Reduction of asymmetric magnetic flux leakage caused by the assembling gap

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With the development of nanotechnology, transmission electron microscope (TEM) becomes an important tool in nano-metrology. In general, practical magnetic lenses in TEM include magnetic pole pieces, magnetic circuit and coil windings. Asymmetric magnetic flux leakage caused by the assembling gap between pole piece and magnetic circuit can deflect the electron beam from the optical axis in adjusting the lens excitation, which will affect the performance of the lens and TEM system. The classical solution by increasing the gap to 0.1-0.2mm(Fig.1) may introduce larger magnetic flux leakage and even deteriorate the optical performance especially for the TEM objective lens. In this paper, the structure of pole pieces and magnetic circuit[1] near assembling gaps was optimized to reduce the magnetic flux leakage and its asymmetry. An example of a 200kV TEM objective lens was given to research the performance after our optimization. Second-order FEM (SOFEM) was chosen to simulate the magnetic lens, as SOFEM can effectively solve the difficulty of large dimensional difference between the total lens and the assembling gap in a complicated geometry model[2]. We increase the size of pole pieces along the z axis and optimize the size of gaps between the pole piece and magnetic circuit to obtain the maximum axial field (B_{max}) and minimum magnetic flux leakage (B_{Lmin}). The final model is shown in Fig.2 and asymmetric magnetic flux leakage is removed by increasing the gap to 0.2mm. As a result, B_{max} is increased from 1.91T to 1.97T, B_{Lmin} at the upper pole piece is reduced from 0.005T to 0.001T, B_{Lmin} at the lower pole piece from 0.056Tto 0.008T when the excitation is 10128.8A-t. Theoretically B_{max}=1.99T without the assembling gap, so the optimization model can meet for meet the demands of 200kV TEM resolution.

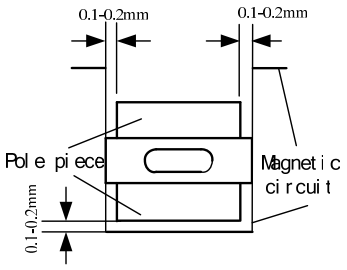

Figure1: Principle to reduce asymmetry

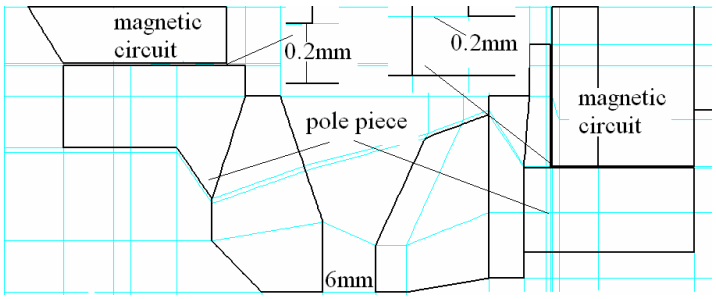

Figure2: The final objective lens model

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