

GLOSSARY



A

a-stage—An early stage in the reaction of a thermosetting resin in which the material is still soluble in certain liquids and fusible. See also B-and C-Stage.

ablative plastics—This description applies to a material which absorbs heat (while part of it is being consumed by heat) through a decomposition process known as pyrolysis, which takes place in the near surface layer exposed to heat.

abrasive wear—Wear caused by contact of hard particles that move while they're forced against a surface, such as a screw or barrel.

absolute viscosity—Of a fluid, the tangential force on unit area of either of two parallel planes at unit distance apart when the space between the planes is filled with the fluid in question and one of the planes moves with unit differential velocity in its own plane.

The C.G.S. unit for absolute (or dynamic) viscosity is the poise (dyne-sec./sq.cm.). The centipoise (0.01 poise) is often used.

absorptance—That fraction of radiant energy that is retained by the sheet.

accelerator —A substance that hastens a reaction, particularly one which speeds up the vulcanization of rubber. Also known as *promoter*.

accumulator—A term used mainly with reference to blow molding equipment which designates an auxiliary ram extruder which is used to provide extremely fast parison delivery. The accumulator cylinder is filled with plasticated melt coming from the extruder between parison deliveries or

“shots” and is stored or “accumulated” until the plunger is required to deliver the next parison.

acetal resins—The molecular structure of the polymer is that of a linear acetal, consisting of unbranched polyoxymethylene chains.

acrylic ester—An ester of acrylic acid, or of a structural derivative of acrylic acid, e.g., methyl methacrylate.

acrylic resin—A synthetic resin prepared from acrylic acid or from a derivative of acrylic acid.

acrylonitrile—A monomer with the structure (CH₂:CHCN). It is most useful in copolymers. Its copolymer with butadiene is nitrile rubber, and several copolymers with styrene exist that are tougher than polystyrene. It is also used as a synthetic fiber and as a chemical intermediate.

acrylonitrile-butadiene styrene

(abbreviated ABS)—Acrylonitrile and styrene liquids and butadiene gas are polymerized together in a variety of ratios to produce the family of ABS resins.

adapter—In an extruder, the portion of the die assembly that attaches the die to the extruder and provides a flow channel for the molten plastic between the extruder and the die.

addition polymerization—Polymerization in which monomers are linked together without the splitting off of water or other simple molecules.

additive —Anything compounded into a polymer to modify its characteristics, such as flame retardants, pigments, etc.

adiabatic—An adjective used to describe a process or transformation in which no heat is added to or

allowed to escape from the system under consideration. It is used, somewhat incorrectly, to describe a mode of extrusion in which no external heat is added to the extruder although heat may be removed by cooling to keep the output temperature of the melt passing through the extruder constant. The heat input in such a process is developed by the screw as its mechanical energy is converted to thermal energy.

adhesion promoter—A coating which is applied to the substrate before it is extrusion coated with the plastic and which improves the adhesion of the plastic to the substrate.

adhesive—A substance which applied as an intermediate is capable of holding materials together by surface attachment.

adhesive wear—Wear resulting from metal-to-metal contact such as screw flights and the inside of a barrel.

adsorption—The adhesion of the molecules of gases, dissolved substances, or liquids in more or less concentrated form to the surfaces of solids or liquids with which they are in contact.

affinity—The attraction for another substance.

aging—The change of a material with time under defined environmental conditions, leading to improvement or deterioration of properties.

air-assist forming—A method of thermoforming q.v., in which air flow or air pressure is employed to partially preform the sheet immediately prior to the final pull-down onto the mold using vacuum.

air gap—In extrusion coating, the distance from the die opening to the nip formed by the pressure roll and the chill roll.

air ring—A circular manifold used to distribute an even flow of the cooling medium, air, onto a hollow tubular form passing through the center of the ring. In blown tubing, the air cools the tubing uniformly to provide uniform film thickness.

air-slip forming—A variation of snap-back forming in which the male mold is enclosed in a box in such a way that when the mold moves forward toward the hot plastic, air is trapped between the mold and the plastic sheet. As the mold advances, the plastic is kept away from it by the air cushion formed as described above, until the full travel of the mold is reached, at which point a vacuum is applied, destroying the cushion and forming the part against the plug.

