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New Pressing Agent for Processing Metal Powders

Introduction

Powder metallurgy has for some time been applied as a highly advanced method for the fabrication of reliable products and has become established as a production method primarily on account of its resource- and energy-saving fabrication of high-quality and complex-shaped components. In comparison to production based on melting metallurgy, with the dry pressing method used in powder metallurgy a metered quantity of powder can be fully automatically shaped to the required dimensions by means of compaction. With this near-net-shaping technology, machine-finishing of the workpieces is hardly necessary or may not be needed at all. Thanks to steady further development in pressing technology, it is now possible to press increasingly complex components with undercutting and even helical toothing.
These advantages facilitate, for instance, the series production of components for the automotive sector, which is a key sales market for powder metallurgy products.
Powders can only be shaped in the dry pressing process with the help of lubricants. These pressing agents are usually mixed into the powders in double cone, eccentric tumbling, V- or Y-mixers [1]. A quantity of 0,3 to 1,0 mass % of a suitable agent is added depending on the application. With the addition of a lubricant, any internal frictional forces between the individual particles of the metal powder in the powder bed and between the particles and the mould can be reduced. Consequently, for example, galling between the metal powder and the mould can be reduced considerably.
As the properties and the addition quantity of the wax pressing agent have a major influence on the powder and component properties (e.g. flow, compaction and debinding behaviour), their further development makes a crucial contribution to optimizing component fabrication.
In the following, the properties of two pressing agents are described. One is a commonly used amide wax-zinc stearate combination (Wax A) and the other METAWAX P-50, a new pressing agent developed by **ZSCHIMMER & SCHWARZ**. This consists of a modified amide wax specially developed to meet the needs of powder metallurgy applications (Tab. 1).

Lubricant	Chemical Despoription	Melting point [°C]	Mass Change [%] after debinding
METAWAX P-50	modified Amide wax	100	ca. 0,6
Wax A	Amide wax zinc stearate mixture	135	ca. 7,0

Tab. 1 Parameters of the used pressing agent

	Lubricant Amount mass-[%]	Grafit UF 4 Amount mass-[%]
METAWAX P-50	0,8	0,5
Wax A	0,8	0,5

Tab. 2 Composition of the powder mixture

Procedure

As described in Tab. 2, metal powder blends were prepared with the two wax pressing agents. The diffusion-alloyed iron powder Distaloy AB from the company Höganäs was selected as the metal powder for this series of tests. The pressing waxes and graphite were mixed into the metal powder in a laboratory eccentric tumbling mixer for a mixing time of 10 min. Fig. 1 shows the SEM image of a particle of the metal powder/METAWAX P-50 batch. In combination with an EDX analysis, the image shows the accumulation of the pressing agent on the surface of the metal powder and in the spaces between the particles. The additive is clearly visible as dark areas on the iron particle.

