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Review

Glasses as engineering materials: A review

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ABSTRACT

Glass products have applications in design engineering, and they can solve many special problems. These materials can work in situations in which plastics and metals would fail and need to be part of designer's repertoire. In some situations, by using these materials, some difficult problems would be solved. This paper contains a number of chapters as follows: a brief about ceramics family, a short history of glass, a brief about physics and the technology of glass fabrication, recently developed glasses with special destinations, testing methods and news about glass parts processing (grinding, waterjet processing, laser cutting, nanoimprint lithography, etc.). The last chapter of this review paper contain some strategic lines of glass usage in industry and estimations about the future of glass development.

1. The ceramics family

Cermets and ceramics are becoming the tool materials for the present and future. By using the cemented carbides at wood working tools (as saw blades, cutting wheels), the wear was reduced significant. Coated cemented carbides displaced the high-speed steel for cutting tools and also high production press dies use the cemented carbide tooling. Ceramics are taking a lot of high-temperature machine tasks, are substrates for computer chips, and are used for prosthetic devices. Glasses and carbon products have applications in design engineering and they can solve many special problems.

These materials can work in situations in which plastics and metals would fail and need to be part of designer's repertoire; sometimes, using these materials, some difficult problems would be solved. Ceramics are defined as solids composed of compounds that contain metallic and/or non-metallic elements, and the atoms of compounds are held together with strong atomic forces (ionic or covalent bonds). The spectrum of ceramic uses is presented in Fig. 1.

The ceramics with high strength and the best toughness (as aluminum, zirconias, oxides, silicon carbides) were named in 1980 as "structural ceramics". In Japan, these ceramics were called "fine ceramics". In 1990, the (ASTM) Committee for ceramics (C28) named this ceramics "advanced ceramics". The definition given by C28 for this class of materials is highly engineered, high-performance, predominantly non-metallic, inorganic, ceramic material having specific functional attributes (by standard ASTM C1145) [1].

Glasses are not ceramics (by previous definition of ceramics), but they are used for similar type of things as ceramics and have some properties that are typical for ceramics. The most common property of ceramics, glasses, and cements is brittleness.

The measure of crack propagation tendency, fracture toughness, is lower at ceramics family than at metals, as is shown in Fig. 2.

2. Brief history of glass: past and present of glass

It is not exactly known when, where, or how humans first learned to make glass. The legends tells us that a Phoenician sailor (by other historians, a Roman sailor), cooking the evening meal on a beach, sets the pots on top of stones of *natron* (a natural mixture of sodium carbonate decahydrate, sodium bicarbonate along with small quantities of household salt). As the cooking fire heated both these stones and the sand below, an unknown liquid began to flow and that was the origin of man-made glass.

In [2] is demonstrated and argued that in ancient times, soda glasses with high alumina concentrations are quite rare around the Mediterranean area or in the Middle East. The few available examples include European Iron-Age dark blue glass colored with cobalt-rich alum that contains up to 8% of alumina. Mineral soda–alumina (m-Na–Al) glass has been found across a vast area stretching from Africa to East Asia. m-Na–Al glass appears around the 5th c. B.C. and is relatively common for periods as late as the 19th c. A.D. It is particularly abundant in South Asia, where raw materials to produce m-Na–Al glass are readily available and was likely manufactured there; however, the number and the importance of the manufacturing centers are unknown as archaeological information is extremely scarce. The interpretation of data obtained using compositional analysis on a large corpus of artifacts (486) shows that at least five subgroups of m-Na–Al glass can be

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