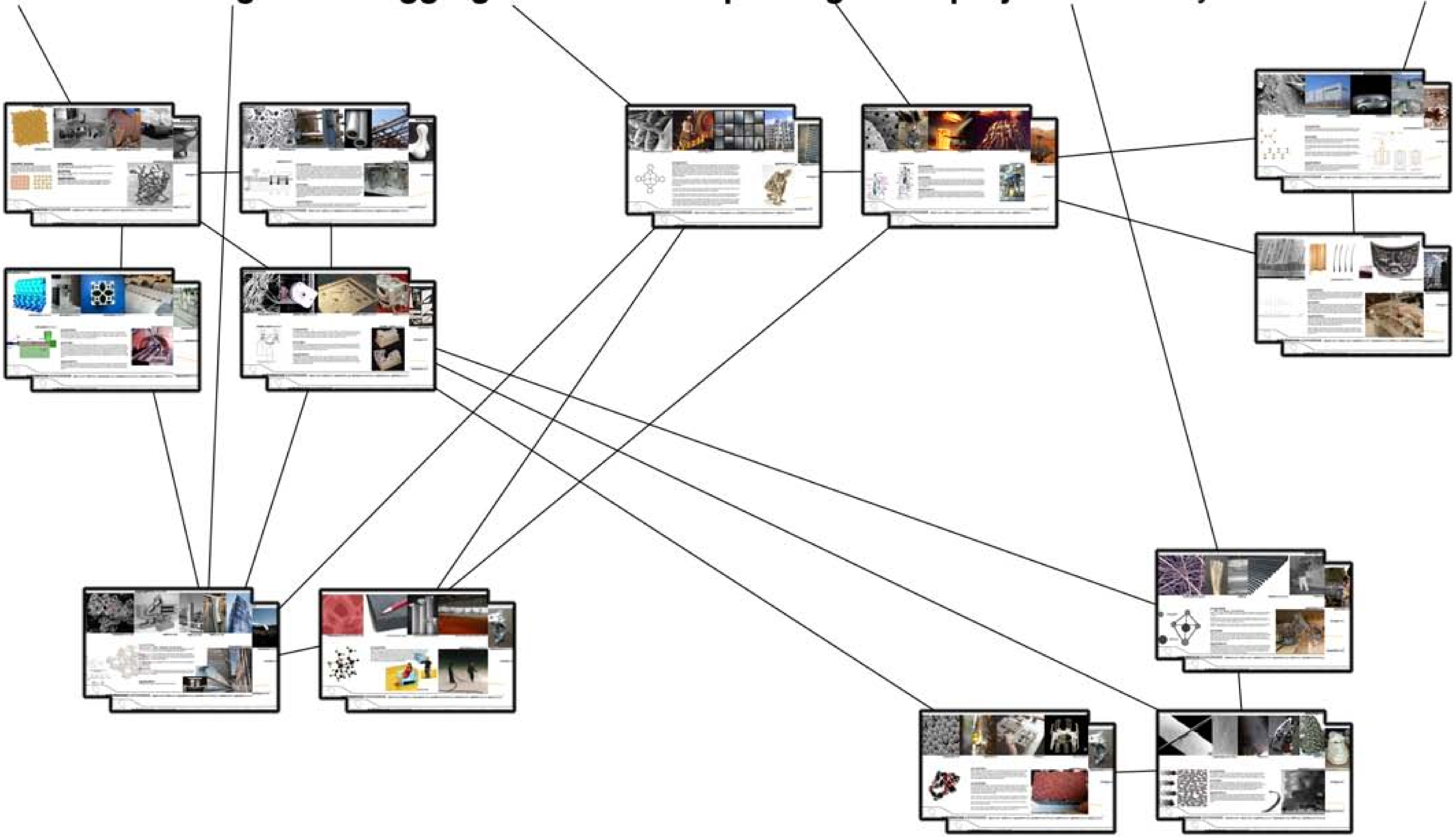
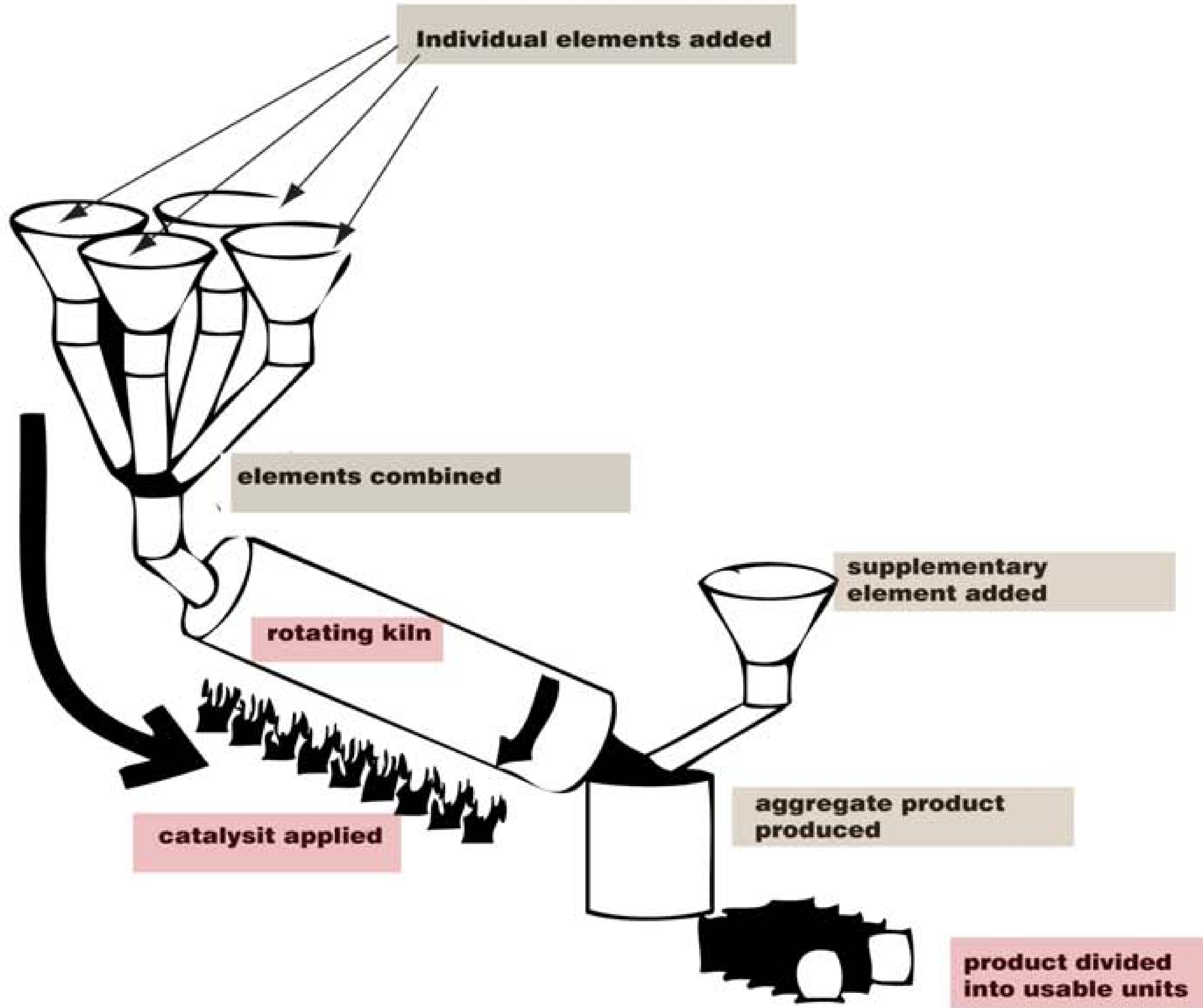
extrusionmetals+**folding**metals+**aggregation**concrete+**pouring**fluids+**polymerization**synthetics+**weaving**fiber



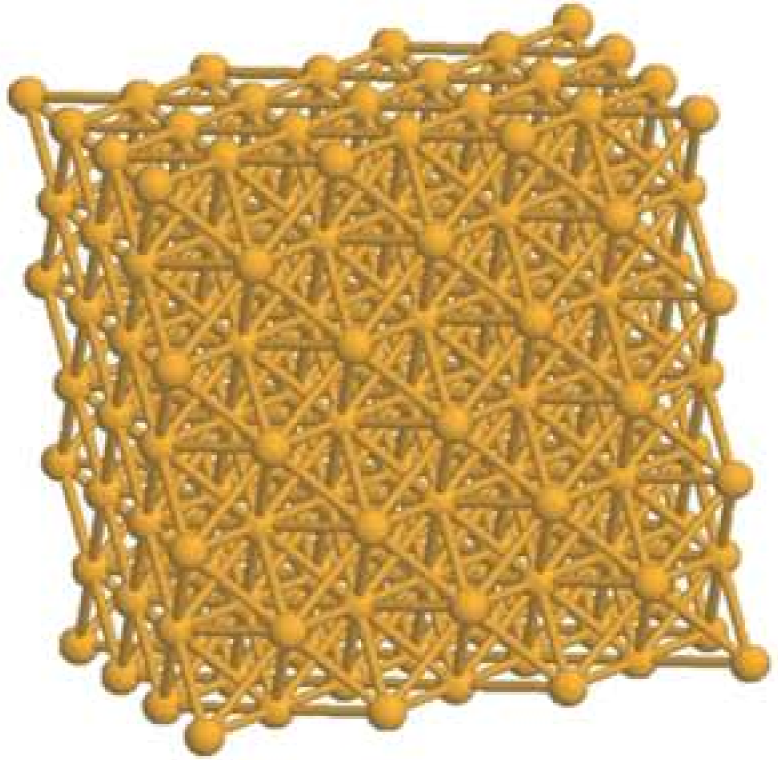
substances+processes

markbearak+**ben**howell+**patrick**oconnor+**kyuseon**hong+**kirk**tracy+**jordan**trachtenberg

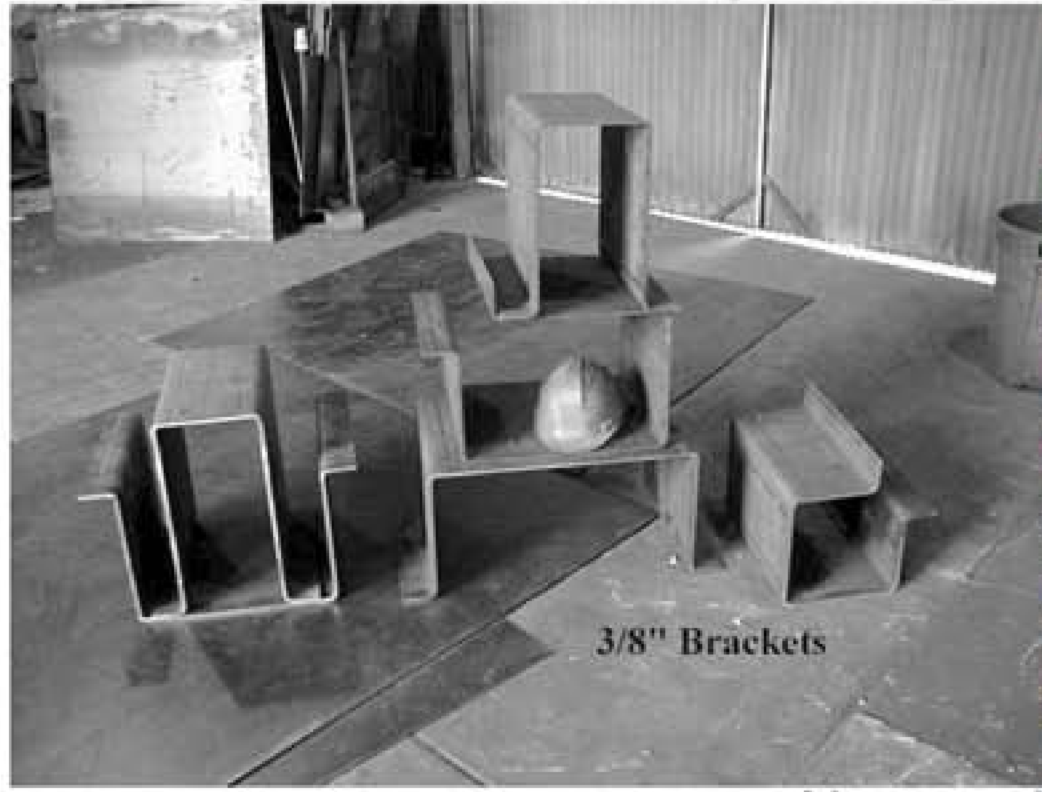


aggregation

Aggregation is the collection of units or parts into a mass or whole. In order to fuse the individual parts together a specific process is applied. During this process a catalyist is used which changes the molecular structure of the elements. Once altered the individual elements combine to create a new product. In the diagram above heat and rotation are used as the catalyist to transform the raw materials into cement.



molecularmetal



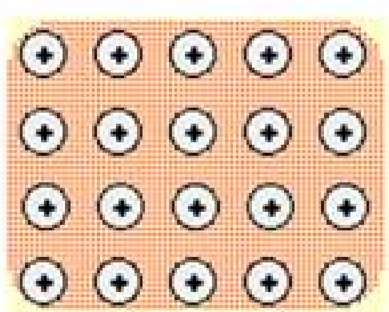
unitbentmetal

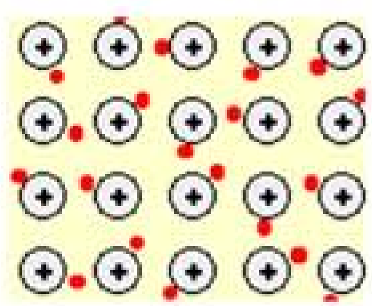
applicationbentmetal

fieldbentmetal

metallic bonds

are similar to covelent bonds in that electrons are shared by multiple positive ions. Metallic bonds are extended, though, meaning that electrons are shared by larger numbers of ion resulting in high conductivity, strength, and relatively low melting points.





propeties

typically metals are shiny, have high density, and are very malleable. They are usually hard, conduct electricity, heat, and sound well.