aliphatic hydrocarbons—Saturated, hydrocarbons having an open chain structure. Familiar examples: gasoline and propane.

alkyd resin—Polyester resins made with some fatty acid as a modifier. See *polyester, fatty acid*.

alkyl—A general term for monovalent aliphatic hydrocarbon radicals.

alloy—Composite material made up by blending polymers or copolymers with other polymer or elastomers under selected conditions, e.g., styrene-acrylonitrile copolymer resins blended with butadiene-acrylonitrile rubbers.

allyl resin—A synthetic resin formed by the polymerization of chemical compounds containing the group $\text{CH}_2=\text{CH}-\text{CH}_2-$. The principal commercial allyl resin is a casting material that yields allyl carbonate polymer.

alpha-cellulose—A very pure cellulose prepared by special chemical treatment.

amino—Indicates the presence of an $-\text{NS}_2$ or $-\text{NH}$ group.

amorphous phase—Devoid of crystallinity—no definite order. At processing temperatures, the plastic is normally in the amorphous state.

amorphous polymer—A polymer having no crystallinity. Polystyrene is an amorphous polymer, while HDPE is semicrystalline.

amps—Amperes, a measure of electrical current flow. It is significant on extruders because the barrel and die heaters must produce a certain amount of heat, and use a certain amount of electric current to do it. If they are faulty, the AMPS reading will be lower. The result could be processing or part quality problems.

angle press—A hydraulic molding press equipped with horizontal and vertical rams, and specially designed for the production of complex moldings containing deep undercuts.

aniline— $\text{C}_6\text{H}_5\text{NH}_2$. An important organic base made by reacting chlorobenzene with aqueous ammonia in the presence of a catalyst. It is used in the production of aniline formaldehyde resins, e.g., and in the manufacture of certain rubber accelerators and antioxidants.

aniline formaldehyde resins—Members of the aminoplastics family made by the condensation of formaldehyde and aniline in an acid solution. The resins are thermoplastic and used to a limited extent in the production of molded and laminated insulating materials. Products made from these



resins have high dielectric strength and good chemical resistance.

anisotropy—The situation where properties vary according to the direction in which they are measured.

annealing—A process of holding a material at a temperature near, but below, its melting point, the objective being to permit stress relaxation without distortion of shape. It is often used on molded articles to relieve stresses set up by flow into the mold.

anti-friction compounds—Materials specifically formulated to reduce or eliminate friction.

antioxidants—Substance which prevents or slow down oxidation of material exposed to air.

antistatic agents—Methods of minimizing static electricity in plastics materials. Such agents are of two basic types: (1) metallic devices which come into contact with the plastics and conduct the static to earth. Such devices give complete neutralization at the time, but because they do not modify the surface of the material it can become prone to further static during subsequent handling; (2) chemical additives which, mixed with the compound during processing, give a reasonable degree of protection to the finished products.

apparent shear rate—The shear rate determined in capillary viscometers without making a correction (Rabinowitsch) for shear thinning. It turns out that the apparent shear rate is equal to $4Q/R^3$ where Q is the volumetric flow rate (m^3/s) and R is the radius (m) of the capillary.

apparent viscosity—The viscosity determined in capillary viscometry without making a correction (Rabinowitsch) for shear thinning. The apparent viscosity is equal to the shear stress divided by the apparent shear rate, which is

$$\frac{\frac{\Delta P}{2L}R}{\frac{4Q}{\pi R^3}}$$

where ΔP is the pressure drop (Pa), Q is the volumetric flow rate (m^3/s), L is the length and R is the radius of the capillary die.

arc resistance—Time required for a given electrical current to render the surface of a material conductive because of carbonization by the arc flame.

armor—A solid or braided metal jacket for imparting maximum abrasion resistance to the completed

cable. Braided armor is sometimes used in lieu of solid armor for improved flexibility.

aromatic hydrocarbons—Hydrocarbons derived from or characterized by presence of unsaturated resonant ring structures.

artificial ageing—The accelerated testing of plastics specimens to determine their changes in properties. Carried out over a short period of time, such tests are indicative of what may be expected of a material under service conditions over extended periods. Typical investigations include those for dimensional stability; the effect of immersion in water, chemicals and solvents; light stability and resistance to fatigue.

artificial weathering—Exposure to cyclic laboratory conditions involving changes in temperature, relative humidity and radiant energy, with or without direct water spray, in an attempt to produce changes in the material similar to those observed after long-term continuous outdoor exposure.

asbestos—A gray, non-burning, non-conducting and chemical resistant amphibole occurring in long fibers or fibrous masses, sometimes used as a filler for reinforcement.

