HIGHER AND SECONDARY SPECIAL EDUCATION OF THE REPUBLIC OF UZBEKISTAN

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MACHINE BUILDING TECHNOLOGIES FACULTY

«Material science»department

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GRADUATE WORK

TITLE: “**Project technology combustor production of ceramic materials for internal combustion engine for cars ”**

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INTRODUCTION

The current state of the development of materials science requires a comprehensive study of new ways of technology and obtaining entirely new materials for special purposes. This is in demand at present in accordance with the current development of economic sectors in our republic, as was noted by our first president, IA Karimov, and as was noted by our current president Sh.Mirziyoyev in the Paths of further development of our republic, Strategies for further development of the Republic of Uzbekistan in 2017-2021 ".

The reforms carried out over the years laid the foundation for national statehood and the sovereignty of ensuring security and the rule of law, the inviolability of the state borders of the rule of law, the reliable system of protecting human rights and freedoms of interethnic harmony and religious tolerance in society, and created decent conditions for life and realizing the potential of our citizens.

Important for the development of the economy is the fact that the republic has such significant strategic resources as oil and gas condensate, natural gas, and precious metals. A wide range of their use opens up great opportunities for expanding the export potential of creating a wide range of joint ventures with the attraction of foreign capital.

The fundamental question of the economic transformation of our page is the cardinal acceleration of scientific and technological progress. It is necessary to implement a new technical reconstruction of the national economy and on this basis to transform the material and technical base of the community in a qualitatively new form.

Improvement of the state youth policy education of a physically healthy, spiritually and intellectually developed self-conceiving, devotee. The youth of young people with firm vital views, increasing their social activity in the process of deepening democratic reforms and developing the civil society of employment and attracting to the private entrepreneurship sector graduates of secondary special, professional and Higher educational institutions;

Support and realization of the creative and intellectual potential of the younger generation, the formation of a healthy lifestyle among children and young people, the wide involvement of their physical culture and sport, the social protection of young people, the creation of decent living and social amenities for young families, Educational institutions of youth and other organizations in the implementation of state youth policy.

This is possible only on the basis of the latest achievements of science and technology, the restructuring of the economic mechanism and the management system.

The efficiency of reconstruction is the pace of economic growth, and depends crucially on engineering. It is the material for the materializing of scientific and technical ideas, creating new tools for labor, systems of machinery that determine progress in other sectors of the economy. Here, the foundations for a broad access to fundamentally new resources, Labor productivity and product quality.

Before the machine-building complex, the task was to raise sharply the technical and economic level and quality of machinery, equipment, and devices. The renewal of the industry is 1.8 times more capital investment than the previous years.

The main direction in the development of machine building and ferrous metallurgy is the radical improvement of the quality of metal products by introducing progressive methods of metal processing by increasing the efficiency of metal application in the national economy. An important reserve for improving the quality and improving the mechanical characteristics of metal, and also for economy in the national economy is the application of high-temperature heat treatment.

Along with putting into operation the new progressive equipment and upgrading the existing units of thermal shops, mechanization and automation of heat treatment are carried out at many plants, which undoubtedly facilitates labor of thermists and increases labor productivity.

Heat treatment has wide possibilities for giving the material a specified number of properties with its help it is possible to achieve unique properties of products.

The development of heat treatment at the present time occurs under the conditions of an acute energy deficit and a stockpile of natural resources. Therefore, the efforts of scientists are aimed at creating qualitatively new technological processes with small energy costs in order to improve the energy efficiency of labor, product quality, automation and mechanization, and environmental protection environment.

I.SPECIAL SECTION

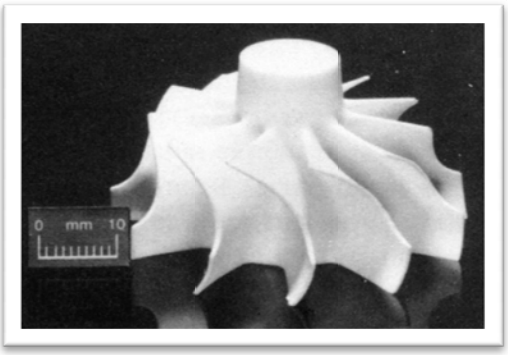
1.1.Ceramic materials and their general properties

In materials science we often divide materials into distinct classes. The primary classes of solid materials are ceramics, metals, and polymers. This classification is based on the types of atoms involved and the bonding between them. Composites are combinations of more than one material and often involve ceramics, such as fiberglass.Ceramics can be subdivided into different groups under various aspects considering chemical composition,microstructure or application. From the application point of view one can distinguish between traditional ceramics and advanced ceramics. The traditional ceramics include tableware, pottery, sanitary ware, tiles, bricks and clinker.

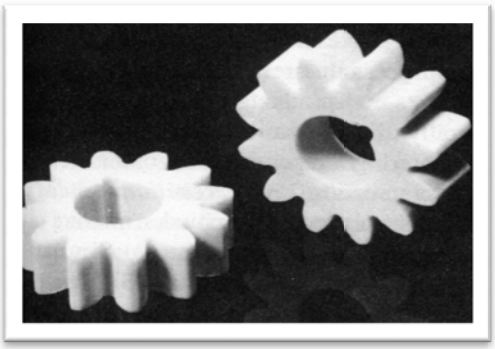
Refractory brick Insulating brick

Figure1.Traditional ceramics

The advanced ceramics may be subdivided into electronic ceramics (insulators, substrates,capacitors, varistors, actuators, sensors), optical ceramics (windows, lasers), magnetic ceramics and engineeringceramics.



Rotor(Alumina)



Gears(Alumina)

Figure2.Advanced ceramic components

The engineering or structural ceramics have applications in mechanical engineering, chemical engineering, high-temperature technology, and in biomedical technology. Special ceramics which are not directly related to the categories mentioned above are reactor ceramics (absorber materials, breeder materials,nuclear fuels) and refractory products.

The properties of ceramic materials, like all materials, are dictated by the types of atoms present, the types of bonding between the atoms, and the way the atoms are packed together. The type of bonding and structure helps determine what type of properties a material will have.

Ceramics usually have a combination of stronger bonds called ionic (occurs between a metal and nonmetal and involves the attraction of opposite charges when electrons are transferred from the metal to the nonmetal); and covalent (occurs between two nonmetals and involves sharing of atoms). The strength of an ionic bond depends on the size of the charge on each ion and on the radius of each ion.

The greater the number of electrons being shared, is the greater the force of attraction, or the stronger the covalent bond.

Table.1.Percentage of ionic and covalent character of the bond for some ceramic materials

Ceramic Material	Atoms in bond	$X_A - X_B$	% Ionic Character	% Covalent Character
MgO	Mg—O	2,3	73	27
Al_2O_3	Al—O	2,0	63	37
SiO_2	Si—O	1,7	51	49
Si_3N_4	Si—N	1,2	30	70
SiC	Si-C	0,7	11	89

These types of bonds result in high elastic modulus and hardness, high melting points, low thermal expansion, and good chemical resistance. On the other hand, ceramics are also hard and often brittle (unless the material is toughened by reinforcements or other means), which leads to fracture.

Imperfections in ceramics.Atomic defects involving host atoms may exist in ceramic compounds. As with metals,both vacancies and interstitials are possible; however, because ceramic materials contain ions of at least two kinds, defects for each ion type may occur. It is highly improbable that there would be appreciable concentrations of anion interstitials. The anion is relatively large, and to fit into a small interstitial position, substantial strains on the surrounding ions must be introduced. Anion and cation vacancies and a cation interstitial are represented in Figure 3.

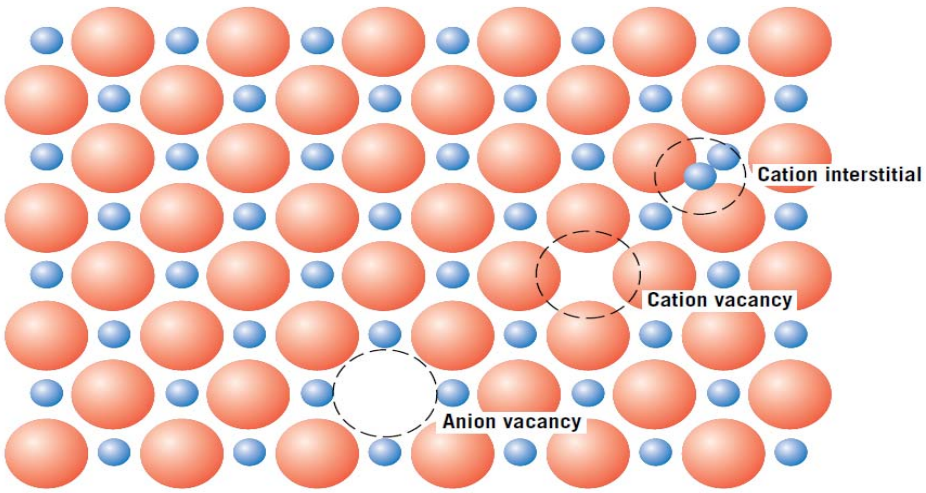


Figure 3.Schematic representations of cation and anion vacancies and a cation interstitial

Electroneutralityis the state that exists when there are equal numbers of positive andnegative charges from the ions. As a consequence, defects in ceramics do not occuralone. One such type of defect involves a cation–vacancy and a cation–interstitial pair.This is called a Frenkel defect (Figure 4). It might be thought of as being formedby a cation leaving its normal position and moving into an interstitial site. There is nochange in charge because the cation maintains the same positive charge as an interstitial.Another type of defect found in AX materials is a cation vacancy–anion vacancypair known as a Schottky defect, also schematically diagrammed in Figure 4. Thisdefect might be thought of as being created by removing one cation and one anion fromthe interior of the crystal and then placing them both at an external surface. Because themagnitude of the negative charge on the cation is equal to the magnitude of the positivecharge on the anion, and because for every anion vacancy there exists a cationvacancy,the charge neutrality of the crystal is maintained.Stoichiometrymay be defined as a state for ionic compounds wherein there is the exactratio of cations to anions as predicted by the chemical formula. For example, NaClisstoichiometric if the ratio of Na_ ions to Cl_ions is exactly 1:1. A ceramic compound is nonstoichiometric if there is any deviation from this exact ratio.

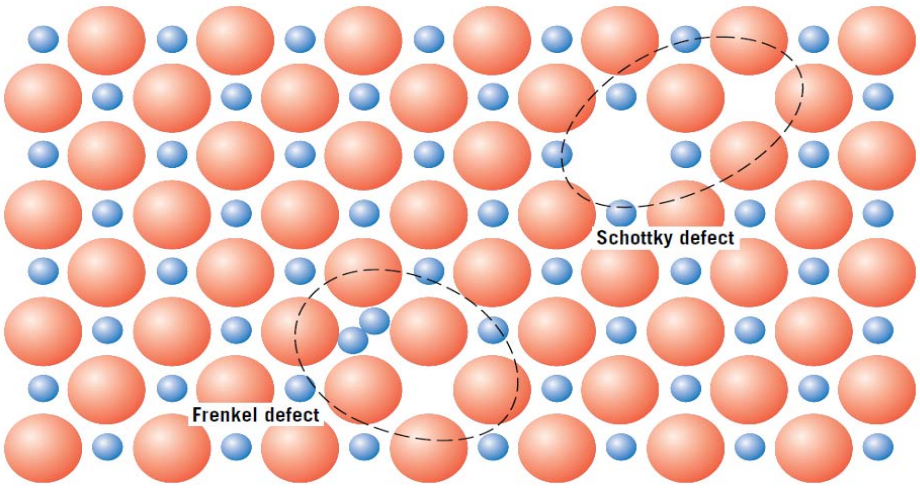


Figure 4.Schematic diagram showing Frenkel and Schottky defects in ionic solids

The most important advantageous features of ceramic materials are:

- low electrical conductivity,
- low thermal conductivity,
- low density,
- high strength at high temperatures,
- wear resistance,
- corrosion resistance, and
- specific physical properties (optical, electrical, magnetic).