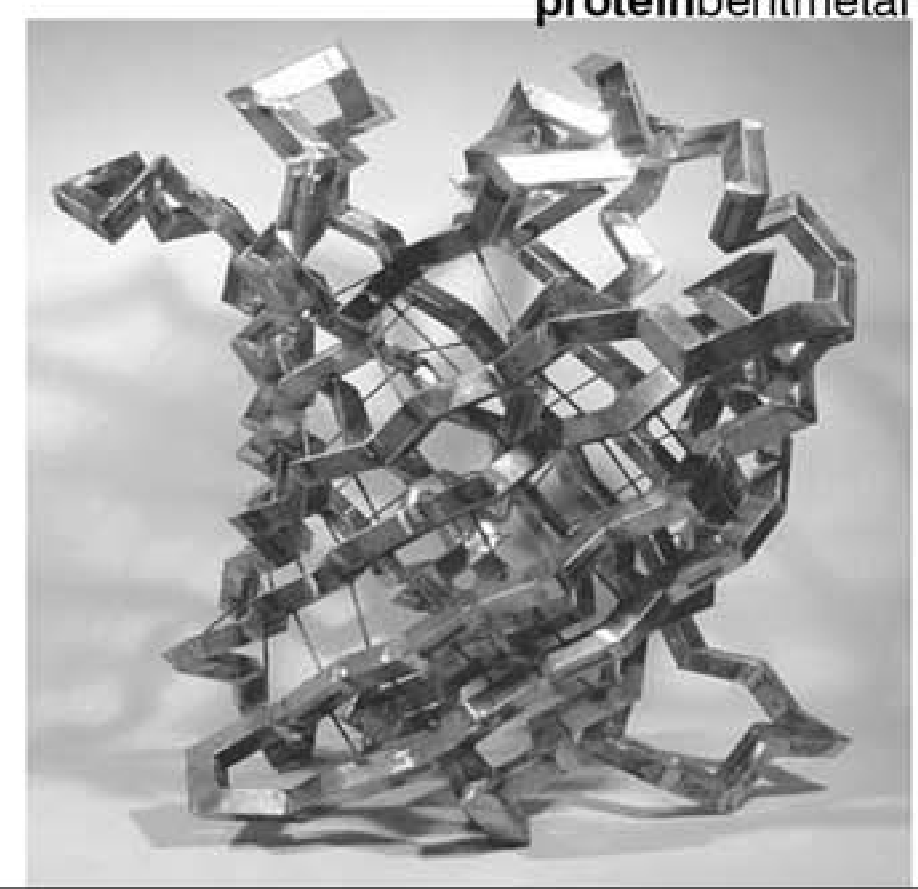
process

bending is a simple process in which pulled metal is forced into shapes meeting any number of needs.

application

bent metal is applied widely in construction, through many different methods. bent metal is often used as a unit that joins components together. it also can be applied as an individual unit that recurrs to make larger metabolic structures.

proteinbentmetal



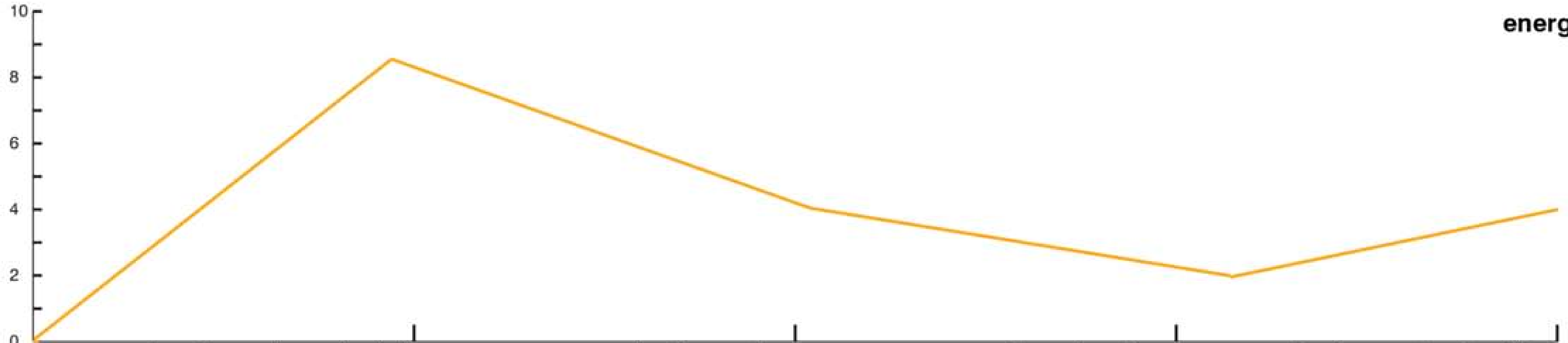
extractionPolyacrylonitrile

productioncarbon

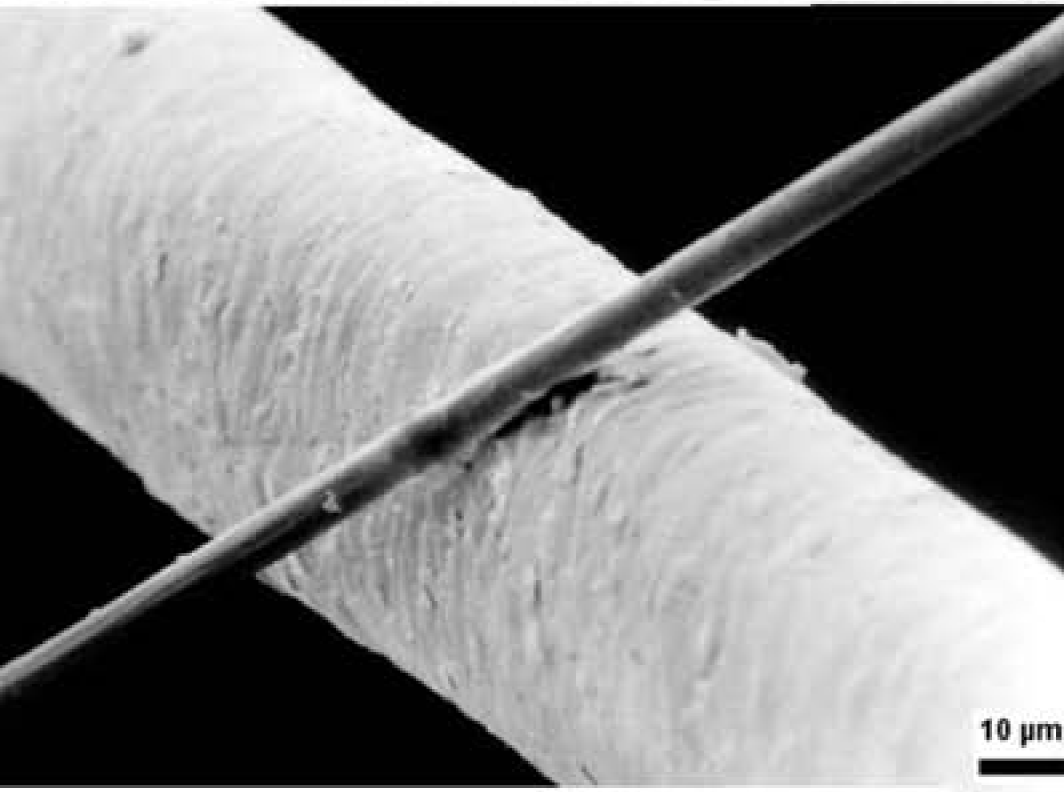
assemblycarbonfiber

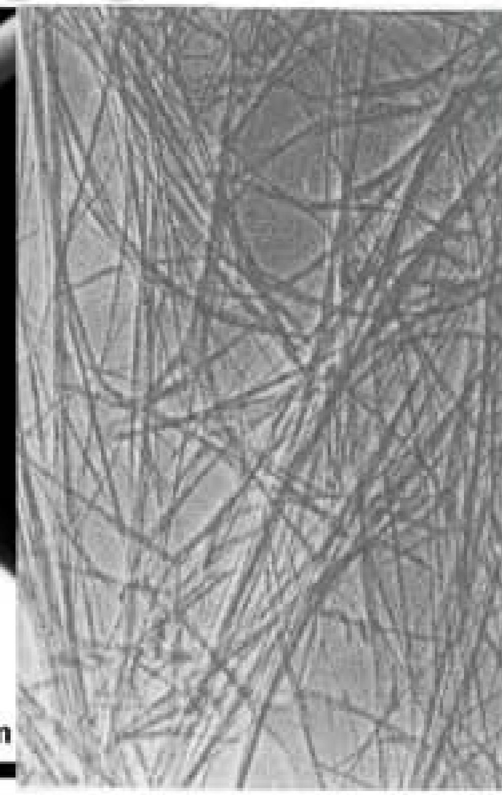
deploymentcarbonfiber

energychart

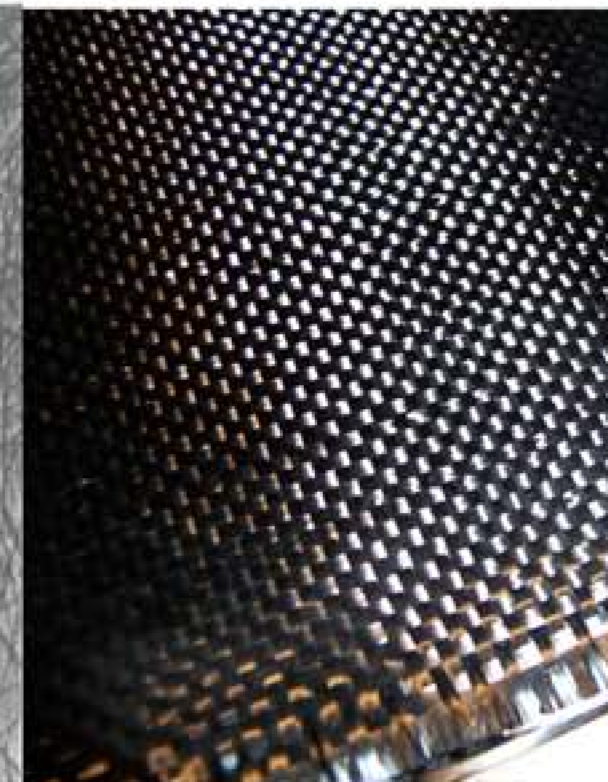


substances+processes **mark**bearak+**ben**howell+**patrick**oconnor+**kyuseon**hong+**kirk**tracy+**jordan**trachtenberg

