§11. Inference of Eddy Current Distribution by Vibration Measurement of Vacuum Vessel

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When plasma column shifts, eddy current flows in vacuum vessel. Due to interaction of the eddy current and magnetic field, electromagnetic force is applied to the vacuum chamber, and the vacuum chamber is deformed (vibrates). Therefore, by measuring the deformation (vibration), we may obtain information about the eddy current in the vacuum vessel and the shift of the plasma column.

Acceleration sensors are set on flanges of diagnostic ports, and the acceleration of the vacuum vessel is measured when toroidal and poloidal field coils are excited. From the spatial distribution of the acceleration (deformation), vibration mode may be obatained. On the other hand, the vacuum vessel is divided into finite elements, and eigen vector (eddy current mode) is calculated from circuit equation on th eeddy current potential. Concerning the same finite elements, eigen vector (vibration mode) is calculated from dynamic equation on the deformation. Transfer matrix between both eigen vectors is calculated. Therefore, the measured deformation is expanded into vibration modes, each vibration mode is transformed to eddy current mode using the inverse transfer matrix, and the eddy current is inferred from the superposition of the eddy current modes.

Figure 1 shows frequency spectrum of horizontal vibration, which was measured with an acceleration pickup from t = 5.49 to 5.50 sec on port MH14 on the equatorial plane, when toroidal field coil and poloidal field coil PF17 were excited[1]. The power supplies to both coils are composed of 2-fold 3-phase full-wave phase-controlled thyristors. Since the ripple frequency of the output voltage and current is 2 x 3 x 2 x 60 Hz = 720 Hz, the first peak of the spectrum corresponds to the ripple frequency.

Figure 2 shows nodes of filament currents, which approximate the eddy currents in the vacuum vessel. The resistance and inductance are calculated from each cross-section and the circumference. Figure 3 shows low-order (long time-constant) eddy current distribution in the vacuum vessel, which was calculated with EDDYCAL (JAEA). The long-time-constant eddy current flows mainly in the outboard of the vessel.

In summary, the number of acceleration sensors needs increased to measure the vibration profile (mode). The second peak of the frequency spectrum should be studied. It is a problem how many modes should be taken to consider the eddy current in the inboard of the vacuum vessel. The vibration mode and transfer matrix are to be calculated with CASKET (JAEA) on the same finite elements, which are the same as those in eddy current mode calculation.

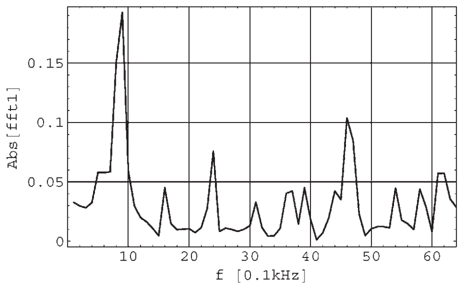

Fig. 1: Frequency spectrum of vibration at t = 5.5 s of shot number 1008, in which TF coil and PF17 coil are energized.

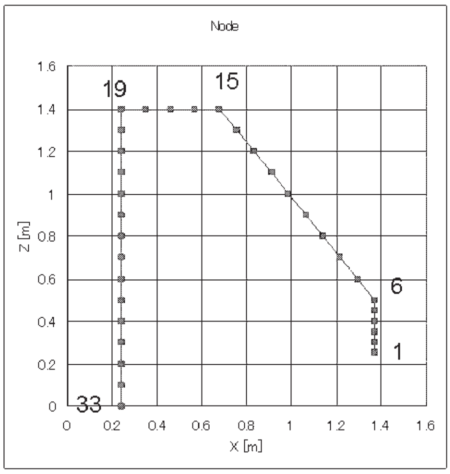

Fig. 2: Node coordinate of filament current.

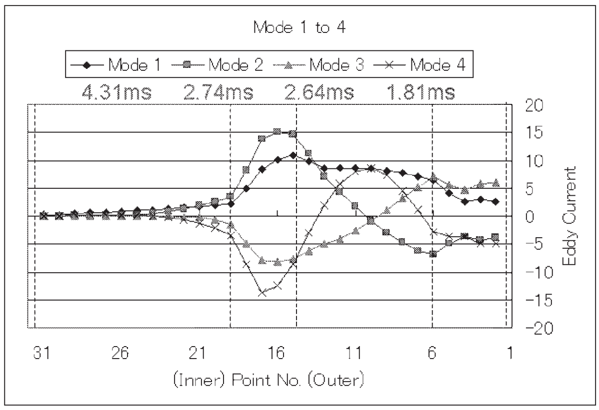

Fig. 3: Low-order (Large time-constant) eddy current distribution in vacuum vessel, which is calculated with EDDYCAL (JAEA).

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1) S. Naitou, K. Nakamura, K. Tokunaga, M. Hasegawa, M. Tomoda, S. Matsufuji, Y. Kojima, et al., Proc. 12th Annual Meeting of JSPF-Kyushu, Okinawa and Yamaguchi Branch, Kyushu Univ. (2008) P22.