These properties lead to applications in many technical areas. For example, the low electrical conductivity leads to applications in insulating techniques. Spark plugs are the best-known applications in engine manufacturing.

The low thermal conductivity is used, for instance, for the protection tiles of the Space Shuttle and in the form of insulation layers in combustion chambers. The resistance against corrosion leads to applications as heat exchangers for corrosive agents. In biomechanics (hip joints, dentures) the compatibility of ceramics with human bodies is of high importance. The excellent wear resistance is exploited for cutting tools, as roller bearings or in the textile industry (thread guidance, yam-guiding grooves). The high temperature strength is used in nuclear fusion technology applications, in the development of gas turbines and in the field of solar energy.

The main disadvantages of ceramics are as follows:

- low tensile strength at room temperature for some materials,
- brittleness,
- large scatter of strengths, and
- subcritical crack extension.

Brittleness means that failure occurs without prior measurable plastic deformation. This is due to the strong atomic bonding of ceramics, which lead to high stresses for the motion of dislocations. Thus, failure can start from small flaws before plastic deformation is possible. This fact can also be expressed in

low resistance against crack extension, which is characterized by the fracture toughness. The absence of local plastic deformation leads to failure at locations of high local stresses, e.g. at notches, at contacts between different material or during thermal shock. In metals these strain-controlled local stresses lead to small plastic strains.The large scatter of strength is caused by the statistical distribution of the flaw size and the flaw location. This requires a statistical description of the strength and a relation between failure probability and the stress distribution in a component.Subcritical crack extension can cause failure under constant or cyclic loading during the operation of a component and will lead, consequently, to a limited lifetime.Due to these disadvantages ceramic materials are applied only in such cases where the positive properties prevailover the negative ones. In order to enforce the positive features of ceramics one has to keep the influence of negative features as low as possible.

Thermal properties.The above relation is not valid above a specific temperature known as Debye temperature. The saturation value is approximately equal to 3R.

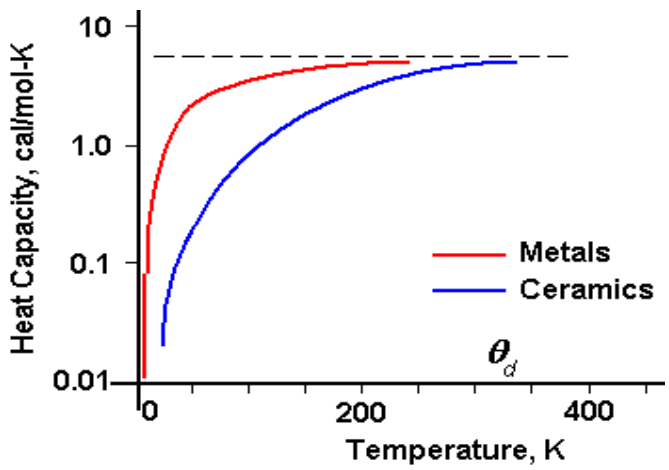


Figure 5.Correlation between Heat capacity and Temperature

Thermal conductivity.Nonmetallic materials are thermal insulators inasmuch as they lack large numbers of free electrons. Thus the phonons are primarily responsible for thermal conduction: k_e(electron thermal conductivity) is much smaller than k_l(lattice vibration). Again, the phonons are not as effective

as free electrons in the transport of heat energy as a result of the very efficient phonon scattering by lattice imperfections.Room-temperature thermal conductivities range between approximately 2 and 50 W/m*K.Glass and other amorphous ceramics have lower conductivities than crystalline ceramics because the phonon scattering is much more effective when the atomic structure is highly disordered and irregular.

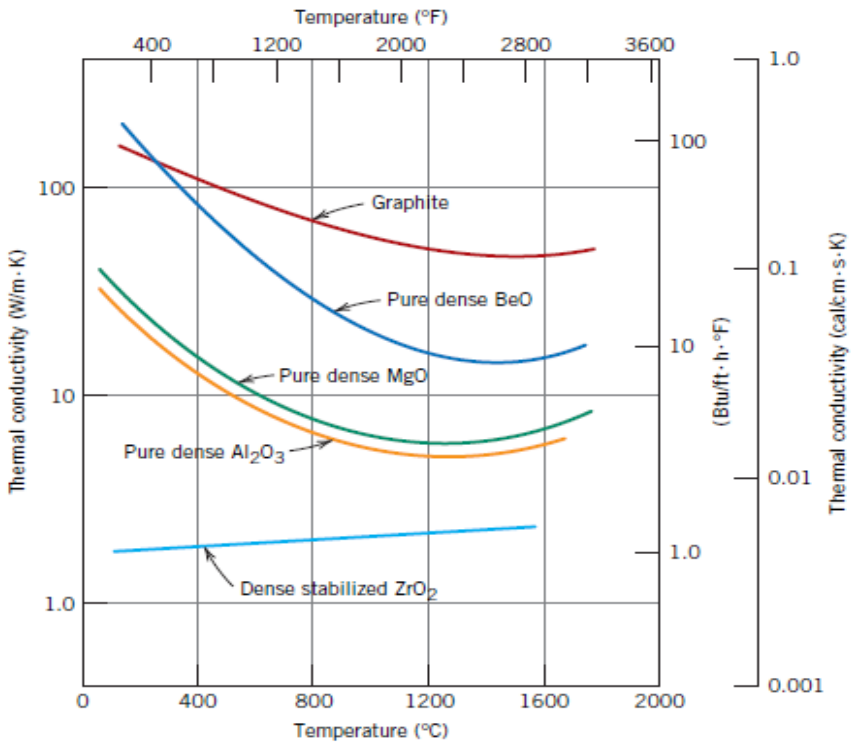


Figure 6.Dependence of thermal conductivity on temperature for several ceramic materials

Porosity in ceramic materials may have a dramatic influence on thermal conductivity;under most circumstances, increasing the pore volume results in a reduction of the thermal conductivity. In fact, many ceramics used for thermal insulation are porous. Heat transfer across pores is typically slow and inefficient. Internal pores normally contain still air, which has an extremely low thermal conductivity—approximately 0.02 W/m*K.Furthermore, gaseous convection within the pores is also comparatively ineffective.

Table 2.Properties of some ceramic and selected nonceramic materials.

Material	Melting Point (°C)	Density (g/cm^3)	Hardness (Mohs)[a]	Modulus of Elasticity[b]	Coefficient of Thermal Expansion[c]
Alumina, Al_2O_3	2050	3.8	9	34	8.1
Silicon carbide, SiC	2800	3.2	9	65	4.3
Zirconia, ZrO_2	2660	5.6	8	24	6.6
Beryllia, BeO	2550	3.0	9	40	10.4
Mild steel	1370	7.9	5	17	15
Aluminum	660	2.7	3	7	24

1.2.Structural ceramic materials and their composition

There is a general consenus that engineering materials can be classified into three primary classes:metals and alloys;ceramics and glasses;andpolymers.Among these three primary classes,metals,metallic alloys and polymers are,byfar,more widely used than ceramics and glasses for various structural and engineering applications.Nevertheless,ceramics have attracted attention in the scientific community in the last three decades.The widespread use of metallic materials is driven by their high tensile strength and high toughness as well as their ability to be manufactured in various sizes and shapes using reproducible fabrication techniques.Similarly,polymers have distinct advantages in terms of their low density,high flexibility and ability to be molded into different shapes and sizes.Nevetheless,polymeric materials have low melting point(less than 400 ^{0}C)as well as very low strength and elastic modulus.Compared with ceramics,metals have much lower hardness and many commonly used metallic materials have a much lower melting point (<2000 ^{o}C). From this perspective, ceramics and glasses have advantageous properties, including refractoriness (capability to withstand high temperatures), strength retention at high temperature, high melting point, and good mechanical properties (hardness, elastic modulus, and compressive strength). In view of such an attractive combination of properties, ceramics are considered as potential materials for high-tempcrature structural applications and various

tribological applications requiring high hardness and wear resistance. Despite having such potential applications, the widespread use of ceramics has been limited, because of their brittleness (poor fracture toughness) and variability in mechanical properties.To combine various advantageous properties of the three primary material classes, a derived material class—that is, composites—is being developed. The composites are generally defined as a class of materials that comprise at least two intimately bonded microstructural phases aimed to provide properties (e.g.. elastic modulus, hardness, strength) tailored for specific applications; it is expected that a specific property of a composite should be higher than the simple addition of that property of the constituent phases. Depending on whether metals, ceramics, or polymers comprise more than 50% by volume of a composite, it can be further classified as a metal matrix composite (MMC), a ceramic matrix composite (CMC), or a polymer matrix composite (PMC) respectively. From the microstructural point of view, a composite contains a matrix (metal, ceramic, polymer) and a reinforcement phase. The crystalline matrix phase can have an equiaxed or elongated grain structure; the reinforcement phase can have different shapes, for example particulates, whiskers, and fibers. The reinforcement shapes can be distinguished in terms of aspect ratio: particulates can be spheroidal; whiskers have a higher aspect ratio (>10); fibers have the largest aspect ratio. It is widely recognized now that the use of fibers or whiskers can lead to composites with anisotropic properties (different properties in different directions). As far as nomenclature is concerned, it is a common practice to designate a composite as M-RP, M-Rw, or M-Rf, where M and R are the matrix and reinforcement, respectively, and the subscripts (p, w. f) essen-tially indicate the presence of reinforcement as particulates, whiskers, or fibers, respectively. One widely researched MMC is AI-SiCp composite; Mg-SiCp is being developed as a lightweight composite; several MMCs arc used as automotive parts and structural components. Some popular examples of CMCs include Al_2O_3-ZrO_2p and Al_2O_3-SiCw; these CMCs are typically used as wear parts and cutting-tool inserts. Various resin-bonded

PMCs are used for aerospace applications. Based on their applications, advanced ceramics are usually classified into two major classes: structural ceramics and functional ceramics. Advanced structural ceramics are those ceramics intended for use as load-bearing members. They are materials that combine the properties and advantages of traditional ceramics, such as chemical inertness, high temperature capability, and hardness, with the ability to carry a significant mechanical stress. Advanced structural ceramics are more expensive than traditional ceramics. Most of the advanced structural ceramics under development today are based on silicon nitride, Si_3N_4; silicon carbide, SiC; zirconia, ZrO_2; or alumina, Al_2O_3. Advanced structural ceramics typically possess some combination of high temperature capabilities, high strength, toughness or flaw tolerance, high hardness, mechanical strength retention at high temperatures, wear resistance, corrosion resistance, thermal shock resistance, creep resistance, and long-term durability. The relationship between processing and properties is especially critical for advanced structural ceramics because subsequent successful operation in severe environments often requires carefully controlled compositions and microstructures. Fabrication generally takes place in four steps: powder processing,consolidation/forming, densification, and finishing. The focus has been on applications for gas turbine, diesel, and spark-ignited engines. Advanced structural ceramics are also under investigation for use in numerous other high performance applications including metal-cutting and shaping tools, and various military applications.

While the applications of structural ceramics demands the optimization of mechanical strength, hardness, toughness, and wear resistance, the performance of functional ceramics is controlled by electric, magnetic, dielectric, optical, and other properties. In general, structural ceramics can be further classified into two classes:

1.Oxide ceramics (Al_2O_3, ZrO_2, SiO_2, etc.) and 2.Non-oxide ceramics (SiC, TiC, B_4C, TiB_2, Si_3N_4, TiN, etc.).

