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Preliminary results from validation measurements of the longitudinal power deposition model for the LHC injection kicker magnet

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The MKIs are fast pulsed transmission line injection kicker magnets of the LHC injection system. To shield the ferrite yoke from the beam, by providing a path for the beam image current, a set of 24 conductive wires is placed in the inner part of a ceramic tube along the length of the magnet aperture. Stringent rise-time specifications require that the wires are capacitively coupled to a grounded metallic cylinder at the upstream end of the tube, while at the downstream end they can be directly grounded. The cylinder also serves to support a set of nine ferrite rings, placed there to damp low frequency modes that can be excited along the length of the tube. Due to the beam screen design, an open-ended, half-wavelength resonating cavity is formed in the region where the screen conductors overlap with the external metallic cylinder. The so-formed cavity couples to the beam spectrum at discrete frequencies, determined by the length and effective dielectric constant of the cavity. Therefore, the impedance spectrum is resonant in nature exhibiting peaks at the cavity's resonant frequencies.

In order to ensure uninterrupted LHC operation, the MKI ferrite yokes must remain below their Curie temperature at all times. Otherwise, waiting for the yokes to cool down leads to long turn-around times and hence significant deterioration of the overall machine performance. To monitor the temperatures reached within the MKIs 4 thermal probes (PT100) are placed in each magnet: two probes at the upstream and two at the downstream end of the magnet. During Run 1 of the LHC, one of the MKIs occasionally exhibited a high ferrite temperature. An impedance mitigation campaign was launched prior to Long Shutdown 1 (LS1) that led to an effective reduction of the MKI beam coupling impedance and to the corresponding RF heating during Run 2. However, thermal measurements during operation have clearly demonstrated that the upstream end of the magnet is consistently hotter than the downstream one. Power deposition caused by beam induced electromagnetic (e/m) fields due to the coupling of the beam spectrum to the MKI real longitudinal impedance, was identified as the main cause. Nonetheless, the simplified approach of a uniformly distributed power deposition along the length of the magnet was in clear contradiction with the measured data. Therefore, a more detailed description of the power dissipation process had to be looked for and carefully modelled to allow for accurate and robust predictions of current and future kicker beam screen designs; e.g. for HL-LHC.

In the present work, the approach followed to obtain estimations for the power loss deposition distributions is presented in detail. The method utilizes sophisticated electromagnetic simulations combined with carefully designed data post-processing to minimize the required simulation data, thus leading to acceptable execution time and storage space per simulation. The method, is then applied to two beam screen designs of the MKI: the one currently in operation and a new one, to be installed as an upgraded version in YETS 17/18. A comparison of the expected power deposition distributions is then carried out and the results are discussed. To validate the predictions of the power deposition model and gain more confidence in the effectiveness of the proposed design, a novel measurement method is proposed and implemented. The method is based on a simple measurement of a transmission coefficient taking advantage of the configuration of the expected e/m modes responsible for RF-heating. Preliminary results of the power deposition measurements are then reported and compared to model predictions.

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