# CHAPTER V
# CONCLUSIONS AND RECOMMENDATIONS

A neutron scattering device, which is called a scatterometer, was developed to measure steam quality on-line for a steam-water mixture in a half-inch stainless steel pipe. The device is designed to be portable at high temperatures and pressures.

Three different geometries of the scatterometer were evaluated by employing the MCNP simulation. The results showed that linearity between void fraction and scattered neutron flux was achieved for all cases. It was concluded that the scatterometer was theoretically adequate for measuring steam quality online in laboratory.

The static air-Lucite experiment was carried out using Lucite rods to simulate the water content in a pipe in order to confirm the possibility of this design. Linearity between the measured Lucite fraction obtained from neutron count rate and the actual Lucite fraction was achieved. This meant that the possibility of measuring void fraction by using a scatterometer could be achieved.

Before the scatterometer was applied to a real steam-water flow system, a dynamic nitrogen-water experiment was performed in order to check the feasibility of the scattering technique and to study the effect of bubble sizes on the relationship between neutron count rate and void fraction. It was found that the technique was applicable. The possibility of using a transmission technique for void fraction measurement was also investigated.

The neutron scatterometer and test section was installed in the experimental autoclave loop of a dynamic steam-water experiment. The effect of temperature on the neutron count rate was studied by varying the density of compressed liquid at 5MPa. As predicted, when the temperature decreased, the neutron count rate increased due to the increase in the density of water. This was because the possibility of neutron interaction was higher when the density of hydrogen atoms was higher. The steam quality generated inside the autoclave was altered by changing the amount of heat added from the autoclave heater. There were three different saturated conditions investigated. The results showed that there was a possibility for the

scatterometer to be used to detect steam quality directly. However, at higher saturated conditions, different calibrations would have to be used.

For future work, it would be interesting to study the effect of pressure on the detector response. Moreover, the adequacy of the scatterometer for measuring on-line the steam quality above 0.1 should be investigated; another side-scattering detector was suggested in order to count all the scattered neutrons from the test section for more accurate analysis. Also, a new calibration process could help to eliminate electronic and external noises in the high temperature and pressure system. Moreover, it was a need for more systematic study of experimental parameters such as temperature, pressure, density of steam-water mixture and geometries.