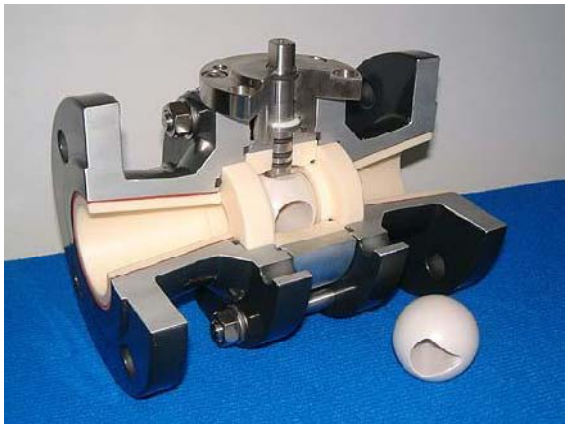
Oxide ceramics.Oxide ceramics include alumina, zirconia, silica, aluminum silicate, magnesia and other metal oxide based materials. They are non-metallic, inorganic compounds that include oxygen, carbon, or nitrogen. Oxide ceramics have high melting points, low wear resistance, and a wide range of electrical properties. The minerals used to make these ceramic materials are crushed or ground into a fine powder that is purified by adding it to a solution and allowing a chemical precipitate to form. The precipitate is then separated from the solution and heated to form a highly pure powder. After purification, small amounts of wax are added to bind the ceramic powder. Plastics may also be added to provide pliability. The powder can then be shaped into different objects by various molding processes such as slip casting, pressure casting, injection molding, and extrusion. After oxide ceramic materials are molded, they are heated in a process known as densification to strengthen the material.

Oxide ceramics vary by maximum use temperature, thermal conductivity, modulus of rupture, modulus of elasticity, electrical resistivity, average crystal size, density, and purity. The maximum use temperature is the highest temperature to which oxide ceramic materials can be exposed without degradation. Thermal conductivity is the linear heat transfer per unit area for a given applied temperature gradient. The modulus of rupture (MOR) or cross-break strength is the maximum flexural strength that oxide ceramics can withstand before failure or fracture occurs. Young's modulus or the modulus of elasticity is a material constant that indicates the variation of strain produced under an applied tensile load. Average crystal size measures the individual grains or crystals within the microstructure of a polycrystalline material. Density is the mass per unit of area. Purity is the percentage, by weight, of major components.

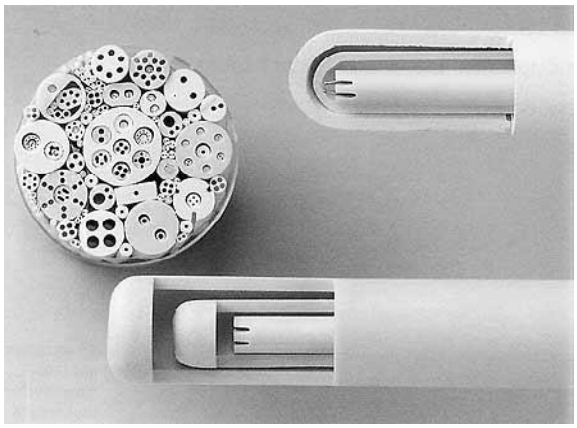
Oxide ceramics are available with a variety of special features. For example, glazes and protective coatings seal porosity, improve water or chemical resistance, and enhance joining to metals or other materials. Machinable ceramics can be machined in the green, glass, or finished state

without excessive chipping. Porous ceramics have many open or closed internal pores that provide a thermal barrier. Fused materials bond individual grains or crystals together without the use of binders. Instead, these industrial ceramic materials are formed through sintering or firing, hot pressing or hipping, extrusion, fusing and casting, or deposition.

Oxide ceramics are used in a variety of applications. Examples include chemical and materials processing, electrical and high voltage power applications, radio frequency (RF) and microwave applications, and foundry and metal processing. Industrial ceramic materials are used to fabricate optical components such as lenses, windows, prisms, and optical fibers. They are also used in the manufacture of semiconductors and parts and tooling. Refractory ceramics have high melting points and are suitable for applications requiring high wear resistance, high temperature strength, electrical or thermal insulation, or other specialized characteristics. Structural components use oxide ceramic materials that have higher compressive strengths and elastic moduli than metals.



Ball valve



Pyrometer tubes

Figure 7.Products made of Al_2O_3

Carbide Ceramics.The carbide ceramics include Silicon carbide (SiC), Tungsten carbide (WC), Titanium carbide (TiC), Tantalum carbide (TaC) and Chromium carbide (Cr_3C_2). In general these ceramics do not occur as a mineral although it is a man made ceramic. For example; for its production (SiC), it is

produced by heating mixtures of sand (source of silica) and coke (carbon) to a temperature of around 2200^0C or 3900^0F,so that the resulting chemical

reaction forms Silicon Carbide and Carbon mono oxide.

Figure8.SiC applications

Nitride Ceramics.The important Nitride ceramics are Silicon Nitride (Si_3N), Boron Nitride (BN), and Titanium Nitride (TiC).As a group the nitride ceramics are hard & brittle and they melt at high temperature (but not generally as high as the carbides). They are usually electrically insulating.

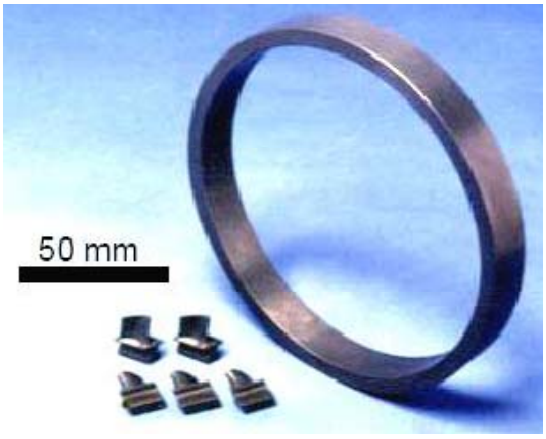


Figure9.Nitride ceramic applications

1.3.Microstructure of ceramic materials and preparation techniques of them

In contrast to metals, high-performanceceramics have higher hardness, lowerductility, and a basically brittle nature. Othergeneral properties to note are: excellent hightemperatureperformance, good wear resistanceand thermal insulation (low thermal conductivity),as well as high resistance to corrosion andoxidation. However, the full advantage that thesematerials can provide is strongly dependent oncomposition and microstructure.

Most high-performance ceramics are based onhigh-purity oxides, nitrides, carbides, and borideswith carefully controlled compositions. Ceramicengineering components are usually producedby powder metallurgical methods. Therequired properties of a specific part are optimizedby selecting parameters associated withthe powder mixture and the pressing and sinteringoperations to obtain the desired microstructure.

Due to the large variations in microstructure,differentceramographic preparation techniquesare applied to achieve the surface quality desiredso structural details are revealed under the microscope.Forceramographic preparation, it isnot sufficient to know that a sample is Al_2O_3.The manufacturing conditions must also beknown because they provide important informationregarding expected porosity, grain size,and impurities. These microstructural variableshave a strong influence on the method selectedfor preparation. An example for two different ZrO_2 ceramic materials is illustrated in Fig. 12 andFigure 13 shows the microstructure of tetragonal ZrO_2 (TZP, or tetragonal zirconia polycrystals).This is a high-strength structural ceramicused for room-temperature applications (e.g. knives andscissors). Tetragonal zirconia polycrystals have a grain size less than 1 mkm, an extremely high bending strength ranging from 800 to 2400 MPa,and fracture toughness (K_{ic}) between 6 and 15 MPa*m, which renders this material resistant to pullout during preparation.

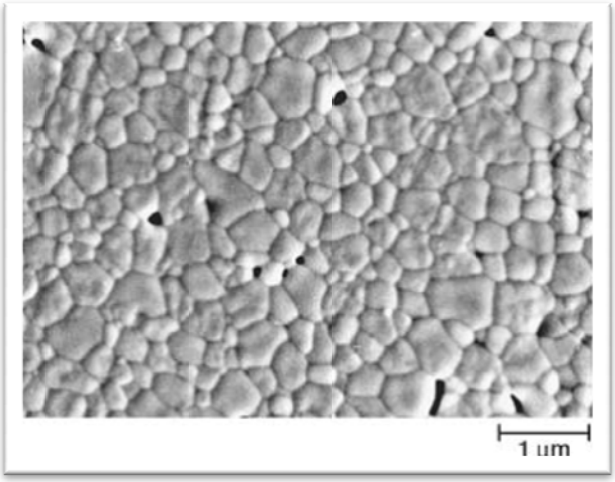


Figure10.Tetragonal zirconia polycrystals with 2 mol % Y_2O_3 thermally etched in air at1300 C.Th scanning micrograph shows afinegrainedmicrostructure.Pores appear black

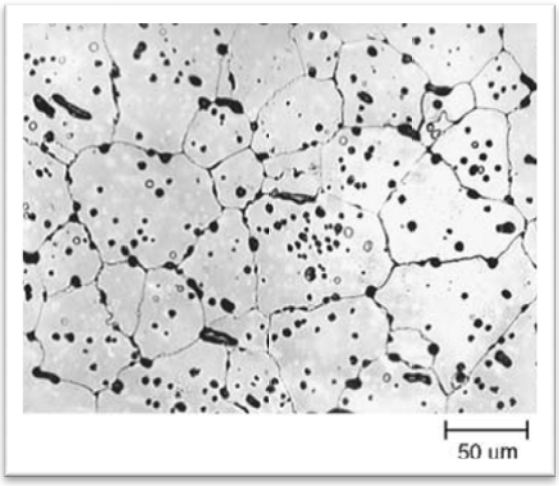


Figure 11.Light micrograph of a cubic stabilized with 12 mol % Y_2O_3 thermally etched in air at 1300 C.The large cubic grains show inter-and-intragranular porosity

The microstructure of cubic ZrO_2 (CSZ, or cubicstabilized zirconia) is shown in Fig.12. Themechanical properties of this material are considerablypoorer than TZP, with a bendingstrength of 200 MPa and a fracturetoughness of 2 to 3 MPa*m.The microstructure is characterized by a high intragranularporosity and a grain size of approximately30 to 50 lm. These materials are verysensitive to mechanical shock. Applications ofTZP and CSZ are focused on their high ion conductivity(e.g., mobility of O_2 ions across thecubic ZrO_2 lattice). Cubic stabilized zirconia isalso used in as k-sensors for automobile catalyticconverters and for $p(O_2)$ measurement in liquidmetals.Because of these differences in mechanicalproperties and microstructure, the ceramographicpreparation of TZP and CSZ is quite different.The tough, fine-grained TZP requireslonger polishing times for the fine-polishing stepwith 1 and 0.25 lm diamond, while CSZ needslonger polishing times for the coarser polishingwith 6 and 3 lm diamond compounds.

Depending on the type of ceramic or ceramiccomponent, the mechanical properties (e.g., fracturetoughness and strength) may vary

considerably,andtherefore the ceramographicpreparationprocedures have to be adjustedaccordingly.

Specimen Preparation.Similarly to metallographic preparation, sequentialsteps have to be performed to prepareceramics for microstructural investigations.Careful selection of sectioning, mounting,grinding, polishing, and etching procedures is required, and each step must be optimized for eachtype of ceramic. However, due to the brittleness,porosity, and chemical resistance of ceramics itis quite often difficult to polish them in the sameway as metals. Automated sample preparation isrecommended. The capability to adjust polishingpressure and the use of special grinding diskswith diamond as the abrasive material is alsopreferred.With this equipment, a flat surface thatdisplays an undistorted "true" microstructuremay be prepared in a reasonable time.

Sectioning.Generally, ceramics are cut witha lubricated (water or a special cutting fluid), rotatingdiamond cutting wheel on a bench-typelab machine or on a precision cutting machine.The cutting speed (low-speed cutting machine:25 to 500 rpm; high-speed cutting machine: 500to 5000 rpm) and the cutting pressure should beoptimized for the properties of a given material.A slow cutting speed and low pressure produceless cutting and surface damage for most ceramics,although some ceramic materials require theopposite (e.g., TZP-ZrO_2). Diamond cuttingwheels are either metal bonded or resin bonded,and normally metal-bonded cutting wheels areselected. However, for very brittle and sensitiveceramics, resin-bonded cutting wheels are recommended.These wheels are softer and willgenerally produce a better cut-surface finish thana metal-bonded diamond wheel, but their weakerbond shortens service life. Additional criteria forselection of cutting wheels also include: the concentration of abrasive, the grain size of abrasive,and the wheel thickness. Generally, low abrasiveconcentration blades are used, because the lowerthe abrasive loading, the higher the contact stresson each abrasive particle and therefore the higherthe cutting rate. The grain size of a diamondblade is usually 94 lm, but for delicate

samples,it may be advisable to cut with a diamond bladeof a finer grit to avoid unnecessary damage tothe material. The thickness of the diamond cuttingwheel is dependent on the thickness of thesample. For samples with limited dimensions itis advisable to use a thinner wheel.

