T&SD Technology & Solutions Division

Effect of Machining Procedures on the Strength of Ceramics for Advanced Diesel Engine Applications

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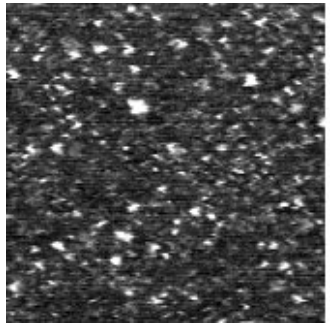
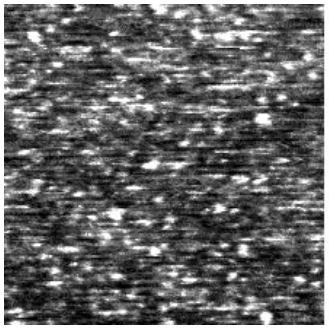
Abstract

Valve train components in heavy-duty engines operate under high stresses and temperatures and in severely corrosive environments. Silicon nitride (Si_3N_4) has been identified as a possible solution material for intake and exhaust valves due to its high corrosion and oxidation resistance and high strength and hardness at elevated temperatures. These properties allow for decreased wear rates, higher fuel efficiency, and enhanced reliability, which are all leading concerns for the current on-highway truck engines. It was determined through a series of bench-rig tests on Si_3N_4 (SN235P material) intake and exhaust valves that the surface finish of the material has a direct correlation to the lifetime of the valve. Therefore, an optimization study was performed to determine a cost-effective machining process to improve the optimal performance and extended life and reliability of advanced ceramic components.

Laser Image *Optical Image*



Wheel Grinding Finish 1

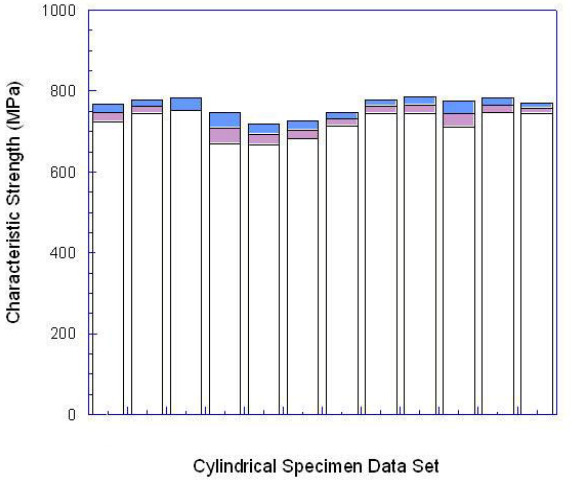


Wheel Grinding Rough 2

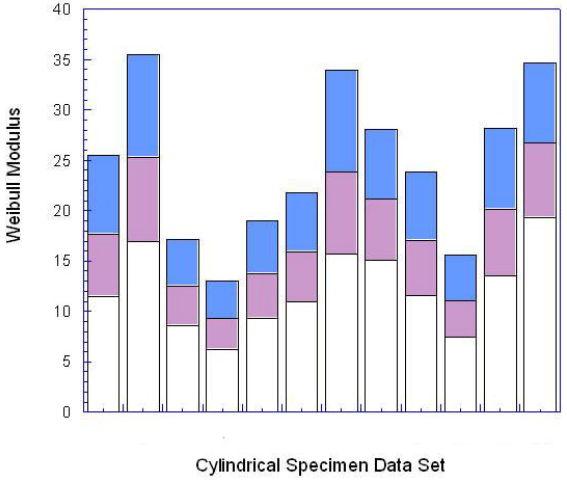
OAK RIDGE National Laboratory

CATERPILLAR®

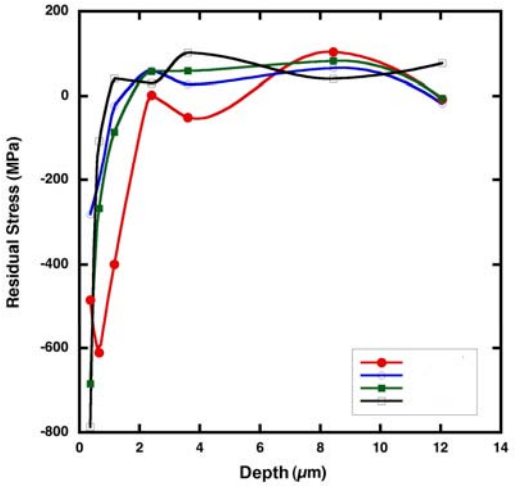
Characteristic Strength



Weibull Modulus



Residual Stress



- Characteristic strength is independent of surface finishing technique
- Finishing technique has a major effect on the probability of failure and Weibull Modulus
- Specimens with the highest Weibull Modulus had high compressive residual stresses
- Theory:
  - Higher compressive residual stresses inhibit crack initiation
  - Finished machining shears the near-surface material more than rough grinding, creating more surface deformation and a potentially more uniform distribution of surface flaws, which leads to an increase in the Weibull Modulus.