CHAPTER VI

CONCLUSION

This research represents a preliminary approach to sintering characteristics and physical properties of waste powder. During sintering of waste powder compacts prepared by isostatic pressing method following conclusions can be drawn.

1) Temperature required for the sintering of waste powder to get theoretical density > 95% decreased with the addition of MgO as sintering aid.

2) It showed the addition of MgO in amount > 0.5% promoted densification at 1500°C. At 1600°C, the high density (95%) was achieved with addition of MgO in between 0.5%- 1.5%.

3) Modified composition (90% waste; 10% alumina) was sintered to the density greater than 95% theoretical density with the addition of 0.5% MgO.

4) Mullite and α-Al_2O_3 are the major phases in all sintered samples. Mg –Al spinel was formed when the samples sintered at 1400°C.

5) Addition of excess MgO (above 1%)made the samples more porous with decreasing densification at higher sintering temperature.

6) The grain morphology was observed as needle like grains at higher sintering temperature.

7) The compacts with above 95% density, showed the better mechanical properties such as hardness and MOR strength.

8) The maximum hardness was given as 5.35GPa and 6.13GPa for the compositions (100% waste + 1wt% MgO; 96.3%dth) and modified with 10%

Al_2O_3 with 0.5 wt % MgO (99.9%dth) respectively which were sintered at 1500°C for 3h. Maximum MOR values for the above composition are 169.3MPa and 213.26MPa respectively.

9) In case of addition of ZrO_2 in small amount (<8wt %), it acts as sintering aid as well as toughening agent.

CHAPTER VII

RECOMMENDATION AND SUGGESTION FOR FUTURE WORK

From the results obtained, it can be predicted that the roller waste can be applicable for industrial purpose specially in making porcelain-grinding media by Isostatic pressing method, which can be used in ball mills since it shows the basic requirements such higher density and hardness of the grinding media. But to evaluate the quality of the grinding media out of the roller waste further work should be done in pilot plant scale to do the application test. For that, the selected suitable composition should be prepared in large amount and the grinding media (pebbles) should be made in different sizes with varying proportions of that. Thereafter abrasion resistance test should be done by subjecting the pebbles for milling action and calculate the weight loss through number of turns during milling. Then only it can be made sure that it will be industrial applicable or not.

Suggestion to improve the work efficient

- Density measurement was taken using Archimedes' principle by water displacement method. This measurement can be further accurated by using mercury as displacing medium instead of water.
- Samples for microstructure analysis were prepared by manual polishing and chemical etching for the optical microscopy. It will give better micro photo graph if those samples were prepared by automatic polishing method.

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Appendix I

TableI: Measured Density for 100% Waste Composition

Temperature MgO%	1400°C		1500°C		1600°C		1700°C	
	Values g/cm3	Error (%)	Values g/cm3	Error (%)	Values g/cm3	Error (%)	Values g/cm3	Error (%)
0	2.1421±0.023	1.07	2.9689 ± 0.024	0.0806	3.009 ±0.062	2.05	3.0143 ± 0.023	0.78
0.5	2.1716± 0.03		3.07785 ± 0.0133	0.433	3.0407 ± 0.0057	0.19	2.966± 0.432	1.46
1.0	2.1943±0.011	0.52	3.1044 ±0.0121	0.39	3.05855± 0.00875	0.29	2.8481 ± 0.068	2.4
1.5	2.2011± 0.01		3.11955± 0.0428	1.37	2. 9954 ± 0.0047	0.155	2.7247± 0.0849	3.118
2.0	2.2261±0.013	0.6	3.098 ± 0.0587	1.897	2.8877± 0.054	1.87	2.635 ±0.0636	2.416
3.0	2.216±0.0086	0.4	3.0881± 0.0011	0.3229	2.6887 ± 0.023	0.85	-	-

Calculation of proportions of each component of Waste powder

From the chemical analysis waste composition contains

SiO_2 = 25.73%, Al_2O_3= 73.19%

From XRD analysis it is identified as α Al_2O_3 mullite as major phase constituents. Since there is no free silica it is assumed that 25.73% SiO_2 has been converted as mullite

$$3\,Al_2O_3 + 2\,SiO_2 \longrightarrow 3Al_2O_3.2SiO_2 \qquad \text{I}$$

$$\frac{nAl_2O_3}{nSiO_2} = \frac{3}{2}$$

$$\frac{WAl_2O_3}{101.9622X\dfrac{25.73}{60.0848}} = \frac{3}{2} \Longrightarrow \quad W\,Al_2O_3 = 65.4946\%$$

Therefore, free α Al_2O_3 = 7.6954%

Similarly weight of mullite is 91.2246%

It is assumed that the waste powder contain 7.6954% α Al_2O_3 and 91.2246 mullite only and ~1% soluble impurities are neglected.