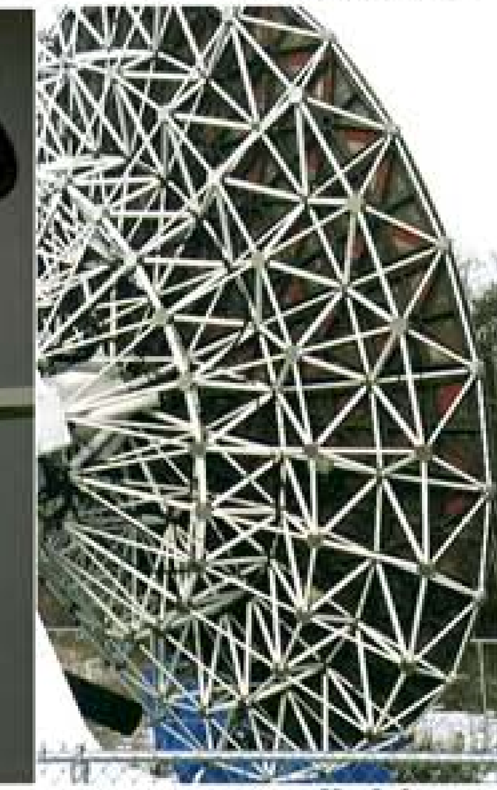




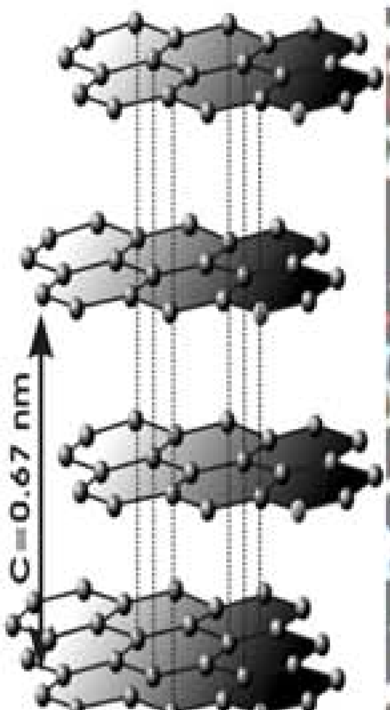
molecularcarbonfiber

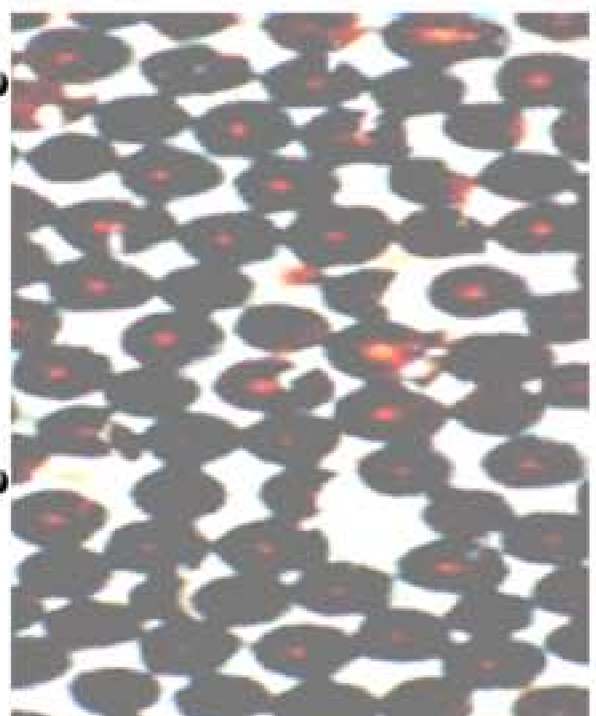


cellsheet



fieldtruss



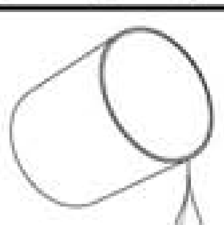


properties
Carbon fiber is made up of tiny threads or filaments. Each carbon filament thread is a bundle of many thousand carbon filaments. A single such filament is a thin tube with a diameter of 5–8 micrometers and consists almost exclusively of carbon

process
The carbon atoms are bonded together in microscopic crystals that are more or less aligned parallel to the long axis of the fiber. The crystal alignment makes the fiber incredibly strong for its size. Several thousand carbon fibers are twisted together to form a yarn, which may be used by itself or woven into a fabric. The yarn or fabric is combined with epoxy and wound or molded into shape to form various composite materials.

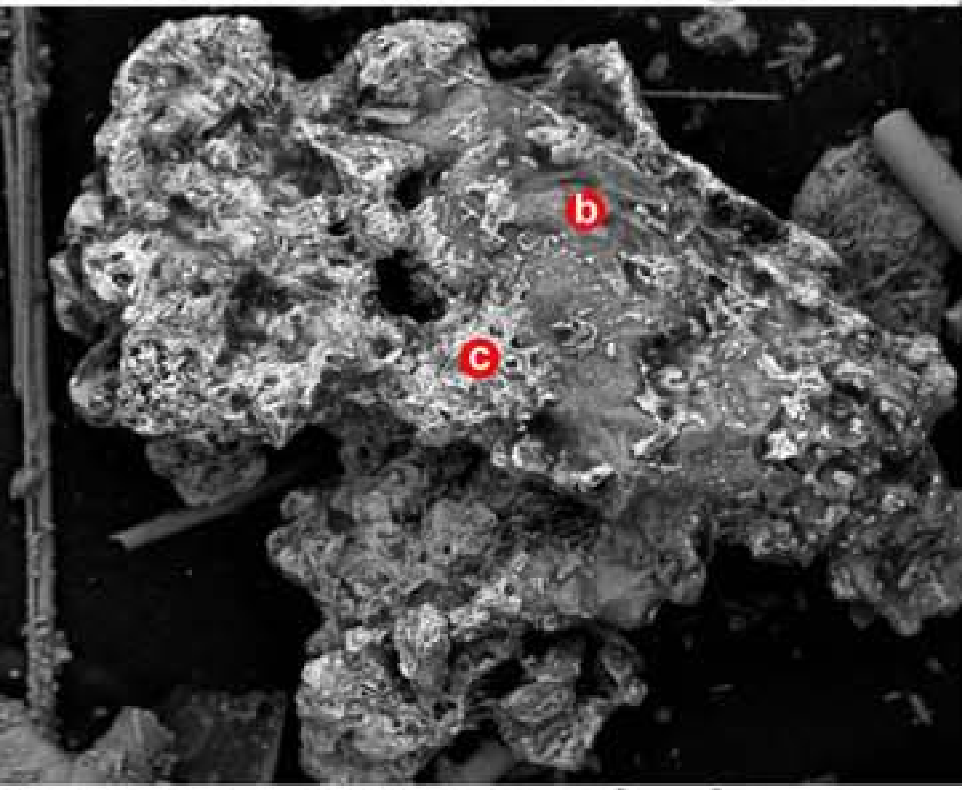
application
Carbon fiber is most notably used to reinforce composite materials, particularly the class of materials known as carbon fiber reinforced plastics. This class of materials is used in aircraft parts, high-performance vehicles, sporting equipment such as racing bikes, radio controlled vehicles, wind generator blades and gears and other demanding mechanical applications

applicationcarbontower



substances+processes

markbearak+**ben**howell+**patrick**oconnor+**kyuseon**hong+**kirk**tracy+**jordan**trachtenberg

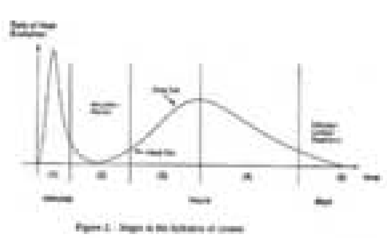


molecularconcrete

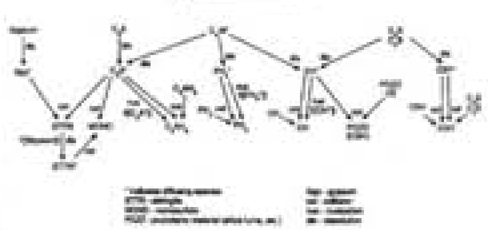
castconcrete

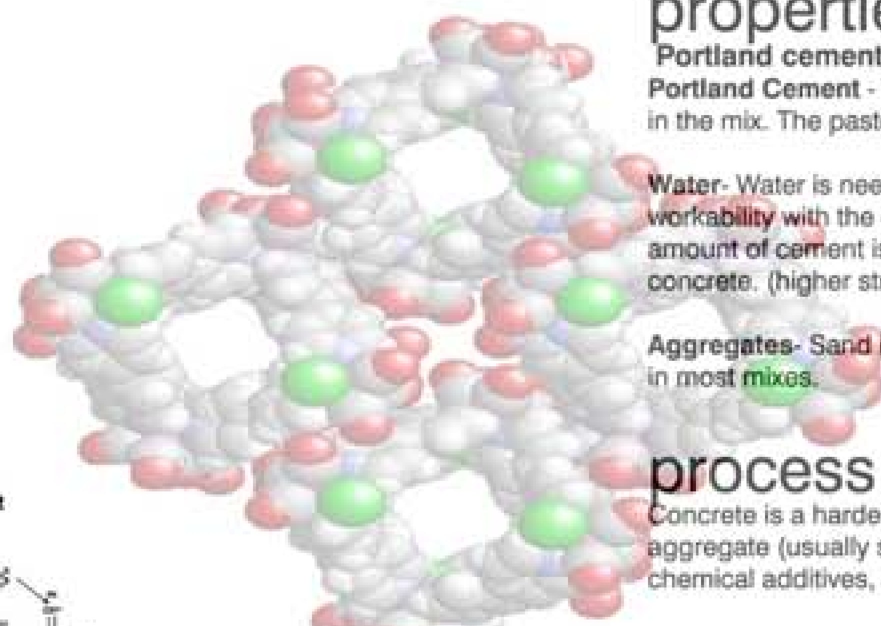
castconcrete

fieldconcrete



State Transition Diagram for Cement Hydration Model





properties

Portland cement + Water + Aggregates (rock, sand, gravel)

Portland Cement - The cement and water form a paste that coats the aggregate and sand in the mix. The paste hardens and binds the aggregates and sand together.

Water- Water is needed to chemically react with the cement (hydration) and too provide workability with the concrete. The amount of water in the mix in pounds compared with the amount of cement is called the water/cement ratio. The lower the w/c ratio, the stronger the concrete. (higher strength, less permeability)

Aggregates- Sand is the fine aggregate. Gravel or crushed stone is the coarse aggregate in most mixes.

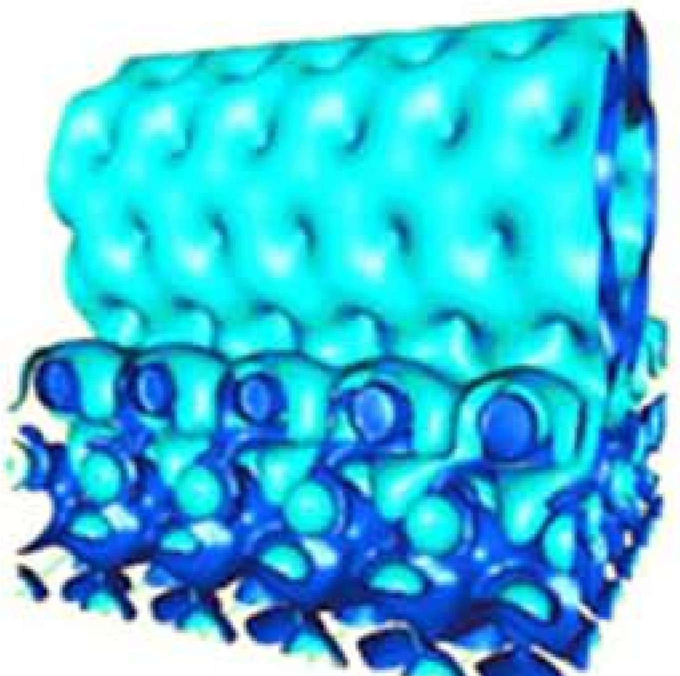
process

Concrete is a hardened building material created by combining a chemically inert mineral aggregate (usually sand, gravel, or crushed stone), a binder (natural or synthetic cement), chemical additives, and water.

application

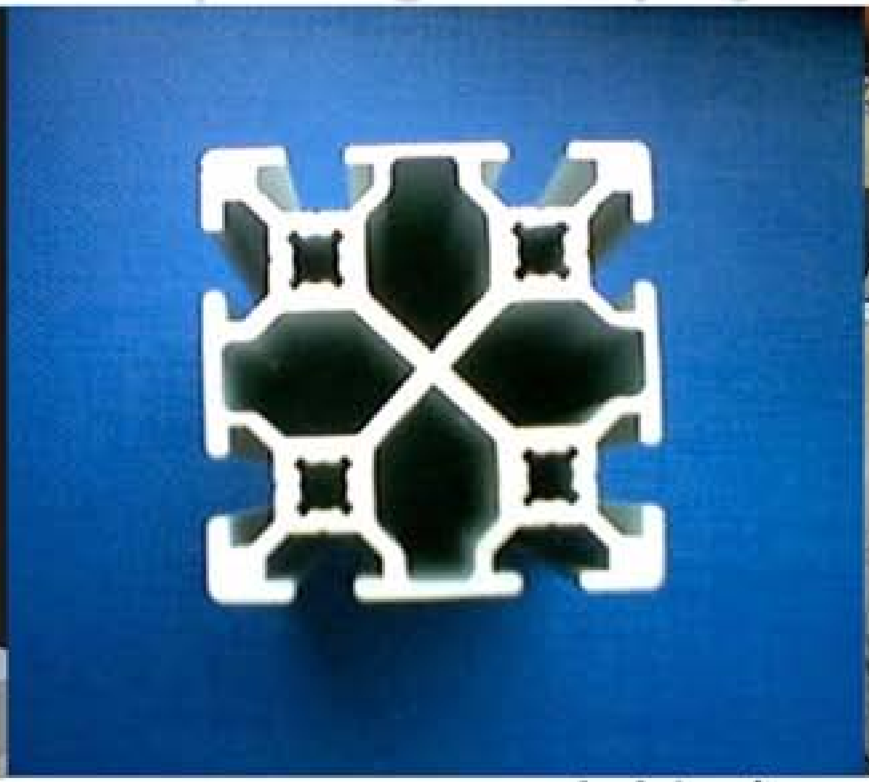
how the specific material is used to make certain structures

innovationsconcrete



molecularaluminum

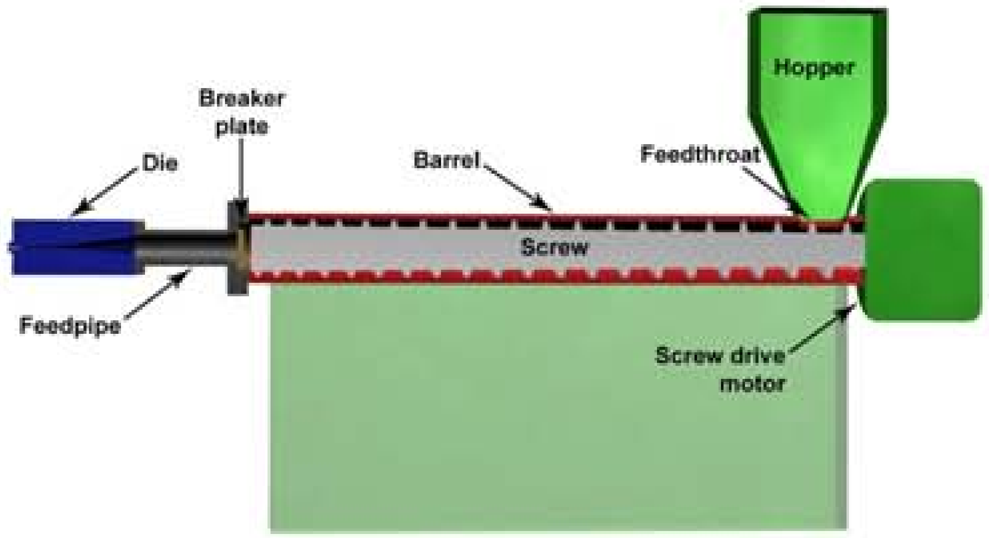
extrudedaluminum



extrudedaluminum

fieldaluminum

extrudedaluminum



properties

Extrusion is the process by which long straight metal parts can be produced. The cross-sections that can be produced vary from solid round, rectangular, to L shapes, T shapes. Tubes and many other different types. Extrusion is done by squeezing metal in a closed cavity through a tool, known as a die using either a mechanical or hydraulic press.

