moulding procedures with application of pressing which identifies the next versions: cold compressing; hot compressing; sinter moulding; isostatical pressing, powder extrusion, and powder rolling; (continuous pressing).
II. Moulding procedures without application of pressing on powders. Among these procedures we can mention: plaster mould casting, metallic mould was pressing, vibration moulding.

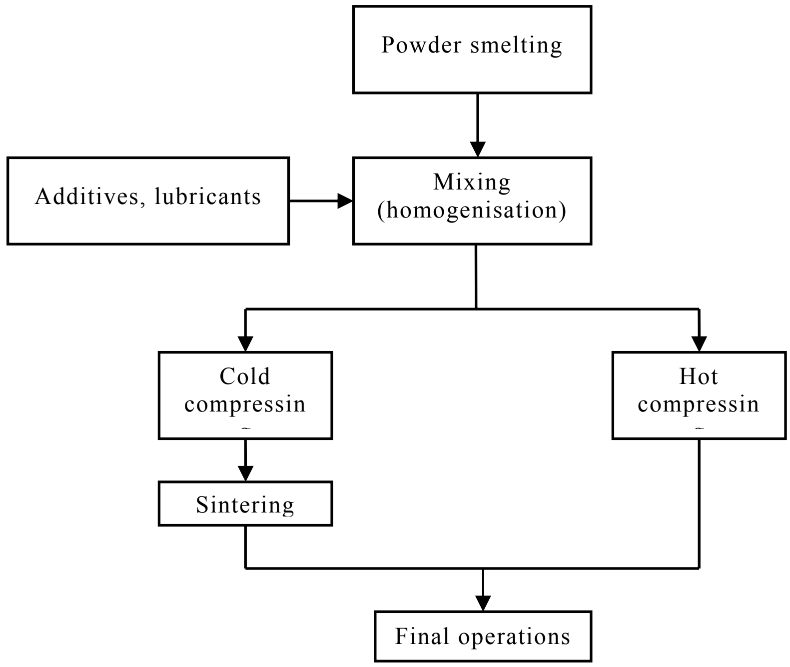


Fig. 1. *Steps for metallic powders smelting.*

4. Casting of gear wheels by superficial hardening

In many cases the loading generates high stresses at or close to the surface such that full density throughout a part is not required. Such loading situation can be covered by selective surface densification (SSD). This process generates a densified surface layer in the range of 0.2 to 1.0 mm and a density gradient ranging from nearly zero porosity at the surface to typically 10 vol.% porosity in the core of a component. SSD is a processing technology which has been successfully applied to the densification of highly loaded parts such as gears and one-way clutch races.

Highly loaded gears are a most prominent application for SSD. It has been shown that SSD by external transverse rolling supplies P/M gears which have sufficient strength and, simultaneously, reduce the generation of noise.

The present method [3] is intended to characterize the evolution of microstructure, hardness, selective surface densification, pore morphology, geometry (DIN quality) and surface roughness of the helical gear displayed in Fig. 2.

Tooth root strength and pitting resistance are tested on a test rig.

The investigation was carried out on a surface densified helical gear with a 33° helix as shown in Fig. 2. The geometric parameters are summarized in Table 1. The wrought steel version of this gear is presently used as a fixed gear in the 4th speed of a passenger car gear box.

The selection of a P/M material for this gear was based on previous processing experience and on rolling contact fatigue tests. From this information two commercial water atomized, pre-alloyed powders were chosen: ferrous metal powder with 1,5%Cr, 0,2%Mo, 0,1% graphite and wax 0,8%, and ferrous metal powder with 1,5%Mo, 0,2% graphite and 0,8% wax.