By using the following equation depending on the presence of the component the theoretical density was calculated.

$$\frac{M_{tot}}{D_{mix}} = \frac{M_{mullite}}{D_{mullite}} + \frac{M_{Corundum}}{D_{Corundum}} + \frac{M_{Zirconia}}{D_{Zirconia}}$$

Where M_{tot} – Total Mass of the Mixture

$M_{mullite}$ – Mass of Mullite Component

$M_{Corundum}$ – Mass of Corundum Component

D_{mix} – Density of the Mixture to be determined

$D_{mullite}$ - Theoretical Density of Mullite (3.17g/cm^3)

$D_{Corundum}$ - Theoretical Density of Corundum (3.9g/cm^3)

TableII: Measured Density for Modified Waste Composition

Temperature MgO%	1400°C		1500°C		1600°C		1700°C	
	Values g/cm3	Error (%)	Values g/cm3	Error (%)	Values g/cm3	Error (%)	Values g/cm3	Error (%)
0	2.1891± 0.02	0.65	3.2055 ± 0.026	0.08	3.1519 ±0.034	1.1	3.1131 ± 0.045	1.5
0.5	2.1872±0.014	0.66	3.3018 ± 0.0133	1.5	3.1871 ± 0.009	0.31	2.9833± 0.04	1.4
1.0	2.146±0.02	1.01	3.2778 ±0.03	0.94	3.116± 0.0075	0.24	2.9189 ± 0.021	0.71
1.5	2.1722±0.02	0.72	3.230± 0.015	0.5	3. 1116 ± 0.022	0.122	2.8861± 0.031	1.08
2.0	2.1765±0.023	1.06	3.218 ± 0.01	0.3	3.08± 0.022	0.7	2.752 ±0.074	2.7
3.0	2.1663±0.03	1.41	3.1846± 0.013	0.4	3.043 ± 0.0008	0.271	3.0502± 0.018	0.59

TableIII: Measured Density of ZrO_2 added Waste Composition

Temperature ZrO2%	1400°C		1500°C		1600°C		1700°C	
	Values g/cm3	Error (%)	Values g/cm3	Error (%)	Values g/cm3	Error (%)	Values g/cm3	Error (%)
0	2.1421 0.23	1.07	2.9689 ± 0.024	0.806	3.009 ±0.62	2.05	3.0143 ± 0.023	0.78
2	2.2493±0.03	1.54	3.1468 ± 0.012	0.38	3.1769 ± 0.009	0.31	2.908± 0.05	1.22
5	2.283±0.01	0.62	3.1972 ±0.032	1.008	3.1878± 0.0097	0.26	2.844 ± 0.05	1.64
8	2.29±0.02	0.87	3.198± 0.015	1.323	3. 20385 ± 0.022	0.099	2.8171± 0.021	1.7

