Development of an Automated Inspection System for Root Attachment in Nuclear LP Turbine Rotor

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The turbine rotor in a nuclear power plant operates at lower temperatures than other types of power plants; however, it requires a significantly greater amount of steam and steam pressure to achieve comparable or higher power capacity. The consequent elevation in steam quantity and pressure necessitates a proportional expansion in the length and volume of turbine blades, culminating in an augmented size of the turbine rotor vis-a-vis power facilities with equivalent capacity in conventional power plants. The design lifespan of the turbine rotor is approximately 30 years, and it is designed to operate below the high-cycle fatigue limit, incorporating materials and manufacturing technology. However, cases of failure predicted to occur due to stress corrosion cracking (SCC) have been reported in the assembly parts of the low-pressure (LP) turbine rotor, specifically in the blade root attachment and rotor shaft. As steam passes through each stage of the rotor, the pressure and temperature of the saturated steam within the turbine decrease, typically undergoing condensation around the fourth stage. Additionally, a series of steam pathways, starting from the steam generator tubes through the moisture separator reheater, influences unintended fine metal particles that, in conjunction with the humid steam environment, create a corrosive environment around the turbine rotor's rear stages. Considering that most domestic nuclear power plants have been in operation for more than 20 years, the exposure of the LP turbine rotor to a humid environment suggests an increasing possibility and risk of damage due to SCC over time. In this study, introduce a standardized ultrasonic testing (UT) system based on stress concentration points for disk-type and solid-type turbine rotors, classified according to the manufacturing methods of nuclear power plant LP turbine rotors. The presented UT system has been optimized for in-service inspections of domestic nuclear low-pressure turbine rotors, focusing on reliability and standardization through 15 years of technological development and inspection experience. Additionally, a brief proposal for an advanced inspection method for the curved axial entry type root attachment, which undergoes LSB design changes due to power plant capacity expansion, is also introduced.