Ceradyne Increases its Range of Products to the Automotive Industry

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Ceradyne recently acquired two new businesses; Quest Technology LP based in San Diego, California and ESK Ceramics GmbH & Co KG based in Kempten, Germany.

These two companies add complimentary products in a number of industrial, engineering, electronic and medical areas, some of which widen our portfolio of products and solutions offered to the automotive world and suppliers to the automotive business.

Cam Rollers for Valve Train and Fuel Systems

Ceradyne continues to explore new engine environment applications for Ceralloy® 147-31N Silicon Nitride, particularly where increased fuel injection pressures have given rise to contact stresses beyond those sustainable between two contacting steel components.

Ceradyne's Ceralloy® 147-31N Silicon Nitride Cam Rollers and Rolling Elements

Ceralloy® 147-31N Silicon Nitride is a strong, tough, lightweight, wear resistant ceramic material with unique tribological and physical properties (low weight combined with high strength and contact fatigue resistance) that allows its use under high contact stress, often exceeding 300 GPa.

To understand the benefits of Ceralloy® 147-31N one must first understand the failure mode of metal cam rollers. A metal cam roller system for heavy-duty diesel engines consists of a steel roller with a bronze pin. The metal roller runs against a steel cam. Failure begins as the bronze pin wears. The wear is accelerated because bronze is a relatively soft metal. The wear of the pin makes it more difficult for the metal roller to rotate. This then results in skidding against the cam lobe and ultimately scuffing, micro welding and galling of both the cam roller and the cam lobe. Fatigue failure will follow. Higher contact stresses particularly those generated at the fuel injection cam operating unit pump injectors, will accelerate the process.

The Ceralloy® 147-31N based cam roller solution consists of a silicon nitride cam roller and a hardened steel pin. The use of a harder pin material eliminates the root cause of failure in the metal cam roller system (the bronze pin). The system eliminates the problem of wear and galling of the metal roller. Silicon nitride has a very low coefficient of friction versus steel (approximately 0.05 lubricated) and a very low mass (3.2g/cc, 60% lighter than steel) which gives the silicon nitride cam roller a lower moment of inertia, making it easier to rotate against the cam, reducing the chance of skidding against the cam lobe.

Silicon nitride is also very compatible with steel from a wear standpoint. The measured wear of a steel pin in a silicon nitride cam roller system is over 95 percent lower than the corresponding wear with a steel roller and bronze pin. No micro welding will occur because of the dissimilarity of materials. Silicon nitride cam roller systems eliminate the major failure modes of metal cam rollers, and are proven to reduce cam lobe wear and increase cam lobe life, even at higher contact stresses. Additionally, silicon nitride has a better rolling contact fatigue life than bearing steels, resulting in a system with improved reliability.

The reliability of silicon nitride has been demonstrated by the fact that over three million cam rollers are currently in engines with no reported field failures caused by material related problems. This excellent mechanical reliability is due to Ceradyne's unique processing techniques that result in no porosity on wear surfaces. The absence of porosity eliminates the major cause of contact fatigue failure.

Ceralloy® 147-31N Silicon Nitride components produced by Ceradyne are currently in regular production for the following applications:

- Cam Roller for Unit Injector Fuel Pumps for Class 8 Diesel Engines
- Cam Rollers for Intake and Exhaust Valves for Class 8 Diesel Engines
- Rollers for Common Rail, and other High Pressure Fuel Pumps for Light Duty Diesel Engines, as well as Very Large Heavy Duty Marine and Locomotive Diesel Engines

The cost of silicon nitride components is significantly higher than steel components. Ceradyne has addressed and continues to address this by minimizing the cost of raw materials through the use of its unique Sintered Reaction Bonded

Silicon Nitride processing route. This, combined with improvements in our continuous and semi continuous ceramic processing and grinding procedures, has reduced the cost difference between silicon nitride and metal. Improvements will continue with our new, specially built manufacturing facility in Lexington, KY.

Most importantly, silicon nitride components are justified on the basis of the life cycle and performance improvements compared to metal components. For example, engine life costs can be reduced because problems related to fatigue in metal rollers or cam lobes during the warranty life of an engine do not arise when the ceramic alternative is used. Continued pressure on manufacturers to offer customers improved warranties make this even more relevant.