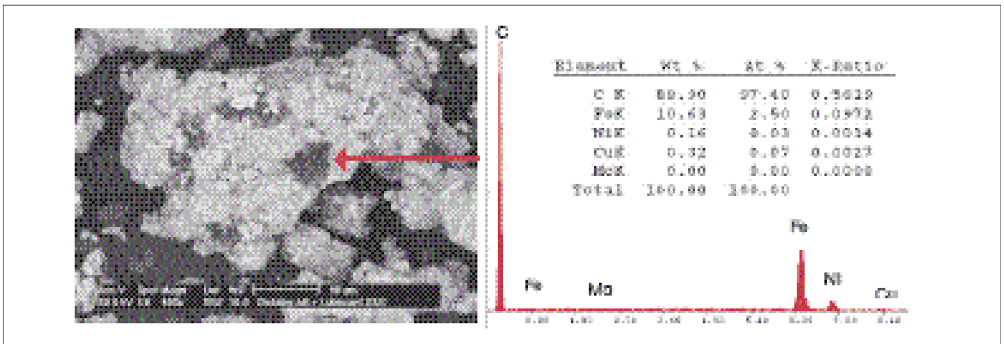

Fig. 1 Electron microscope analysis from the metal powder METAWAX P-50 mixture

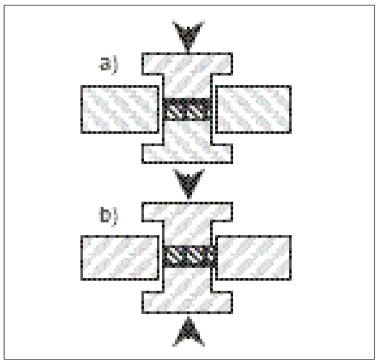

Fig. 2 Press action a) single side b) double side

A hydraulic press was used for the pressing tests. As part of the tests, cylindrical specimens with 20 mm diameter were prepared at three different pressures by one- and two-sided compaction (Fig. 2).
The press used is equipped with position sensors and force transducers to record the force curves during the pressing cycles. As a result, not only the green densities of the compacts, but also the respective ejection forces and force transmission values could be determined. For this purpose, during the one-sided pressing cycles, the forces induced by the movement of the top punch on the bottom punch were recorded. The difference calculated from the applied upper punch force and the resulting bottom punch force delivers the force transmission. The lower the maximum value of the force transmission is, the lower the friction occurring in the compact. Accordingly, conclusions could be drawn concerning the internal lubricant effect of the pressing agent. Then

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Lubricant	Sintered Density [g/cm³]	Shrinkage [%]	Hardness (HV 30)
Wax A	7,087	0,33	145
METAMWAX P-50	7,112	0,26	142

Tab. 3 Results of the cylindric samples, double sided pressed with 8 t/cm² compaction pressure

the test specimens pressed on two sides were sintered in a bell-type kiln at 1120°C in a cracking gas atmosphere (75 vol. % hydrogen/ 25 vol. % nitrogen). Conclusions could then be made concerning the sintered densities, microstructural formation and the resulting degrees of hardness.

Results

Fig. 3 shows the determined green densities of the pressed cylinders. It can be seen that higher density values can be achieved with the METAWAX P-50 at all pressures. For field application, this means that the necessary green densities and required component dimensions can be obtained at lower pressures. In the examination of the recorded ejection forces (Fig. 4), it is shown that for the same quantity of pressing agent, with the METAWAX P-50 lower forces are registered at the lower punch during the ejection motion of the cylinders. Compared to Wax A, this indicates a better formation of a sliding film on the wall of the mould, as a result of which tool loads can be reduced.
With the determined force transmission values, the results with reference to the ejection forces can be corroborated. The curve shapes (Fig. 5) show that better force transmission is achieved with METAWAX P-50 than with Wax A. Consequently, the internal and external sliding effect can be improved with the addition of the Zschimmer & Schwarz pressing wax. Another important aspect of the required additive properties is debinding during sintering. By means of thermographic analysis, the decomposition behaviour of the two pressing agents was tested. Fig. 6 describes the thermal decomposition of the pressing additives in a nitrogen atmosphere. As METAWAX P-50 is purely organic in structure, no appreciable residue remains in the component or the sintering furnace. The debinding phase is completed by a temperature of 500°C and the weight percentage of the residue is well below 1 %. This is an advantage compared to Wax A, which contains zinc stearate and leaves up to 7 mass % residue. Fig. 3 shows the measured sintered densities of the pressed cylinders. These cylinders were compacted at 8 t/cm² pressure. Polished sections of the microstructure were prepared from these test specimens and the Vickers hardness determined. The sections were produced perpendicular to the direction of pressing and etched with Nital.
The results show that after thermal treatment the sintered densities of the METAWAX P-50 batch are corresponding to the green densities – higher than those of the Wax A batch. Microstructural analysis of the two sections (Fig. 7) shows the expected content of ferrite, martensite, bainite and ultrafine lamellar perlite. Corresponding to the similar microstructural formations of the two metal powder/additive blends, the HV 30 values are comparably high.

