HIGH TEMPERATURE SOLID LUBRICANT MATERIALS FOR HEAVY DUTY AND ADVANCED HEAT ENGINES pdf

1: High Temperature Lubricants in Connecticut (CT) on www.enganchecubano.com

f DOE/NASAl NASA TM-1 High Temperature Solid Lubricant Materials for Heavy Duty and Advanced Heat Engines C. DeliaCorte and J.C. Wood.

Engine builders have grown increasingly concerned that many modern motor oils do not provide adequate wear protection for new engines, particularly those using flat-tappet cams. Duralec from Royal Purple is a complete line of high performance lubricants specifically developed for all of your fleet vehicle needs. Duralec Commercial products are Driving an older vehicle? Does it have at least 75, miles on it? HMX is synthetic motor oil specifically designed by Royal Purple engineers to minimize wear inside older Royal Purple HPS Series motor oil is specifically formulated to maximize performance and meet the demands of high performance engines and modified engines. Through technical partnerships with most prestigious Teams of car racing, MOTUL has developed a wide range of lubricants The reinforced synthetic base stock provides very Through technical partnerships with most prestigious Teams of car racing, MOTUL has developed a wide range of lubricants for Engineered to help enhance fuel economy. Mobil 1 Advanced Fuel Economy motor oils are designed to help deliver outstanding engine protection Low viscosity, advanced full synthetic formulaHelps increase engine efficiency and improve fuel economy, based on 0. Mobil 1 advanced full synthetic motor oils deliver exceptional performance and protection for vehicles of all ages and for all driving conditions â€" normal to extreme. These oils meet or exceed Mobil 1 Extended Performance is an advanced full synthetic motor oil that keeps your engine running like new and provides protection Mobil 1 Racing 0W and 0W were developed specifically for racing engines and are not recommended for street use. These high performance, fully synthetic formulas are specially balanced for friction Mobil Super High Mileage premium conventional oils offer outstanding wear protection under a wide variety of operating conditions, and they have been proven to fight sludge and help reduce Helps extend engine life for modern diesel engines even in severe applications. Mobil 1 Turbo Diesel Truck is a full synthetic heavy-duty performance diesel Valvoline All Fleet Plus engine oils are formulated to provide optimum performance in modern low emission diesel engines operating under a variety of service conditions including engines with Valvoline Daily Protection Motor Oil is specially formulated for the full life of the engine and comes in both multi-viscosity and mono-grade formulations. Valvoline Full Synthetic High Mileage with MaxLife Technology is specially formulated to provide maximum engine protection against friction and This top-grade product is expertly made in compliance with stringent industry standards to offer a fusion of a well-balanced design and high level of craftsmanship. Manufactured from industry-leading materials

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2: Dodge Ram Oils, Fluids, Lubricants â€" www.enganchecubano.com

@article{osti_, title = {High temperature solid lubricant materials for heavy duty and advanced heat engines}, author = {DellaCorte, C. and Wood, J.C.}, abstractNote = {Advanced engine designs incorporate higher mechanical and thermal loading to achieve efficiency improvements.

Department of Commerce, Port Royal Rd.. This report was prepared as an account of work sponsored by an agency of the united States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, com- pleteness, or usefulness of any information, apparatus, product, or process dis- closed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily consti- tute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. This approach often leads to higher operating temperatures of critical sliding elements e. For these applications solid lubricants must be considered. These applications include cylinder kits of heavy duty diesels, and high temperature Stirling engines, sidewall seals of rotary engines and various exhaust valve and exhaust component applications. The following paper describes the tribological and thermophysical properties of these tribo- materials and reviews the results of applying them to engine applications. Other potential tribological materials and applications are also discussed with particular emphasis to heavy duty and advanced heat engines. Improved efficiency results from higher thermal and mechanical loading and reduced emissions are achieved by higher combustion temperatures and reduced oil volumes in the upper cylinder region. Some of the most challenging tribological problems in advanced heat engines occur with components which are in contact or close proximity to the exhaust gas stream. Several solid lubricant coatings and powder metallurgy composites have been developed at NASA for high temperature applications. This film has potential application for ceramic exhaust valve guides and turbocharger components. Past applications, tribological and physical properties and feasibility for use in heavy duty applications will be reviewed. Finally, potential applications with particular emphasis on exhaust gas path components valves, turbochargers, etc. One discusses the use of PS coatings as cylinder wall coatings for Stirling engines Ref. Testing was conducted for 25 hours In another paper by Sliney Ref. In this review, Sliney concludes that PS coatings are appropriate candidates for gas turbine engine applications. In this application, the PS was coated over a thick thermal barrier layer of PSZ to protect the aluminum housing of the engine. The use of the PS coating allowed for significantly higher operating temperatures and increased efficiency. However, these materials do not provide the low levels of friction and wear exhibited by conventional liquid lubricants. These processing requirements add cost and complexity and often limit the widespread use of these materials. Specific numeric designations describe particular compositions. Differing compositions display slightly differing mechanical and tribological properties allowing the composition to be tailored for an application. For instance, PS, which contains more carbide matrix than PS, is slightly harder. To make the composites, the three components are physically blended then conventionally plasma sprayed to generate PS coatings or processed via a powder metallurgy route shown in Figure 1. Both the material system and powder metallurgy processing are covered under U. Figure 2 shows the microstructure of PM Table I gives the material composition and selected thermophysical and mechanical properties of the PM composite. Table II gives representative tribological data for both the coating and powder metallurgy composite. Table III gives thermophysical data needed for assessing engineering feasibility of using PM in an application. Even at elevated temperatures, well beyond the capability of bronzes and graphite, PM has useful strength for applications such as bushings and valve guides. These soft films prevent wear and reduce friction in sliding contact by providing an easily sheared layer between the rubbing surfaces. The load capacity of these soft

