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SHOT-PEENED HIGH-MOLY GEARS

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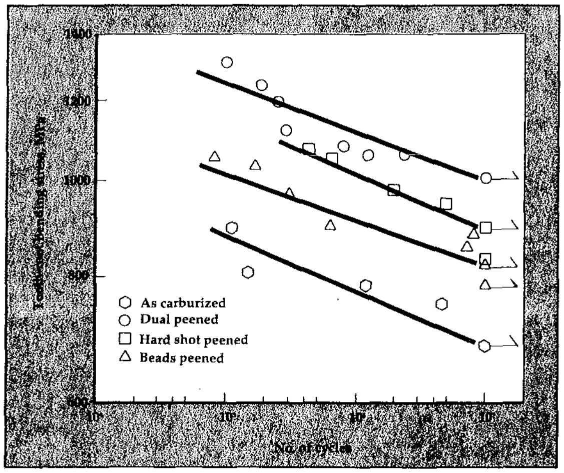
Japanese automakers are using a "dual peening" method to boost compressive residual stresses (and, consequently, the fatigue durability) of transmission gears and other auto parts, reports Daido Steel Co. Ltd. In the process, carburized parts are first peened at a high intensity using large steel shot ("hard shot peening"), and then peened at a low intensity using smaller shot ("beads peening").

Typical peening conditions:

- Hard shot peening: Almen arc height (peening intensity), 1 mm (0.04 in.); shot diameter and hardness, 0.8 mm (0.03 in.) and 700 HV; peening time, 90 s.



Various peening methods can be used to increase the fatigue properties of carburized gears. These Daido Steel Co. Ltd. data show that dual peening, a two-step combination of hard shot peening (high intensity, large steel shot) and beads peening (low intensity, smaller shot), provides the greatest improvement for these SCM420 (AISI 4118) alloy steel parts.

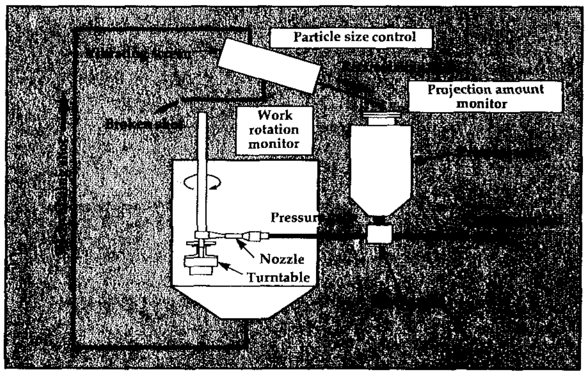
- Beads peening: Almen arc height, 0.05 mm (0.002 in.); shot diameter and hardness, 0.1 mm (0.004 in.) and 800 HV; peening time, 15 s.

Dual-peened gears have the highest fatigue strength, followed by hard-peened and beads-peened parts. In the two-stage process, explains Daido, beads peening increases the part's already high fatigue strength by increasing the level of residual compressive stresses at and just beneath the surface.

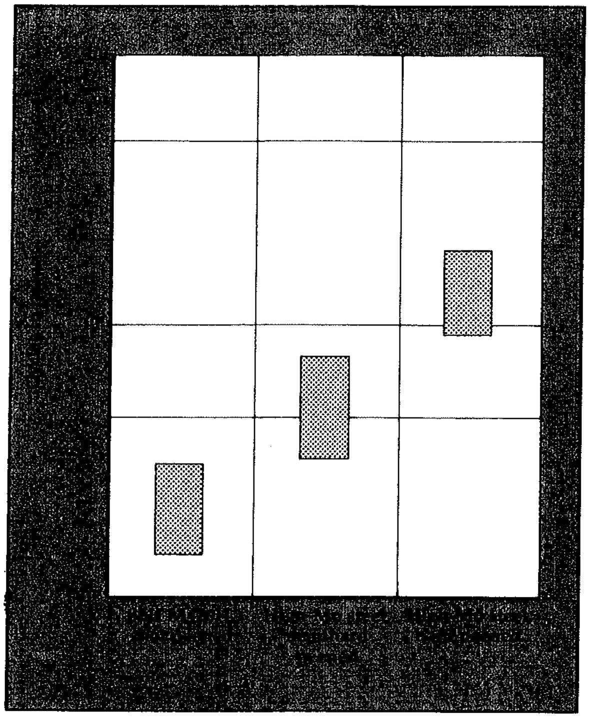
Diado also claims that its DSG1 alloy steel (0.2 C, 0.05 Si max, 0.07 Mn, 0.015 P max, 0.015 S, 1 Cr, 0.4 Mo) is ideal for peened parts because it provides better fatigue properties, and reduces the surface roughening and toughness decrease associated with peening of conventional grades, such as SCM420 (AISI 4118). This steel, which is the most widely used carburizing grade in Japan, has more silicon (0.24%), less molybdenum (0.15%), and no maximum specified phosphorus content.

