§29. Study of the Microwave Sintering Applied to the Metal Powder Compacting Body and Investigation into the Penetration Mechanism of the Electro-magnetic Field in it

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Micro-wave sintering is one of powerful method to produce small ceramics. Since R.Roy showed that even metal powder and metal green compact could be heated by micro-wave in 1998, many attempts to heat metal powder by micro-wave were performed. The results of these experiments and some calculation revealed that the surface oxidation of the metal powder is the clue to enable to heat the metal powder and metal green compact[1].

Above experiments the heating samples were the uniform metal green compacts. This year the green compact of the double layer structure was used to confirm the change of the heating efficiency. Figure 1 shows typical sample used in this experiment and the sample in the micro-wave reactor (multi-mode).

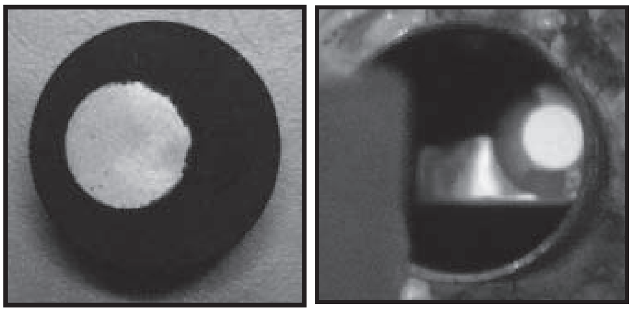

Fig. 1 Sample of the double layer structure
Left: before sintering
Right: during sintering

The center part of the sample is Fe, and the outer region in the sample is Fe_2O_3 or Fe_3O_4. The outer diameter is 20mm. First the 10mm diameter green compact of Fe powder pressed with 100-500MPa was made, and second Fe green compact and iron oxide (Fe_2O_3/Fe_3O_4) was pressed with 50-200MPa using 20mm diameter jig. Therefore, the Fe core region was not always positioned in the center. In Fig.1 (right) shows the sample in the multi-mode kiln (1.75kWx3, Panasonic) during heating process. The bright center region can be seen in the figure, also the outer region was not brighter than the center region. Figure 2 shows the temperature of the sample (center region and outer region) and the atmosphere. The iron oxide of Fe_2O_3 and Fe_3O_4 were used in the outer region. Both case it is found that the temperature of the center region was higher than the outer region. The solid lines in figure show the time of the power change, i.e, 1.75kW->3.5kW, 3.5kW->5.25kW respectively. When the outer region was Fe_3O_4, the temperature rose rapidly at the first time of the power increase (top in Fig.2), however, when the outer region was Fe_2O_3, the temperature was seemed to increase gradually. This difference may be caused by the electro-magnetic characteristics of the outer region. Up to now it is unknown why this difference occurs. Even the time dependences of the sample temperature were different with two case, the reachable temperature of the center region were same range (800-900 degree).

Figure 3 shows the maximum temperature of each green compact and the pressure of it. Under the pressure range of 100-500MPa the maximum temperature of each green compact is around the same. These results show the method for micro-wave sintering using the cover of the dielectric medium will be the practical way to make applications. Therefore, next year we will plan more precise experiment using the single mode micro-wave apparatus.

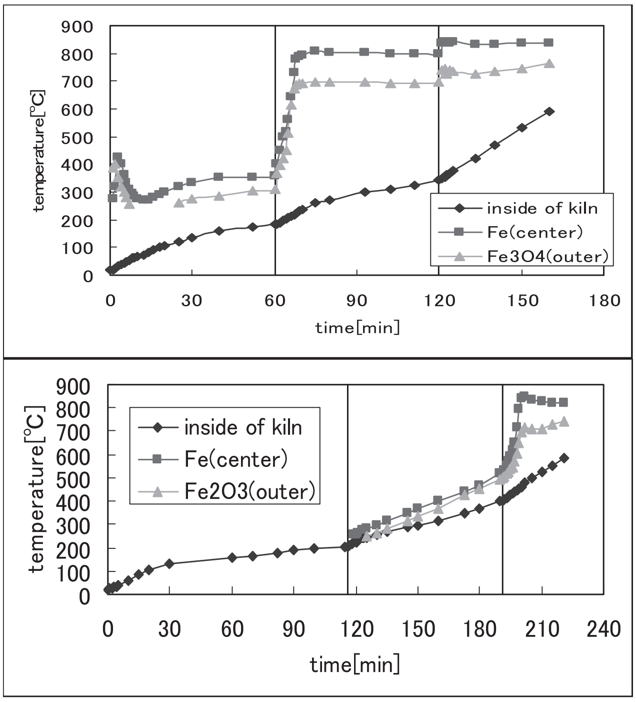

Fig.2 Temperature of the sample during microwave sintering.
Top: the outer region is Fe_3O_4
Bottom: the outer region is Fe_2O_3

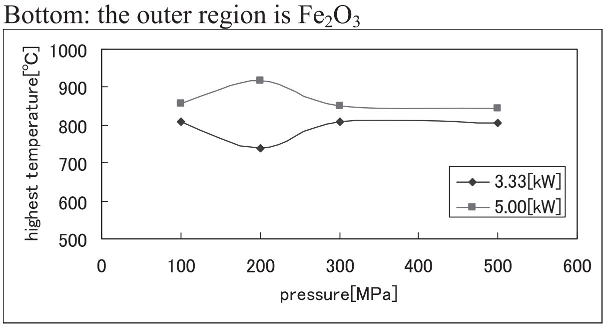

Fig. 3 Maximum temperature dependence on the pressure of the green compact

1) e.g. N. Nishino, et. al, GCMEA 2008