films is greatly enhanced by application over hard bearing substrates. Unfortunately, soft metal lubricants like silver and gold are relatively inert and bond poorly especially to ceramics Ref. To improve this bond, adhesion enhancing interfacial bond layers of active metals are used. For example, Reference 14 describes the use of titantium as a bond layer for depositing silver onto alumina for room temperature lubrication. The films are applied by first sputtering a A thick Cr bond layer onto an alumina test disk. Then a 2pm thick Au lubricant layer is applied. Films produced in this manner exhibit friction which ranges from about 0. Representative wear data is shown in Table V. Current efforts are underway to further characterize this lubricant system at alternate loads and sliding velocities and to evaluate it for us on other high temperature materials like superalloys. This characteristic makes these materials well suited to advanced heat engine components in the exhaust gas stream. Alternately valve guides could be made from PM and run against a conventional valve stem. Figure 5 illustrates a typical valve layout from a heavy duty engine along with lubrication possibilities. By u tilizin g solid lubrication in this critical area liquid lubrication could be minimized or removed entirely, reducing the potential for oil leakage into the exhaust stream and increasing emissions. Exhaust waste gate exhaust gas recirculation EGR and manifold heat riser valves are another application well suited to solid lubricants. This type of application, shown schematically in Figure 6, usually employs an oscillating shaft or plunger operating in a bushing. In these applications the duty cycle total sliding cycles or distance is lower than for valve guides but nonetheless critical because these components must be free to operate even after being stationary for long periods of time. Greases and conventional solid lubricants graphite, teflon, M 0 S 2 for example , lack the thermal stability required. Current designs rely on locating the sliding components in cooler areas but this approach can increase overall size and complexity. Incorporating high temperature solid lubricants can greatly simplify this application. PS has been successfully tested in a butterfly type turbocharger waste gate valve as a shaft lubricant coating. Over hours of engine testing have been successfully accumulated on a large heavy duty diesel engine. Alternately, valve stem bushings could be fabricated, via powder metallurgy processing, from PM Turbochargers, on the other hand, function well using circulating oil lubrication Ref. In addition, their high speeds up to , rpm appear to preclude the use of solid lubricants Ref. However recent developments in both foil gas hydrodynamic bearings Ref. Foil Gas Bearings are compliant hydrodynamic fluid film bearings which, use ambient air rather than oil as their working fluid. At speeds above about rpm, foil bearings generate a thin gas film which prevents sliding contact. However, during startup or shutdown and high speed overloading e. Foil Gas Bearings are generally useful at high speeds and light loads. This unique combination of capabilities has led to the successful use of foil bearings for turboaltemators and air cycle machines for aeronautics applications. Recent developments in both bearing technology and tribology have been made to overcome these problems and efforts are currently underway to demonstrate on "oil-free" foil gas bearing supported turbocharger. These improvements have been achieved through careful optimization of bearing geometry and analysis of the gas film using computers. With load capacities nearing psi at , rpm, foil bearings are now adequate to handle static and dynamic radial and thrust loading typical of medium size hp turbochargers. In this case, a wide range of PS compositions was applied to Inconel X journals and operated against Inconel X foils in a high temperature bearing rig. The bearings were then started and stopped for thousands of cycles. Friction and wear was periodically measured. Figure 7 shows some selected results. Several PS coatings performed satisfactorily even after start stop cycles. For a typical heavy duty truck engine turbocharger, to start-stop cycles are required. Therefore the PS type technology appears to be suitable. DellaCorte However, the increased costs associated with plasma spray coating and finish grinding necessitate alternate approaches to lubricating foil bearings in this application. In addition to the bearings, floating ring type seals to separate the compressor and turbine gas flows need lubrication. Fortunately, these seals are very lightly loaded and experience only small displacements reducing lubrication requirements. However a simple hard facing e. Cr or Cr 2 0 3 may be adequate. Figure 9 from Reference 18 shows a possible schematic design for a foil bearing supported turbocharger and the locations of the bearings and seals which require solid lubricants. The application of foil bearings in heavy duty engine turbochargers