Mounting.For automatic sample preparation,specimens can be mounted or may be glued directlyonto a sample holder. The two possibilitiesfor metallographic mounting are hot mounting,with compression and heat, and cold mounting.It should be noted that sensitive, small, and verybrittle ceramics specimen are susceptible to damageand cracking when using hot mounting, becauseof the high pressure and temperature thatis needed for this process. The mounting materialshould be either very hard or have good abrasionresistance. Additionally, before the sampleis mounted consideration must be given to theetching technique that is to be used. This willguide the selection of a mounting material mostsuited to the complete sample preparation. Forexample, when using thermal etching techniquesor molten-salt etching techniques the sampleshould be removed from the mount before etching.When etching in a boiling chemical solution,the mount should be of a material that willnot be attacked by the acid mixture.

Mechanical Preparation (Grinding and Polishing).It is preferable to perform the grindingand polishing procedures with an automaticor semiautomatic machine. The structure of eachand every ceramic product has been specificallyadjusted to exhibit required properties, and thuseach material will exhibit a unique behavior duringpreparation. Table 1 contains preparationstandards for structural ceramics (e.g., Si_3N_4 andAl_2O_3) as well as AlN. In general, resin-bonded diamond disks areemployed for grinding. In individual cases, siliconcarbide paper is used. The surface damage generated during sectioningand grinding has to be removed during finegrinding, or lapping and polishing. Fine grindingand/or lapping retains the plane of the specimensurface, and no further damage is introduced.During grinding process and mchining employed with engineering ceramics, the graphic below

(Figure.14) illustrates the potentially deleterious effects of the grinding process being conducted with excessive or inappropriate force.

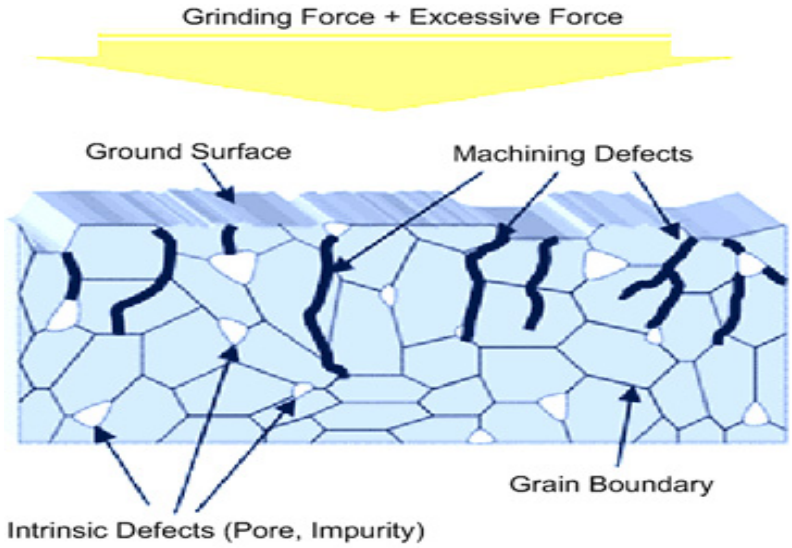


Figure12.Graphical example of grinding and machining defects

The grinding stresses leads to both surface and subsurface defects, both of which may generate the critical defect at failure.Complete removal of the damaged surface musttherefore be achieved by subsequent polishingsteps. Polishing should be performed on hardcloths. The highest removal rates will occur duringsteps with the application of 6 and 3 μm diamondgrain size. Polishing with 1 μm diamondremoves a minimal amount of material. Allbreakouts and scratches should be removed duringthese steps. In general, fine polishing with a SiO_2suspension is only applied if small and finescratches have to be removed. In some cases, thisfinal step can also produce a slight relief on thesample surface, which may be beneficial for microscopy.

Microscopic Examination.For the investigation of ceramic microstructuresand the identification of flaws and defects,the use of light optical microscopy (LOM) orscanning electron microscopy (SEM) are mostcommon. Since most of the ceramics are electricalinsulators, samples for SEM investigationshave to be coated by an electrical conductivelayer such as carbon, gold, or gold-palladium alloys.Metals are used for simple microstructuralanalysis, while carbon is used for simultaneouschemical analysis, for example, energy-dispersivex-ray (EDX) analysis. Standard scanningelectron

microscopes are normally equippedwith different detectors. The backscatter detectoris useful for multiphase materials, when the differentphases reveal a strong mass contrast. Inthis case, no etching is required. Secondary electrondetectors are sensitive to small differencesin height of a polished and etched surface.Themicroscopic examination of ceramic specimensin the as-polished state has proved useful. Anevaluation of the number of pores, their distribution,and possible pullouts can only be assessedin this state. Evaluation of inclusions, contaminationand cracks should alsobemadebeforeetching.In order to reveal grain boundaries, phases,and other microstructural details, ceramic specimenshave to be etched. Ceramic microstructures,examined under the LOM (>200x) willshow a low contrast and a milky image. Ceramicspermit light rays to penetrate the surfacewhere scattering and internal reflection occurs.To eliminate light scattering and to improve thereflectivity, coating the surface with a reflectivelayer is recommended. Such a layer should be between 5 and 10 nm thick and can be appliedby sputter coating with either gold or aluminum.

CeramographicEtching.Three etching methodscan be distinguished: optical, electrochemical,and physical contrasting. The most frequentlyused etching methods forhigh-performance ceramics are solution etching,thermal etching, and plasma etching. Plasmaetching works only in case of silicon-base ceramics(SiC,Si_3N_4). Details of the etching procedureare described below. Thermal etching ismostly used for oxide ceramics. Typical etchingtemperatures are 150 ^{o}Cbelowsinteringtemperature in air. Etching time can vary between15 min and some hours, depending on thestructure and composition of the grain boundarythat evaporates during the heat treatment. Thermaletching of nonoxide ceramics requires aninert atmosphere or an encapsulation of the samplein a quartz tube.

Oxide Ceramics.Apart from etching withvery aggressive chemical solutions, thermaletching in air is also an important method fordeveloping the microstructures of Al_2O_3andZrO_2 ceramics .The polished and “demounted”samples are placed in an air furnace.Exposure temperature and

time are selected sothat the heat treatment does not alter the microstructure.The temperature should be approximately100 to 150 ^{o}Cbelowthesintering temperature. Temperatures that are toohigh or etching times that are too long may resultin grain growth.Generally, chemical solutions are used to developmicrostructures, grain boundaries, and thedomain structure of other oxide ceramics such as$BaTiO_3$ (fig.17)and PZT. Thermal etchingin air can also be used to show the grain boundaries,but it will not develop the domain structure.If the grain size exceeds 5 μm, the microstructureof the ceramic material can also berevealed with a thin section under polarizedlight.

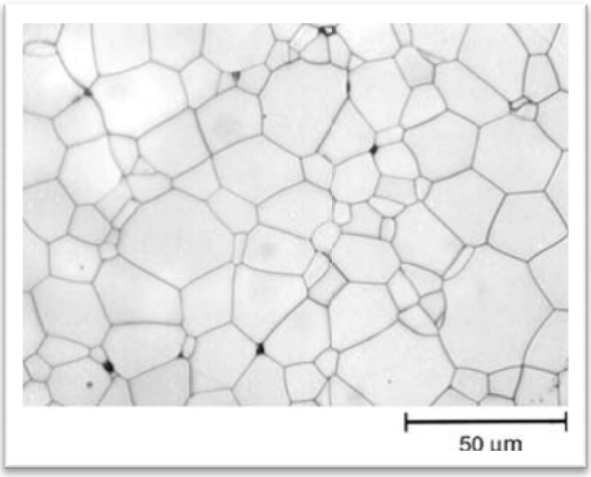


Figure13.Light micrograph of translucent alumina.Isotropically grown grains with 15 lm average grain size and a porosity of less than 0.5%.Thermally etched at 1500°C

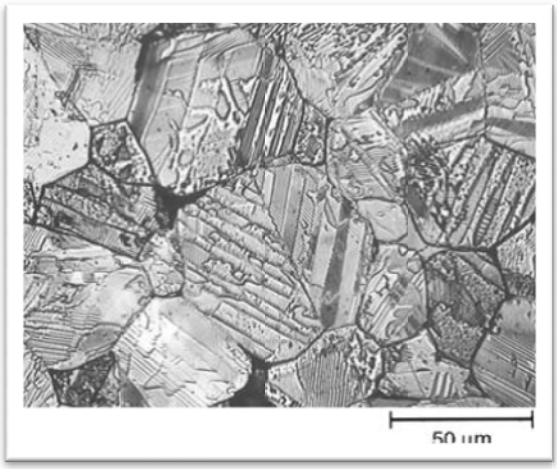


Figure14.Light micrograph of a chemically etched surface of a BaTiO ceramic showing the grains and domain patterns within the grains.
Etchant:95ml distilled H_2O+3ml HCl(32%)+2ml HF(40%)

1.4.Ceramic components for internal combustion engines.

The choice of metal as the material from which heat engines are made is an unfortunate one. This is because metals are relatively low temperature materials for heat engines and they are also good thermal conductors, two properties that are detrimental to efficient combustion.

Historically, when the internal combustion engine was first being developed, it was an unavoidable choice because metals were the only

suitable material available at that time. Recognising this problem, development of new materials for IC engines is now being encouraged by some foreign countries' Governments.

The maximum service temperature of many metals is less than 600 C, and thus metal engines are required to operate at temperatures too low for fuel to be burnt completely. Also, as metals are good thermal conductors, the heat generated within the metallic combustion chamber is easily conducted through the metallic casing. Liquid cooling is thus required to prevent the metallic engine from overheating and this hastens heat loss (about 30% of the heat generated is lost to the coolant or radiator water). Furthermore, resulting incomplete combustion products are discarded through the exhaust adding to airborne pollution.

These temperature trade-offs required of metallic internal combustion engines result in low combustion and low thermal efficiencies. Thus, metallic internal combustion engines suffer primarily from threeproblems: 1. Low combustion efficiency (due to the lower operating temperatures of metals), 2. Substantial heat loss (due to the high thermal conductivity of metals), and 3. Some wear (resulting in some limited metal component life).

Compared to metal materials, the engineering ceramics has some special advantages such as high wear-resistance, high erosion/corrosion-resistance, high-temperature oxidation resistance, high hardness, low thermal expansion and creep, and so on. In terms of wear-resistance, the ceramic material will be 10-100 times higher than the metal one. Ceramic products can be used in some high erosion conditions such as strong acid and alkali etc. Hardness of ceramic material can be several times higher than that of the stainless steel. Therefore ceramic products are widely used in the critical working conditions.

Advanced ceramic materials such as Al_2O_3,Si_3N_4,ZrO_2 and so on can be applied as the following engine components: Cylinder Liners ,Valve seat inserts , Piston bodies , Cylinder head liners ,Turbo charger inserts ,Valves ,Pump bodies ,Catalyst substrates , Mechanical seals ,Fuel delivery systems

Based on materials' properties, advanced structural ceramic components could provide the following benefits:

1. *Lower Density* provides reduced weight, which could lead to reduced fuel consumption, emission, and increased performance.

2. *Higher Elastic Modulus* provides less deformation, dimensional stability, reduced stress, increased strength and durability, which could lead to reduced fuel consumption, emission and maintenance, and increased performance.

3. *Higher Hardness* provides increased wear resistance, surface finished, reliability and durability.

4. *Enhanced Thermal Shock Resistance* of ASPRO treated alumina in comparison with original non-treated ceramics is comparable with the thermal shock resistance of the metal and enables the use of low-cost alumina ceramics for engine components.

5. *Lower Thermal Expansion* provides reduced stress during engine operation, which could lead to increased reliability and durability and reduced maintenance

6. *Lower Thermal Conductivity* may increase performance and reduce fuel consumption as a result of reduction of heat dissipation.