process

Extrusions, often minimize the need for secondary machining, but are not of the same dimensional accuracy or surface finish as machined parts. Surface finish for steel is 3 &microm; (125 μ in), and Aluminum and Magnesium is 0.8 μm (30 μ in). However, this process can produce a wide variety of cross-sections that are hard to produce cost-effectively using other methods. Minimum thickness of steel is about 3 mm (0.120 in), whereas Aluminum and Magnesium is about 1mm (0.040 in). Minimum cross sections are 250 mm2 (0.4 in2) for steel and less than that for Aluminum and Magnesium. Minimum corner and fillet radii are 0.4 mm (0.015 in) for Aluminum and Magnesium, and for steel, the minimum corner radius is 0.8mm(0.030 in) and 4 mm (0.120 in) fillet radius.

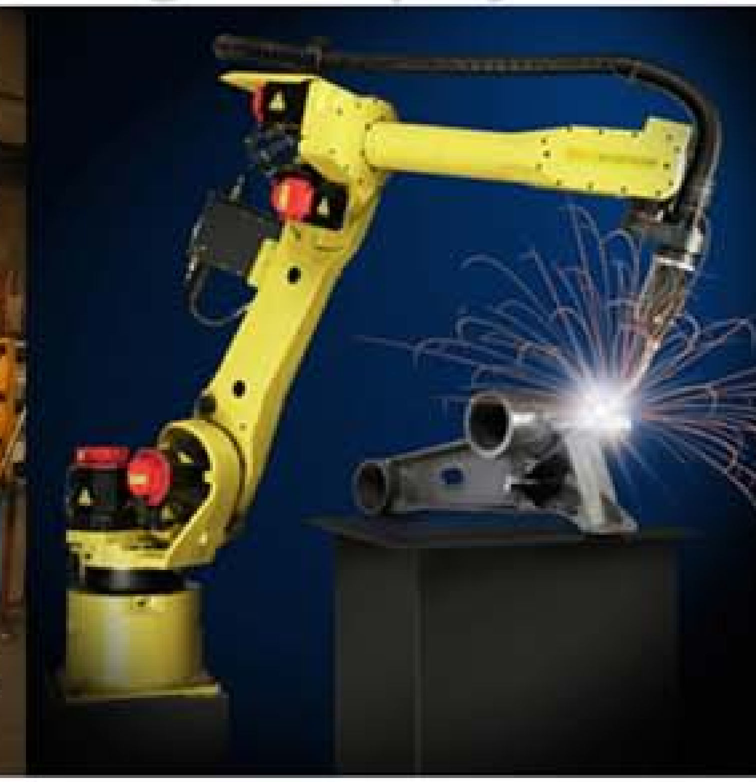
application

Extrusion produces compressive and shear forces in the stock. No tensile is produced, which makes high deformation possible without tearing the metal. The cavity in which the raw material is contained is lined with a wear resistant material. This can withstand the high radial loads that are created when the material is pushed the die.