would eliminate the need for oil lubrication, auxiliary cooling, and the potential for oil leakage into the intake or exhaust flow stream. Also, since gas foil bearings exhibit significantly lower frictional losses, approximately 3 hp vs. The application of solid lubricants to foil bearings for "oil-free" turbochargers has the potential to reduce emissions and increase fuel economy. Cost and rotor stability problems remain as critical issues for this application. Current research efforts supported by the Department of Energy, Department of Defense and NASA are underway to address these issues and demonstrate prototype hardware. These seemingly contradictory goals are being met with improved materials, higher operating temperatures and pressures and new approaches to lubrication problems. Solid lubrication plays an important role in achieving the design goals especially in the area of exhaust gas stream components. The attributes which make them viable lubricant candidates are wide operating temperature range, stability and versatility in application methods. Furthermore, using advanced solid lubricants for cylinder head applications and turbocharger bearings and seals enables "dry" running designs which may significantly reduce emissions and fuel consumption. More efforts, however, are needed to demonstrate these technologies and further develop them for commercial use. Patent 4,,, March 1, , Harold E. Patent 5,,, July 23, , Harold E. Sliney and Christopher DellaCorte Detroit, MI, February 26 - March 2, , pp. Detroit, MI, February March 2, , pp. Hotel Inter-Continental New Orleans. September , , Elsevier Science Publishers, B. Data table from reference 3. At least six repeat tests were run for each data point given.

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3: High Temperature Grease

Several novel solid lubricant composites and coatings designated PS/PM have been employed to dry and marginally oil lubricated contacts in advanced heat engines.

Structure-function relationship[edit] The lubricity of many solids is attributable to a lamellar structure. The lamellae orient parallel to the surface in the direction of motion and slide easily over each other resulting in low friction and preventing contact between sliding components even under high loads. Large particles perform best on rough surfaces at low speed, finer particles on smoother surfaces and at higher speeds. These materials may be added in the form of dry powder to liquid lubricants to modify or enhance their properties. Other components that are useful solid lubricants include boron nitride, polytetrafluorethylene PTFE , talc, calcium fluoride , cerium fluoride, and tungsten disulfide. Applications[edit] Solid lubricants are useful for conditions when conventional lubricants are inadequate, such as: A typical application is a sliding or reciprocating motion that requires lubrication to minimize wear, as, for example, in gear and chain lubrication. Liquid lubricants will squeeze out while solid lubricants do not escape, preventing fretting, corrosion, and galling. Another application is for cases where chemically active lubricant additives have not been found for a particular surface, such as polymers and ceramics. Graphite and MoS2 act as lubricants at high temperature and in oxidizing atmosphere environments, where liquid lubricants typically will not survive. A typical application include fasteners that are easily tightened and unscrewed after a long stay at high temperatures. The lamellar structure orients parallel to the sliding surface, resulting in high bearing-load combined with a low shear stress. Most applications in metal forming that involve plastic deformation use solid lubricants. Graphite[edit] Graphite is structurally composed of planes of polycyclic carbon atoms that are hexagonal in orientation. The distance of carbon atoms between planes is longer and, therefore, the bonding is weaker. Graphite is best suited for lubrication in air. Water vapor is a necessary component for graphite lubrication. The adsorption of water reduces the bonding energy between the hexagonal planes of the graphite to a lower level than the adhesion energy between a substrate and the graphite. Because water vapor is a requirement for lubrication, graphite is not effective in vacuum. Graphite is characterized by two main groups: Synthetic graphite is a high temperature sintered product and is characterized by its high purity of carbon Primary grade synthetic graphite can approach the good lubricity of quality natural graphite. Natural graphite is derived from mining. The quality of natural graphite varies as a result of the ore quality and its post-mining processing. The higher the carbon content and the degree of graphitization high crystalline the better the lubricity and resistance to oxidation. Molybdenum disulfide [edit] MoS2 is mined from some sulfide-rich deposits and refined to achieve a purity suitable for lubricants. Like graphite, MoS2 has a hexagonal crystal structure with the intrinsic property of easy shear. MoS2 lubrication performance often exceeds that of graphite and is effective in vacuum as well, whereas graphite is not. Particle size and film thickness are important parameters that should be matched to the surface roughness of the substrate. Large particles may result in excessive wear by abrasion caused by impurities in the MoS2, and small particles may result in accelerated oxidation. Boron nitride[edit] Hexagonal boron nitride is a ceramic powder lubricant. Furthermore, boron nitride has a high thermal conductivity. Cubic boron nitride is very hard and used as an abrasive and cutting tool component. Polytetrafluorethylene[edit] Polytetrafluorethylene PTFE is widely used as an additive in lubricating oils and greases. Contrary to the other solid lubricants discussed, PTFE does not have a layered structure. The macro molecules of PTFE slip easily along each other, similar to lamellar structures. PTFE shows one of the smallest coefficients of static and dynamic friction, down to 0. For parts that are inaccessible for lubrication after assembly, a dry film lubricant can be sprayed. After the solvent evaporates, the coating cures at room temperature to form a solid lubricant. Pastes are grease-like lubricants containing a high percentage of solid lubricants used for assembly and lubrication of highly loaded, slow-moving parts. Black pastes generally contain MoS2. The bonding can be improved by prior phosphating of the substrate. Use of free powders has

