CHAPTER 6

COMPARISON OF PROPERTIES OF Mg/MgO MMCs FABRICATED BY TWO DIFFERENT SINTERING TECHNIQUES

This chapter compares the properties of pure magnesium (Mg) and Mg/MgO composites produced via powder metallurgy using two different sintering methods. In the first part, pure Mg and Mg/5MgO composites were fabricated at sintering temperatures of 450 °C, 500 °C, and 550 °C using a rapid microwave sintering technique. In the second part, pure Mg and Mg/MgO metal matrix composites (MMCs) with varying MgO content (5%, 10%, and 15% by weight) were fabricated at a constant sintering temperature of 500 °C using a novel sintering method. The properties of pure Mg and Mg/5MgO MMCs sintered at 500 °C by both techniques were then compared.

Pure Mg and Mg/5MgO composites were successfully fabricated using both sintering techniques. The pure Mg samples sintered by the novel sintering method exhibited a higher density than those sintered by the rapid microwave method. However, the opposite trend was observed for the Mg/5MgO samples. XRD analysis revealed similar diffraction patterns for both pure Mg and Mg/5MgO composites, regardless of the sintering technique used. In both methods, some of the Mg was oxidized to MgO, as confirmed by quantitative XRD analysis. However, the amount of MgO formation differed significantly between the two methods, with the rapid microwave sintered samples showing more MgO phase formation compared to those sintered by the novel sintering technique. This difference, shown in Table 6.1, is attributed to the rapid heating characteristics of microwaves compared to the slower heating rate of the novel sintering method. Additionally, the smaller powder size used in rapid microwave

sintering was more susceptible to oxidation compared to the larger powders used in the novel sintering technique.

Table 6.1 Comparison of MgO phase formation in rapid microwave sintering and the novel sintering method for pure Mg and Mg/5MgO samples

Sintering Method	Composition	MgO phase before sintering (vol. %)	MgO phase after sintering (vol. %)
Rapid Microwave Sintering	Pure Mg	0	5.6
	Mg/5MgO	2.49	10.6
A Novel Sintering Method	Pure Mg	0	1.45
	Mg/5MgO	2.49	5.30

The microstructure of pure Mg and Mg/5MgO composites sintered by rapid microwave (Figures 4.2 and 4.3) and the novel sintering method (Figures 5.6 and 5.7) showed the distribution of the MgO phase within the Mg matrix. In both cases, MgO particles were primarily located at the grain boundaries, as confirmed by EDS analysis. However, the grain size in the samples sintered by the rapid microwave method was significantly smaller than in those sintered by the novel sintering technique. This is due to two main factors: first, the Mg powders used in rapid microwave sintering were much smaller than those used in the novel method; second, the rapid heating characteristic of microwave sintering leads to greater grain size refinement compared to the slower heating rate of the novel method.

The hardness of both pure Mg and Mg/5MgO samples is higher in rapid microwave sintering than the novel technique as shown in Table 6.2. This is mainly due to grain refinement effect which is more dominant in rapid microwave sintered samples. Moreover, large MgO formation in microwave sintered samples also contribute to higher hardness as compared to samples sintered by novel sintering technique.

Table 6.2 Comparison of hardness, CYS, UCS, and failure strain in rapid microwave sintering and the novel sintering method for pure Mg and Mg/5MgO samples

Sintering Method	Composition	Hardness ($HV_{0.05}$)	0.2%CYS (MPa)	UCS (MPa)	Failure Strain (%)
Rapid Microwave Sintering	Pure Mg	51 ± 1	61 ± 5	142 ± 9	18.4 ± 0.6
	Mg/5MgO	61 ± 10	130 ± 8	168 ± 7	4.9 ± 1.2
A Novel Sintering Method	Pure Mg	44 ± 4.9	65 ± 1.5	161 ± 1.9	18.0 ± 0.6
	Mg/5MgO	48 ± 2.7	68 ± 1.7	172 ± 1.3	16.0 ± 0.4

The 0.2 % compressive yield strength (CYS), ultimate compressive strength (UCS), and failure strain of pure Mg and Mg/MgO samples fabricated by both sintering techniques are presented in Table 6.2. It was observed that the pure Mg sample exhibited a lower 0.2% CYS in rapid microwave sintering compared to the novel sintering method, whereas the opposite trend was found for the Mg/5MgO sample. The Mg/5MgO composite sintered by rapid microwave showed a significant increase in CYS compared to the novel technique. Additionally, there was a notable difference in the failure strain between Mg/MgO and pure Mg samples, influenced by the sintering method. This difference is primarily due to the formation of a larger amount MgO phase during rapid microwave sintering, which increases the brittleness in the sample. As a result, the 0.2% CYS sharply increases, while the failure strain decreases substantially in the rapid microwave sintered Mg/5MgO sample. In contrast, the UCS of both pure Mg and Mg/5MgO samples was higher in the novel sintering method compared to rapid microwave sintering.