extrudedaluminum

extractionaluminum

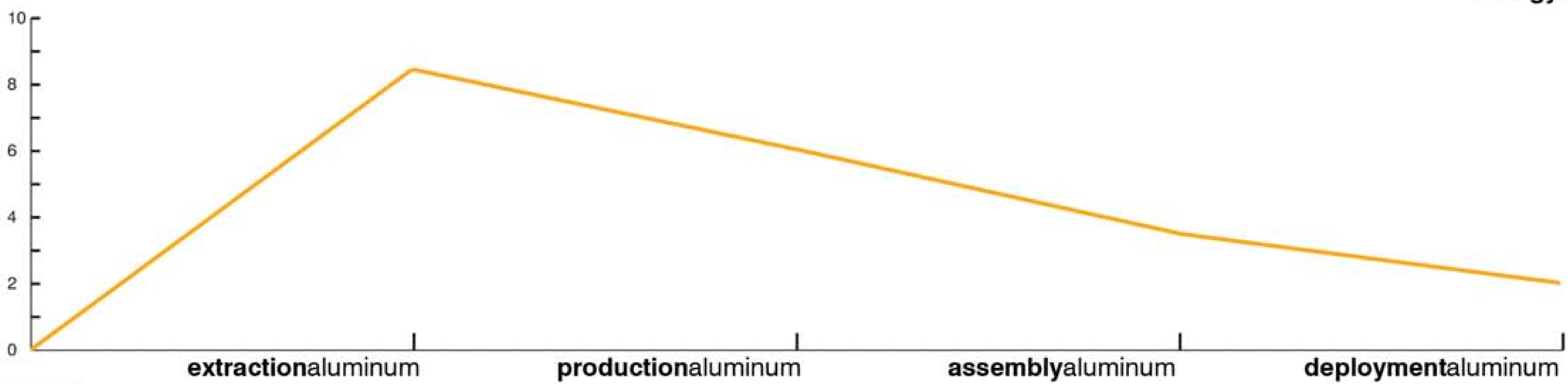
productionaluminum

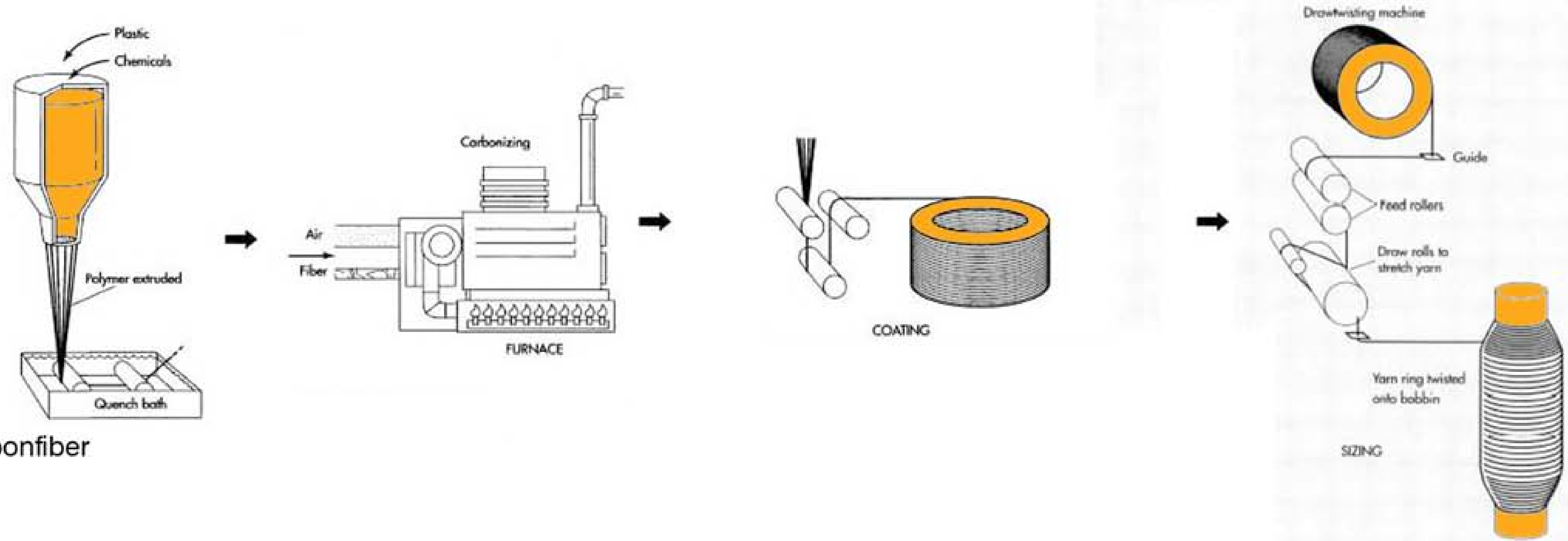


assemblyaluminum

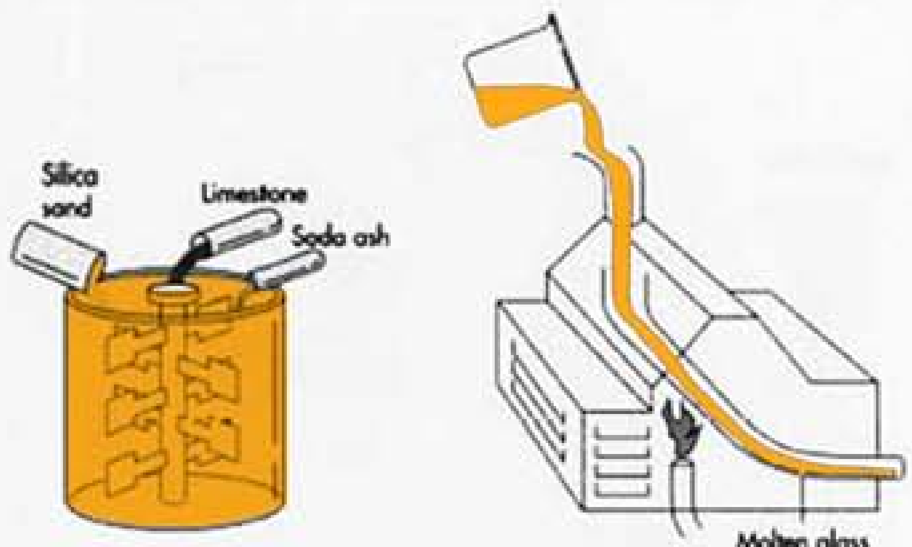
deploymentaluminum

energychart



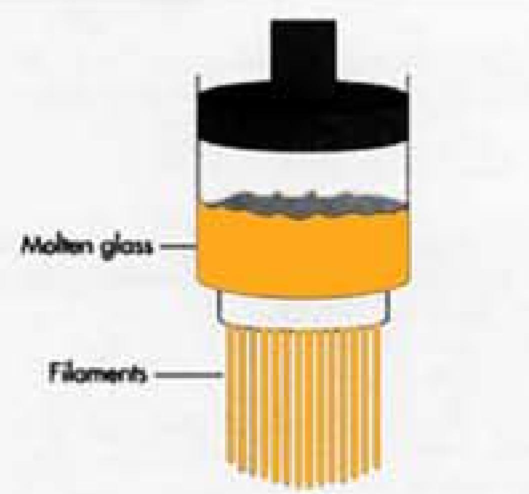


carbonfiber

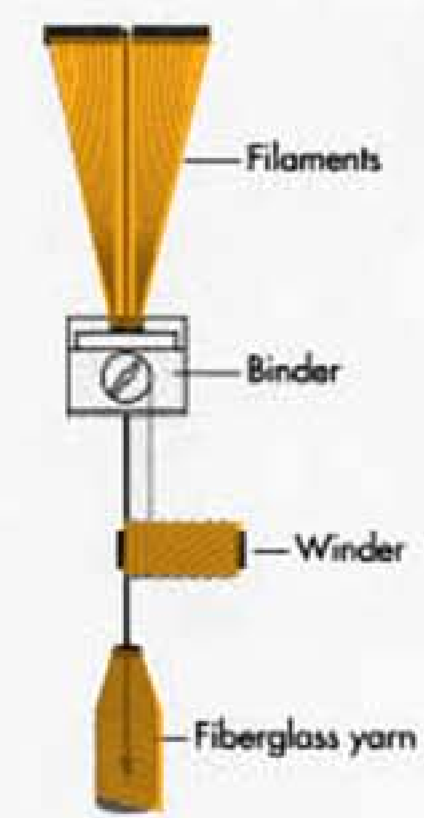


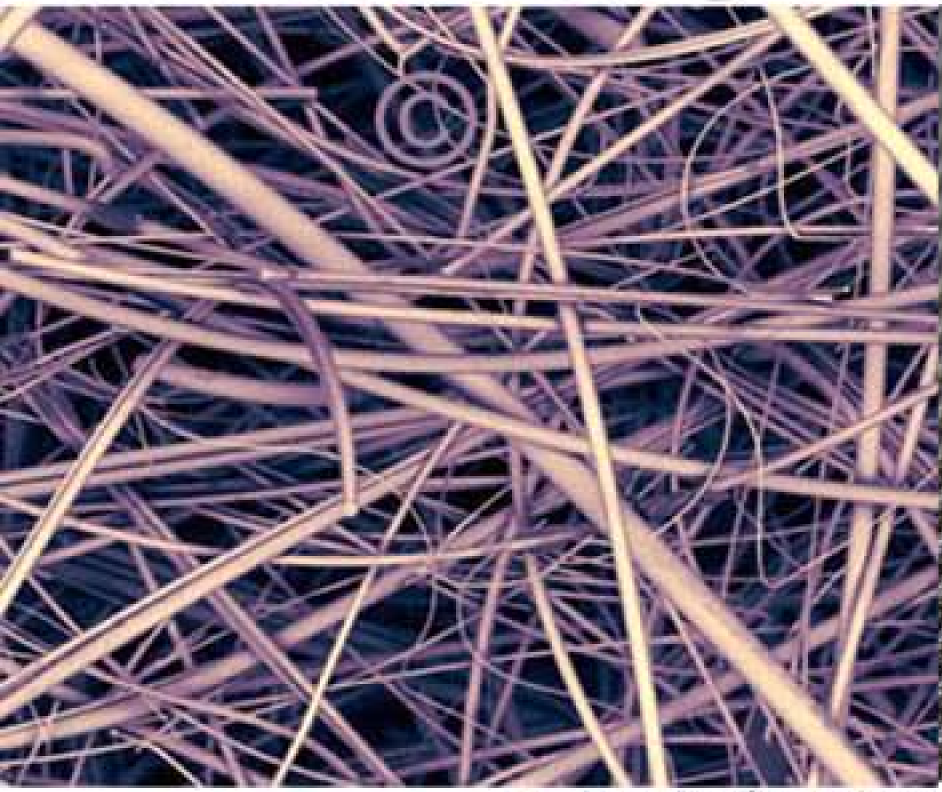
fiberglass

Fiberglass raw materials are mixed together and melted.



The molten glass is passed through platinum bushings that contain hundreds of holes. Fine filaments are extruded.



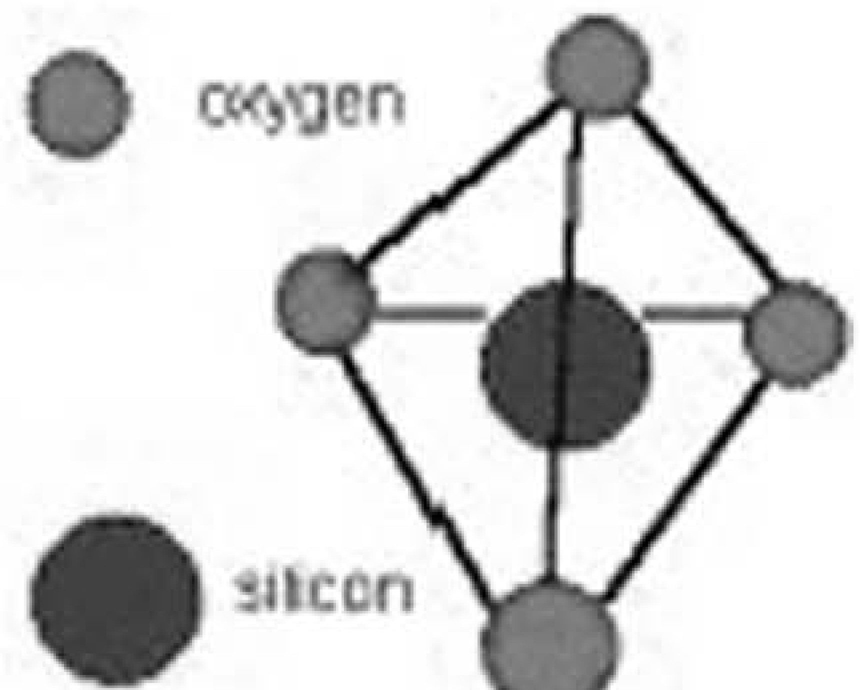


molecularfiberglass

cellfiber

fieldfiberstructure

fieldshell



properties

Silica + Air+Polymer + Various Elements

Silica - The main component of fiberglass is silica. This substance is constantly in a liquid state and contains a high level of viscosity. In order for silica to maintain its crystylin e structure it must be heated to high temperatures.

Vaccuum Air Dry- In order to produce wrapping forms the fine fiberglass fillaments are placed over a plywood mold. Once in place a vaccuum sealed container is placed over mold and all the air is removed. This process seals the filimeents and gives the fiberglass strength.

Elements- Specific elements such as alkali, soda lime, and carbon are added to the silica during the melting process. These elements give the fiberglass different characteristics, which allow for its varying uses.

process

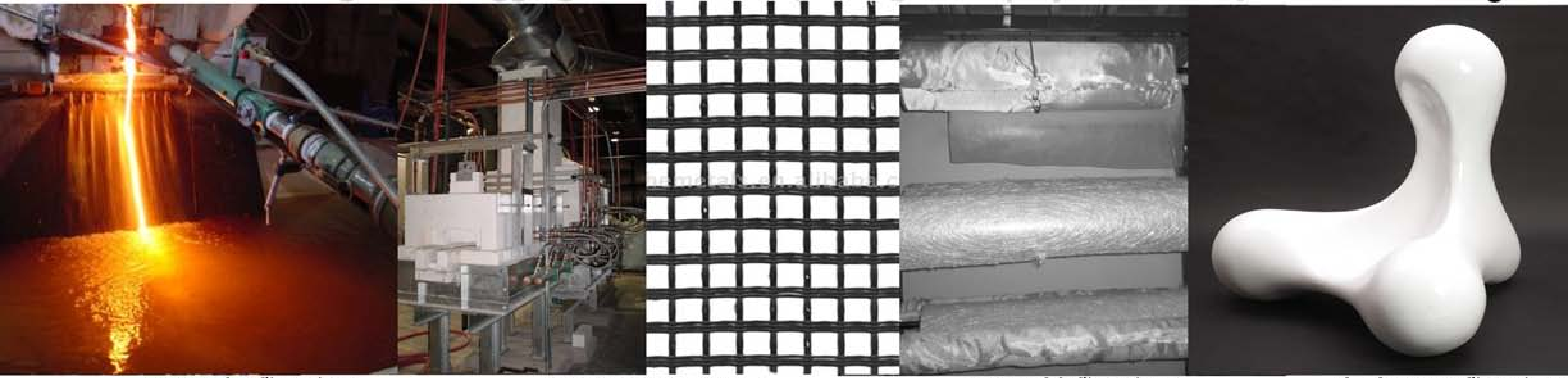
Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing. Glass is unlike other polymers in that, even as a fiber, it has little crystalline structure (see amorphous solid). The properties of the structure of glass in its soft stage are very much like its properties when spun into fiber.

application

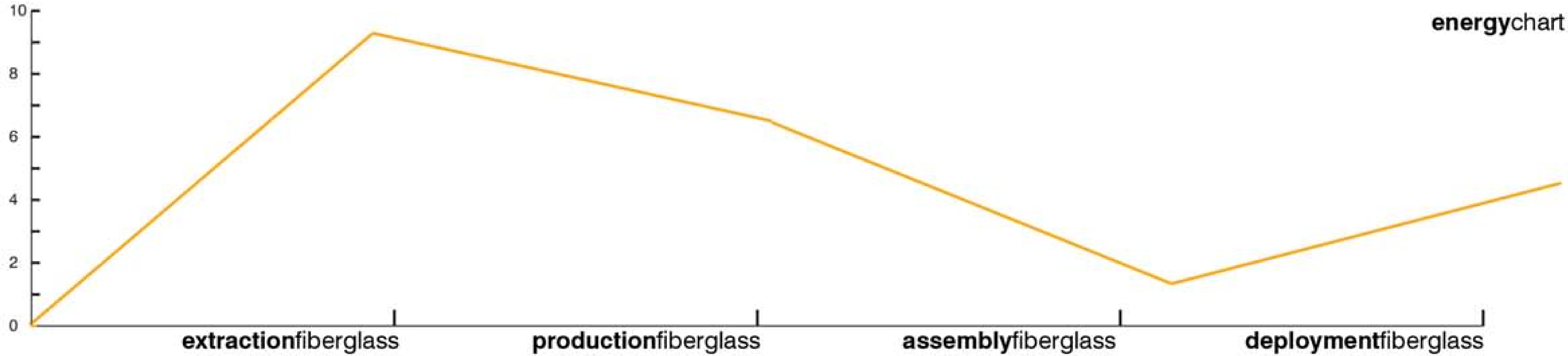
Fiberglass textiles are commonly used as a reinforcement material for molded and laminated plastics. Fiberglass wool, a thick, fluffy material made from discontinuous fibers, is used for thermal insulation and sound absorption. It is commonly found in ship and submarine bulkheads and hulls; automobile engine compartments and body panel liners; in furnaces and air conditioning units; acoustical wall and ceiling panels; and architectural partitions.

applicationshell

markbearak + **ben**howell + **patrick**oconnor + **kyuseon**hong + **kirk**tracy + **jordan**trachtenberg

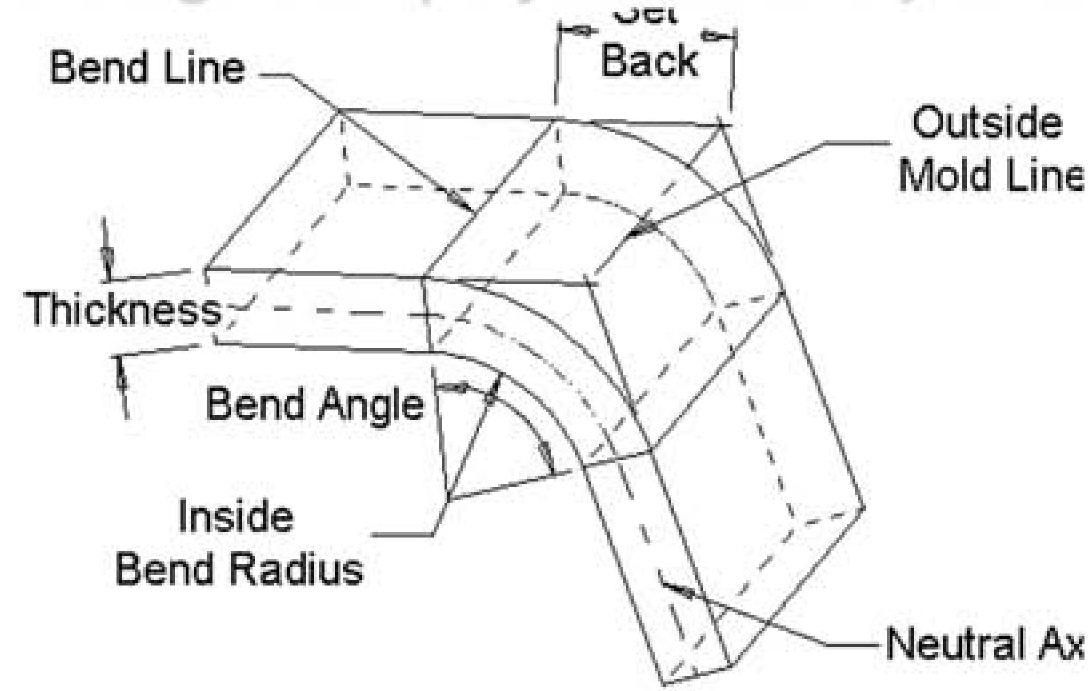


extractionfiberglass **production**fiberglass **assembly**fiberglass **deployment**fiberglass



