Sinter-Joining of Ceramic to Graphite Using Vibratory Hot Press

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振動ホットプレスによるセラミックグラファイトの焼結接合

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It is well known that the sintering of oxides, of metals and of other substances occurs several hundred degrees below the melting point of the lowest melting component. During the sintering process, evaporation-condensation, surface diffusion, volume diffusion, viscous flow and plastic deformation are taken place in a sintering body.

In current ceramic sinter-joining techniques, a suitable filler is used between the surface of two sintered bodies in order to make a good contact. In this joining technique, material transfers by diffusion are important.

On the other hand, at present joining technique using vibratory hot-pressing a ceramic powder was sintered and simultaneously joined to a graphite body, and in this case viscous flow and plastic deformation have important role.

It is the purpose of this paper to describe the new joining technique using vibratory hot-press,

and examples for the ceramic to graphite joining are also shown photographically.

The schematic layout of the vibratory hot press design used in this investigations is shown in Fig. 1.

The ceramic powder (1) was compressed by the hydraulic ram (2) at a fixed pressure, through four springs (3) which transmitted the vibration. The

Table 1. Components of sample powders.

	Powder A	Powder B	Powder C
Al ₂ O ₃	28.70 wt%	91.48 wt%	77 wt%~ powder A + 23 wt%~ graphite
SiO ₂	67.39	6.07	
Fe ₂ O ₃	0.52	0.27	
CaO	1.36	0.17	
MgO	tr.	1.39	23 wt%~ graphite
Na ₂ O	0.74	0.25	
K ₂ O	1.28	0.06

- 1) ceramic powder
- 2) hydraulic ram
- 3) spring
- 4) out-of-balanced motor
- 5) bottom punch plate
- 6) graphite mold
- 7) graphite punch
- 8) Cu electrode (water cooled)
- 9) alumina insulation plate

Fig. 1. The schematic layout of a vibratory hot-press apparatus.

Fig. 2. Pressure and temperature diagram during vibratory hot-pressing.

sample : powder A

sintered at 1320°C
pressure 60 kg/cm²

Fig. 3. A sample of a sinter-joined alumina ceramic.

Fig. 4. Electron-micrographs of the sinter-joined contact parts (pressure : 60 kg/cm², vibration time : 4.5 min)

vibration was generated by the out-of-balanced motor (4) which was attached to a bottom punch plate (5). The frequency of vibration was only 60 c/s. The graphite mold (6) was heated by resistance heating¹⁾. Two graphite punches (7) served as electrodes and joint bases.

Three different ceramic powders were used in this investigation, and which were shown in Table 1. All three ceramic powders were joined by the same procedure which was shown in Fig. 2.

Fig. 3 shows an example of the sinter-joined powder A to graphite component and a joining condition. Electron micrographs of the contact parts between ceramic (I) and graphite (G) are shown in Fig. 4. Arrows show the joined surface

boundaries. Apparently the existence of the stirred and mixed regions in the graphite bodies suggests that the strong joint of ceramic and graphite was accomplished by the forced viscous and/or plastic flow due to compression and vibration at high temperatures.

The bending strength of joint was stronger than that of graphite which is low bending strength component (350 kg/cm²).

References

- 1) T. Suzuki and S. Saito, *Powder and Powder Metallurgy* **18**, 28 (1971).

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