Appendix II
Microphotographs

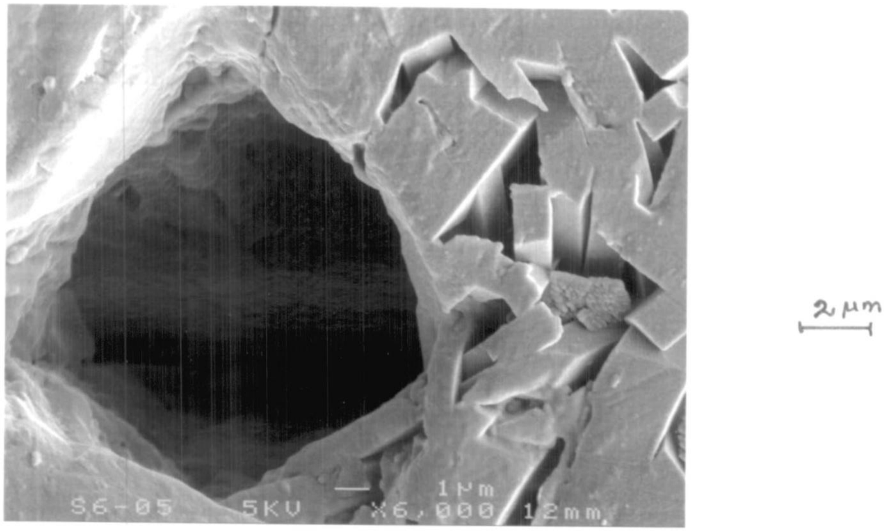

Fig I: SEM Microphotograph of 100% Waste Powder Mixture (1.5% MgO) after Sintering at 1500°C for 3h

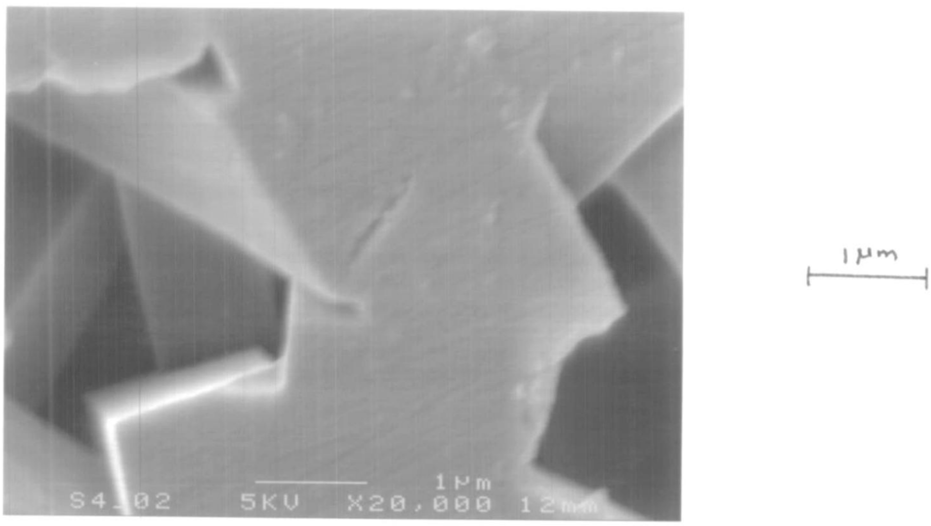

Fig II: SEM Microphotograph of 100% Waste Powder Mixture (1.0% MgO) after Sintering at 1600°C for 3h

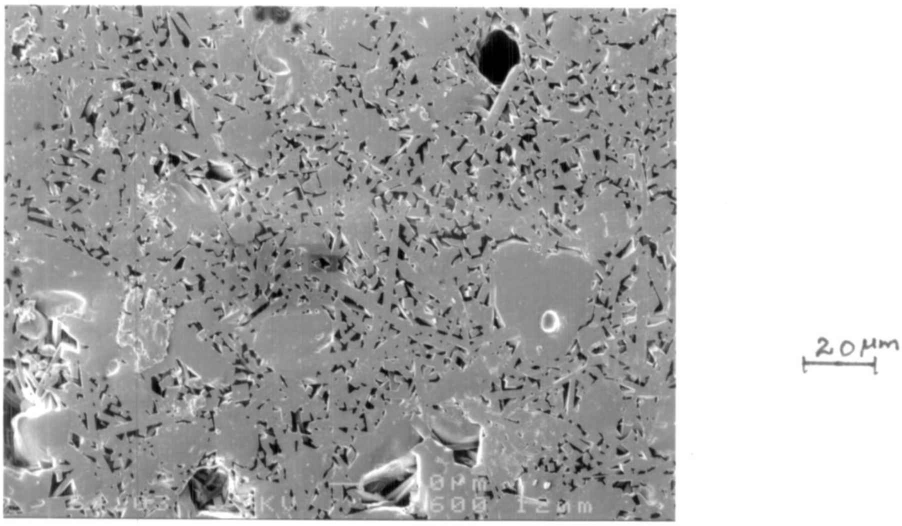

Fig III: SEM Microphotograph of 100% Waste Powder Mixture (1.0% MgO) after Sintering at 1600°C for 3h

Fig IV: SEM Microphotograph of 100% Waste Powder Mixture (5% ZrO2) after Sintering at 1600°C for 3h