extractionore

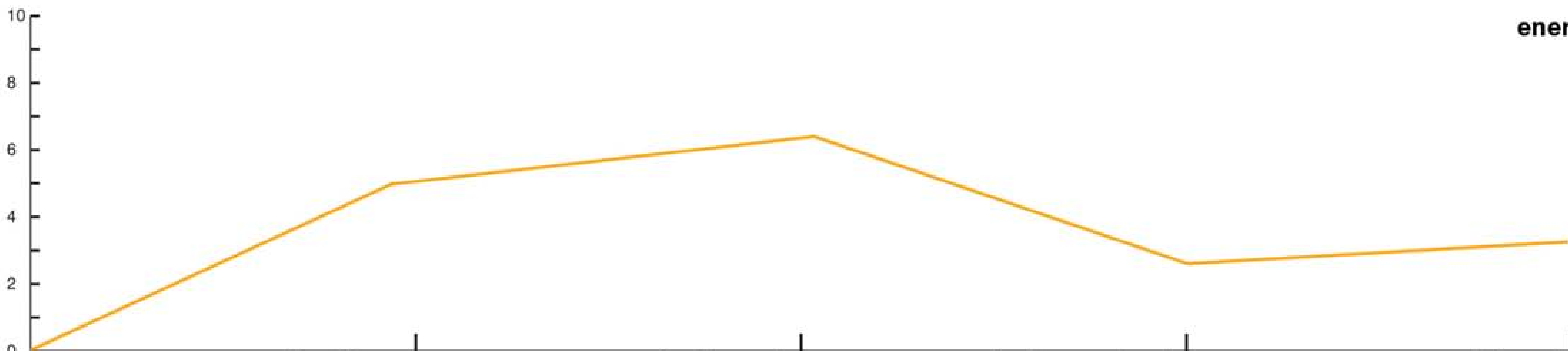
productionmetal



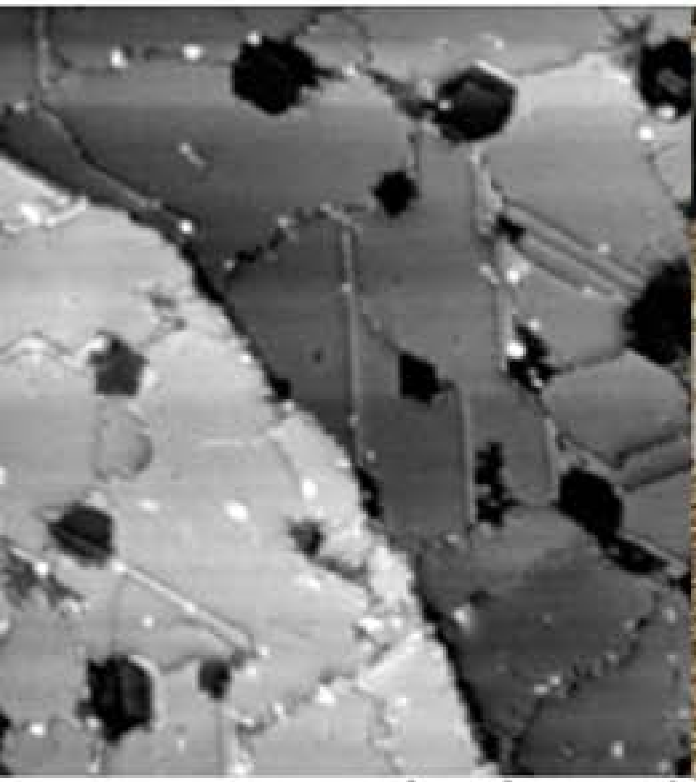
assemblymetal

deploymentmetal

energychart



markbearak+**ben**howell+**patrick**oconnor+**kyuseon**hong+**kirk**tracy+**jordan**trachtenberg

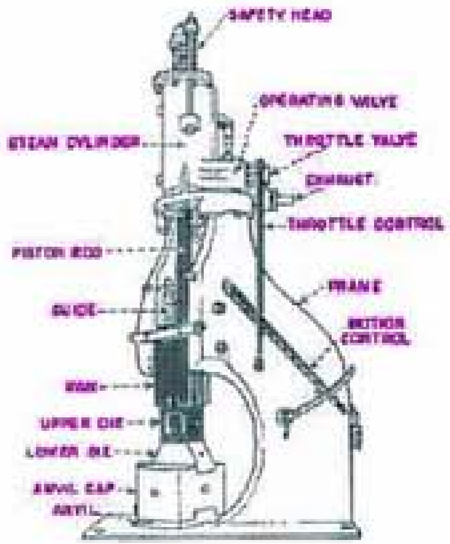


molecularmetal

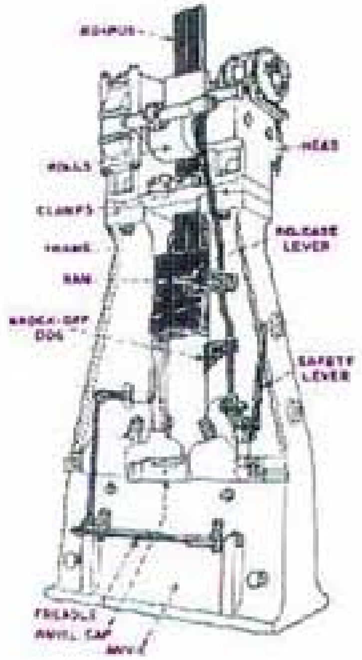
forgedmetal

forgedmetal

fieldmetal



forgedmetal



properties

Forging is the process by which metal is heated and is shaped by plastic deformation by suitably applying compressive force. Usually the compressive force is in the form of hammer blows using a power hammer or a press.

process

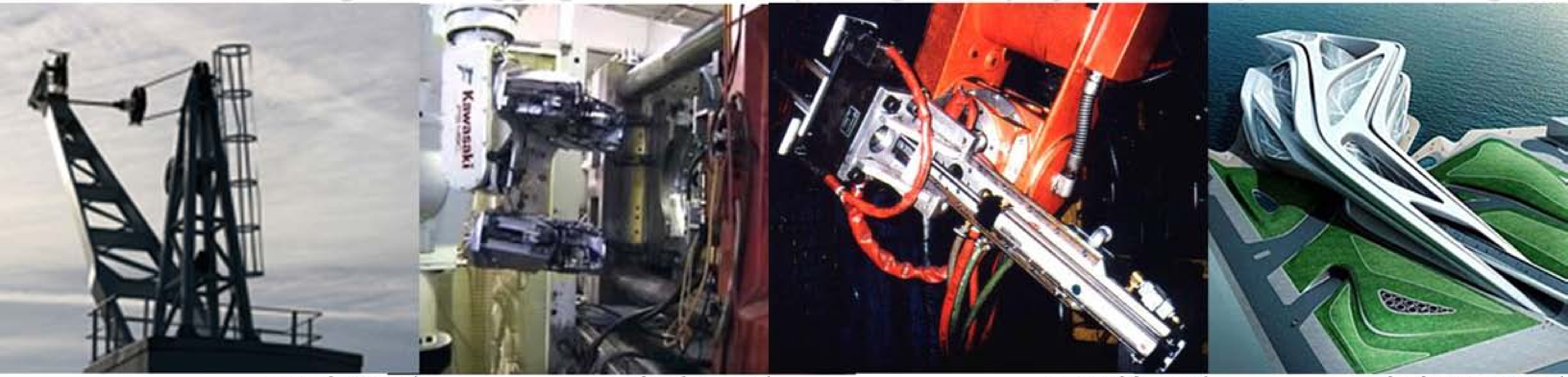
Forgings are consistent from piece to piece, without any of the porosity, voids, inclusions and other defects. Thus, finishing operations such as machining do not expose voids, because there aren't any. Also coating operations such as plating or painting are straightforward due to a good surface, which needs very little preparation. Forgings yield parts that have high strength to weight ratio-thus are often used in the design of aircraft frame members.

application

Forging refines the grain structure and improves physical properties of the metal. With proper design, the grain flow can be oriented in the direction of principal stresses encountered in actual use. Grain flow is the direction of the pattern that the crystals take during plastic deformation. Physical properties (such as strength, ductility and toughness) are much better in a forging than in the base metal, which has, crystals randomly oriented.

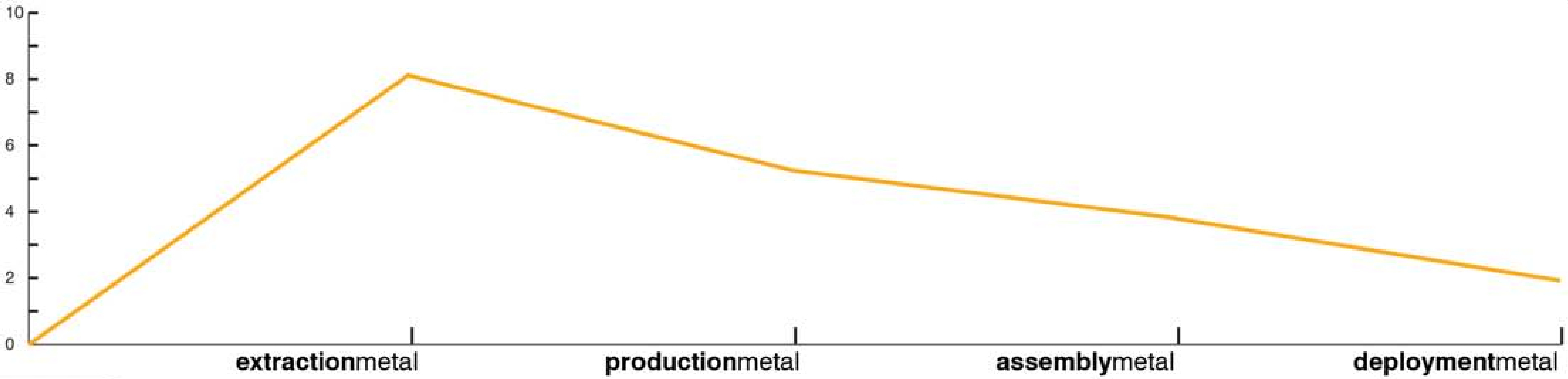
forgedmetal

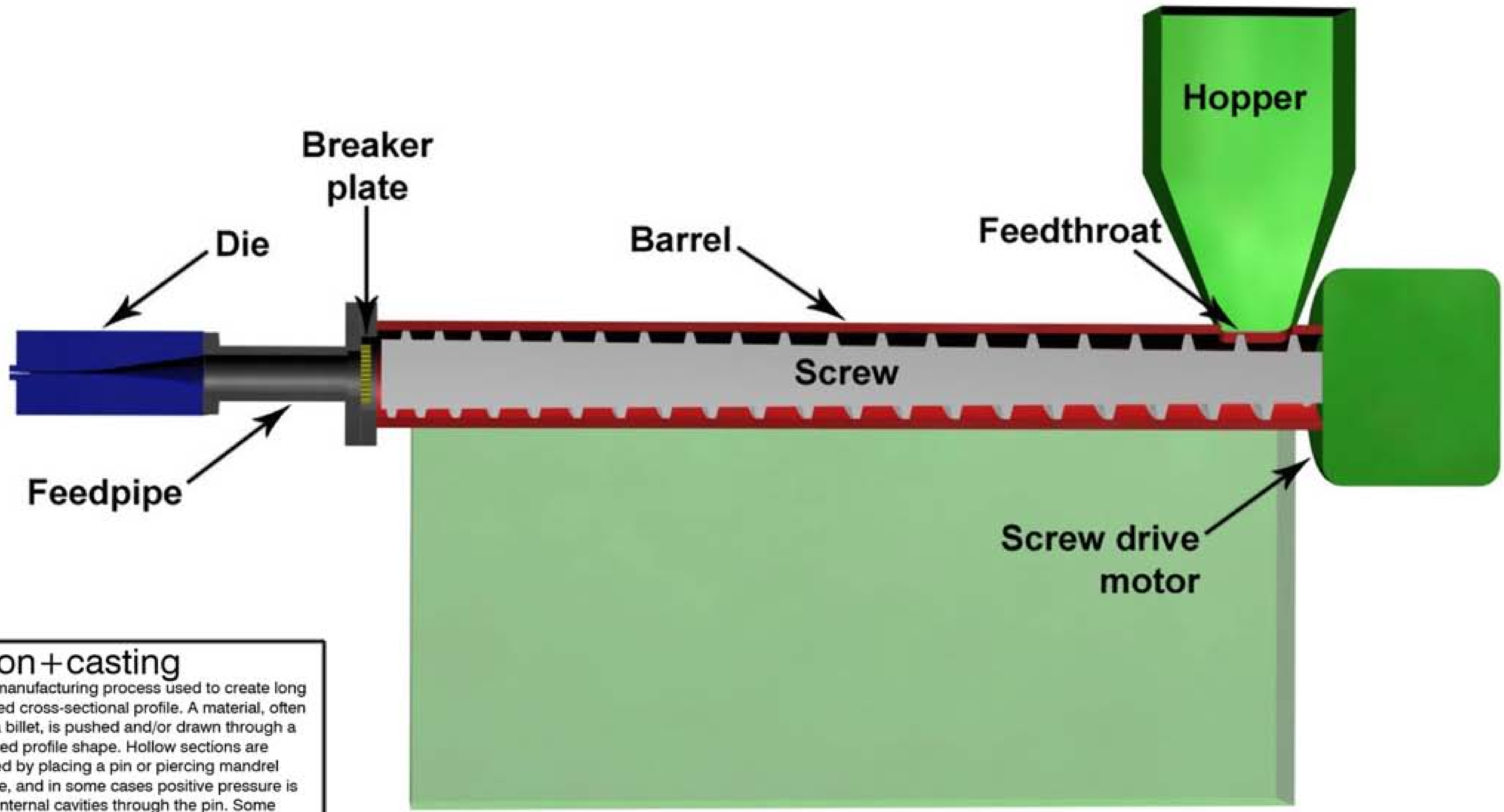
extrusionmetals + **folding**metals + **aggregation**concrete + **pouring**fluids + **polymerization**synthetics + **weaving**fiber



