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# Study of Deep Subsurface Fatigue Degradation in Rolling and Sliding Tribocontacts under Variable Loading

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## Abstract

Abstract: The paper evaluates the effectiveness of soft gas nitriding of alloyed structural steels 38KhMYuA, 38KhN<sub>3</sub>MA, and 38KhN<sub>3</sub>MFA, used in highly loaded gear transmissions, and establishes the limits of application of thin nitrided layers in terms of contact fatigue. The studies are conducted after nitriding at a temperature of 580°C and a duration of 7 hours using microhardness testing, layer-by-layer chemical analysis by high-temperature gas analysis, X-ray structural analysis, and contact fatigue testing of rollers simulating rolling and sliding conditions, typical for helical gearing. It is found that soft nitriding ensures the formation of a hardened layer 0.18–0.25 mm thick with a microhardness of 4.8–5.5 GPa while maintaining a ductile core with a hardness of 240–260 HB. It is shown that under elevated contact stresses, failure of nitrided samples initiates in the subsurface layers and develops via a deep contact fatigue mechanism, accompanied by the formation of deep spalling and a so-called white etching area. The results obtained demonstrate the limited effectiveness of thin nitrided layers under high contact loads and point to the feasibility of using materials with thicker hardened layers (0.8–1.2 mm) or design and technological solutions aimed at reducing contact stress and increasing the service life of gears. © Allerton Press, Inc. 2026.

## Abstract

Author keywords

Indexed keywords

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## Author keywords

contact fatigue; deep spalling; hardened layer; microcracks; nitriding; rolling contact; slip; stress state; tribocontact; variable loading

## Indexed keywords

### Engineering controlled terms

Building materials; Etching; Failure (mechanical); Fatigue testing; Hardening; Helical gears; Rolling; Spalling; Stress analysis; Structural analysis; Thermal fatigue

### Engineering uncontrolled terms

Contact fatigues; Contact Stress; Deep spalling; Hardened layers; Nitrided layer; Rolling contacts; Slip; Stress state; Tribocontact; Variable loadings

### Engineering main heading

Microhardness; Nitriding

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