Preface

The demand of porous materials in terms of applications in various fields of engineering and technology is increasing day by day though these materials have been in use for a long time in different areas depending on the suitability and requirement. Porous ceramics is an important category of porous materials which find wide range of applications because of their unique properties in comparison to other materials and their solid counterparts. During the last decade, there has been a thrust on research activities related to processing and fabrication of porous ceramics in terms of developing new materials and methods, improvement of existing products and processes, substitution of low cost raw materials and additives in order to get cost effective products, establishment of alternate products, improved and new characterization techniques, possible applications in diverse areas etc. The present study is an effort to develop and establish a simple and alternate process for fabrication of cost effective porous ceramics (alumina in this case) with wide range of microstructure and properties, using low cost additives (rice husk) via. dry processing route. Systematic experiments were carried out to optimize the mixture composition and process parameters in order to establish fabrication steps and to end up with defect free porous compacts. Based on the optimized composition and process parameters, Standard Operating Procedure (SOP) has been laid out. The effect of pore microstructure on physical, mechanical, thermal, electrical and permeability characteristics of the developed samples have been systematically studied. The results of these investigations are reported in this thesis. The thesis includes ten chapters.

Chapter-1 gives the introduction of the subject. It highlights the definition, classification, properties and applications of porous ceramics.

Chapter-2 describes the background knowledge of various shape forming processes adopted for fabrication of porous ceramics. It also contains a brief review of the literatures available for fabrication of porous ceramics using rice husk as pore forming additive.

Chapter-3 contains the aim and objectives of the present research work.

Chapter-4 is based on selection, optimization and establishment of a low cost alternate binder (sucrose) in dry processing of ceramic powder owing to its inherent ability to form H-bonds. It is important to mention here that though sucrose has been used as a binder and rheology modifier in plastic forming and wet processing of ceramics, its use in dry pressing is a new attempt. The suitability and effectiveness of sucrose as binder during dry powder pressing of alumina ceramics has been described in terms of the properties of green compacts. This basic study based on sucrose suggested that sucrose played a dual role such as binder and pore former in the overall processing of ceramics.

Chapter-5 deals with fabrication of porous ceramics with tailored microstructure and properties using an agricultural waste material, rice husk (RH) as the pore former, which burns out during heat treatment leaving pores in the sintered compact. Though RH has been used as a pore former by several researchers for fabrication of porous ceramics, microstructural tailoring of porosity, pore size and pore connectivity of porous compacts using RH is a new approach. Sucrose was found as the best low cost binder in this process. The reason for non-suitability of PVA binder in this system is also highlighted. Combination of rice husk and sucrose together as pore former and binder, respectively, which has been used for formulating new compositions, optimizing the process parameters, standardizing the process and developing products with tailored microstructure and properties, is a different and unique approach.

Chapter-6 describes the effect of composition on resulting porosity and pore microstructure of the developed porous compacts. Also the chapter explains the effect of microstructure on mechanical properties the porous samples. Porous alumina with 22-66 vol% porosity and 50-516 µm pore size (length) with diversified microstructure having isolated and /or interconnected pores were fabricated using this process. Microstructure of samples revealed mixture of two types of pores such as randomly oriented elongated coarse pores and fine pores(avg. size 4 µm), created during burnout of rice husk and sucrose respectively. The obtained porous alumina exhibited flexural strength of 207.6-22.3 MPa, compressive strength of 180-9.18 MPa, elastic modulus of 250-18 GPa and Rockwell hardness of 149-18 HRD.

Chapter-7 describes the effect of pore microstructure on thermal and thermo-mechanical properties such as thermal conductivity and thermal shock resistance of the obtained porous ceramics. Experimental values of thermal conductivity range from 1.2 to 24 W/mK at room temperature. The experimental results agree closely with predictions made based on Effective Medium Theory (EMT) for ellipsoidal shape dispersed phase in a continuous matrix (two phase system).

Chapter-8 highlights the effect of pore microstructure on electrical properties of the developed porous ceramics. The room temperature dielectric constant (ε') ranges from 3.6 to 6.3 and corresponding loss tangent ($\tan\delta$) ranges from 0.4×10^{-3} to 0.03×10^{-3} at 1 Hz frequency. The measured experimental values of ε' fitted well with the predicted model obtained from Maxwell-Garnet theory. Similarly, the experimental data points of the $\tan\delta$ values were close to the power law model.

Chapter-9 describes the effect of pore microstructure on permeability characteristics of the porous alumina compacts. Permeation was observed for samples with porosity 20-40% having only interconnected pore microstructure. Samples with porosity below 20% were having majority of isolated pores. The Darcian permeability (k_1) of porous alumina ranges from 0.38×10^{-10} m^2 to 9.15×10^{-10} m^2. The Non-Darcian permeability (k_2) ranges from 0.33×10^{-5} to 3.92×10^{-5} m.

Chapter-10 describes the summary and conclusions drawn on the basis of the present investigation.