extractionmetal **production**metal **assembly**metal **deployment**metal

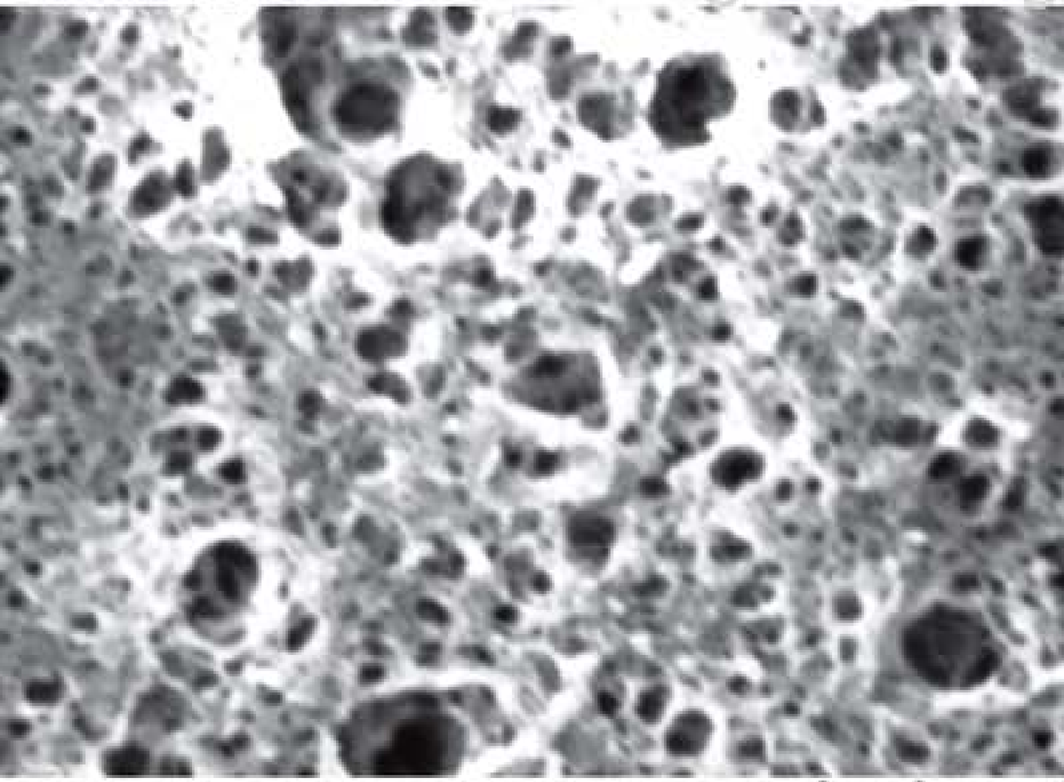
energychart





extrusion+casting

Extrusion is a manufacturing process used to create long objects of a fixed cross-sectional profile. A material, often in the form of a billet, is pushed and/or drawn through a die of the desired profile shape. Hollow sections are usually extruded by placing a pin or piercing mandrel inside of the die, and in some cases positive pressure is applied to the internal cavities through the pin. Some materials are hot drawn while others may be cold drawn.



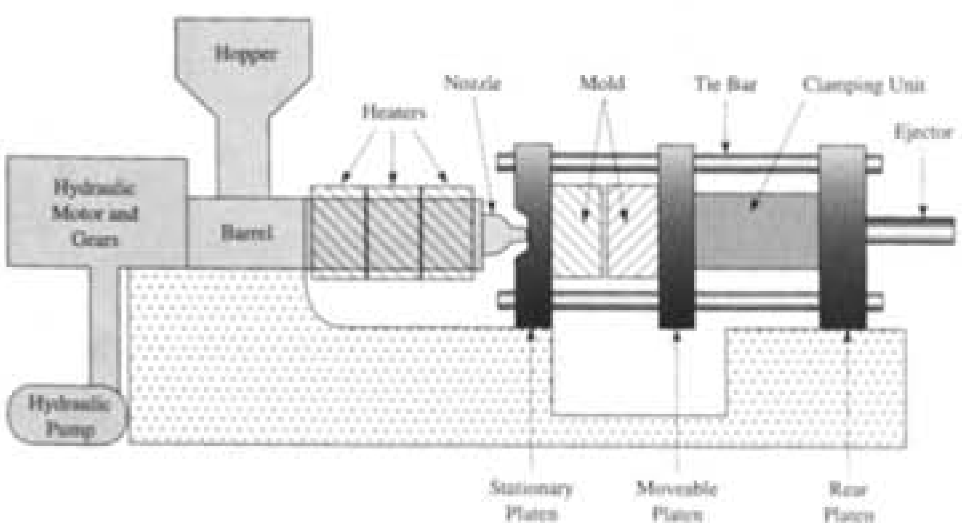
molecularsteel

injectionsteel

injectionsteel

fieldsteel

injectionsteel



properties

The most commonly used thermoplastic materials are polystyrene (low cost, lacking the strength and longevity of other materials), ABS or acrylonitrile butadiene styrene (a co-polymer or mixture of compounds used for everything from Lego parts to electronics housings), nylon (chemically resistant, heat resistant, tough and flexible - used for combs), polypropylene (tough and flexible - used for containers), polyethylene, and polyvinyl chloride or PVC (more common in extrusions as used for pipes, window frames, or as the insulation on wiring where it is rendered flexible by the inclusion of a high proportion of plasticiser). Injection molding can also be used to manufacture parts from aluminium or brass.

process

Injection molding (British variant spelling: moulding) is a manufacturing technique for making parts from both thermoplastic and thermosetting plastic materials in production. Molten plastic is injected at high pressure into a mold (British variant spelling: mould), which is the inverse of the product's shape. After a product is designed by an Industrial Designer or an Engineer, molds are made by a moldmaker (or toolmaker) from metal, usually either steel or aluminium, and precision-machined to form the features of the desired part. Injection molding is widely used for manufacturing a variety of parts, from the smallest component to entire body panels of cars.

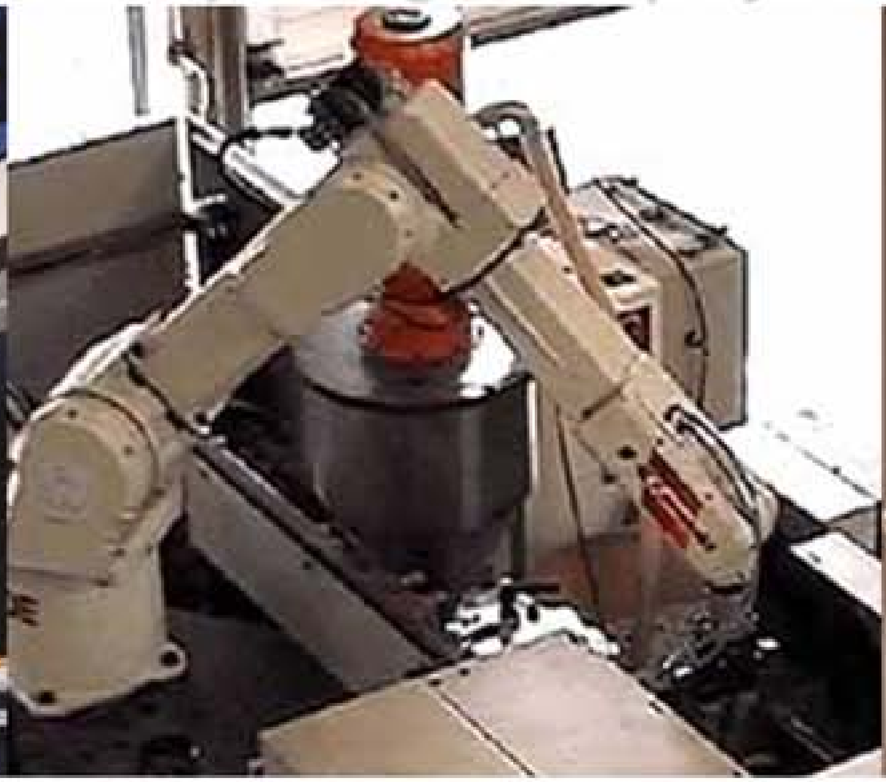
application

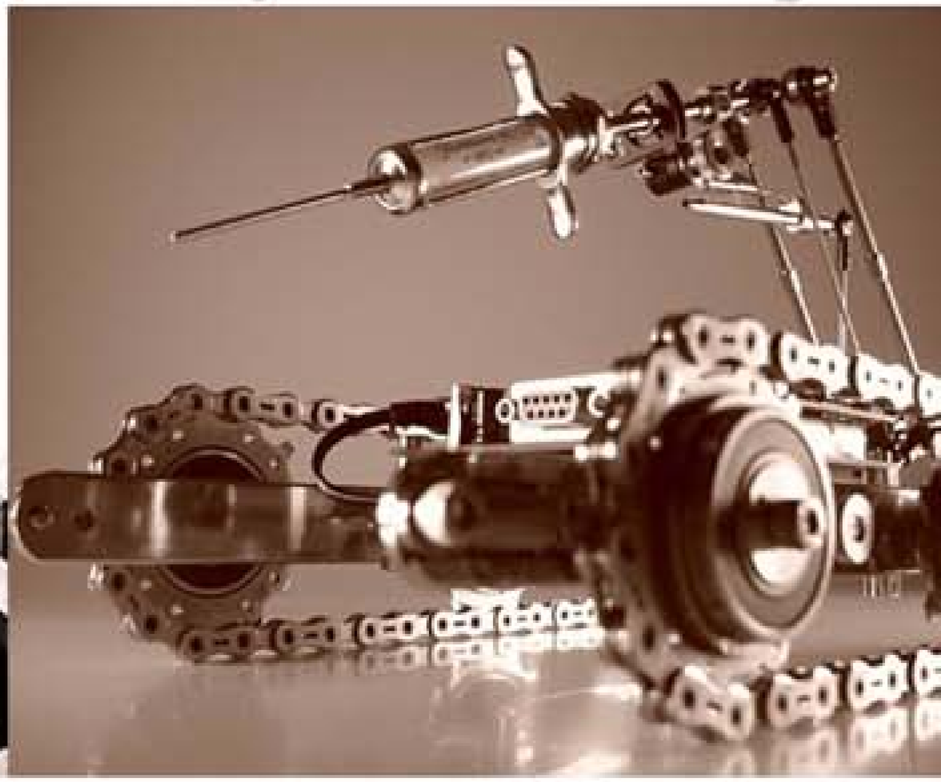
Injection molding is the most common method of production, with some commonly made items including bottle caps and outdoor furniture. Injection molding typically is capable of an IT Grade of about 9-14.