ASTM—Abbreviation of American Society for Testing and Materials, an association for establishing standard testing and reporting procedures.

atactic—A chain of molecules in which the position of the methyl groups is more or less random.

autoclave—(1) Closed strong vessel for conducting chemical reactions under high pressure; (2) in low-pressure laminating, a round or cylindrical container in which heat and gas pressure can be applied to a resin impregnated paper or fabric positioned in layers over a mold.

autoclave molding—Modification of the pressure bag method for molding reinforced plastics. After lay-up, entire assembly is placed in stream autoclave at 50 to 100 psi. Additional pressure achieves higher reinforcement loadings and improved removal of air.

automatic mold—A mold for injection or compression molding that repeatedly goes through the entire cycle, including ejection, without human assistance.

average molecular weight (viscosity method)—

The molecular weight of polymeric materials determined by the viscosity of the polymer in solution at a specific temperature. This gives an



average molecular weight of the molecular chains in the polymer independent of specific chain length. Falls between weight average and number average molecular weight.

B

B-stage—An intermediate stage in the reaction of a thermosetting resin in which the material softens when heated and swells in contact with certain liquids but does not entirely fuse or dissolve. Resins in thermosetting molding compounds are usually in this stage. See also *A-stage* and *C-stage*.

backing plate (support plate)—In injection molding, a plate used as a support for the cavity blocks, guide pins, bushings, etc.

back pressure—In injection molding, the pressure exerted by the hydraulic system behind the injection piston to resist the force of the plastic in pushing the screw back to the shot size position. Back pressure results in more mechanical energy being put into the plastic. In extrusion, the resistance to the forward flow of molten material.

baffle—A device used to restrict or divert the passage of fluid through a pipeline or channel. In hydraulic systems the device, which often consists of a disc with a small central perforation, that restricts the flow of hydraulic fluid in a high pressure line. A common location for the disc is in a joint in the line. When applied to molds, the term is indicative of a plug or similar device located in a stream or water channel in the mold and designed to divert and restrict the flow to a desired path.

bag molding—A method of applying pressure during bonding or molding, in which a flexible cover, usually in connection with a rigid die or mold, exerts pressure on the material being molded, through the application of air pressure or drawing of a vacuum.

bagley correction—A term used in capillary viscometry to describe the excess pressure drop in the entrance to the capillary due to extensional (elongational) viscosity. It is usually negligible when very long capillaries are used (i.e. $L/D > 35$). If shorter capillaries are used, the viscosity measurement errors may be 10%–30% or even higher.

bakelite—The proprietary name for phenolic and other plastics materials produced by Bakelite Limited, but often used indiscriminately to describe any phenolic molding material or molding. The name is derived from that of Dr. Leo Hendrik Baekeland

(1863-1944), a Belgian who, through his work on synthesis of phenolic resins and their commercial development in the early 1900's, is generally considered to be the "father" of the plastics industry.

ball check—A specific design type of non-return valve which accomplishes its job by using a ball which allows the material to flow in one direction, but restricts the flow in the other.

banbury—An apparatus for compounding materials composed of a pair of contra-rotating rotors which masticate the materials to form a homogeneous blend. This is an internal type mixer which produces excellent mixing.

barrel—An integral part of a plastic processing operation since it is used to convey material, via a screw or other device, toward the tooling involved in the process. Barrels usually comprise the external barrel and a liner which is typically made from bimetallic materials. Also, barrels are normally fitted with heater bands or cooling devices.

barrier screw—A screw in a plastics processing machine which has alternating flights of two different diameters to separate solid from melted polymer.

