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Complex Shaped PM-parts by Warm Flow Compaction Process

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Abstract

There is an increasing demand for PM-processes with the capability to produce parts of higher complexity than with conventional press and sinter technology in high production numbers. Warm-flow-compaction (WFC) makes use of improved flowability of powders when blended in an appropriate ratio with fine powder fractions and lubricating binders. Here the process is shown with examples of PM-Steels. General features possible with the process like pressing of undercuts and threaded bores are shown.

Keywords: Complex shapes, pressing, compaction

1. Introduction

The shaping possibilities for economical production of PM-parts is limited to straight walled parts due to the fact, that the part release has to be performed best by pushing the part out of the die. Thus undercuts are impossible to allow this simple pushing out. For the production of parts with an offset in axis or with small back cuts, like small grooves, split die concepts or additional assisting punches are possible. But there is no general concept along to make the production of more complex parts with aspects lateral to pressing direction possible.

2. Principles of WFC

The capability of powders to flow perpendicular to the pressing direction and forming therewith parts of higher complexity was tested with a die for a „cross-shape". The flow distance can be regulated by screw fixtures.

Two effects cause this flowing behaviour of the powder binder mixture. At first the packing density of the powder is increased by adding fine powder which fits between the bigger particles in the mixture. Secondly binder or lubricant is added to such an amount that a highly filled liquid forms during heating the powder-binder blend. Both effects together provide the powder with a flowability which is best described as a viscosity of a highly filled liquid, (1, 2). This mixture has all aspects of a liquid but on a very high viscosity level. The viscous behaviour gives the material the capability to flow around corners without forming shear cracks in the powder during compaction. The process takes place at elevated temperature (90-130°C), at which at least parts of the binder are liquid.

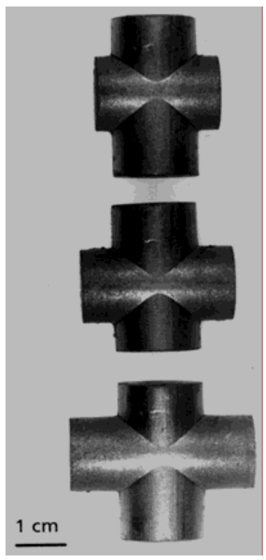

Fig. 1. Green parts produced from a cross-shaped die showing the cross-flow capability of the WFC-powder blends. Parts are compacted only from top and bottom.

The viscosity and the critical shear stress of the powder-binder blend are so high that the material does not deform on heating under the load of its weight as e.g. MIM-parts with higher amounts of binder do. The different powder geometries require different sintering cycles. Powder blends with good interlocking need no extra debinding cycles prior to sintering. The demonstrating parts made of steel powders were heated to the sintering temperature with a heating rate of 10K/min without any dwell time in between. Parts made of powder blends of only gas atomised powders require additional debinding times which can be handled in the normal sintering furnaces. Extra debinding cycles are only required when sintering furnaces are critical for the use of binders in general, e.g. cold wall or with sensitive refractory liners.

3. Threads by powder pressing

The most astonishing feature of WFC is the production of threads by uniaxial die pressing. In this way also threads can be formed via powder metallurgical pressing and sintering. A punch with a thread on its outer surface is used. After compaction the punch is unscrewed from the green part. Appropriate ratios of punch diameter and shrinkage will allow the production of threads without secondary operations.

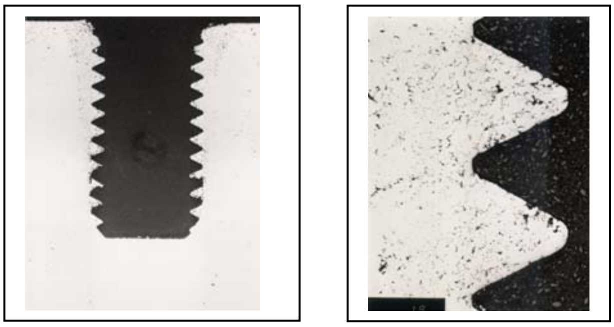

Fig. 2. Metallographic micrographs of sintered thread, produced by WFC

In the case of tungsten carbide hardmetal it is possible to adjust the shrinkage by the amount of admixed binder. In this way the direct production of a thread is possible. If a punch with an outer thread of e.g. M6 is used, it is possible to screw a bolt with an outer diameter of M5 into the part after sintering, (3).

4. Economical aspects

WFC is between MIM and normal press and sinter. There are the steps as powder blending, which cause more efforts in WFC than in normal press and sinter process. But there is especially one process step totally avoided, which is time consuming in MIM, the debinding step. The parts have sufficient strength after pressing, so that the parts do not lump during heating to sintering temperature.
Another point is the powder required for the different processes. The fine powders which are necessary for the MIM-process raise the price of parts so that the production route becomes non competitive for parts with higher wall thickness. The low amount of fine powder required with WFC makes this process attractive. Additional secondary operations can be avoided by WFC, as some details like undercuts, crossholes, and even thread holes may be produced already in the pressing stage, Figure 3.

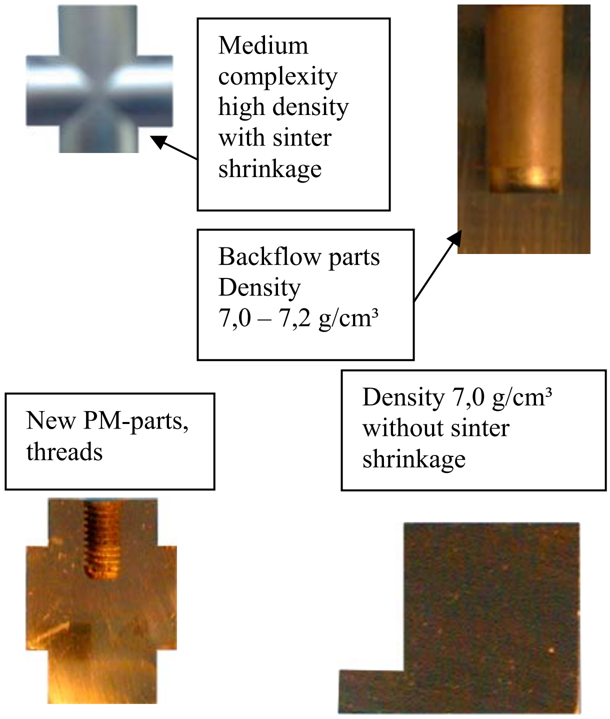

Fig. 3. Possible features and densities producable by WFC

5. Summary

The principle of the warm-flow-compaction (WFC) is applicable to virtually all powders. There are no special prerequisites for the action of the underlying process. The basis is the mixture of blending coarse (normal coarse) powders with a finer fraction in order to increase the packing density. On the other hand this is simultaneously decreasing the free volume, which has to be filled by a plastifying agent to foster flow on high densities of the powder arrangement.
Certainly there has to be discussed the permanent balance between sinter shrinkage and tolerances on parts. The higher amounts of lubricant or binder, which have to be mixed into the powder blends, lead to higher shrinkage when the parts are sintered to high densities.
Further efforts will be made to widen the shaping capabilities of the conventional PM–process on the basis of the experiences with warm-flow-compaction (WFC).

6. References

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