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05A-068

INSPECTION OF THIN COPPER HEAT EXCHANGER TUBES USING SQUID-NDE SYSTEM

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In recent years, the copper heat exchanger tubes for air conditionings have a thickness of less than 1 mm for better performances. During the process of thinning tubes, micro flaws have accidentally occurred on the surface of a tube. As for such thin tubes, even a shallow flaw only a few tens micrometer in depth will be a potential cause of a tube breakage in bending or flaring processes. At the present time, it is difficult by commercial eddy current testing system to detect such shallow flaws less than 50 micrometer in depth.

This study is aimed at developing a SQUID-NDE system for the inspection of micro flaws on thin copper heat exchanger tubes employing a high-Tc SQUID gradiometer and a Helmholtz-coil inducer. In the system, the high-Tc SQUID gradiometer was cooled at about 77K using a coaxial pulse tube cryocooler. As specimens, copper tubes 6.35 mm in outer diameter and 0.825 mm in thickness with artificial surface flaws several tens mm in depth were prepared. These flaws were made using an electric discharge machine. The specimens were inspected using the SQUID-NDE system. In the experiments, the tubes were moved by a motor through the inducer, which generated an excitation field to induce eddy currents circulating along the tube circumference. The gradiometer was set above the top of a tube with a lift-off 1.5 mm. The SQUID-NDE system could detect an anomalous magnetic response due to the flaw of 10 micrometer in depth with a good signal to noise ratio at a velocity of tube motion 32 m/min and with an excitation field of 15 micro Tesla at 3 kHz.

Keyword(s): SQUID, Copper heat exchanger tube, Eddy current, Micro flaw

05A-021

STRENGTH-BASED AND WAVE-BASED LIQUEFACTION CHARACTERIZATION

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Soil response to seismic loading and the associated infrastructure damage have been studied by many prominent researchers for more than 60 years. The underlying microscale mechanisms are relatively well known even though unexpected behavior and emerging phenomena are still being recognized and discovered. Thus, today's state of the art still reflects significant uncertainty; this is particularly the case in deformation prediction in both horizontal and vertical directions. The purposes of this study are to analyze post liquefaction shear strength and to explore the potential use of wave-based techniques to monitor liquefaction and post liquefaction response. The first part presents a detailed analysis of triaxial test results to identify robust strength criteria. The second part documents experimental data on the characterization of liquefaction events with P-wave reflection imaging and S-wave trans-illumination techniques. The relevance of multiple coexisting temporal and spatial scales is highlighted. The following results are obtained: 1) the post liquefaction shear strength can be estimated within the framework of critical state soil mechanic, where the monotonic stress path is an upper envelop of the cyclic stress path; 2) the P-wave reflection images obtained before and two days after liquefaction represents the depression of the soil-water interface and the upper and lower surface of the silt layer provide insightful information about the effect of liquefaction and post liquefaction densification not only at the surface but in the subsurface; 3) excess pore pressure migration from liquefied deep layers may cause zero-effective stress in dilative shallow layers; 4) multiple liquefaction events may take place in a given formation for a given excitation level. P-wave reflection is a valuable tool to monitor the evolution of subsurface structures such as soil layers during liquefaction and S-wave trans-illumination technique can be used to yield a comprehensive picture of the spatial evolution of liquefaction.

Keyword(s): Liquefaction, Multiple liquefaction, Pore pressure, Post-liquefaction, P-wave reflection, S-wave trans-illumination