

Particle Modification and Powder Design using the NARA-Hybridizer

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Abstract

Particle design becomes a requirement if certain properties of metallic, intermetallic or ceramic powders have to be tailored. The hybridization process allows optimisation of powder properties as spheroidisation, agglomeration or change of chemical composition of the material by coating of particles. Using this technology powder properties as flow behaviour, bulk and tap density can be tailored to the requirements of the process. Furthermore composite materials can be produced by coating core particles with powders of different chemical composition.

The paper reports on the hybridization technology as well as results obtained in the fields of binderless agglomeration of fine metallic powders, particle modification and preparation of composite powders.

Introduction

Particle modification is an efficient way in order to influence important properties of powders as flow characteristics, green density, compaction behaviour etc. Furthermore particle design technologies are useful if composite powders, coated powders or agglomerated powders have to be produced. In general the following processes are relevant for particle modification:

- Particle spheroidisation --> optimisation of flow characteristics of powders
- Lowering of particle size (e.g. crushing) --> Increase of sinterability
- Milling --> preparation of compound particles (e.g. for reactive sintering)
- Binderless agglomeration --> recycling of fine powders
- Coating of particles --> preparation of functional compound particles

(2) Selection of techniques and equipment for particle modification:

- Crusher, mill --> Lowering of particle size
- Planetary ball mills --> Lowering of particle size, preparation of compound particles
- Mechano-fusion --> Coating of particles
- Hybridiser (NARA) --> spheroidisation, agglomeration, coating

The Hybridisation System (NARA NHS-0) can be used universally in order to influence most of the powder properties. In the following paper some experiments and results are reported using very different starting powders.

Experiments

For the experiments a NARA Hybridiser NHS-0 was used (figure 1). It is widely used for micro encapsulation processes in cosmetics, medicine, and for chemical specialities. Applications in powder metallurgy are not known yet but seem to be promising. This device increases Van-der-Waals-Forces between particles by introduction of mechanical energy into the powder. This is done by acceleration of powder particles by the rotor blades (figure 2 and 3). The process needs no binder addition or application of any external pressure. The specifications of this equipment are described below. Process parameters as processing times etc. are given in the section results.

- Water cooling
- Processing unit can be operated under protective atmosphere (as argon, nitrogen...)
- rpm max. 16200 min^{-1}
- max. powder quantity to be operated in one batch: 50 g

