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"Simulation of Magnetic Field Uniformity in a 100g Kibble Balance Using Finite Element Analysis" at CSIR-NPLI

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In the realm of precision measurements, the Kibble balance is a vital instrument for determining the Planck constant, crucial for redefining the kilogram in terms of fundamental constants. Central to its operation is the interaction between a magnetic field and a moving coil, governed by electromagnetic principles, where the balance achieves high precision by equating mechanical and electrical forces. The magnet system in the Kibble balance is indispensable, ensuring a uniform and substantial magnetic flux density essential for accurate measurements during both static weighing and dynamic velocity modes. In the Kibble balance, maintaining stable magnetic flux ensures the consistent generation of induced voltage, essential for accurate measurements.

Finite Element Analysis (FEA) plays a pivotal role in designing and simulating the magnetic circuit to achieve precise magnetic field characteristics. To significantly enhance precision and accuracy in our measurement systems, we employed Altair Flux to optimize two sets of magnets, each with an equal number of magnets (e.g., 5, 6, or 7). These magnets have inner radii of 8mm, outer radii of 20mm, and a height of 3mm. The magnet sets are strategically positioned with their repulsive faces facing each other, surrounding a 15mm length coil. The primary objective of employing FEA in this context is to ascertain the range of magnetic field profile flatness along the path of the coil. This flatness profile indicates how uniform and stable the magnetic flux density remains across the coil's trajectory, which is crucial for minimizing measurement uncertainties and errors. Through simulation and analysis using Altair Flux, our study aimed to optimize the arrangement and dimensions of the magnet sets to achieve the desired magnetic field characteristics. This includes evaluating different air gap widths and coil positions to enhance the uniformity and stability of the magnetic field profile.

KEYWORDS: Kibble balance, electromagnetic , Altair Flux