QUESTEK® INNOVATIONS LLC

FERRIUM® C69

Case-Hardened Gear and Bearing Steel with Ultrahigh Surface Hardness

Overview of Ferrium® C69 Properties

Temper	YS (ksi)	UTS (ksi)	El (%)	Core Hardness (HRC)	Case Hardness (HRC)
Overage	*180*	*230*	*17*	*48-50*	*65-67*

Materials by Design® Objective

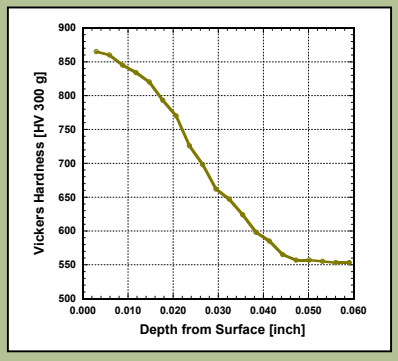
QuesTek's design objective was to create a unique steel that combined maximum case hardness with a tough ductile core, promoting high wear and contact fatigue life. The alloy was designed to reduce the weight of aerospace gears by as much as 50% in high power density transmission systems.

Description

Ferrium® C69 is a member of a new class of carburized secondary hardening gear and bearing steels that utilize an efficient M_2C precipitate strengthening dispersion. *Ferrium* C69 combines a tough ductile core with an ultra-hard carburized case that can achieve hardness levels of up to 67 HRC, promoting high wear and contact fatigue life. *Ferrium* C69 is the product of an ongoing research and development program with the objective of reducing gear weight by as much as 50% over conventional carburized gear steels. Applications are primarily high power density transmission systems including helicopters, heavy machinery, racing, and manufacturing.

Advantages

Ferrium C69 possesses surface properties superior to those of conventional gear steels yet it provides a flaw tolerant core. These surface properties allow either higher contact stresses at an equivalent life, thus reducing the gear size, or significantly longer wear life at the same contact stress when compared to existing carburized gear steels. Thermal resistance is a consequence of the high stability of the strengthening carbide and ensures gear hardness will be maintained to temperatures in excess of 850ºF. High hardenability allows gas cooling, which reduces the distortion that normally results from quenching. *Ferrium* C69 can be heat treated to an intermediate case hardness of 60 HRC, providing grindability equivalent to current gear materials, and then tempered to 67 HRC case hardness with extremely low distortion.



Processing

Ferrium C69 was designed for high-temperature carburizing. This allows solution heat treatment to be combined with the carburizing treatment and *Ferrium* C69 is therefore quenched directly from the carburizing temperature. After quenching to room temperature *Ferrium* C69 is subjected to liquid nitrogen immersion to assure a complete martensitic transformation. A final temper at 875ºF (468°C) produces an ultrahigh-hard surface with excellent wear resistance. *Ferrium* C69 has excellent thermal resistance up to the temper temperature. If desired, *Ferrium* C69 can be nitrided to increase the surface hardness to near 70 HRC (1100 HV). Final shot peening is recommended for superior fatigue and wear performance.

For additional information regarding QuesTek's Ferrium C69 contact ***Charles J. Kuehmann*** *by e-mail or call 847.425.8222.*

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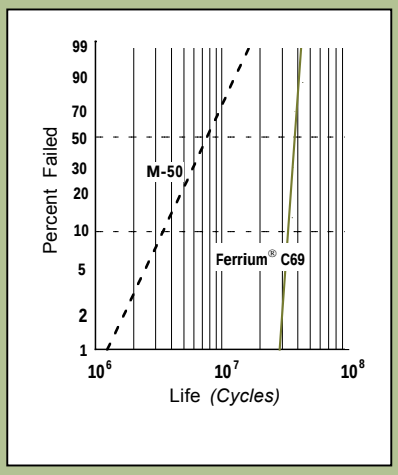
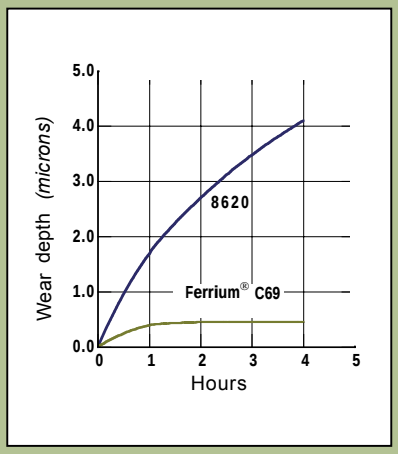
FERRIUM® C69

Case-Hardened Gear and Bearing Steel with Ultrahigh Surface Hardness





Case carburizing produces a gradient in the volume fraction of the M_2C carbides and results in an increase in hardness and surface residual compressive stress. The efficiency of the M_2C strengthening response allows this class of steels to achieve very high surface hardness with very low carbon content. Thus, this class of steels has the ability to achieve very high surface hardness without the formation of detrimental primary carbides.

Rolling Contact Fatigue

Fatigue properties of *Ferrium* C69 are compared to standard M50. The fatigue test is a standard three-ball on rod NTN RCF test using a contact stress of 786 ksi. The results shown to the left, demonstrate that *Ferrium* C69 exhibits a longer fatigue life at a given failure rate (or, conversely, a lower rate of failure at a specified fatigue life) than alloy M50. The data suggest that at a failure rate of 10%, the fatigue life of *Ferrium* C69 is more than an order of magnitude longer than that of M50.

Wear

The test results from a Falex gear wear simulator are shown. A dramatic reduction in wear rate is demonstrated by the advanced *Ferrium* C69 alloy over that of standard commercial grade AISI 8620. Whereas wear depth for *Ferrium* C69 appears to level off in the submicron range after approximately one hour of initial wear, the wear depth for gears made from conventional AISI 8620 steel (through hardened to 56-58 HRC) is greater after one hour and continues to increases with time.

Product Forms

Ferrium C69 is manufactured in typical ingot, bar and billet forms.

Other

US Patent Number 6,176,946 B1.

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