The processing sequence employed in the present investigation is:

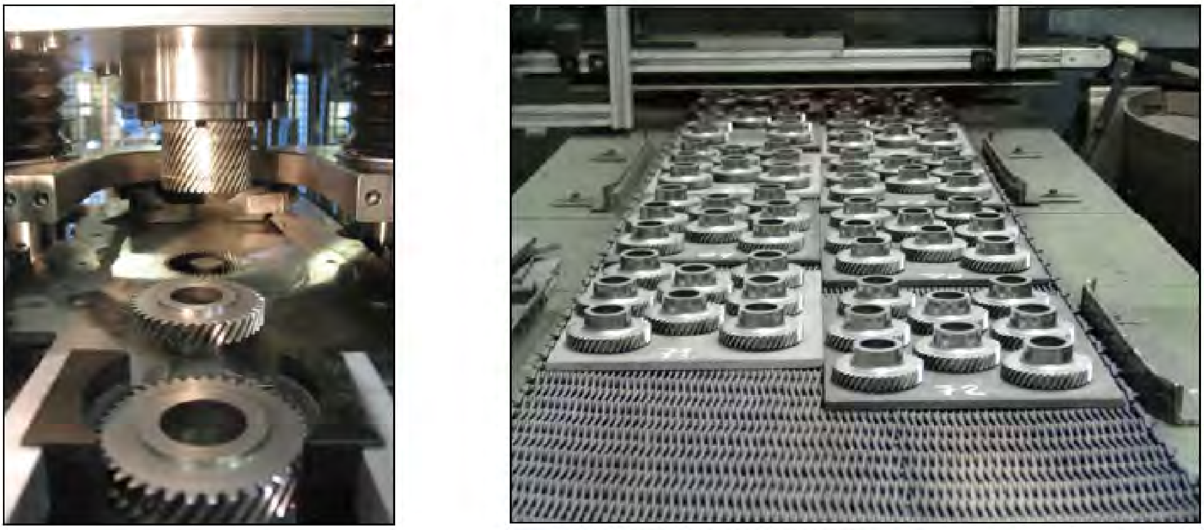
- pressing of helical gear with over measure;
- sintering to ≈ 90 % of theoretical density;
- turning;
- selective densification by transverse rolling;
- case hardening;
- final surface finishing by honing.

Pressing was performed at 600 MPa on a hydraulic 350 to press (Fig. 3) which is equipped with a gear-box driven adapter to rotate the punch.

Fig. 2. *Gear wheel, made of Metallic powders, with hardened surface and its specifications.*

Table 1

Gear Parameter	Unit	Value
Number of teeth, z	-	39
Normal module, m	-	1,8
Pressure angle, α	°	16
Helix angle, β	°	33
Helix direction	-	Right
Outside diameter, da	mm	88,88
Root diameter, dr	mm	78,38
Pitch diameter, d	mm	83,70



a) *b)*

Fig. 3*. a) Pressing on a hydraulic 350 to press; b) Mo-gears sintered on a belt furnace*