Conclusion

Based on the results presented, it can be said that METAWAX P-50, the pressing agent specially developed by ZSCHIMMER & SCHWARZ, can be used to prepare a metal powder that is very suitable for dry pressing. The agent can be mixed into the metal powder without any changes being necessary to the preparation process in conventional mixer types. In the application it leads, compared to the commercially available additive, to an improvement of the powder pressing properties. Furthermore the additive can be debinded from the component without residue and does not lead to any contamination in the furnace system.

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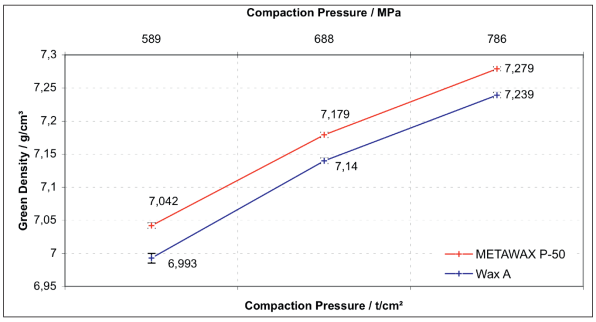

Fig. 3 Measured green densities of the double side pressed cylinders

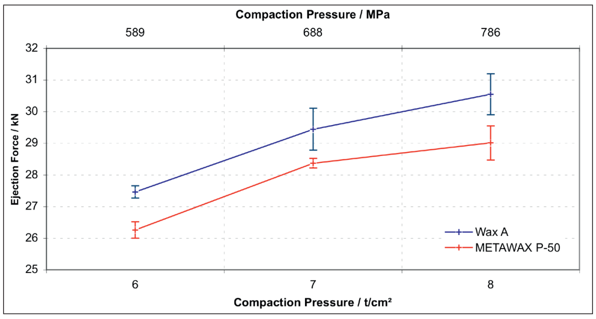

Fig. 4 Ejection force during the double side pressing cycle

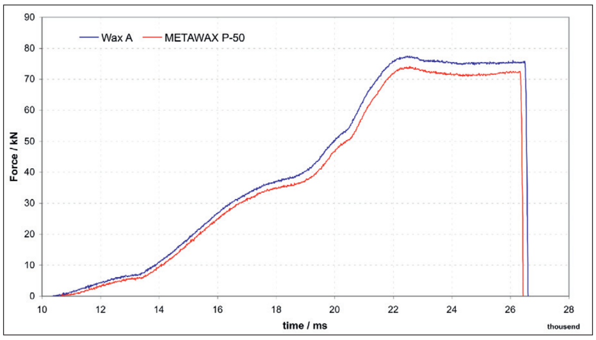

Fig. 5 Course of the calculated compacting pressure transmission

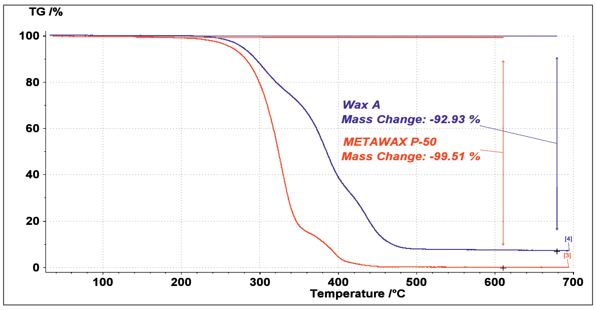

Fig. 6 Thermal debinding examinations of the lubricants

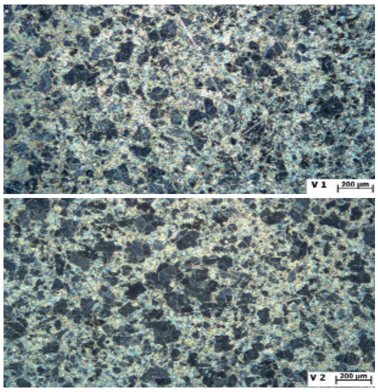

Fig. 7
Optical micrograph pictures of the cylinder bodies (double sided, pressed with 8 to/cm² compaction pressure);
V1=Wax A
V2=METAWAX P-50