EMATs For Rail Inspection?

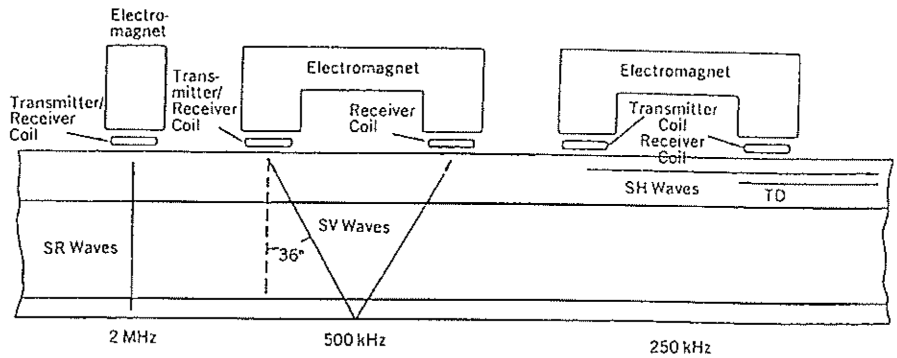

Figure 1 — Schematic of EMAT beam geometry

Rail flaw inspection is another track maintenance task that continues to be supported by ongoing research activities. One major thrust in this research has been toward the enhancing of conventional rail flaw inspection equipment, particularly through improved inspection strategies. (See *Tracking R&D, RT&S* January 1987; December 1985; July 1985).

Another research activity is that of developing improved inspection technology; it will be discussed here.

EMAT equipment

Recent research includes the development of a new type of ultrasonic inspection equipment: the *electromagnetic acoustic transducer* or EMAT. A recent report[1] describes a series of laboratory and field tests in which EMAT technology has been applied to the inspection of internal rail defects.

Electromagnetic acoustic transducers can generate ultrasonic waves within a thin surface layer of the rail steel. The equipment accomplishes this by generating a bias magnetic field and employing a set of pulsed wire coils. This differs from the more conventional ultrasonic probes, which generate their ultrasonic beams within the transducer and transmit these to the rail through a couplant. By producing their ultrasonic waves within the rail head itself the EMATs do not require direct physical contact with the rail. Thus EMATs are non-contact transducers, and consequently are more tolerant of non-ideal rail surfaces. Such surfaces can occur because of surface pitting, corrosion, or when there is a film of oil or grease on the head of the rail.

The recent research activities referred to have addressed three types or models of ultrasonic waves (see Fig. 1). These waves, which are developed by separate EMAT systems, are the *shear vertical* (SV), *shear radial* (SR), and the *shear horizontal* (SH). The SV wave is similar to that produced by conventional ultrasonic probes. However, its angle of propagation can be readily changed by altering the frequency of the transmitter pulse. As shown in the figure, the SR wave produces a wave that propagates straight down, that is in a direction 0 degrees to the surface normal. The SH wave, in turn, propagates in a direction parallel to the surface of the rail, but occurs within the rail head. This type of wave cannot be easily generated by conventional piezoelectric transducers. Still, it does offer a potential for improved detection of transverse defects in the head of the rail.

Advantages	Disadvantages
No contact is required	Low efficiency
• Predictable coupling	
• Nonideal surface tolerance	Large magnet required
• Potential high speed	
• Temperature variation tolerance	Limited resolution
• No water path delay	
• No wheel reverberation/noise	Sensitive to lift-off
SH elastic wave at 90° possible	
• Sensitive to TD, VSH	New technology
No refractive index effect	• Complex electronics
	• Limited field experience
SR elastic wave at 0° possible	
• Very sensitive to VSH	

Table 1 — EMATs for rail inspection

Advantages and disadvantages

Preliminary laboratory and field tests[1] in which 83 defects and 16 non-defective conditions were examined, revealed a high degree of detection and characterization of rail flaws. Only three incorrect measurements were noted.

Several disadvantages were found by the investigators with regard to the EMAT systems tested, and were noted in this report. One is an inefficiency in generating ultrasonic energy in comparison to the traditional piezoelectric transducers. Thus, these systems require a large bias magnet and additional electric power. Moreover, they have limited resolution, and are sensitive to any vibration in the gap between the EMAT probe and the head of rail.

Since the EMAT systems in these tests were low frequency types ranging from 250 kHz for the SH waves to 2 MHz for the SR waves, this resulted in lower spacial resolution, which can cause a measurement problem at the rail ends, and in a sensitivity to acoustical noise. Consequently, the operating speeds for these prototype EMATs are limited to 2 to 3 mph for the SH EMAT, and up to 8 mph for the SR EMAT. The test report[1] did note, however, that simulated speeds up to 30 mph were employed successfully by the EMATs under laboratory conditions.

On balance, the EMAT device represents a new rail inspection technology which must be carefully developed and introduced into any operating environment. Table 1 provides a more comprehensive listing of the advantages and disadvantages of the EMAT system. However, based on the preliminary research indicated, it would appear that EMAT technology offers the potential for improving the detection of internal rail defects. -

Reference:

1. Graham, L. G., and Martin J. F., "Ultrasonic Inspection of Railroad Rails by Electromagnetic Acoustic Transducers (EMATs)", Department of Transportation Report FRA/ORD 86/09, May 1986.