High Friction Coatings for Components and Shims

EKagrip® is a friction enhancing coating used at joints in powertrain, transmission, suspension and drive applications providing high friction joints transferring high torque whilst saving overall construction mass. The products are available in various foil, washer and shim forms as well as direct coatings. They are unaffected by typical in-engine environments and can be re-used, easing dismantling and re-assembly.

When friction joints are designed, physical parameters such as overall size and surface pressure usually can only be varied within a tight window. Load transmission capability in friction joints is thus limited by the friction coefficient of the mating materials, but many applications require higher levels of power transmission. Therefore, new ways of enhancing power transmission capability are necessary. One approach is to apply a nickel diamond coating either to the actual parts of the joints or to friction foils for installation in the joint. This can increase load transmission capacity by up to 300 percent.

Especially in the automotive industry, there is a general move toward compact, lightweight designs that must nevertheless be totally reliable. Typical applications are central bolt designs in crankshaft and camshaft applications, continuously variable timing, and balancer shaft modules. The demand for maximum power density; i.e., the transmission of ever-greater forces and torque in increasingly compact designs, poses a major challenge to engineers. In friction joints, the given coefficient of static friction imposes definite physical limits on power transmission capabilities. These limits can be overcome with friction-enhancing coatings.

EKagrip® nickel diamond coatings consist of an electroless nickel matrix in which a specified quantity of diamond particles of defined size is co-deposited. These coatings can be applied either to the joint compo-

DDC Series 60 Rocker Arm Assembly with Ceradyne's Ceralloy® 147-31N Silicon Nitride Cam Roller

nents directly or to thin foils or shims for installation in the joint. After coating, the parts are heat-treated to relieve inherent tensile stresses and to impart sufficient diamond retention strength. Assembly; i.e., applying the bolt preload on a crankshaft with a central bolt design, causes the diamond particles to press into the opposing surface of the counterpart. As a result, a micro scale form fit is created between the base part and its counterpart. The key parameters influencing the extent of micro scale

ESK's EKagrip® nickel diamond coatings can be applied to joint components directly or to thin foils or shims.

form fit are the counterpart hardness, the counterpart surface roughness and the applied surface pressure.

EKagrip® friction coatings can transmit up to three times as much load as conventional systems and there is no need to modify the joint design. Now in production are a variety of engine applications mainly focusing on crankshafts, camshafts and balancer shaft modules. Several fastener applications are in test program status, and there are potentials in suspension, transmission and chassis applications.

Water Pump Seals

ESK Ceramics is manufacturing water pump seal faces from EKasic® silicon carbide. These are used in heavy-duty diesel engines.

Damage to a diesel engine is usually caused by breakdown of the cooling system, with resultant overheating of the engine and oil system. The water pump is, therefore, extremely important. The point at which the pump shaft passes through the pump casing is sealed with a mechanical seal, which is the critical component of the pump.

The seal ring material must satisfy a wide range of requirements. It must be resistant to wear and corrosion by the coolant, in this case water and antifreeze. The rings must also be extremely rigid and not deform at the high temperatures in the seal assembly since a running engine can produce coolant temperatures of over 100 °C (212 °F); the seal surfaces may even reach several hundred

ESK's EKasic® silicon carbide water pump seals are Used in heavy-duty diesel engines.

degrees Celsius at friction hot spots. Therefore the material must therefore have very high thermal conductivity to dissipate heat. Conventional seal faces can fail prematurely resulting in unscheduled maintenance and equipment downtime.
Ekasic® silicon carbide is and excellent thermal conductor and is extremely resistant to corrosion by hot water, and improves hydrodynamics even under strong frictional stress. EKasic® SiC is the material of choice for all tribological applications where poor lubrication is a risk. The use of Ekasic® silicon carbide has resulted in pumps that extend the engine's service life, allowing engine manufacturers to extend the warranty on their water pumps and engines.

For further information about these and other applications, please visit Ceradyne's web site at www.ceradyne.com or contact:

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