Wheel magnetizing system for high-speed railway track non-destructive testing and monitoring

A. Antipov[1], Anatoly Markov[2]

[1]Faculty of Physics, St.Petersburg State University, Russia, [1]NDT Facilities Dept., Radioavionica Corp., Russia

When evaluating the condition of the railway track, a testing speed is of great importance. This is due to operational features: if the testing speed is too low, delays in the movement of trains occur due to the need for the railway track inspection. Ideally, the testing speed should correspond to the usual speed of trains on a given section of the railway. Unfortunately, none of the currently used testing methods, for various reasons, does satisfy this requirement. In particular, when the railway track is monitored by the Magnetic Flux Leakage (MFL) method at high speeds due to the influence of eddy currents, the problem of insufficient depth of rail magnetization arises. So, when using a traditional U-shaped magnetizing system with an interpole distance of 0.8 m at a speed of 80 km/h, the penetration depth of the magnetic field into the metal is only about 4 mm, which is not enough to detect deep-seated flaws. In order to magnetize the rail more deeply, a longer exposure time of the magnetic field to the studied area is required, which makes it necessary to extend the distance between the poles of the magnetizing system. However, the possibilities to increase the interpole distance of a traditional U-shaped magnetizing system are limited. The presence of air gaps between the poles of a moving magnetizing system and a fixed rail increases the magnetic resistance of the circuit, decreasing the magnitude of the magnetic flux entering the rail, and a long massive magnetic core worsens the overall dimensions of the system. As a result, it becomes impossible to create a compact, light, and energy-efficient U-shaped magnetizing system with a large interpolar distance. For high-speed magnetic testing, we proposed a fundamentally different magnetizing system in which the magnetic field is injected into the rail through the wheels of the rolling stock. The axles of the wheelsets are used as magnetic cores of electromagnets, as a result of which a closed magnetic circuit is formed, including both rails. Direct contact of the magnetic poles, the role of which is played by the wheels, with the rails improves the energy efficiency of the system. The results of measurements of the magnetic flux in the rail, performed for a mobile flaw detector on a trolley with a distance between the axes of 3 m, show that to create a magnetization of the rail in a static state of 1 T, a combined magnetomotive force of electromagnets on both axes of 40 kAT is required. With the same magnetizing force of electromagnets, the traditional U-shaped magnetizing system provides similar magnetization, but with an interpolar distance of 0.8 m. Thus, with the same energy costs we managed to increase more than three times the distance between the poles. The greater interpolar distance allows increasing the penetration depth of the field into the rail, according to computer simulation, by about 3 times. As a result, the ability to detect defects at high speeds along the entire rail section improves significantly. The results obtained during the operation of mobile flaw detectors with wheel magnetizing systems show that at speeds of 40-60 km/h longitudinal and transverse cracks of the rail head are detected at depths up to 20-22 mm, which is more than 50% of the rail defects encountered. High stability and repeatability of the magnetic testing signals allows tracking the development of defects during repeated periodic inspection, which makes it possible to monitor the railway track condition. A further extension in the interpolar distance of the wheel magnetizing system opens up prospects for increasing the testing speeds to 120 km/h and higher.