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Industrial applications of high technology ceramics in wear

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Abstract- Ceramic materials are characterized by outstanding hardness, extreme compressive strength and elastic modulus, wear resistance, thermal shock resistance, chemical stability and high temperature properties. Therefore they have potential materials to be use at industrial applications. Especially, ceramics show superior performance in tribological applications where wear and friction are very crucial parameters. Alumina (Al_2O_3), silicon nitride (Si_3N_4), silicon carbide (SiC), zirconia (ZrO_2), boron carbide (B_4C), boron nitride (BN) etc. are very well known industrial wear parts. They are used as a cutting tool, sand blast nozzle, metal forming, paper de-watering, valve, ball bearing, seal, grinding media, textile and wire guide, mill liner, hip joint, etc. These kind of industrial ceramic wear parts are produced with special requirements according to in their service conditions.

Tribological materials can be categorized according to the industrial application field. In this case, basically a classification can be made as follows: rolling bearings, biomedical applications, manufacturing, automotive, paper and textile industries. The total amount of engineering ceramics consumed in America and Europe is ~ 225,000 tons. Alumina is the most widely used ceramic among them due to high wear and corrosion resistance as well as it serve cost advantage. After Al_2O_3, SiC, ZrO_2, Si_3N_4, B_4C, BN are used respectively in North America ceramic materials market as a wear part. Ceramic balls used commercially in roller bearings are generally Si3N4 due to high fracture toughness. The tribological properties of biomaterials play an important role in the performance of many artificial organs and medical devices. A total of 600,000 knee, hip and shoulder joint operations are performed annually in America. Al_2O_3, ZrO_2, Si_3N_4, SiC, B_4C are used as bone joint coverage part due to high wear and corrosion resistance. In medical applications, screws and bone plates Si_3N_4 are preferred over alumina and zirconia due to their high strength and low density. Manufacturing operations are highly demanding tribological applications. High temperatures, high production rates, desired surface properties and reliability, environmental conditions play an important role in determining the end-life, product surface quality, and surface functional properties. In cutting operations, the insert must have a high abrasion resistance to prevent dimensional changes that can occur to the rubbing tip, a hot hardness to maintain sharp and appropriate cutting edges at high temperatures formed during machining, chemical resistance to avoid reaction with the work piece, high strength and fracture toughness to absorb the impact, high thermal shock resistance to overcome the effects of the continuous heating and cooling cycle. Cars are the most widely used machines today and there are many tribological pieces (pistons, wheels, bearings, transmissions etc.). When the tribological performances of the machines are improved, fuel consumption is reduced, engine power is increased, oil consumption is reduced, the emissions of harmful gases are reduced, durability and reliability and engine life are extended. During the paper production process, the product moves at high speeds (100 km/min) on ceramic dewatering foils during the removal of water from the paper pulp. Desirable properties in this application are abrasion and chemical resistant materials. So ceramic materials have potential in paper production.

Keywords- wear, tribology, biomedical, bearing, automotive, ceramic