7. *Higher Specific Heat* provides better heat absorption.

8. *Higher Corrosion/Oxidation resistance* provides reduced surface damages and maintenance, increased reliability and durability.

9. *Higher Maximum Temperature Use* provides capability to operate the engine at higher temperature, increased reliability and durability, which could lead to reduced fuel consumption, emission and maintenance, and increased performance.

The main objective of my diploma work is to illustrate feasibility of projecting ceramic cylinder liner.I have selected throughoutly suitable materials both in terms of economically and function.The general properties of these materials are given below,which can help you understanding my alternative:

Table 4. General properties of Alumina

Properties	units	value
Physical		
Density,P	g/sm^3	3.7-3.97
color		Ivory/white
Crystal structure		hexagonal
Water absorption	% at room temperature	0.0
Hardness	Mohs	9
Mechanical		
Compressive strength	MPa, at room temperature	2070-2620
Tensile strength	MPa, at room temperature	260-300
Modulus of elasticity	GPa	393
Flexural strength	MPa, at room temperature	310-379
Poisson's Ratio		0.27
Fracture toughness,K_{1c}	MPax $m^{1/2}$	4.5
Thermal		
Maximal use temperature	^oC,no load condition	1750
Thermal shock resistance	$\wedge T(^oC)$	200
Thermal conductivity	W/m*K at room temperature	35
Coefficient of linear Thermal expansion,α_l	Mm/m*^oC (~25^oC through ±1000^oC)	8.4
Specific heat,C_p	Cal/g*^oC at room temperature	0.21

Table 5.General properties of TZP

properties	units	value
physical		
Density,P	g/sm^3	6.04

color		white
Crystal structure		tetragonal
Water absorption	%,at room temperature	0.0
Hardness	Mohs	6.5
Mechanical		
Compressive strength	MPa at room temperature	2500
Tensile strength	MPa at room temperature	248
Modulus of elasticity	GPa	207
Flexural strength	MPa at room temperature	900
Poisson's Ratio		0.32
Fracture toughness,K_{lc}	$MPaxm^{1/2}$	13.0
Thermal		
Maximal use temperature	^oC,no load condition	500
Thermal shock resistance	$\wedge T(^oC)$	280-360
Thermal conductivity	W/m*K at room temperature	2.7
Coefficient of linear Thermal expansion,α_l	Mm/m*^oC (~25^oC through ±1000^oC)	11.0
Specific heat,C_p	Cal/g*^oC at room temperature	0.10

My cylinder liner consist of 84 % Al_2O_3 and 16% ZrO_2-3% Y_2O_3due to fact that the latter is much more expensive in compared to former.If I raised the amount of latter,it would has been more costly.It is definitely apparent that the properties of abovementioned material is more predominant in compared with cylinder liner which is made of only Al_2O_3,which is obvious in table below.

Table 6.Properties of ZTA in comparison to Al_2O_3

Properties	TZP(16%)- Al_2O_3(84%)	Al_2O_3
Density (g/sm^3)	4.1	3.98

Bend strength (MPa)	760	400
Stress Intensity Factor,K_{ic}(MPa*$m^{1/2}$)	15	3-4
Vickers Hardness (H_v)	1750	2100
Thermal Expansion Coefficient(x10^{-6}/^oC)	8.1	5.5-10
Thermal conductivity (W/m*K)	23	36
Maximal temperature of use (^oC)	1800	1650
Elastic modul (GPa)	310	400

The addition TZP (Tetragonal zirconia polycrystal)- to the alumina matrix increases fracture toughness easily by two times and can be improved by as high as four times while strength is more than doubled.

And also I'm going to give information why I have doped zirconium dioxide with 3% Y_2O_3. At elevated temperatures the equilibrium structure of ZrO_2 is tetragonal(t) and at low temperatures it is monoclinic (m). On cooling TZP from the high temperatures required for fabrication the t -m transformation may occur in the zirconia particles. This transformation is accompanied by an increase in volume of about 3%. The transformation is a thermal, i.e., it is not time dependent and proceeds very rapidly. If the transformation takes place in the ZrO_2 particles during fabrication of TZP-Al_2O_3 ceramics, then the 3% volume change produces stresses in the alumina matrix around the transformed particle leading to microcracking. These microcracks increase the toughness of the ceramic by their ability to deflect and bifurcate a propagating crack. Control of the extent of themicrocracking determines the increase in toughness. The optimum conditions are when the particles are large enough to transform but only small enough to causelimitedmicrocrack development. If microcracking becomes extensive then the cracks can interact resulting in a decrease in strength. If a stabilizing oxide, say 3 mol% Y_2O_3, is added to the zirconia then it is possible to suppress the t -m transformation on cooling from the fabrication

temperature. The ZrO_2 particles can be retained in the metastable tetragonal form at room temperature. Whether the transformation takes place depends on the amount of stabilizing oxide and the particle size. The presence of the alumina matrix makes it difficult for the volume expansion associated with the transformation to be accommodated. The constraint is such that small particles are less likely to transform than large particles. With a suitable combination of amount of stabilizing oxide and particle size it is possible to obtain a dispersion of metastable tetragonal particles.

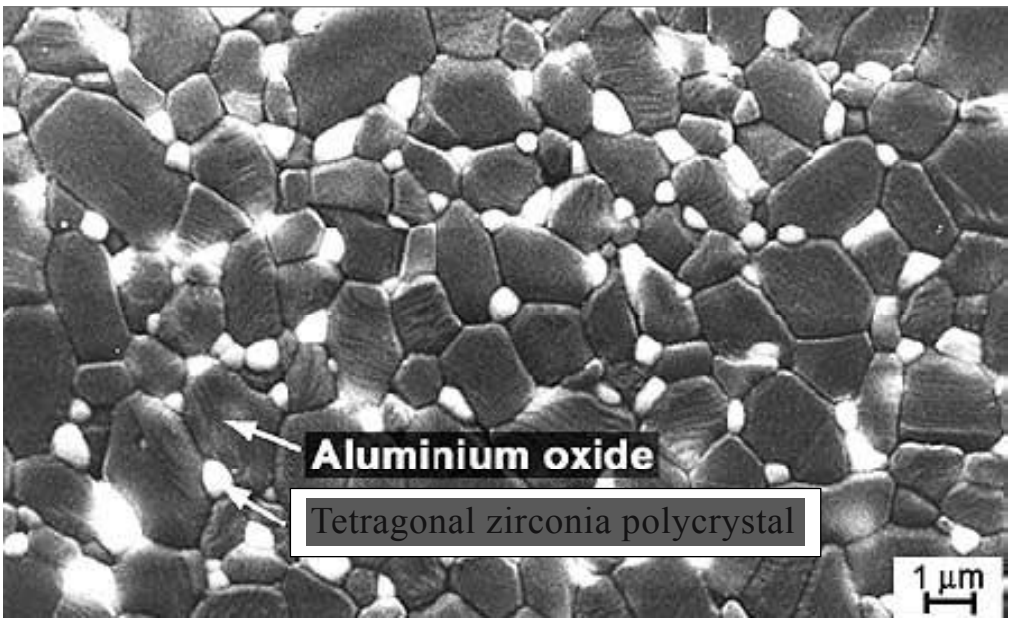


Figure 15.TZP toughened Alumina (16% TZP and 84% Alumina)

Two-phase ceramics are in general less brittle than single-phase materials and, usually, have higher fracture toughness.The value of density and elastic modulus increase, as a result of reduced amount of second phase in the material composition. Reduction of the elastic modulus mostly correlates with the density changes. We should note that density and elastic property changes are not so significant and do not reduce the material strength, but indicate on structural changes in the materials. The reduction of the density and elastic modulus could be a result of micro crystal defects.

Thermal shock refers to the thermal stresses that occur in a component as a result of exposure to a temperature difference between the surface and interior or between various regions of the component.

The results of calculating the cast iron sleeve are shown in Fig. 23, and the ceramic sleeve - in Fig.24.Numerical experiments confirmed the theoretical assumptions that as a result of the use of ceramic sleeves and an increase in the surface temperature, the ignition foci from the central part of the chamber move to the walls. The increase in temperature in the wall region leads to a decrease thickness of the thermal boundary layer, and, as a result, to an increase in the intensity of heat transfer, i.e. To an increase in the heat transfer coefficient.Simulation of the working process showed that if in the design mode n = 1000 min-1 the average heat transfer coefficient is α = 161.5 W / (m^2 K), and the resulting gas temperature T = 758.6 ° C, then in the nominal mode n = 2800 Min-1, their values are respectively equal to α = 296.6 W / (m^2 K), T = 755.8 ° C [135]. For a qualitative comparison of the effect of the heat insulator on the thermal state of the sleeve, a comparative table 7 was compiled based on the results of the calculations.

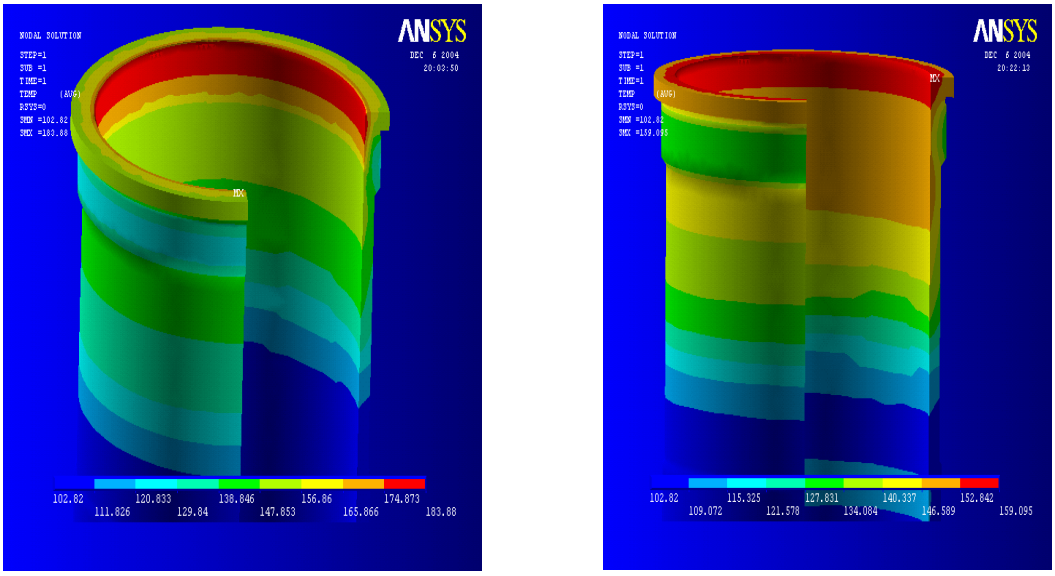


Figure16.Temperature filed of cast iron sleeve at n=1000 min^{-1} and n=2800 min^{-1}

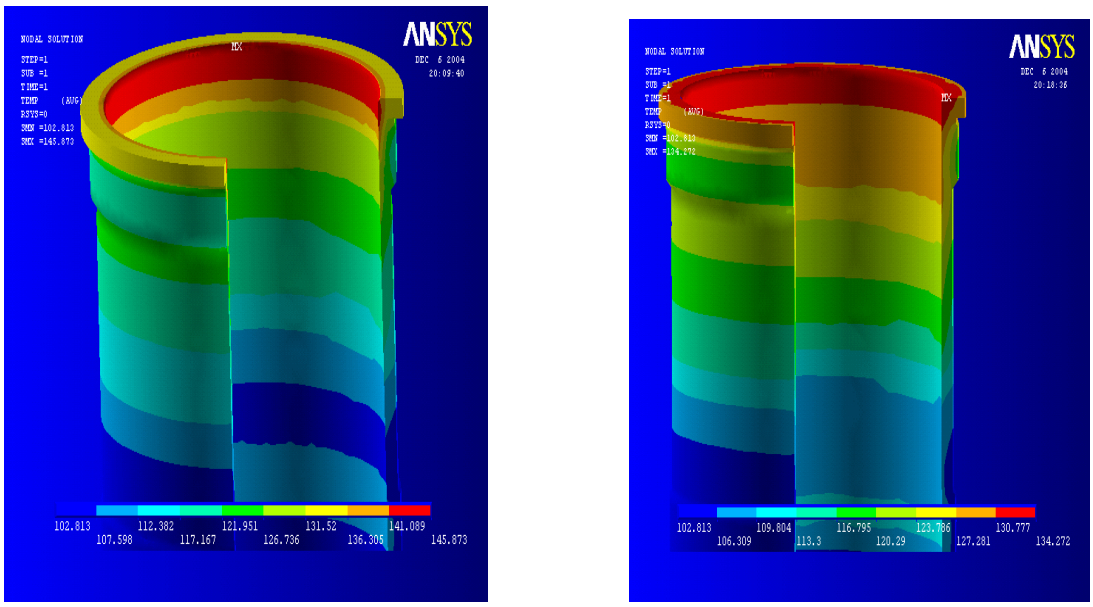


Figure17.Temperature filed of TZP-Alumina sleeve at n=1000 min^{-1} and n=2800 min^{-1}

As a control point, the point on the end face of the sleeve at the point of contact with the heat insulator is considered (Figs 23 and 24). This surface creates a seal with the cylinder head. The contact surface of the seal, of course, is also a surface.