its limitations, since adhesion of the solid particles to the substrate is usually insufficient to provide any service life in continuous applications. However, to improve running-in conditions or in metal-forming processes, a short duration of the improved slide conditions may suffice. After application and proper curing, these "slippery" or dry lubricants bond to the metal surface and form a dark gray solid film. Many dry film lubricants contain special rust inhibitors which offer exceptional corrosion protection. Most long-wearing films are of the bonded type but are still restricted to applications where sliding distances are not too long. AF coatings are applied where fretting and galling is a problem such as splines , universal joints and keyed bearings , where operating pressures exceed the load-bearing capacities of ordinary oils and greases, where smooth running in is desired piston, camshaft , where clean operation is desired AF coatings will not collect dirt and debris like greases and oils , and where parts may be stored for long periods. Solid lubricants such as PTFE, graphite, MoS2 and some other anti-friction and anti-wear additives are often compounded in polymers and all kind of sintered materials. MoS2, for example, is compounded in materials for sleeve bearings, elastomer O-rings , carbon brushes, etc. Solid lubricants are compounded in plastics to form a "self-lubricating" or "internally lubricated" thermoplastic composite. MoS2 compounded in nylon reduces wear, friction and stick-slip. Furthermore, it acts as a nucleating agent effecting in a very fine crystalline structure. The primary use of graphite lubricated thermoplastics is in applications operating in aqueous environments.

4: Mobil Delvacâ„¢ Super 15W | Heavy Duty Engine Oils | Mobilâ„¢

Several novel solid lubricant composites and coatings designated PS/PM have been employed to dry and marginally oil lubricated contacts in advanced heat engines. These applications include cylinder kits of heavy duty diesels, and high temperature Stirling engines, sidewall seals of rotary engines, and various exhaust valve and exhaust.

5: Mobil Delvac 1â„¢ ESP 0W | Heavy Duty Engine Oils | Mobilâ„¢ Canada

Note: Citations are based on reference standards. However, formatting rules can vary widely between applications and fields of interest or study. The specific requirements or preferences of your reviewing publisher, classroom teacher, institution or organization should be applied.

6: Dry lubricant - Wikipedia

High temperature solid lubricant materials for heavy duty and advanced heat engines Conference DellaCorte, C. ; Wood, J.C. Advanced engine designs incorporate higher mechanical and thermal loading to achieve efficiency improvements.

7: Henkel Loctite C High Temperature Solid Film Lubricant - PWA from www.enganchecubano.com

DellaCorte and J.C. Wood, High Temperature Solid Lubricant Materials for Heavy Duty and Advanced Heat Engines, NASA TM , Sept. , also in M.R. Guyal, Heavy Duty Engines, A Look at the Future, ASME, NY, ,

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