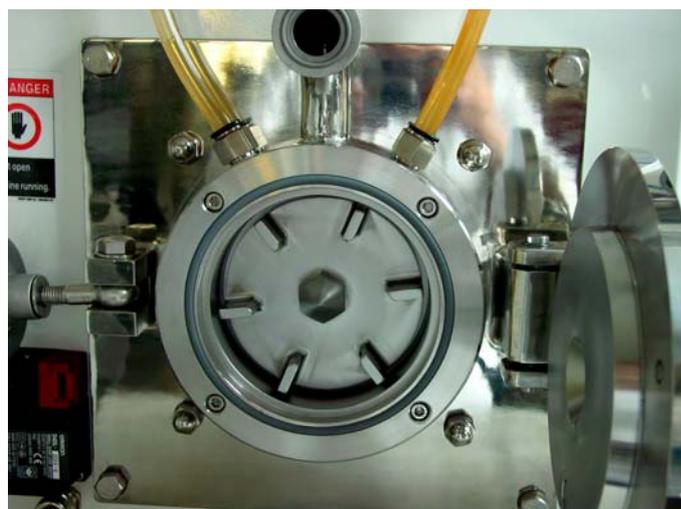


Fig. 1 and 2. NARA-Hybridizer NHS-0

Hybridizer

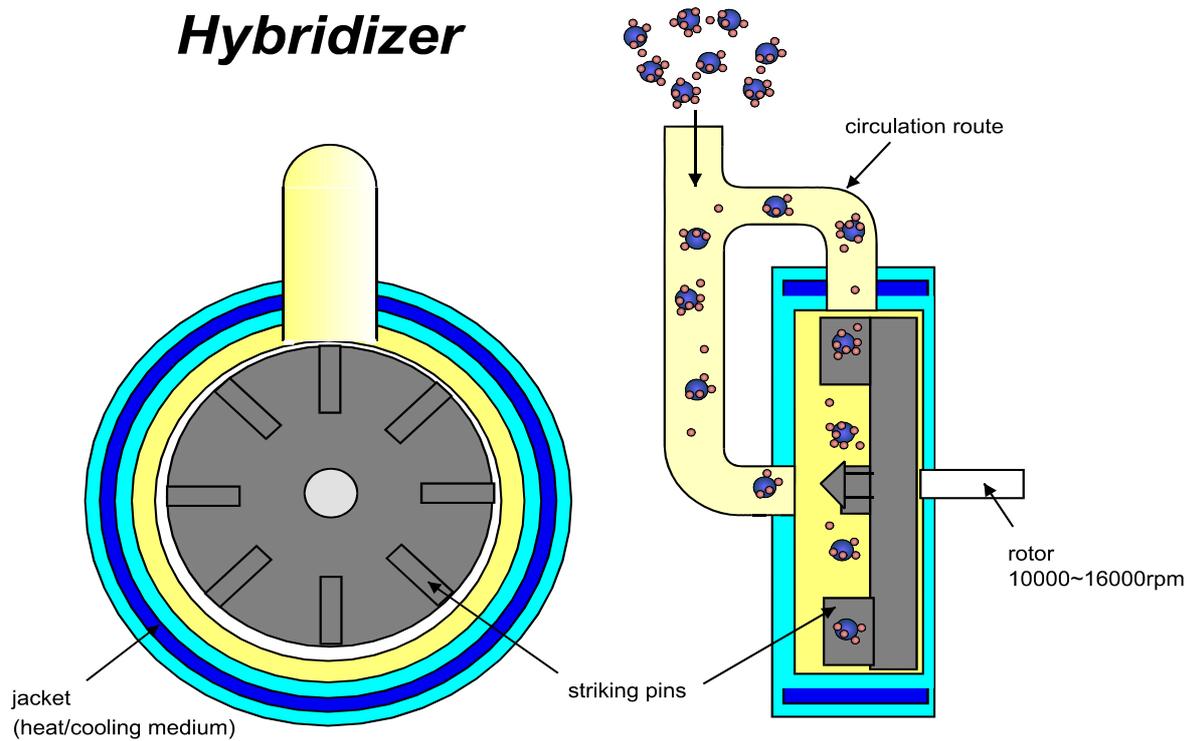


Fig. 3. NARA Hybridizer (schematic)

Results and discussion

1. Change of particle form (spheroidisation)

For the experiments iron powder (Hoeganaes ABC 100.30; 63...150 μm) was used. Aim of the investigations was to spheroidise the irregular particles. Starting and processed powders are shown in figure 4 and 5.