Comparison table 7.

Temperature of liner, ^{0}C	Castiron liner n=1000 min^{-1}	Cast iron liner n=2800 min^{-1}	Ceramic liner n=1000 min^{-1}	Ceramic liner n=2800 min^{-1}
Maximal temperature	134.2	159.1	145.9	183.9
Minimal temperature	102.8	102.8	102.8	102.8
Temperature at the reference point	133	153	131	147

As can be seen from Table 7, and also from Figures 23 and 24, ceramic material does have a heat-insulating effect and the temperature at the reference point decreases. However, to further use this effect, a modification of the sleeve is necessary. The fact is that pig iron and compound of alumina and zirconia

have different coefficients of thermal expansion, which differ by more than 4 times, which, in particular, can lead to the appearance of a "step" on the mirror of a cylinder made of alumina, at a mode n = 2800 min-1, Which will be instantly destroyed by the edge of the piston or the first piston ring.

II.CONSTRUCTIONAL SECTION

2.1.PRESSMOLD DESIGN

Necessary basic information for calculating press mold:

1. Detail which produced from powder sketch design.
2. The chemical composition of the powder or brand
3. The value of pressure in pressing this powder
4. Pressing type(method)

Detail sketch design:

Material: 15% zirconia + 85 % aluminum

The most remained porosity: Ω = 6%

Limited deviations in dimensions: for hole

H 8, for shaft h7

1. Calculating value of compaction force

Pressing force: P = qFn, t

Where, q – needed pressure for compaction of powder, t/sm^2; F – pressing surface, sm^2; n – simultaneously the number of simultaneous pressing details;

Required pressure value in compacting powder associate with:chemical composition, powder particle dimension and technological properties of powder.. Therefore it (q) is determined from special,where primary rate is chemical composition of powder and the value of remained porosity.

1. g = 100- Ω = 100-6 = 94% 2. Powder chemical composition– Zirconia+Aluminum

F-the surface of pressing, which is perpendicular surface to the direction of pressing ,in this case it is determined from hatched circle surface:

$$F = \frac{\pi}{4}(D^2 - d^2), см$$

$$F = \frac{3,14}{4}(7,8^2 - 7,2^2) = 0,786(126,3 - 111,5) = 1163,6 см$$

n – the number of pressing details 1

and so all necessary elements in equation are determined:

P = qFn that is

q = 6,1 t/sm^2

F = 7,065 sm$^{2;}$

n = 1

if we put determined value of elements

R = 6,1·7,065·1 = 43,09 t/sm^2

2. Calculating pressing height

Pressing height is equal to the sum of detail height and additional layer, additional layer is spent in changing dimensions va mechanical treatment after taking detail from press form and sintering.

$$h_{прmin} = H - l_h + \varepsilon_h + n_k$$

Where, H – detail height in sketch; l_h – detail dimensions changes when it is taken from press mold; ε_h – detail dimensions changing as a result of sintering; n_k – remained additional layer for mechanical processing.

$h_{pr\ min}$=144-1,44+2,88+1=138,68 mm

3. Calculating press form height

Press moldheight N, that is height of loaded powder in press form which is determined as follows:

$N_{zk} = h_{prmin} \cdot K$=1.927*138,68=267

Where,h_{prmin} – detail pressing height; k – powder pouring coeffitsient, which is determined as follows **;**

$$K = \frac{\rho_n}{\rho_{нас}} = 3.854/2 = 1.927$$

ρ_{nas}– mass unit of volume of powder, g/sm^3

ρ_n – achieved density in pressing, g/sm^3 which is determined as follows:

$$\rho_n = \rho_{мат.пор} \frac{(100 - x)}{100} = 4.1*94/100 = 1.927$$

where,$r_{mat.por}$ –powder material's real density ,g/sm^3; x – achieved density in pressing ,%

ρ_{nas} – volume mass unit of powder material, g/sm^3

4. Calculating inner diameter dimensions of matrix

Determining diameter of matrix:

$D = D_d - l_D + \varepsilon_D + n_k = 78-0.78+1.17+1=79.39$ mm

Where, D_d – minimal diameter of compaction detail in mm; l_D – dimension of elastic aftereffect in mm; ε_D – shrinkage in sintering in mm; n_k- allowance for calibration in mm.

5. Calculating press mold's matrix for strength

Calculation of matrices for strength is to determine the thickness of the wall, since other parameters are found either depending on the size of the compressible article, or for design reasons.

The exact calculation of the stresses acting on the wall of the matrix is very complicated, and in practice, the empirical rule is used: the wall thickness of the entire cylindrical matrix must be no less than the radius of the working cavity. Insufficient stiffness of the matrix is often the cause of the appearance of transverse cracks in the compact during the vortexing. At high specific pressing forces, composite matrices are used to increase rigidity, as well as to ensure safety. The matrices are manufactured from alloyed tool steels or hard alloys, and the cages are made of soft structural steels. The joining of the matrix and the casing is carried out by hot fit. The working cavity of the matrix is grinded after its assembly. The clip, placed on the matrix in hot storage, increases its strength and dimensional stability.

Very big pressure appears internal part of press mold while powder materials are being pressed,this pressure is specified with Q which is termed press form's inner pressure. It works to split press form.

$Q = P/F$, t/sm^2

Where, R – required compaction force, t ; F – compaction surface, sm^2

Matrix's wall width is determined from strength condition.Strength condition is determined below showed equation according to force and pressure influence vector direction showed in figure.

$$\sigma_в = Q\frac{R_1}{\delta}$$

Where,R_1 – inner diameter of die which is equal to half of diameter calculated above, 52/2 = 26 mm; Q – inner pressure value of die, MPa; δ –width of die wall, mm.

If we calculate wall width from aboveshowedequation,it will be written as follows:

$$\delta = Q\frac{R_1}{[\sigma_d]}$$

Where,$[\sigma_v]$ – Ultimate tensile strength of material which is choosen for die. In this case material brand for die is St 30XGT whose tensile strength is found from Маричников or Material Science books. St30XGT brand steel's tensile strength is 1500 MPa.

1.Q=43.09 t/sm^2=430.9 MPa R_1=39.695 mm

$$\delta = 430.9\frac{39.695}{1500} = 11.4$$

6. Determining measurements of core

The dimensions of the core depend on the internal dimensions of the product, the elastic aftereffect, shrinkage during sintering and the permissible wear value.

Determining nominal diameter of the core:

$d = d_{max} – l_D – \varepsilon_D – n_k$

where,d_{max} – maximal inner diameter of detail, mm; l_D - Amount of elastic aftereffect , mm; ε_D – dimension changing in sintering, mm; n_k - remained layer for mechanical processing, mm.

So,d = 72 – (0,01·78) - (0,01·78) – 1 = 69.44 mm

7. Determining dimensions of Punch

Punch dimensions is determined according to press mold's structural ones, because punch's outer diameter moves through inner diameter of matrix. Punch's inner diameter moves through outer diameter of core,so it is determined as follows:

- Punch's outer diameter is equal to inner diameter of matrix which also consist of some clearance so that punch can move without obstacles.
- Punch's inner diameter is equal to outer diameter of core but punch's inner diameter is a bit large in compared to outer diameter of core due to fact that there is some clearance between these.
- In most cases punch's height is decided as equal to press form's height.

Press form's other extra parts that is press form base ,bolt-nuts,handles and other similar detail's dimensions are determined according to press form's design.

III.TECHNOLOGICAL SECTION

3.1.Preparing powders for production

It is obvious that we should be vigilant to storing of ceramic powders so that we can produce high-quality products.Because the quality of product is definitely associated with the condition of storage.Depending on their characteristics and the stage of processing, the raw materials are stored in open stockpiles, warehouses which are subdivided into boxes, large volume feeders, tempering silos, ageing silos, souring silos or dry silos. The silos are equipped with level indicators,overload valves and filters or gas displacement units, where displaced dusty air is blown off. Some materials are also delivered in liquid or slurry form and therefore are stored in tanks or other vessels.

Some processing methods are utilized in order to produce powdered ceramic cylinder sleeve. In powder conditioning, the powders prepared by various methods are subjected to a variety of treatments to improve or modify their physical, chemical characteristics.Ceramic powders should undergo following treatments:

1) pre-drying.2) dry screening. 3) milling(grinding).4)component mixing 5)compaction 6)sintering

1.Pre-drying

Sometimes ceramic raw materials need to be pre-dried, in our case ceramic powders may be dried using fluidised bed technology and also rotary dryers may be used.I have chosen fluidised bed technology in which fluidised bed reactor is used to carry out a variety of multiphase chemical reactions. In this type of reactor, a fluid (gas or liquid) is passed through a solid granular material at high enough velocities to suspend the solid and cause it to behave as though it were a fluid.

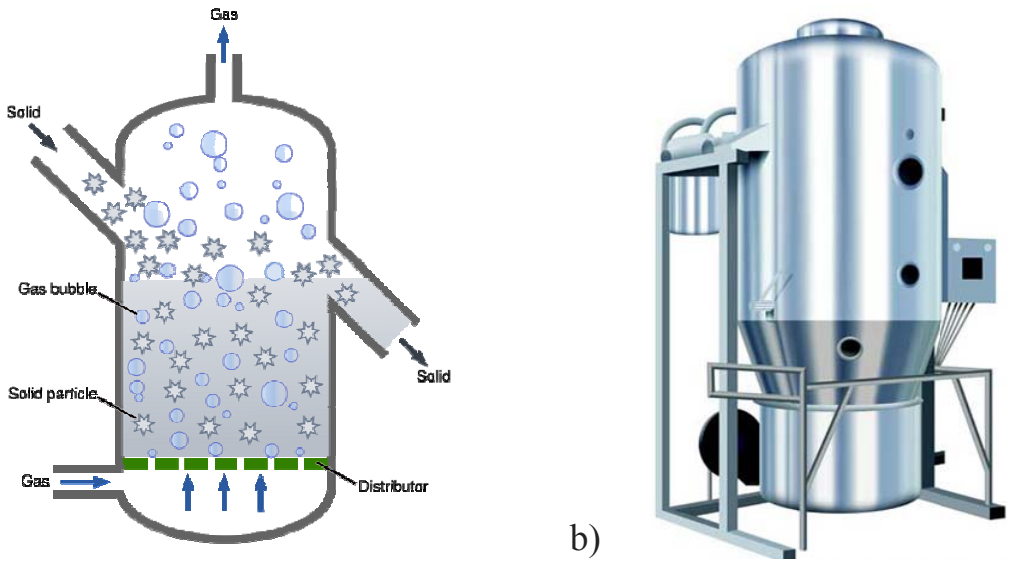


Figure18.a)Basic diagram of a fluidised bed reactor b) fluidised bed dryer

2.Dry screening

In order to optimise certain properties of ceramics (e.g. density), it is sometimes necessary to blend defined size-gradings of material. Dry screening usually involves vibrating screens,heated electrically to prevent the build-up of material and clogging.