benzene ring—The basic structure of benzene, the most important aromatic chemical. It is an unsaturated, resonant 6-carbon ring having three double bonds. One or more of the 6 hydrogen atoms of benzene may be replaced by other atoms or groups.

beta gage (or beta-ray gage)—A gage consisting of two facing elements, a B-ray-emitting source and a B-ray detector. When a sheet material is passed between the elements, some of the B-rays are absorbed, the percent absorbed being a measure of the areal density or the thickness of the sheet.

biaxial deformation—Stretching in two directions.

billow—Prestretching sheet by inflation with air pressure.

bimetallic liner—A liner which is centrifugally cast and made of two or more metals.

binder—In a reinforced plastic, the continuous phase which holds together the reinforcement.

black body—A body that emits the maximum amount of radiant energy at a given wavelength.

blanking—The cutting of flat sheet stock to shape by striking it sharply with a punch while it is



- supported on a mating die. Punch presses are used. Also call *die cutting*.
- bleed**—To give up color when in contact with water or a solvent; undesired movement of certain materials in a plastic (e.g. plasticizers in vinyl) to the surface of the finished article or into an adjacent material. Also called *migration*.
- blend**—An intimate combination of two or more polymer chains having different features that are not bonded to each other.
- blister**—A raised area on the surface of a molding caused by the pressure of gases inside it on its incompletely hardened surface.
- block copolymer**—An essentially linear copolymer in which there are repeated sequences of polymeric segments of different chemical structure.
- blocking**—An undesired adhesion between touching layers of a material, such as occurs under moderate pressure during storage or usage.
- bloom**—A visible exudation or efflorescence on the surface of a material.
- blow molding**—A method of fabrication in which a parison (hollow tube) is forced into the shape of the mold cavity by internal air pressure.
- blow pressure**—The air pressure used to form a hollow part by blow molding.
- blow rate**—The speed at which the air enters the parison during the blow molding cycle.
- blowing agents**—See *foaming agents*.
- blowup ratio**—In blow molding, the ratio of the mold cavity diameter to the parison diameter. In blown tubing (film), the ratio of the final tube diameter (before gusseting, if any) to the original die diameter.
- blown tubing**—The thermoplastic film which is produced by extruding a tube, applying a slight internal pressure to the tube to expand it while still molten and subsequent cooling to set the tube. The tube is then flattened through guides and wound up flat on rolls. The size of blown tubing is determined by the flat width in inches as wound rather than by the diameter as in the case of rigid types of tubing.
- blueing**—A mold blemish in the form of a blue oxide film which occurs on the polished surface of a mold as a result of the use of abnormally high mold temperatures.
- blunt thread start**—The thread design where the start of a thread has been squared off for the exact locating of the container in a printing of labeling machine. See *lug*.
- bore**—The inside diameter of a barrel.
- boss**—Protuberance on a plastic part designed to add strength, to facilitate alignment during assembly, to provide for fastening, etc.
- boston round**—A particular shape of container; cross section as well as shoulders are round.
- bottom blow**—A specific type of blow molding machine which forms hollow articles by injecting the blowing air into the parison from the bottom of the mold.
- bottom plate**—Part of the mold which contains the heel radius and the push-up.
- branched**—In molecular structure of polymers (as opposed to *linear*), refers to side chains attached to the main chain. Side chains may be long or short.
- branched polymers**—Polymers can be classified as linear or branched. Linear polymers have the monomeric units linked together, linearly, with little or no long chain branching. In branched polymers, side chains are attached to the molecular chain backbone. High-density polyethylene (HDPE) is linear, while low-density polyethylene (LDPE) contains both short and long chain branches. Linear LDPE (LLDPE) is a copolymer with controlled short chain branches. This results in polymer that is "stiffer" than LDPE in shear but "softer" in extension. In extension the LLDPE chains slide by without getting entangled since the chain branches are very short.
- breakdown voltage**—The voltage required, under specific conditions, to cause the failure of an insulating material. See *dielectric strength*.
- breaker plate**—A perforated plate located at the rear end of an extruder head. It often supports the screens that prevent foreign particles from entering the die.
- breathing**—The opening and closing of a mold to allow gases to escape early in the molding cycle. Also called *degassing*. When referring to plastic sheeting, "breathing" indicates permeability to air.
- bubbler mold cooling (Injection Molding)**—A method of cooling an injection mold in which a stream of cooling liquid flows continuously into a cooling cavity equipped with a coolant outlet normally positioned at the end opposite the inlet. Uniform cooling can be achieved in this manner.