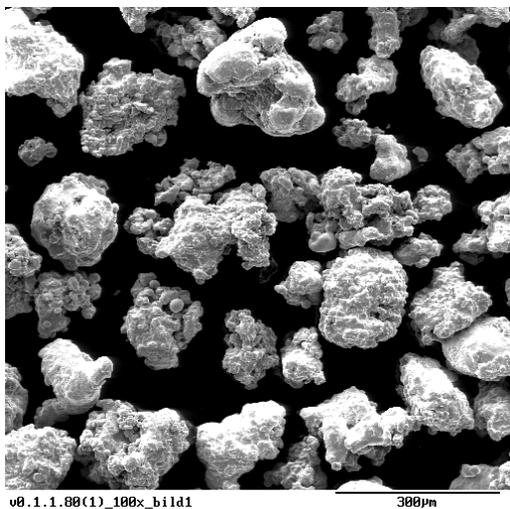


Fig. 4
Starting Fe powder

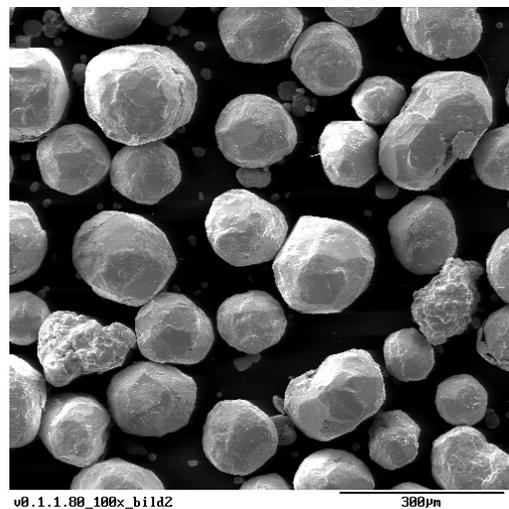


Fig. 5
Processed Fe-powder (12000 min^{-1} ; 90 s)

As shown in the figures the Fe-particles were spheroidised due to the treatment. The surface was smoothed by impact forces. As a result of this both bulk and tap density were increased considerably and the flow behaviour was improved. On the other hand green density was decreased due to surface hardening. It is expected that the sintering behaviour is influenced positively due to introduction of defects in the structure.

(2) Particle coating

For the experiments diamond particles (250-300 μm) and Ti-powders ($d_{50}=38\mu\text{m}$) were used. It is known from literature [1] that a size ratio of 1:5 1:10 between coating and core particle is favourable for the coating. Aim of the investigation was to produce compound particles with improved densification and sintering behaviour. The mixed raw powders and the processed material are shown in figures 6 and 7.

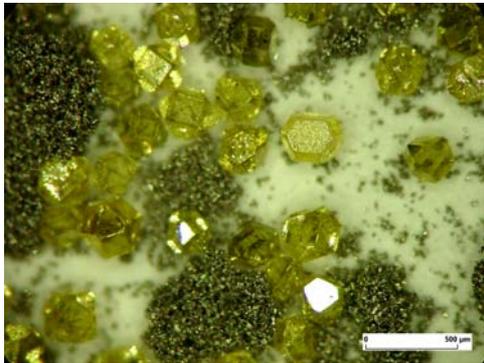


Fig. 6
Starting mixture diamond + Ti

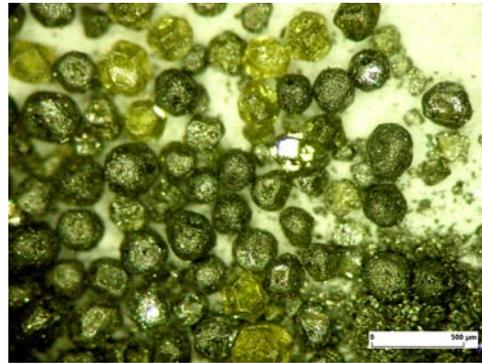


Fig. 7
Processed powder (diamond + Ti (90/5*10 wt.%); 5000 min^{-1} ; 5x180 s

As shown in figure 7 the diamond particles were almost fully coated after the treatment. It is expected that both compaction and sintering behaviour of the compound material are improved but tests have to be carried out to prove this. Furthermore an improved homogeneity of the material is expected.

The tests revealed that soft particles are suitable for coating of coarser harder particles and vice versa. Other experiments carried out with combinations of alumina and Al-powders or NiAl and Ni-powders were also successful.

Conclusions

It was shown that the NARA-Hybridisation system can be used successfully for particle design in powder metallurgy. Although further tests with different materials have to be carried out it was already proven that the following applications exist:

(1) Particle shape design (spheroidisation) :

- Particles of irregular shaped (Fe but also Ti and Al) have been spheroidised
- The surface of the particles is smoothed
- Bulk and tap density are increased considerably; the flow behaviour of the powder was improved
- The green density was decreased due to surface hardening; Sintering behaviour is expected to be improved due to higher defect concentration

(2) Particle coating:

- Coating of hard core material with soft particles (Ti - Al, diamond - Ti, diamond - Cr), and vice versa is possible
- A particle size ratio of 1:5 ... 1:10 is favourable for high quality coatings
- Compound particles with soft surface layers show good compaction behaviour

References

[1] Proceedings of NARA Seminar in Scandinavia; Trends in powder technology, 2th December 1996