

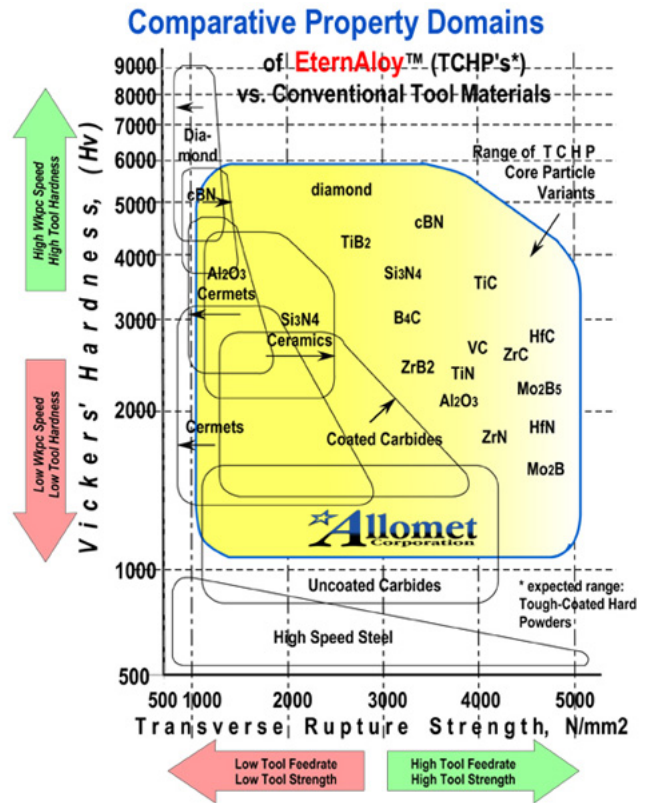
TCHP vs. Conventional Material Mechanical Property Ranges

Materials have always been either hard or tough, not both. No longer.

EternAloy™ promises new paradigm combinations of light weight, low coefficient of friction, and resistance to shock, chemical and abrasive wear, and heat failure. TCHPs, when sintered, can combine the highest combinations of toughness (4000-5000+ MPa), hardness/wear resistance (3000-5000 Vicker's Hv30), and light weight (5-10 g/cc) ever known. This is achieved by producing a homogeneous "core-rim" structure of an unprecedented 50-80 volume% of the most wear resistant refractory core materials known in a tungsten carbide matrix support structure with toughness and strength ultimately exceeding that of WC-Co substrates.

TCHP products are expected to have a higher range of fracture toughness than their conventional counterparts because (1) the WC coatings evenly space the hard particles (avoiding crack-propagation zones), (2) the perfect atom-by-atom distribution of Co (impossible by mixing) appears to suppress grain growth, (3) Co concentrations can be increased without trading off wear resistance provided by the core particles (not WC), and (4) because thin WC coatings will leverage nanoproperties.

Allomet and its development partners have demonstrated the feasibility of coating and sintering TCHPs while retaining the targeted uniform "core-rim" structure (contiguous WC-Co ligaments around the core particles) in TCHP variants of Al₂O₃-WC-Co, TiC-



WC-Co, TiN-WC-Co, SiC-WC-Co, TiB₂-WC-Co, B₄C-WC-Co, and diamond-WC-Co. We have already demonstrated mechanical properties equal or superior to those of carbides, ceramics, cermets, and cBN-diamond compacts, and are developing cubic boron nitride (cBN) variants.



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The major breakthrough of TCHPs was proving that cobalt does NOT come close to penetrating the protective WC coating during sintering. This avoids dissolution and chemical alloying of WC and Co with many core particle materials such as TiN. (Chemical involvement of TiN would greatly reduce the maximum toughness of the matrix phases to that of conventional brittle cermets).

The second major breakthrough was demonstrating that TCHP powders can readily be pressed and liquid-phase sintered or sinter-HIPped like ordinary carbides in commonly-available equipment. During liquid-phase sintering, 85-95% of the protective WC coating remains as solidus to form preferred nucle-

ation and reprecipitation "rim sites" of WC during cooling, reforming and maintaining the desirable core-rim structure after sintering. This has many advantages in developing a "chemically tough" substrate while assuring "mechanical toughness" through coating and particle uniformity and homogeneity that is inherently superior to that of any mixed powders.

Combined increases in hardness and fracture toughness enable combined increases in speeds *and* feeds, reduced cutting energy, and operation without cutting fluids. This results in major improvements in productivity, energy consumption, environmental and health conditions, and uniformity and conformance to specification of machined parts.