Figure19.Separation of powders into groups of liked sizes

3. Milling (grinding)

Further size reduction is necessary for many ceramic applications in order to achieve very high mechanical and physical properties. They consist of rotating vertically orientated rolls operating within an outer ring, and pressure is developed between the roller and ring, e.g. by centrifugal force. Raw material

from the primary crushing stage is introduced to the mill with or without water, and ground until the required size grading is achieved. Dry and wet roller mills are used to obtain particles of around 1 mm diameter. In this Milling equipment with water is used due to fact that it is much more effective than the one without water. For wet milling 30-40 vol% of powder with 1 wt% of dispersing agent such as water, alcohol or hexane is employed.

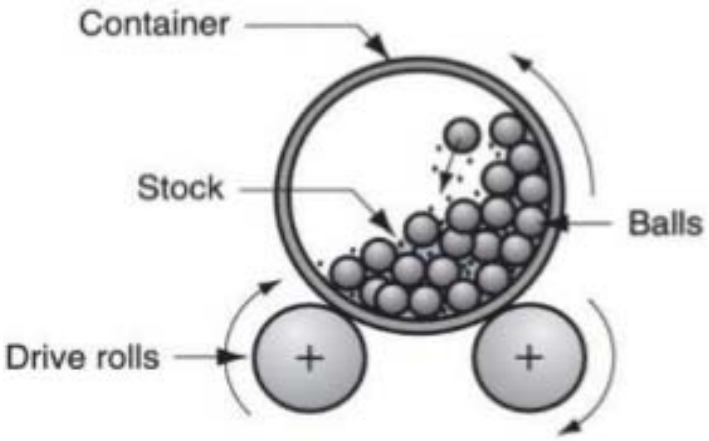


Figure 20..Ball mill

Even finer grinding can be obtained using continuous or batch ball mills (in which hard ceramic spheres are tumbled within horizontally mounted drums).Ball mills are the normal choice for the ceramic sleeve production in industry, and when used wet they can produce powders graded below two hundred microns.

4.Component mixing

Mixing time, intensity and sequence have a significant impact on the properties of the mix and consequently on the ultimate product.737 gr alumina(84%) and 130 gr TZP(16%) are mixed in double cone mixer to produce a cylinder sleeve.The prepared raw materials alumina and TZP, in controlled proportions,must be mixed and homogenised to achieve the required physico – chemical uniformity.

Most ceramic forming operations require raw materials with a defined water or bonder content,and minor additives such as pigments, anti-scum agents and binders and plasticizers must be accurately dosed and then uniformly distributed in the mix.SoIt is often necessary to add a binder to the ceramic powder.The binder has two functions. In some shaping methods,such as extrusion, the binder provides the plasticity necessary for forming. The binder also provides the dry (green)shape with strength sufficient to survive the handling process between shaping and sintering. One of the most important requirements for the binder is that we must beable to eliminate it from the compact during the firing process without any disruptive effect: polymers are thus often ideal binders.Therefore I decide to add 4-5% poly vinyl alcohol in order to a high green strength.All these components are blended to achieve random mixture which is showed below.

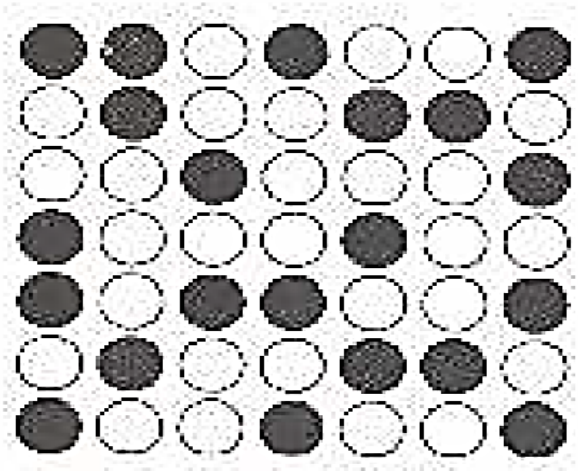


Figure21.Random mixture of Alumina and TZP

3.2.Compacting powders and sintering green body

1.Compaction

Dry pressing is ideally suited to the formation of simple solid shapes and consists of three basic steps: filling the die, compacting the contents, and ejecting the pressed solid. Figure 23.1 shows a schematic diagram of the doubleaction dry-pressing process. In the press the punche are movable. When the bottom punch is in the low position a cavity is formed in the die and this

cavity is filled with free flowing powder. In dry pressing the powder mixture will contain between 0 and 5 wt% of a binder. Once the cavity has been filled, the powder is struck off level with the top of the die. The top punch descends and compresses the powder either to a predetermined volume or to a set pressure. During pressing the powder particles must flow between the closing punches so that the space between them is uniformly filled. A particle size distribution of between 20 and 200 mkm is often preferred for dry pressing: a high volume fraction of small particles causes problems with particle flow and also results in sticking of the punches. The pressures used in dry pressing may be as high as 300 MPa, depending upon material and press type, to maximize the density of the compact. After pressing, a punche move upward.The compact is then ejected.Because the dry-pressing process is so simple and involves low capital equipment costs it is the most widely used high-volume forming process for ceramics.

Figure 22.Typical press mold for the compacting of ceramic powders

2.Sintering green body

It is the process of consolidating either loose aggregate of powder or a green compactof the desired composition under controlled conditions of temperature and time.

Stages in solid state sintering

• In general, solid state sintering can be divided into three stages – 1st stage: Necksare formed at the contact points between the particles, which continue to grow.During this rapid neck growth takes place. Also the pores are interconnected and thepore shapes are irregular.

• 2nd stage: In this stage, with sufficient neck growth, the pore channels become morecylindrical in nature. The curvature gradient is high for small neck size leading tofaster sintering. With sufficient time at the sintering temperature, the pore eventuallybecomes rounded. As the neck grows, the curvature gradient decreases and sinteringalso decreases. This means there is no change in pore volume but with change in poreshape => pores may become spherical and isolated. With continued sintering, anetwork of pores and a skeleton of solid particle is formed. The pores continue toform a connected phase throughout the compact.

• 3rd or final stage: In this stage, pore channel closure occurs and the pores becomeisolated and no longer interconnected. Porosity does not change and small poresremain even after long sintering times.

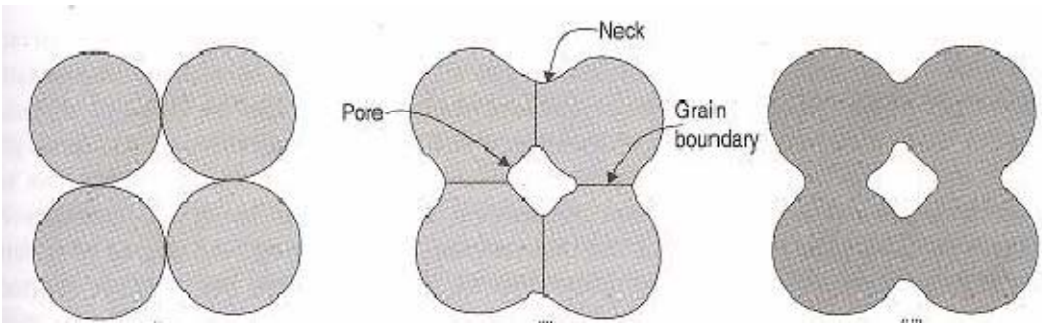


Figure 23.Conditions of ceramic powders when it is sintering

IV.ECONOMICAL SECTION

The production process in any enterprise assumes the presence not only of people, but also of certain means of production, i.e. Production assets that are part of the social wealth. The division of the means of production into the basic (means of labor) and circulating assets (objects of labor) is conditioned by the material conditions of production and takes place under any social mode of production.

Distinctive features serve many production cycles and retain their natural form. They transfer their value to the products they produce in parts as they wear out (in the amount of the established depreciation rates). Sprouted food is consumed entirely in each new production cycle and does not retain its natural form in the production process. They transfer their value to the created products completely, immediately. The fixed assets are divided into industrial and non-production assets.Privately structured financial functions function in the sphere of material production, participate repeatedly in the production process, wear out gradually and transfer their value to the created product Parts by depreciation. These are buildings, facilities of industrial enterprises, mining, concentrating, metallurgical equipment, machine tools, vehicles, etc.Non-productive fixed assets do not participate in the production process and are intended for direct consumption, wear out gradually and lose their value in parts. These include the basic funds belonging to industrial enterprises of housing and communal services.The basic production assets, i.e. The means of labor participate in many production cycles, retain their natural-material form until the end of exploitation, and transfer their value to the manufactured product in parts as they wear out, are reimbursed first in cash, then in kind.By the degree of participation in the production process, the basic production assets are divided into active and passive parts. The active part of the fixed assets, which directly affect the change in the form and properties of the objects of labor, include machines, equipment, vehicles, instruments, inventory, etc. Passive part of the funds

include building structures, etc., i.e. Funds that provide conditions for the implementation of the production process.

Table 1 Technical engineer annual salary fund

Thenameposotions	Discharge	Coeffitsientondischarge	The number of workers on list	The most minimal salary	Salary on described discharge	Reward 20%	Additions 14%	General salary
Engineer	10	5.362	1	149.775	803.09	160.61	112.43	1076.14
Technologist	9	4.997	1	149.775	748.42	149.68	104.77	1002.89
Worker	3	2.998	1	149.775	449.02	89.80	62.86	601.69
Total								

Total annual salary				32168.74

Table 2 Account of energy costs

Energy consumer	Processes and production types	Annual volume of production	Energyconsumtion Kw/h	Total energy consumption Kw/h
Chambergasfurnace	sintering	60000	0,061	2,14
Press-form	pressing	60000	0,778	27,33
mixer	mixing	60000	0,066	2,32

Table 3 Material resources costs account

Material resources name	The unit of measurement	A unit production expenditure	A single material cost,sum	Price,sum
Alumina	gr	737	21950	18657
Zirconia	gr	130	382000	57300
Jami	gr	867	403950	75957

Table 4 Basic funds amortization allowance account

Basic funds name	Value of basic fund in sum	Amortization norms ,%	Value of amortization
Chamber gas furnace	57300000	5	2865000
Press-form	38200000	5	1910000
mixer	22920000	5	1146000

Table 5 Plant expenditure budget

Expenditure types	Cost in sum
Engineer,technologist and worker's primary and additional salary	32168,74
Social insurance expenses(25%)	8042,19
Basic funds amortization	5921000
Repairing basic funds(10%)	3216,87
Safety engineering expenses(15%)	4825,31

Other expenditure of plant(7%)	2251,81

Table 6.Total cost of production per year

№	Name of the cost	Unit Measurements	Amount	The share of expenses from total amount of expenses %
1	Expensesraw	thousand sums	10346,35	3,2
2	Annual Amortization Amount	thousand sums	4775000	66,25
3	Wage fund	thousand sums	32168,74	3,17
4	Costs of social insurance	thousand sums	8042,19	4,87
5	Electricityconsumption	thousand sums	15346	2,89
6	Consumptionofmaterials	thousand sums	9331,38	19,49
	Total	thousand sums	4850234,66	100

V.SAFETY ENGINEERING

5.1.Occupational health and hygiene

The environment of the workplace can affect the overall health and safety of all employees. Plant layout and other physical situations need to be considered to ensure workers are not placed at risk.

Plant layout

The layout of plant should always be considered from a health and safety perspective as well as from a production perspective.

The following matters should always be considered:

• the location of designated raw material and delivery areas

• that raw materials are stored in an easily accessible area close to the start of the production area

• lineal workflow through the production line

• clear areas of work

• reduction of blind spots throughout the plant, and

• traffic management and designated forklift and pedestrian segregation.

