Chapter 2
Coupling Mechanism

Abstract An EMAT consists of a coil to induce dynamic electromagnetic fields at the surface region of a conductive material, and permanent magnets (or electromagnets) to provide a biasing magnetic field. An EMAT configuration depends on the modes of elastic waves to be excited and detected. Optimum design of an EMAT requires understanding the coupling mechanism of energy transfer between the electromagnetic and elastic fields. This is a long-running topic and many studies appeared (Thompson (1977, 1978, 1990); Kawashima (1976, 1985); Il'in and Kharitonov (1981); Wilbrand (1983, 1987); Ogi (1997); Ogi et al. (2003); Ribichini et al. (2012)). This chapter presents the comprehensive analysis on physical principles of EMATs.

Keywords Eddy current · Liftoff · Lorentz force · Magnetostriction · Piezomagnetic constants · Theoretical calculation

2.1 Background

Previous studies revealed that three mechanisms contribute to the coupling: (i) Lorentz force mechanism caused by the interaction between eddy currents and the static magnetic flux density, (ii) magnetization force mechanism between the oscillating magnetic field and the magnetization, and (iii) magnetostriction mechanism by the piezomagnetic effect. The Lorentz force mechanism arises in all conducting materials, while other two appear only in ferromagnetic materials. For nonmagnetic metals, therefore, the Lorentz force mechanism explains the transfer with an EMAT (Gaerttner et al. 1969). The coupling is rather complicated for ferromagnetic materials. Thompson (1978) studied the field dependence of the guided-wave amplitude in ferromagnetic thin plates and derived a theoretical model

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