bulk density—The mass per unit volume of a molding powder as determined in a reasonably large volume. The recommended test method is ASTM D1182-54.

bulk factor—Ratio of the volume of loose molding powder to the volume of the same weight of resin after molding.

burning behavior—The characteristics exhibited by the substance when it ignites and burns.

burning rate—A term describing the tendency of plastics articles to burn at given temperatures. Certain plastics, such as those based on shellac, burn readily at comparatively low temperatures. Others will melt or disintegrate without actually burning, or will burn only if exposed to direct flame. These latter are often referred to as self-extinguishing.

bushing (extrusion)—The outer ring of any type of a circular tubing or pipe die which forms the outer surface of the tube or pipe.

butadiene— $\text{CH}_2 = \text{CH} \cdot \text{CH} = \text{CH}_2$. A gas, insoluble in water but soluble in alcohol and ether, obtained from the cracking of petroleum, from coal tar benzene or from acetylene produced from coke and lime. It is widely used in the formation of copolymers with styrene, acrylonitrile, vinyl chloride and other monomeric substances, where it imparts flexibility to the subsequent moldings.

butadiene styrene plastics—A synthetic resin derived from the copolymerization of butadiene gas and styrene liquids.

butt-fusion—A method of joining pipe, sheet, or other similar forms of a thermoplastic resin wherein the ends of the two pieces to be joined are heated to the molten state and then rapidly pressed together to form a homogeneous bond.

buttress thread—A type of threading in which the thread sides terminate abruptly in threading gradually tapering down to the neck finish. Designed to withstand maximum force in one direction only. Cross section of thread is triangular.

butylene plastics—Plastics based on resins made by the polymerization of butene or copolymerization by butene with one or more unsaturated compounds, the butene being in greatest amount by weight.

C-stage—The final stage in the reactions of a thermosetting resin in which the material is relatively insoluble and infusible. Thermosetting

resins in a fully cured plastids are in this stage. See *A-stage* and *B-stage*.

cable—A standard conductor; or a group of solid or standard conductors laid together but insulated from one another.

calender—(v.) To prepare sheets of material by pressure between two or more counter-rotating rolls. (*n*) – the machine performing this action.

capillary viscometer—An instrument used to measure polymer melt viscosity. It consists of a heated reservoir used to melt the polymer, which is subsequently pushed by a piston and flows through a 1-mm- to 2-mm-diameter round die. From the force required to move the piston and the corresponding volumetric flow rate, the viscosity can be determined. The Rabinowitsch correction is necessary to account for the shear thinning effects and the Bagley correction to account for the excess pressure drop at the die entrance (see *rabinowitsch correction* and *bagley correction*).

caprolactam—A cyclic amidetype compound, containing 6 carbon atoms. When the ring is opened, caprolactam is polymerizable into a nylon resin known as type-6 nylon or polycaprolactam.

carbon black—A black pigment produced by the incomplete burning of natural gas or oil. It is widely used as a filler, particularly in the rubber industry. Because it possesses useful ultraviolet protective properties, it is also much used in polyethylene compounds intended for such applications as cold water piping and black agricultural sheet.

carreau model—A mathematical expression describing the shear thinning behavior of polymers. It is more realistic than the power-law model because it fits the data very well at both high and low shear rates.

$$\eta = \eta_0 \left(1 + (\lambda \dot{\gamma})^2 \right)^{\frac{n-1}{2}}$$

where: η_0 , λ , and n are curve fitting parameters and is the shear rate. Because of the mathematical complexities it is not possible to obtain analytical solutions with this model, but it is excellent for numerical simulations of flow processes.