Surface roughening by peening media is accelerated by carburizing anomalies, such as the intergranular oxidation which can occur at prior austenite grain boundaries during carburizing in an endothermic atmosphere. The process depletes oxide-forming alloying elements adjacent to the grain boundary, which results in a local decrease in hardenability and promotes the formation of soft transformation products on quenching. Less silicon in DSG1 helps reduce intergranular oxidation.

The decrease in toughness of peened parts is caused by the work hardening associated with decomposition of retained austenite to martensite. Case toughness of peened DSG1 is improved via compositional modifications that allow more austenite to be retained following carburizing. In particular, the level of phosphorous (a grain boundary embrittling element) is reduced and limited, and the molybdenum content is increased (which also helps decrease intergranular oxidation).



Schematic of the facility at Nissan Motor Co. Ltd. for hard shot peening of high-molybdenum steel transaxle gears. A compressed-air nozzle provides the required high shot velocities. An arc height of 0.95 mm (0.04 in.), and 0.6-mm (0.02 in.) diameter, 60 HRC shot are used. Impeller-type systems are suitable for lower intensity semihard and conventional peening.



Results of durability tests of shot-peened final gear sets for Nissan transaxles. Input torque: 600 N-m (440 lbf-ft). Gears made of a new high-molybdenum (0.4% Mo) steel and peened using the hard or semihard technique outperformed those of conventional Ni-Cr-Mo steel (SNCM420H) peened at a normal intensity. The Japanese automaker also is using 0.8% Mo steel.

Diado tests show that peened DSG1 has better fatigue properties than peened SCM420, regardless of the peening method used. The gain is said to be caused by higher surface hardness and larger compressive residual stresses, which result from a carburized layer free of intergranular oxidation.

Tough transaxle gears: Hard-shot-peened, high-molybdenum steel gears already are being used in manual transaxles for passenger cars made by Nissan Motor Co. Ltd. Their fatigue strength is said to be 1.6 times higher than that of conventional transmission gears. Peening parameters: Almen arc height, 0.95 mm (0.04 in.) min; shot diameter and hardness, 0.6 mm (0.02 in.) and 60 HRC min; coverage, 300% min. Peening is performed using a compressed-air nozzle because conventional centrifugal-projection equipment could not reliably provide the required high shot velocities.

Two steels are used, which differ primarily in their molybdenum content. Both contain 0.18 C, 0.1 Si, 0.7 Mn, 0.01 P, 0.015 S, and 1 Cr. The steel having 0.8% Mo is used for the transaxle final gear set (mainshaft and ring gears) for 2-liter (2 L), four-wheel-drive vehicles. The 0.4% Mo steel is used for gears for 1.8 to 3-L, front-wheel-drive cars. The high-molybdenum grades were selected from among those recently developed by Japanese steelmakers such as Daido and Kobe Steel Co.

For automatic-transaxle gears for front-drive, 1.5 to 1.8-L passenger cars and 1.8 to 2-L commercial vehicles, Nissan uses the 0.4% Mo steel and a "semihard" peening technique. Peening conditions: Almen arc height, 0.7 mm (0.03 in.) max; shot diameter and hardness, 0.8 mm (0.03 in.) and 53 HRC; coverage, 300% min. Conventional impeller-type machines are used. According to Nissan, the major difference between semihard peening and conventional peening is the use of a lower arc height (0.4 mm, 0.02 in.) in the latter method.

The conventional carburizing steels typically used for these gears are SCr420H (0.2 C, 0.25 Si, 0.7 Mn, 0.025 P, 0.02 S, 1 Cr) and SNCM420H (0.2 C, 0.25 Si, 0.7 Mn, 0.025 P, 0.02 S, 1.6 Ni, 0.5 Cr, 0.15 Mo).

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Bibliography: Copies of the papers discussed in this article can be ordered from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001; Tel: 412/776-4841; Fax: 412/776-5760.

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• "Development of High Strength Transmission Gears," by Y. Okada, T. Matsumoto, A. Kawaguchi, T. Tanaka, and K. Nishio, Nissan Motor Co., Ltd. (SAE Paper 920761).