CHAPTER 6

CONCLUSIONS AND FURTHER STUDY

Pore Structure and Air Flow Characteristics.

The pore structure of porous material was investigated through pressure drop measurement. The pore structure was determined by both two- and three-dimensional approaches. The major results were as follows:

1. The effect of pore structure was clearly identified at reduce absolute total pressure of mercury manometer at the range of $8x10^2$ to $3x10^4$ Pa and the pressure drop between 1x10 to $2.5x10^3$ Pa of castor oil manometer.

2. Pressure drop across the specimen thickness increases as mass flow rate increases and absolute total pressure decreases, i.e., as the degree of vacuum increases, for each specimen. The experimental pressure drop per unit length is always higher than the corresponding calculated value and the relative discrepancy between them increases as absolute pressure decreases.

3. It clearly shows that pressure drop per unit length increases as air flow rate increases and the effect are higher at longer mean free path of gas molecules. This means that flow resistance for a given mean free path should increase as the pore structure changes or pore size decreases. Therefore, effective surface area S_V and porosity ε of the specimen are considered to decrease at reduced gas pressure.

4. At a short mean free path, S_V showed only slight changed with increasing air flow rate. At a long mean free path, the S_V value dropped remarkably with increasing air flow rate, which seemed to confirm some relationship between the pore structure and flow characteristics of gas through the porous material. The same trend was observed for all specimens despite the fact that pore shapes and sizes were different, and a sharp drop of S_V started around Kn = 0.01 that corresponds to the slip-flow region.

5. The fractal dimension obtained from the proposed three-dimensional analysis ranges from 1.20 to 1.46. The fractal dimensions are large for specimens with larger pores and small with smaller pores. The fractal dimensions obtained from two-dimensional image are larger than

1.5 for any specimens. So, the interpretation of fractal dimension by pressure drop across the porous medium shows a better accuracy and reveals a quantitative picture to visualize a three-dimensional information of the internal pore structure.

6. The permeability was found to increase as the fractal dimension increased which meant that permeability was closely related to fractal dimension of the pore structure.

7. The fractal dimensions obtained visually from counting and from the experimentally S_V slope. The discrepancy indicated the existence of stagnant air pockets and dead-end voids. The discrepancy was larger for specimens that have larger fractal dimensions.

8. The experimental pore area and image pore area are compared and the difference in percentage between these two areas that indicated the existence of stagnant air pockets and dead-ends as stated in connection with fractal dimension. The differences in both values were nearly the same.

9. The three-dimensional approach gave a physically more meaningful picture of pore structure, especially when the fractal dimension was large. This suggested that the mysterious of air pocket could be discovered by applying the concept of fractal dimension to the measurement of air flow through porous specimens and to image analysis of the cut specimens.

Effect of Matrix Content on the Physical Properties and Pore Structure of Spinel Refractories.

The physical properties and pore structure of porous spinel refractory containing TiO_2 and Al_2O_3 powder mixed at equi-molar ratio as matrix were investigated. The results were summarized as follows:

1. $Al_2O_3 \cdot TiO_2$ was detected in all specimens except TA30, while solid solutions of $MgO \cdot Al_2O_3$-$2MgO \cdot TiO_2$ and $Al_2O_3 \cdot TiO_2$ - $MgO \cdot 2TiO_2$ were found in all specimens without exception.

2. Boundary cracks increased with increasing matrix content, thus causing the such physical properties; as bulk density, apparent porosity, pore size, permeability and compressive strength to change.

3. The average pore size decreased as the matrix content increased and the pore shape became more complicated for the TA system, but for S10 system the pore essentially remained their original

shapes regardless of the matrix content.

4. The pore shape showed a fractal nature and its fractal dimension decreased as the matrix content increased. The fractal dimension changed significantly around 10-15 wt. % matrix content, where values of mean pore size and permeability peaked.

5. The fractal dimension increased in proportion to the amount of $MgO.Al_2O_3$ - $2MgO.TiO_2$ solid solution present.

Further Study.

The present experimental apparatus was designed to measure pressure drop across porous ceramic specimens of certain specified pore sizes ranging from 0.12-1,000 μm. It would be beneficial if this experimental apparatus be modified to use a bigger vacuum pump and wider ranges of mercury and castor oil manometers in order to measure higher pressure drop associated with smaller mean pore diameters and the specimen thickness is much thinner. Then, one can visualize pore structure more clearly and the apparatus can be used as physical property testing equipment in ceramic refractory laboratory.