SUMMARY AND CONCLUSIONS

The acceptances of beam in Indus-2 electron storage ring has been studied by using analytical formulation and particle tracking codes MAD-8, ELEGANT, RACETRACK and TRACY-3 (Chapter 1). The loss of electrons due to elastic scattering between electrons and the nuclei of the residual gas atoms for rectangular and elliptical shape of the vacuum chamber was studied using linear beam dynamics. Analytical expressions for the shape factors for rectangular and elliptical shape of vacuum chamber as a function of position along the circumference of storage ring have been derived (Chapter 2). These expressions are very useful to estimate the beam lifetime due to elastic scattering of electrons with the nuclei of residual gas atoms in realistic conditions like non uniform vacuum pressure in storage ring. The expression for shape factor for the rectangular shape of vacuum chamber is similar to the expression for the average shape factor available in the literature. It indicates that the approach followed for deriving the expression is appropriate. The expression of shape factor for elliptical shape of vacuum chamber was derived using the same approach as used for rectangular chamber. The expression of shape factor for elliptical shape was found to be different from the existing expression because in existing expression the loss of electrons was considered at one location only which does not happen in a modern electron storage ring.

The electron-electron interaction within a bunch known as Touschek scattering was studied. Parameters affecting the Touschek scattering such as betatron coupling and RF phase modulation were also studied. The betatron coupling in Indus-2 was measured and found to be ~0.5%, this value of coupling was used for the estimation of Touschek lifetime. Effect of RF phase modulation on beam lifetime in Indus-2 was studied (Chapter 3). The effect of aperture on beam lifetime was studied by conducting beam experiments without and with application of closed orbit correction. The results show that with closed orbit correction, there is an increase in beam lifetime. The contribution of vacuum lifetime and Touschek lifetime in
measured beam lifetime was separated by storing electrons uniformly in all 291 RF buckets and also storing electrons in two-third RF buckets keeping rest of the RF buckets empty (Chapter 4). These studies are very useful to know the limiting factor of beam lifetime i.e. either vacuum lifetime or Touschek lifetime. The effect of RF cavity voltage on beam lifetime was studied to find the limiting momentum acceptance either in transverse or in longitudinal plane.

The vertical and horizontal aperture available for stable beam motion at scraper location in Indus-2 at beam energy 2.5 GeV with 100 mA stored beam current was measured by using movable beam scrapers (Chapter 5). The objective of the measurement was to find an appropriate vertical aperture for undulators which are planned to be installed and also to understand the beam loss mechanism. The measured vertical and horizontal aperture at scraper location was found to be ±4.1 mm and ±12.45 mm respectively. The beam lifetime variation with the movement of vertical and horizontal scraper was measured and analyzed using analytical formulations and particle tracking code ELEGANT. Vacuum lifetime was calculated using partial pressure of the residual gases present in the vacuum chamber. From the measured beam lifetime with scraper position from the beam centre, the contribution of beam lifetime due to elastic scattering of electrons with the nuclei of residual gas atoms, bremsstrahlung, Touschek scattering and quantum excitation was estimated separately. The contribution to beam lifetime due to elastic coulomb scattering, bremsstrahlung and Touschek scattering are separated from the measured total beam lifetime. The theoretical value of vacuum lifetime due to elastic coulomb scattering in vertical plane closely follows the values obtained from fitted curve of measured data. The quantum lifetime is studied by inserting the vertical and horizontal scraper to the vicinity of the beam core (Chapter 5). The beam sizes obtained from quantum lifetime limitation are close to the beam sizes measured using X-ray diagnostic beamline. The quantum lifetime limit in longitudinal plane was studied by
reducing the RF cavity voltage. The vacuum and Touschek lifetimes obtained using scrapers were closely same as obtained using partial bunch fill experiments. The vertical and horizontal apertures studies using movable beam scrapers show that the beam lifetime is limited due to elastic coulomb scattering and inelastic scattering between electrons and nuclei of residual gas atoms. The measured vertical aperture at scraper location was found to be less than its theoretical estimated value. The vertical aperture was improved by minimizing the closed orbit distortion in vertical plane and it resulted into ~40% increase in beam lifetime (Chapter 5). It shows that the lifetime of stored electron beam in Indus-2 depends on the vertical aperture. These studies indicate that the beam lifetime in Indus-2 will further improve with reduction in vacuum pressure. The vertical aperture measurement carried out also indicate that the beam lifetime will not be reduced after installation of insertion devices as the vertical aperture available in undulators will be ± 8 mm. The beam lifetime due to a high density of electrons in a bunch was studied by storing the electrons in a single bunch in one RF bucket out of 291 RF buckets in Indus-2 ring. It was observed experimentally that the Touschek scattering effects are dominant at lower energy.