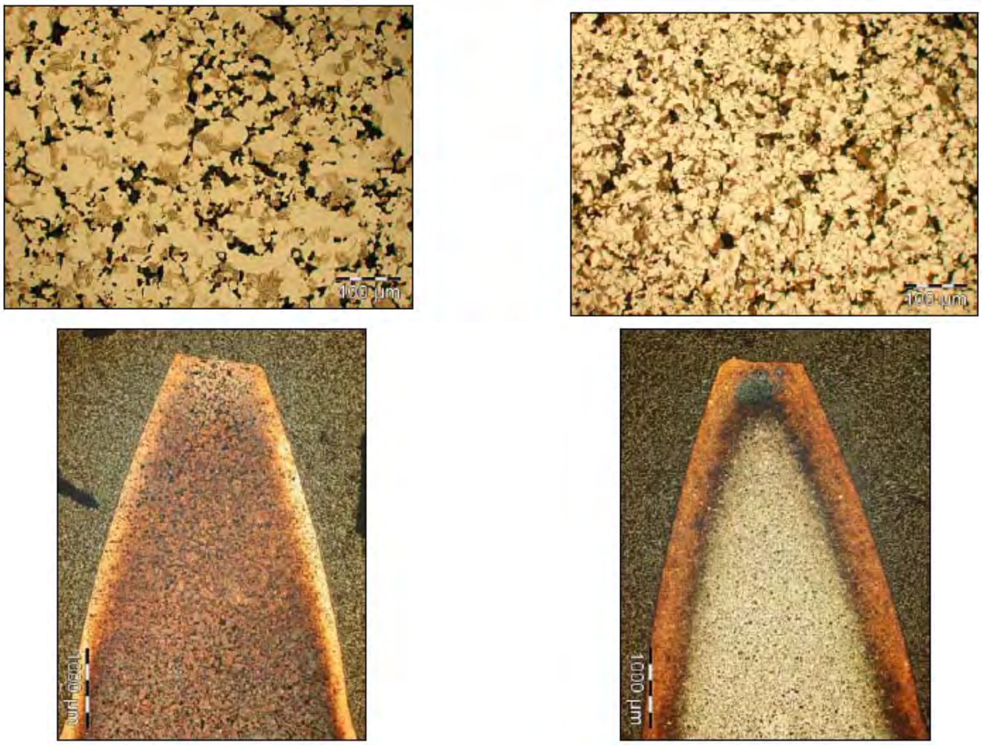
Table 2*. Sintering conditions*

Material	**Furnace**	**Temperature**	**Time**	**Atmosphere**	**Cooling rate**
		[°C]	[min]		[Ks-1]
CrL	Roller hearth	1160	30	N_2/H_2	≈0.2
Mo	belt	1120	30	N_2/H_2	≈0.2

The two materials were sintered with the parameters shown in Table 2. The gears were placed on ceramic plates to avoid distortion (Fig. 3). The dew point in the roller hearth furnace was controlled and kept below 60°C to keep the oxygen content of the chromium containing material CrL below 0,1 wt.%. The average density of as-sintered gears is fairly uniform, i.e. ρ = 6.98-7.02 g/cm³ in the core region. After sintering, the gears were turned to improve concentricity which influences the radial run out Fr and the pitch error Fp.

After machining the gears were selectively densified on a circular force controlled rolling machine. In this process, an as-sintered gear with over measure is put into the center between two mating rolling tools.

The microstructure of Mo- and CrL-gears after sintering shows ferrite and pearlite in both cases as displayed in Fig. 4. The Brinell hardness is 82 HB respectively 77 HB. These low hardness values are prerequisite for cold forming by transverse rolling.



a) *b)*

Fig. 4. *a) Mo-gear after sintering; b) CrL-gear after sintering.*

5. The planetary precessional transmissions

The precessional transmissions of big dimensions include the satellite block with conical roller teeth, placed on an intern cone. The conical rollers, installed on axles with the possibility of rotation around them, replace the sliding friction between the gear elements, impending in the precessional gear, with the rolling friction of the rollers on the surfaces of the central wheels teeth [1].

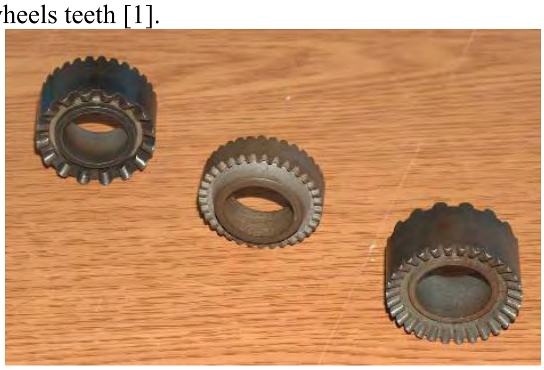


Fig. 5. *Sintered satellites from P/M for precessional transmissions.*

The execution of the conical roller teeth of the satellite block becomes difficult at the decreasing of the precessional transmissions dimensions.

In this case a distinctive interest represents the manufacturing of the toothed gears from metal powder. The reduction of power losses at sliding friction between gear elements is achieved by means of the usage of metal powder containing solid lubricants such as: molybdenum sulphide, graphite etc. There exist some special fields of precessional gear functioning, such as vacuum conditions from cosmos, where the manufacturing of the toothed gears from metal powder represents currently a very improved solution.

6. Conclusion

It can be praised that the manufacturing of the products from metal powder is advantageous and far-reaching, and represents a highly qualitative and profitable way for producing of the toothed gears.

References

[1]. Bostan I. *Precessional transmissions with multi-pair gearing*. Stiinta Publishing House, 1991, 356 s.

[2]. Iacobescu A., Urecheatu Gh., Homei D. *Materials study*, Academia Trupelor de Uscat Publishing House, Sibiu, 1998.

[3]. Günter Rau, Lorenz S. Sigl *P/M gear for a passenger car gear box,* International Conference on Gears, Munich, September