casein—A protein material precipitated from skimmed milk by the action of either rennet or dilute acid. Rennet casein finds its main application in the manufacture of plastics. Acid casein is a raw material used in a number of industries including the manufacture of adhesives.



cast—(1) To form a “plastic” object by pouring a fluid monomer-polymer solution into an open mold where it finishes polymerizing. (2) Forming plastic film and sheet pouring the liquid resin onto a moving belt or by precipitation in a chemical bath.

cast film—A film made by depositing a layer of plastic, either molten in solution, or in a dispersion, onto a surface, solidifying and removing the film from the surface.

casting (n.)—The finished product of a casting operation; should not be used for molding, e.g.,

casting area—The moldable area of a thermoplastic in square inches for a given thickness and under a given set of injection molding conditions. Casting area is a measure of flow under actual molding conditions where flow is unrestricted by cavity boundaries.

catalyst—A substance which markedly speeds up the cure of a compound when added in minor quantity as compared to the amounts of primary reactants. See *hardner, inhibitor, promoter*.

cavity—Depression in a mold made by casting, machinery, hobbing, or a combination of these methods; depending on number of such depressions, molds are designed as *single-cavity* or *multi-cavity*.

cell—A small particle or completely enclosed cavity.

cell (closed)—A cell totally enclosed by its walls and hence not interconnecting with other cells. (See *cell* and *cell, open*).

cell (open)—A cell not totally enclosed by its walls and hence interconnecting with other cells. (See *cell* and *cell, closed*).

cellular plastics—Plastics containing numerous small cavities (cells), interconnecting or not distributed throughout the mass.

celluloid—A thermoplastic material made by the intimate blending of cellulose nitrate, e.g., with camphor. Alcohol is normally employed as a volatile solvent to assist plasticization, and is subsequently removed.

cellulose—A natural high polymeric carbohydrate found in most plants; the main constituent of dried woods, jute, flax, hemp, ramie, etc. Cotton is almost pure cellulose.

cellulose acetate—An acetic acid ester of cellulose. It is obtained by the action, under rigidly controlled conditions, of acetic acid and acetic anhydride on purified cellulose usually obtained

from cotton linters. All three available hydroxyl groups in each glucose unit of the cellulose can be acetylated but in the material normally used for plastics it is usual to acetylate fully and then to lower the acetyl value (expressed as acetic acid) to 52-56% by partial hydrolysis. When compounded with suitable plasticizers it gives a tough thermoplastic material.

cellulose acetate butyrate—An ester of cellulose made by the action of a mixture of acetic and butyric acids and their anhydrides on purified cellulose. It is used in the manufacture of plastics which are similar in general properties to cellulose acetate but are tougher and have better moisture resistance and dimensional stability.

cellulose ester—A derivative of cellulose in which the free hydroxyl groups attached to the cellulose chain have been replaced wholly or in part by acetic groups, e.g., nitrate, acetate, or stearate groups. Esterification is effected by the use of a mixture of an acid with its anhydride in the presence of a catalyst, such as sulfuric acid. Mixed esters of cellulose, e.g., cellulose acetate butyrate, are prepared by the use of mixed acids and mixed anhydrides. Esters and mixed esters, a wide range of which is known differ in their compatibility with plasticizers, in molding properties, and in physical characteristics. These esters and mixed esters are used in the manufacture of thermoplastic molding compositions.

cellulose nitrate (Nitrocellulose)—A nitric acid ester of cellulose manufactured by the action of a mixture of sulfuric acid and nitric acid on cellulose, such as purified cotton linters. The type of cellulose nitrate used for celluloid manufacture usually contains 10.8-11.1% of nitrogen. The latter figure is the nitrogen content of dinitrate.

cellulose propionate—An ester of cellulose made by the action of propionic acid and its anhydride on purified cellulose. It is used as the basis of a thermoplastic molding material.

cellulose triacetate—A cellulose material made by reacting purified cellulose with acetic anhydride in the presence of a catalyst. It is used in the form of film and fibers. Films and sheet are cast from clear solutions on to “drums” with highly polished surfaces. The film, which is of excellent clarity, has high tensile strength, and good heat resistance and dimensional stability. Applications include book jackets, magnetic recording tapes, and

