CERAMICS IN COMBUSTION ENGINES

Benefits of alumina ceramics over metals

⊡ Higher thermal efficiency

Maximum efficiency of a heat engine is:

$$\eta_{max} = 1 - T_c/T_h$$

where:
T_c - temperature of the cold sink (cooling media), K;
T_h - temperature of the hot source (combustion chamber), K.

According to the expression higher combustion temperature results in better theoretical efficiency of the engine.
In addition to this higher temperature causes the fuel burning to be more complete, which also increases the engine efficiency.
Metal combustion chamber (cylinder) is capable to operate at max. 1000 K (1341ºF). If the chamber is made of a ceramic the operation temperature may be increased to 3000 K (4941ºF). Higher temperature in the combustion chamber improves the engine efficiency.

⊡ Lower inertia forces

All combustion engines have accelerating parts (reciprocating or/and rotating).
A certain part of the combustion energy is consumed for driving these parts.
The inertia forces developed by the moving parts are proportional to their weights. Therefore decrease of the parts weights will increase the engine efficiency.
Alumina (as compared to metals) has a lower density and a higher specific strength.
Replacement of the materials of the moving parts from metals to alumina ceramic will result in higher engine efficiency.

⊡ Better tribological properties

Alumina ceramics with fine grain structure may be polished to very high surface quality, which provides low coefficient of friction.
The main disadvantage of ceramics is low fracture toughness causing increased wear rate by the fracture mode of the abrasive wear when the material cracks in the subsurface regions surrounding the wear groove.
Toughened ceramics with homogeneous fine grain microstructure have low wear rate.
Depending on the operating temperature liquid lubricants, Solid lubricants or metallic overlays may be used for the lubrication of engine ceramic parts.

10.2 Current and potential applications of alumina in combustion engines

Current application of alumina in combustion engines:

- **Reciprocating engines**
  - Valve guides
  - Cam follower rollers
  - Thermal barrier coatings (e.g., exhaust pipes)
  - Turbocharger rotors
  - Ball bearings
  - Pump seals
  - Spark plug insulators
- **Turbine engines**
  - Nozzles
  - Ceramic lining of combustors
  - Turbine blades

Potential applications of alumina in combustion engines:

- **Reciprocating engines**
  - Ceramic liners of combustion chambers
  - Pistons
  - Piston rings
  - Cylinder heads
  - Valves and valve guides
- **Wankel engines**
  - Three-sides rotors
  - Housing (combustion chamber)
  - Side plates
- **Turbine engines**
  - Rotors
  - Exhaust components
  - Vanes
  - Shrouds

Source : http://www.substech.com/dokuwiki/doku.php?id=tribological_properties_and_applications_of_alumina#tribological_properties_of_alumina_reinforced_composites