# CHAPTER IX

# SUMMARY AND CONCLUSION

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In the present work some of the physical properties of glow discharge and arc plasma have been experimentally investigated and theoretical analysis of the observed results has been presented. It is expected that the conclusions drawn from the investigation will extend our knowledge regarding the process of initiation and maintenance of the low density and high density plasma.

## A. Energy loss mechanism in a collision dominated plasma:

The loss of energy of the electrons due to collision with neutral atoms and molecules in a collision dominated plasma has been theoretically investigated. It is shown that as the loss factor K is dependent upon (E/P), the reduced field, it is essential to take into consideration the variation of K in calculating the current through the plasma. The theoretical expression for the plasma current thus deduced agrees very well with observed experimental results. Further the values of the plasma parameters such as electron density drift and random velocity of the electron calculated from theoretical expressions combined with experimental results in air, hydrogen and nitrogen agree quite well with literature values.

B. Some new methods suggested for measurement of plasma parameters:

i) Measurement of plasma current and capacitative current in a radio frequency gas discharge:

By introducing a variable choke in parallel with the discharge tube and noting the resonant current in the main as well as in the parallel circuit containing choke, the plasma current as well as the capacitative current can be separated and measured. A mathematical formulation of the theory of measurement has been presented.

ii) Radio frequency conductivity of an ionised gas in a transverse magnetic field:

The variation of the imaginary part of the radio fequency conductivity of an ionised gas in a transverse magnetic field has been calculated by taking into consideration the variation of the axial electric field in presence of transverse magnetic field. The analysis shows that the rf conductivity becomes a minimum at a certain value of the magnetic field, which is solely dependent upon the pressure. Some numerical calculation of the magnetic field for the minimum radio frequency conductivity for certain values of pressure has been presented.

iii) Propagation of microwaves through a plasma filled wave guide - a possible diagnostic method:

Propagation of microwaves through a plasma filled wave guide has been considered starting from the basic electromagnetic equations of Maxwell. The cut-off frequencies $_c$ and $\omega_{cp}$, without and with plasma, $\alpha$ and $\beta$ where $\alpha$ is the attenuation constant per unit length and $\beta$ is the phase constant per unit length have been shown to be implicitly related with $\sigma_r$ and $\sigma_i$, the real and imaginary conductivity, and $\epsilon'$ and $\epsilon''$, the real and imaginary dielectric constants of the plasma. From these measurement the electron density and collision frequency of electrons with neutral atoms can be calculated.

iv) Critical frequency for microwave propagation in a rarefied magnetised plasma:

In this section a detailed theoretical investigation has been presented to find how the critical frequency for microwave propagation in a plasma is affected in presence of magnetic field; the values of $\epsilon'$, the real part, and $\epsilon''$, the imaginary part of the dielectric constant have been calculated in presence of transverse magnetic field from which the numerical values of cut off frequency for a variation of magnetic field from 10 to 100 gauss have been obtained for an assumed value of electron plasma frequency. It is observed that the cut-off frequency increases with the increase of the magnetic field.

An interesting result obtained is that $\omega_c^2 = \omega_p^2 + \omega_H^2$ which suggests that, as if, the electron plasma frequency has increased from $\omega_p$ to $(\omega_p^2 + \omega_H^2)^{1/2}$ - a result which can be obtained when we consider the effect of magnetic field on electron plasma oscillation.

C. Low density plasma in a magnetic field:

In this chapter a low density plasma has been subjected to a varying transverse magnetic field and with the help of two probes one along the axis and the other along the periphery, the radial voltage developed has been measured for three values pressures. It is suggested that the voltage thus developed is the resultant of two voltages, namely the diffusion voltage in presence of magnetic field and the Hall voltage. A detailed mathematical analysis has been carried out in which the values of both these voltages have been calculated separately and an expression for the resultant voltage obtained. The experimental results are in excellent agreement with the theoretical calculation specially for values of magnetic field greater than 150 gauss. It is suggested that the discrepancy observed for low values of magnetic field may be due to dependence of diffusion co-efficient on 1/H instead of on $1/H^2$. It is pointed out that in all Hall voltage measurement in plasma the contribution of diffusion voltage in presence of magnetic field should be taken into consideration.

D. Current generation process, high current density and cathode phenomena in an arc plasma:

A detailed mathematical theory has been presented regarding the mechanism of current emission phenomena, the high current density in metallic arcs. The mathematical analysis is based upon some reasonable assumptions and it has been shown that all arcs are basically thermionic in nature irrespective of the melting point of the cathode material. A generalised theory has been developed for calculating the current density and the cathode fall, and the experimental part consists in measuring cathode fall with wide variation of pressure. The experimental results are in excellent agreement with theoretical calculations. The results clarify the nature of much of the complex physcal processes occurring near and at the cathode surface of the arc and it is concluded that in the arcs studied in this investigation thermionic processes have a dominant role to play.

E. Low frequency oscillation in an arc plasma:

Low frequency socillations in the range of 2 KC/S to 6 KC/S have been detected in a mercury arc plasma. Besides the frequency of oscillation the output voltage has also been measured for variation of arc current from 1.7 to 2.3 ampere for three values of pressure and for a transverse magnetic field varying upto 114 Gauss. A theoretical treatment of the plasma has been presented which can satisfactorily explain the experimental results. The possible origin of these low frequency oscillations has been discussed.

F. Evaluation of plasma magnetisation co-efficient:

In this chapter an analytical derivation of the expression $C_1 = \left(\frac{e}{m} \cdot \frac{1}{v_r}\right)^2$ which has been defined as 'plasma magnetisation co-efficient' has been derived. From the theoretical treatment it has been deduced that $C_1$ is a function of H/P, the reduced magnetic field. Previous and present experimental results are in accordance with the theoretical deduction. The effective cross-sectional area of an arc, in presence of megnetic field has also been discussed.