Noise

In the metal product manufacturing industry, numerous items of plant and various activities such as grinding, hammering steel, guillotining, cutting metal,pressing and even disposing of metal objects in bins can produce noise that can be damaging.If employees in your workplace are exposed to noise that exceeds the exposure standard of 85 dB(A) averaged over an eight hour period or a peak noise level of 140 dB(c) then your workplace is too noisy and one or more of the controls must be implemented to ensure employee noise exposure does not exceed the standard.Furthermore if any of the following occurs, noise controls are likely to be required:

• employees have to raise their voice to communicate at a distance of one metre, or

• employees have a temporary reduction in hearing or ringing in the ears after leaving work for the day.

The noise regulations set out a hierarchy of controls to be applied when fixing noise hazards. These are:

1. Elimination of noise sources

2. Substitution of quieter plant or processes, or use of engineering measures

3. Administrative measures, and

4. Hearing protectors.

Hearing tests must be provided where hearing protectors are required to make sure that employees' exposure does not exceed the noise standard.

It is worth noting that if there are changes to the workplace, like a new machine coming in or more machines being compressed into a smaller area then it may be necessary to redo noise level tests.

Lighting

The quality of lighting in a workplace has a significant effect on safety andproductivity. Good lighting in the workplace promotes:

• a reduced risk of injuries through better visibility

• a reduced risk of short and long term health problems such as headaches and eye strain and vision impairment loss, and

• a brighter, cleaner workplace resulting in a more active, cheerful environment.

This can be achieved by:

• making full use of natural light by installing windows and skylights

• ensuring overhead and fixed lighting is at appropriate levels and is appropriately maintained and replaced

• using task lighting with a flexible arm to enable light to be directed to the spot where light is needed

• painting ceilings and walls a lighter colour allowing more light to be reflected and assisting in increasing the light within the workplace.

Temperature of workplace

Under the OHS Act, employers have a responsibility to provide a safe and healthy workplace. This broad duty of care includes ensuring workers are not subjected to excessive heat or cold that may cause illness. Heat illness covers a range of medical conditions that can arise when the body is unable to properly cope with working in the heat. Signs and symptoms of heat illness include nausea, dizziness,weakness, clumsiness, collapse and convulsions. Employees exhibiting these symptoms should seek immediate first-aid/medical attention.

Some conditions are:

• heat stroke – a life threatening condition that requires immediate first aid andmedical attention

• fainting in heat (heat syncope)

• heat exhaustion

• heat cramps

• heat fatigue.

As with any other occupational health and safety risk, there are general procedures to follow when assessing the risk of heat at work. These include consulting the employees who are exposed to the heat as well as their health and safety representatives. In consultation with your employees a Heat Alert Program should be considered as it is the best way to minimise the risk of heat illness.

For indoor work

• air conditioning/air circulation fans/good ventilation

• insulation of roof and wall insulation or shielding of sources of heat and external ducting of hot exhausts.

For outdoor work

• suitable protective clothing with ventilation, sunburn creams and skin protector,air-conditioned vehicles and rest areas.

In addition, ensure employees have access to adequate supplies of cool drinking water. Allocated breaks should also be made available as determined by the conditions, preferably providing shade during their breaks.

5.2.Safety engineering and safety

The safety issues associated with the use of furnaces can be divided into three categories.

- High-temperature hazards. Working with high temperatures is the obvious safety hazard when using furnaces.Protective goggles or safety glasses should beused in all situations. As the temperature increases, the intensity of the emitted light rises and the maximum shifts to shorter frequencies. This is apparent to anobserver. At 1000°C the color of a furnace enclosure is a pleasing red. At 1600°C it is a brilliant painful white and goggles or glasses with green lenses shouldbe used. Handling objects that have come from a furnace should be done using specially designed tongs and furnace tools and hands should be protected withinsulating gloves. Even if an object is not glowing red it can still be at a temperature of 500°C.

-Electrical hazards. Electrical dangers should never be underestimated. All electrical equipment operating at mains voltages can be lethal. A current 100 mA (acor dc) would almost invariably be fatal if passed through the body. Most electrical accidents are caused by worn-out equipment or faulty wiring, both of which can be avoided. All potentials in excess of a few tens of volts must be properly insulated and physically isolated before maintenance. A typical laboratory box furnace uses 240 or 208 V single phase at 50 or 60 Hz to generate 10 kW of power. This requires a current of about 40 A. All electrical equipment not fully insulated must be properly earthed in the interests of safety.

-Chemical hazards. Some of the chemicals used in ceramic processing are toxic. One important example is lead and its oxides, which are widely used in theproduction of certain types of glasses and pigments.Care should be taken to read safety data sheets that accompany any chemicals and to take the necessary

preventative action. Other safety issues can arise from unwanted reactions that occur within the furnace.

5.3.Fire safety

The Occupational Safety and Health Administration (OSHA) requires employers to implement fire protection and prevention programs in the workplace.

Fire is a chemical reaction that requires three elements to be present for the reaction to take place and continue. The three elements are:

- Heat, or an ignition source
- Fuel
- Oxygen

These three elements typically are referred to as the “fire triangle.” Fire is the result of the reaction between the fuel and oxygen in the air.

Fire Classifications

Fires are classified as A, B, C, D or K based on the type of substance that is the fuel for the fire, as follows:

Class A—fires involving ordinary combustibles, such as paper, trash, some plastics, wood and cloth. A rule of thumb is if it leaves an ash behind, it is a Class A fire.

Class B—fires involving flammable gases or liquids, such as propane, oil and gasoline

Class C—fires involving energized electrical components

Class D—fires involving metal. A rule of thumb is if the name of the metal ends with the letters “um,” it is a Class D fire. Examples of this are aluminum, magnesium, beryllium and sodium. Class D fires rarely occur in the roofing industry.

Class K—fires involving vegetable or animal cooking oils or fats; common in commercial cooking operations using deep fat fryers.

Fire prevention methods.

Service or fueling areas at job sites must have a 20BC-rated fire extinguisher within 75 feet of each pump. Fire Extinguishers

There are different types of fire extinguishers designed to put out the different classes of fire. Selecting the appropriate fire extinguisher is an important consideration for a factory contractor.The wrong extinguisher actually may make a fire emergency worse.

VI.ECOLOGICAL SECTION

6.1.Pollution from internal combustion engines

In cities across the globe, the personal automobile is the single greatest polluter, as emissions from more than a billion vehicles on the road add up to a planet-wide problem. Driving a private car is a typical citizen's most air polluting activity. The negative effects of automotive emissions are maximum when you sit in traffic surrounded by cars trucks and buses, their engines idling. Everyone sitting in a traffic jam is getting poisoned.

Internal combustion (IC) engines are used in a variety of stationary applications ranging from power generation to inert gas production. Both spark ignition and compression ignition engines can be found. Depending on the application, stationary IC engines range in size from relatively small (~50 hp) for agricultural irrigation purposes to thousands of horsepower for power generation. Often when used for power generation, several large engines will be used in parallel to meet the load requirements. A variety of fuels can be used for IC engines including diesel and gasoline among others. The actual fuel used depends on the owners/operators preference but can be application dependent as well.

The operation of IC engines results in the emission of hydrocarbons (NMHC or VOC), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). The actual concentration of these criteria pollutants varies from engine to engine, mode of operation, and is strongly related to the type of fuel used.

The Combustion Process

Gasoline and diesel fuels are mixtures of hydrocarbons (made of hydrogen, oxygen and carbon atoms.) Hydrocarbons are burned by combining with oxygen. Nitrogen and sulphur atoms are also present and combine with oxygen when burned to produce gases. Attempts to reduce exhaust emissions from gasoline and diesel engines have been compromised by limitations of

testing, inherent flaws in the design and inadequate maintenance of emission control devices.

Diesel engines a pose different emission control problems than gasoline engines. Diesels require more sophisticated and expensive components than the catalytic converters fitted to gasoline engines. Diesel emissions contain nitrogen oxide gases and carbon particles, the smallest of which contribute to lung and heart disease. Increases in airborne fine particulate matter increases the risk for myocardial infarctions, strokes and heart failure. Particle deposition in the lungs activates the sympathetic nervous system and triggers the release of systemic pro-inflammatory responses. Brook and Rajagopalanb stated: "Higher circulating levels of inflammatory cytokines cause vascular endothelial dysfunction and activation of vasoconstrictive pathways while blunting vasodilator capacity. At the molecular level, the generation of oxidative stress with the consequent up-regulation of redox sensitive pathways appears to be a common mechanism of these pro-hypertensive responses. Due to the ubiquitous, continuous and often involuntary nature of exposure, airborne fine particles may be an important and under-appreciated worldwide environmental risk factor for increased arterial BP.

6.2.Ecological advantages of engines with ceramic components

A Ceramic Engine is expected to be capable of using various fuels because of its high operating temperatures. Renewable fuels such as cellulosic bio-ethanol or straight vegetable oils (SVO) could be used in this engine. SVOs are unprocessed or unmodified vegetable oils. A Ceramic Engine as a portable power source using SVOs as fuel for rural communities and villages in the third world could enhance the quality of life of the citizens in these communities.

Additionally, special ceramic coatings applied to the combustion zone surfaces of the piston crown, valve faces, and head have shown the ability to significantly reduce NOx and PM emissions in diesel engines. These ceramic coatings can be used by themselves or combined with an oxidation catalyst to

give even greater reduction of PM. Ceramic engine change the combustion characteristics such that less dry, carbon soot, is produced. Also, when combined with an oxidation catalyst, ceramic coatings allow retarding of the engine to reduce NOx, whilen CO and particulates are maintained at low levels.

In the case of gaseous fuels, ceramic coatings have shown the ability to allow the user to operate their engines with timing significantly advanced generating higher power levels. Also, wider ranges of fuel composition and ambient air temperature fluctuations are tolerated without the deleterious effects of pre-combustion. Tests are currently underway to evaluate the effects of the coatings on specific emissions from gaseous fueled engines.

Zirconia is a low thermal conductivity material, it reduces the heat loss from the cylinder to the surroundings. Therefore the efficiencies are increased and the emissions are reduced because of various chemical reactions takes place inside the cylinder at high temperature. Brake thermal efficiency and mechanical efficiency of coated piston are increased by the average value of 9% and 25% respectively. 7% reduction in total fuel consumption and 6% reduction in specific fuel consumption were achieved with the coated piston. 14% of NOX emissions were reduced due to coating because of nitrogen has observed by zirconia. 23% of unburned HC emissions were reduced by using the coated piston. CO emissions are reduced by 48% because of at high temperature CO easily combines with O2 and reduces CO emission.

VII.CONCLUSION

In today's competitive automotive world cylinder liners provided with good hardness and wear resistance properties were best choosen to provide customer satisfaction. For the cylinder liner manufacturing industries to remain competitive in the present market situation implementation of ceramic materials will be best suited in order to increase the life of the liners which they produce to satisfy customer requirements .It not only provides cylinder liners with good wear resistance,thermal efficiency and lighter design but also improves the standards of customer satisfaction and also acts as an important heat treatment process compared to other traditional techniques.

After studying and analyzing ceramic cylinder liner using compound of alumina and TZP following conclusions were drawn:

a) The cylinder liner made of compound of alumina and TZP is lighter than the existing cylinder liner.

b) Energy efficiency of such kind cylinder liners are much more higher in compared to existing cylinder liners.

c) Interestingly such alternative cylinder liners' wear and corrosion resistance are a far higher than cast iron ones.

All diesel engines could conceivably benefit both economicallyand from a performance viewpoint from the application of ceramics, largeengines would seem to have the strongest need for these materials . Thisis because large engines currently experience corrosion problems due tolow-grade fuels, cooling and thermal stresses are major designconsiderations, internal stresses are lower than in small engines, enginelife is a more critical economic factor, and the engines operate at a

higher load factor.

Applications that do not require the development of new lubricants

have the best possibility for near- term success. The use of ceramics in

applications requiring high- temperature lubricant films is less likely to

achieve commercial utilization. The controlling factor in the latter

application is not the ceramic materials properties but the development of new methods for lubrication or new lubricants. Emphasis should therefore be placed on the development of ceramics for corrosion-resistant and temperature-resistant applications .

As you can see abovementioned text,There are some obstacles which don’t enable to use such kind of cylinder liners in industry and so various further researchsshoul be conduct in order to deal with such concerns.

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