A.3: Studies, analysis and cure of beam instabilities due to HOMs in Indus-2 RF cavities up to beam current of 150 mA

Higher Order Modes (HOMs) of RF cavities in a synchrotron light source are one of the main reasons for beam current limitation. The interaction between HOMs of RF cavities and electron beam spectra may give rise to beam instabilities in Indus-2. These instabilities may limit the beam current and beam lifetime, which need to be addressed. Indus-2 storage ring has four RF cavities equipped with precision temperature controller for the cooling system and Higher Order Mode Frequency Shifter (HOMFS) to avoid harmful HOMs. Studies were carried out to identify harmful HOMs and check the severity of a particular HOM. The offline (i.e. without beam) measurement of frequencies of important longitudinal and dipole HOMs of RF cavities has been done at different cavity water temperatures and HOMFS positions. Analysis of the measured data gives the sensitivity of a particular HOM with varying temperature as well as HOMFS position. Indus-2 storage ring is being regularly operated at beam energy 2 GeV and beam current around 100 mA. During routine operation of Indus-2, the online measurements with beam were done. The signals from the HOM pick-up probes of RF cavities were observed to check harmful HOMs supported by the cavity at different values of beam energy (up to 2 GeV) and beam current around 100 mA. Some of the modes such as Longitudinal modes L1 (~950 MHz), L3 (~1432 MHz), L4 (~1521 MHz) and L5 (~1628 MHz) were found to be quite prominent at specific operating conditions. Based on offline and online measurements growth rates of HOMs were estimated. Suitable methods were evolved to cure beam instabilities due to HOMs. Based on theoretical understanding, HOM related experiments were carried out with the aim of maximizing the stored beam current at injection energy i.e. 550 MeV. The temperatures of precision chillers of RF cavities were optimized in different steps to avoid harmful HOMs and finally beam current of 251 mA was achieved in the Indus-2 at 550 MeV. Fig. A.3.1 shows the beam current of 251mA accumulated in Indus-2.

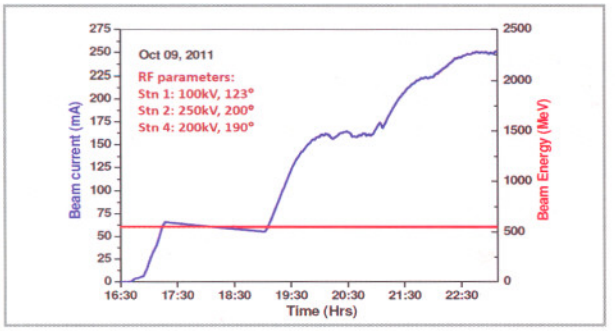

Fig. A.3.1: 251 mA beam current stored in Indus-2 at injection energy after the optimization

Repeatable performance was obtained with beam current around 200 mA.

The experiments were continued to take care of different HOMs at injection energy and ramping of beam energy from 550 MeV to 2 GeV. The temperatures and HOMFS positions were optimized. Figs. A.3.2a and A.3.2b show the relative strength of Longitudinal Mode L5 at beam energy 550 MeV and Longitudinal Mode L4 at beam energy 2 GeV respectively, in four RF cavities using pick-up probes. It is observed that the strength of modes L5 and L4 was reduced after optimization at higher beam current 205 mA and 140 mA respectively. Similar results were observed for other harmful HOMs.

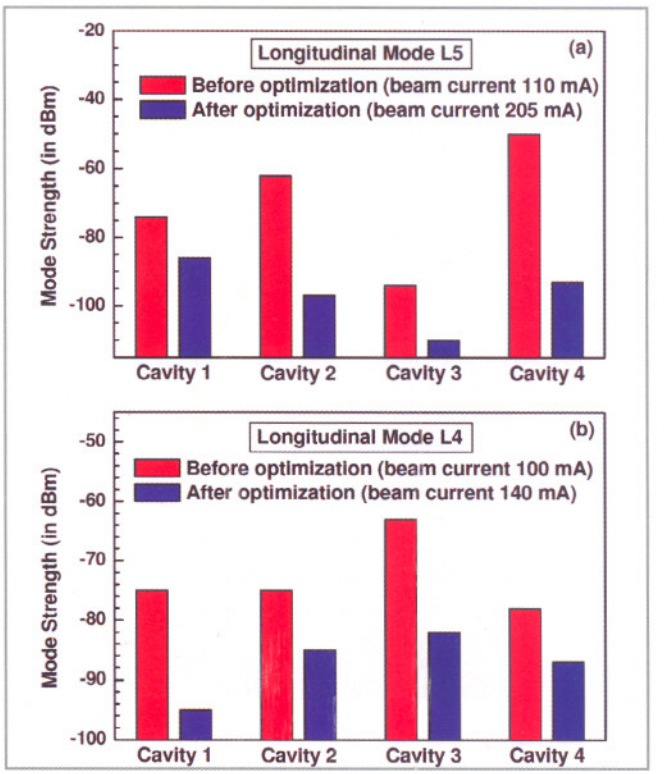

Fig. A.3.2 : Mode strength of Longitudinal mode (a) L5 at beam energy 550 MeV and (b) L4 at beam energy 2 GeV in four RF cavities before and after optimization.

With the precision chiller temperatures set at 50.0°C (cavity #1), 48.0°C (cavity #2), 51.0°C (cavity # 3), 58.5°C (cavity #4) and optimization of HOMFS, finally 183 mA beam current at 2 GeV was achieved. The studies for further improvement to achieve stable operation of Indus-2 at higher beam current are continued.

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