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SYNTHETIC GRAPHITE : MANUFACTURE, PROPERTIES AND USES

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Synthetic graphite is the result of graphitization of carbon at high temperatures. It is variously known as 'Synthetic Graphite', 'Artificial Graphite', 'Manufactured Graphite' and 'Electric-furnace Graphite'. Commercially produced synthetic graphite is a mixture of crystalline graphite and cross-linking intercrystalline carbon. Although much of the graphite used in the industry is natural graphite, synthetic graphite is indispensable for certain purposes. Among engineering materials, synthetic graphite is unusual because a wide variation in measurable properties can occur without significant change in chemical composition. To the technologist it may be of interest from many aspects—its electrical properties, lubricating properties or its ability to retain certain properties unchanged after irradiation.

Manufacturing Process

Synthetic graphite can be prepared in the laboratory by different processes from a wide range of raw materials mixed in varying propertions. Graphite is not obtained by heating pure carbon alone. The presence of a metal or metallic oxide is necessary. The quality of synthetic graphite depends upon many factors, particularly the raw materials from which the graphite is made, the temperature and the method of manufacture. Synthetic graphite can be made from almost any organic material that leaves a high carbon residue on heating at 2500-3200°C. (5300-6748° F.) in an electrical furnace. At present there are three commercial processes for the manufacture of synthetic graphite.

1. Pure granular or powdered carbon with suitable binder is used as raw material which is extruded. The blocks are heated electrically in a packing of petroleum coke. The 'green' shapes are fired to give rigid bodies by carbonization and are refired at very high temperature to complete the process of graphitization.

2. The most commonly used raw material is petroleum coke. After calcining and sizing, petroleum coke is mixed with coal-tar pitch and heated to 165°C. (361°F.) to form "green" shapes by extrusion or moulding. They are baked to 750-1400°C. (1606-2968°F.) in gas or oil-fired kilns. Graphite is produced by heating the baked shapes to 2600-3000°C. (5512-6360°F.) by passing 1.6—3.00 KW electric current per pound of graphite through the bed

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of a furnace which is covered by an insulating blanket of silicon carbide, coke and sand. As a result of normal manufacturing process, graphite exhibits marked anisotropy in its mechanical properties measured parallel and perpendicular to the axis of extrusion.

3. A mixture of anthracite (high grade coal) or petroleum coke, quartz and saw dust, are heated in electrical furnace, out of contact with air, at a temperature of about 3000°C (6360°F.), in which graphitic carbon is deposited as a residue In this process metallic carbide is first formed which is substantially decomposed to give graphite. The ash constituent present in anthracite (8-10%) furnishes the oxides necessary for graphitization.

The following factors affect the uniformity and quality of synthetic graphite.

(a) The crystallographic structure of graphite. In an extruded or moulded section, graphite will be anisotropic to a varying degree dependent upon the orientation of unit crystals.

(b) The rates of heating and cooling affect the kinetics of the crystal growth process. High temperature graphitization is essentially the growth of very small, largely two dimentional graphite nucleii in an ungraphitized carbon.

(c) The properties of the end product would be dependent upon the mean grain size and also upon the distribution of grain sizes.

Thus, variation in properties can be expected with orientation relative to the extrusion direction, from heat to heat, from block to block within a heat and with the position within a given block.

The precise process of block formation, such as extrusion, pressing or deposition will influence the preferred orientation of the graphite crystallites relative to the extrusion or pressing axis.

Physical and Mechanical Properties

Among Physical properties of Synthetic Graphite, the density, the coefficeint of thermal conductivity and the thermal expansion are relevant. The electrical resistivity may have empirical relationship to the thermal conductivity and may be used to economize both time and money. The thermal conductivity of graphite falls rapidly with increasing temperature. At room temperature the thermal conductivity of synthetic graphite is comparable to that of aluminium or brass. Synthetic graphite is resistant to thermal shock because of its high thermal conductivity and low elastic modulus. The thermal and electrical properties of synthetic graphite are determined by crystalline structures, bonding between crystallites and defects.

The principal mechanical requirement for synthetic graphite is its compressive strength. Cowan, concluded that the mechanical strength, Young's modulus and the rigidity modulus are increased with rise in temperature and also noted that Young's modulus depends upon the grain size. Other factors reported to affect mechanical properties are density, oxidation and period of storage. An unusual property of synthetic graphite is its increased strength at high temperature.

Uses

In recent years, natural graphite is replaced by synthetic graphite in many ways, viz. in moderators and reflectors in atomic reactors and in thermal columns, rocket motor nozzles, missile rudder vanes, crucible and dies. Synthetic graphite is acceptable in atomic reactors and nuclear engines because of its radiation damage resistance property which is one of the most important properties of moderator materials. Since 1950, Los Alamos Scientific Laboratory of Atomic Energy Commission is working on the use of nuclear reactors in which synthetic graphite is the primary structural material and on engines which incorporate such reactors.

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