injectionsteel

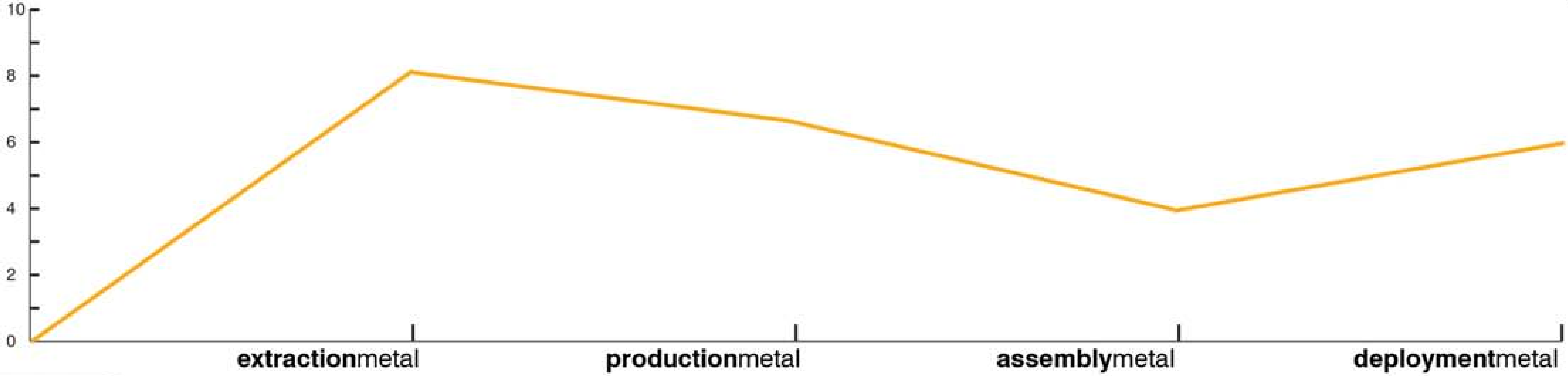

extractionmetal

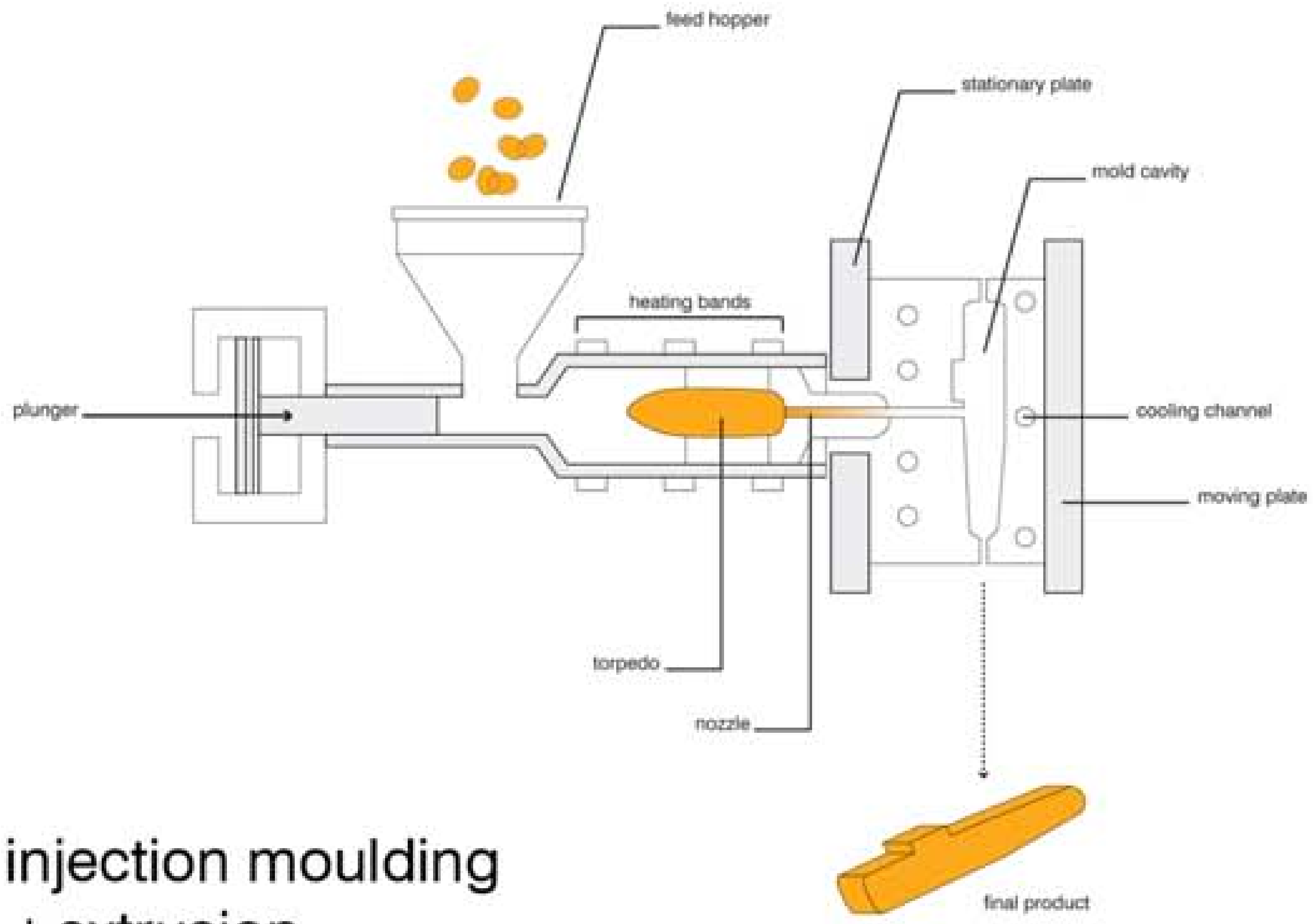

productionmetal

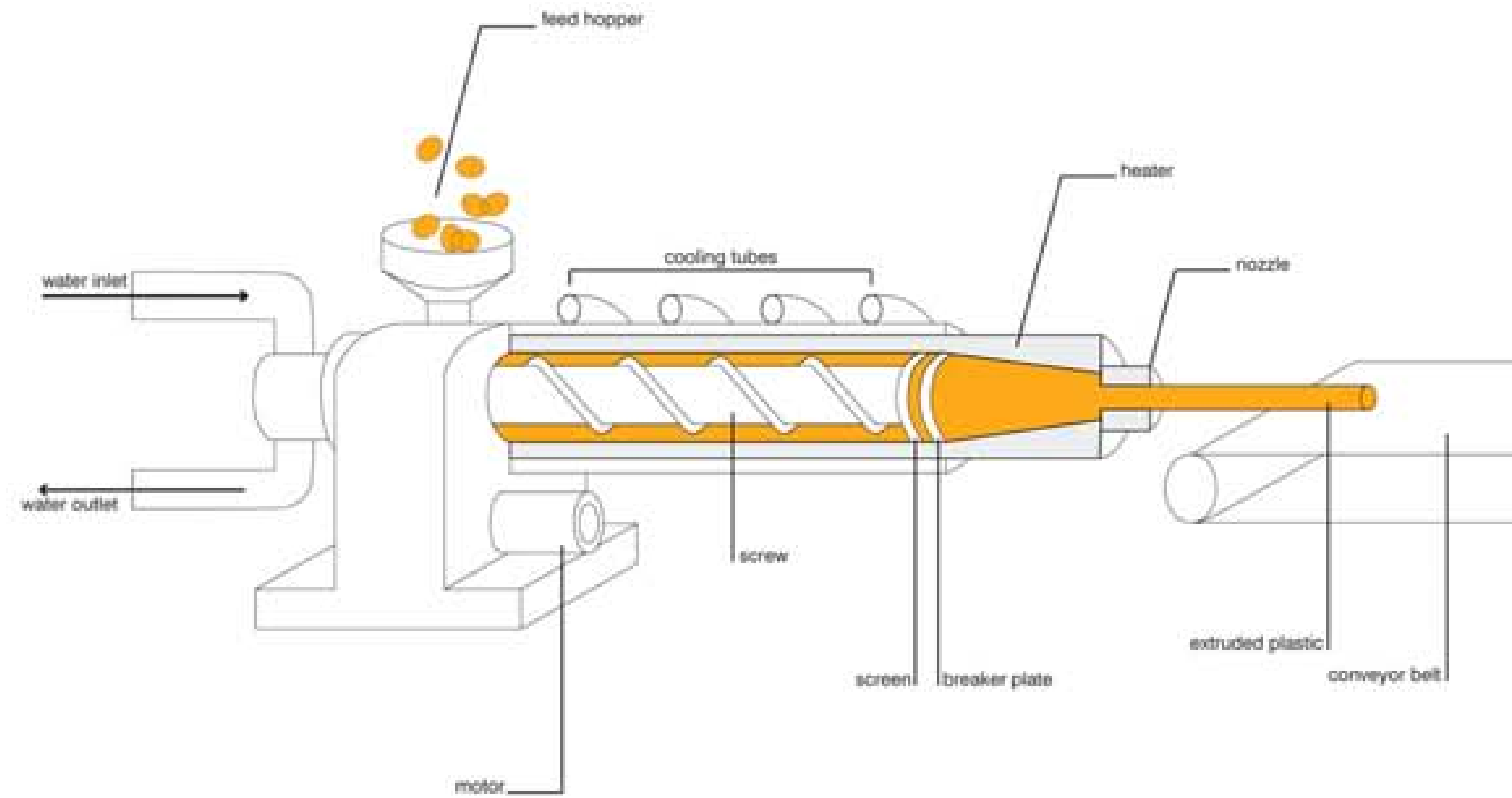

assemblymetal


deploymentmetal

energychart





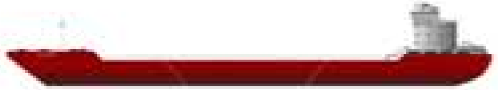


injection moulding +extrusion

Injection moulding and extrusion are two common methods for producing polymerized materials. Both methods require heating up the polymerized material to a liquid state where it then undergoes transformation into its final state. For injection moulding, the liquid state is pushed into a mould where it is cooled and then released. The extrusion method churns the liquid into a nozzle where it is pushed out onto a conveyor belt and cools, forming the final extruded form.

extractionlaminate

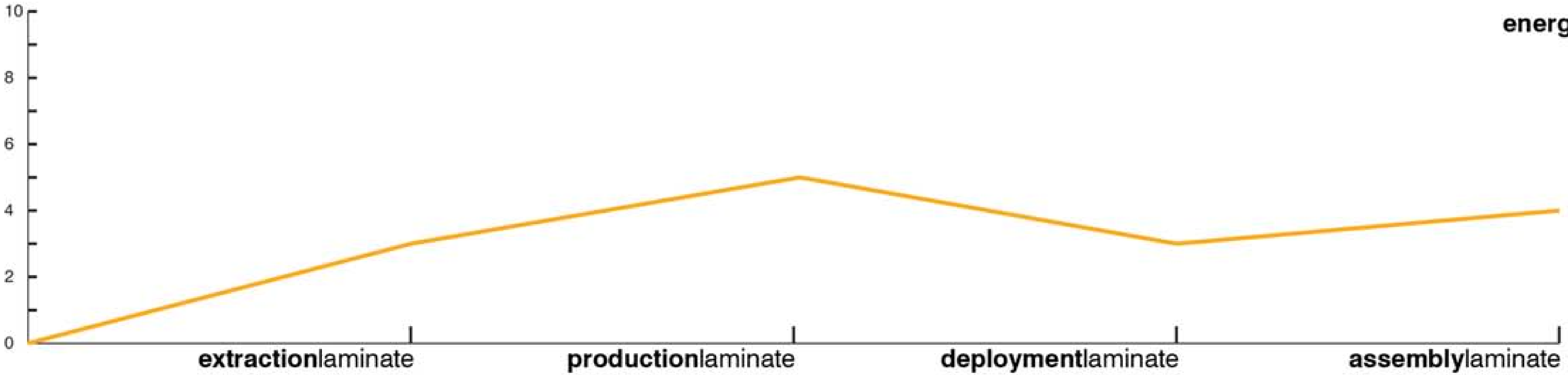
productionlaminate

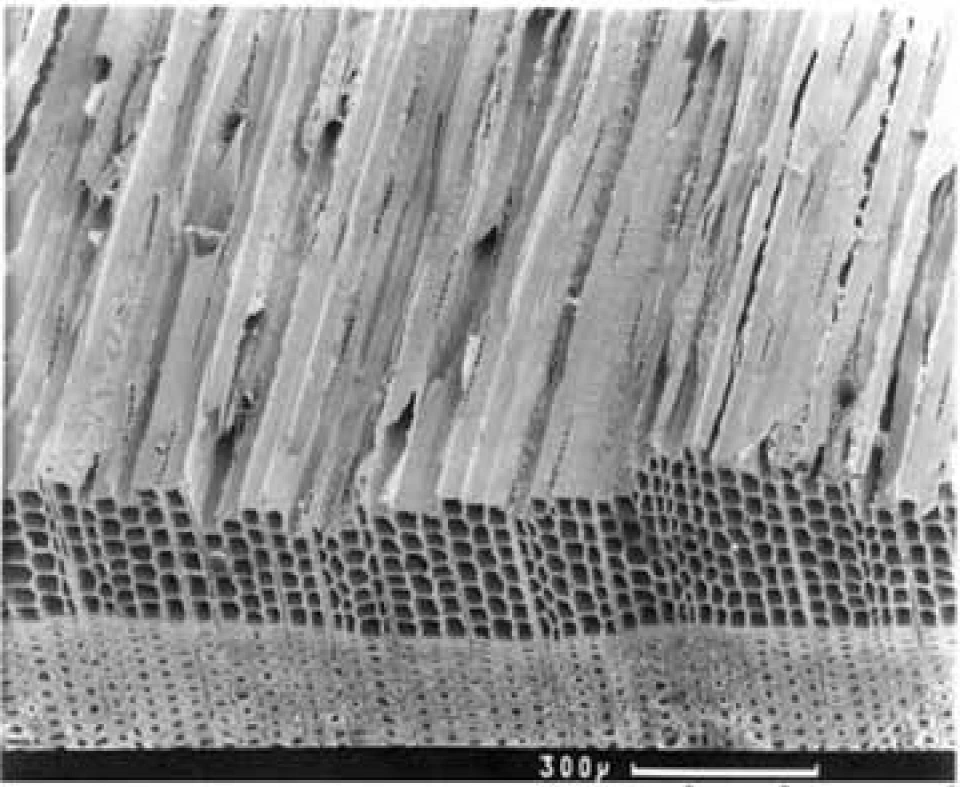


deploymentlaminate

assemblylaminate

energychart

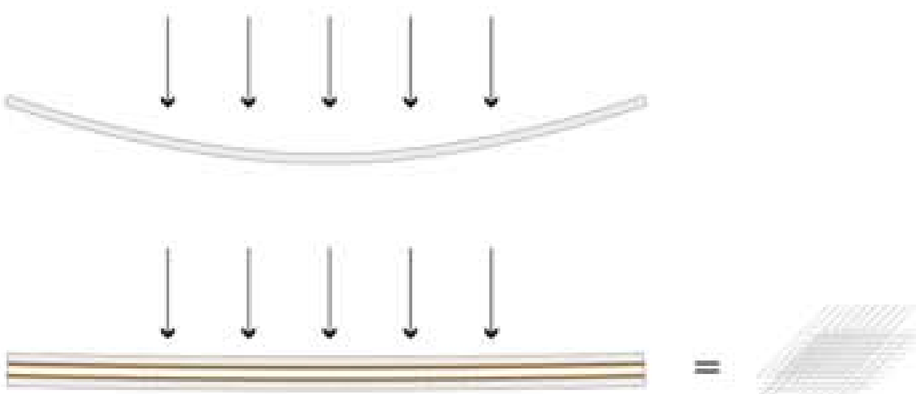




molecularwood

pressurelamination

compoundlamination



properties

Lamination gets its strength by means of multiplication. Compressive strength is achieved by aggregating numerous layers of a given material. Wood is a common material used for laminates. The molecules of wood are arranged in strands that when laminated together in opposite directions form a structurally sound member in compression. The key to laminates is strength in numbers.

process

Both natural and synthetic materials are used for lamination. Materials gain durability when sheets or strips are layered and adhered together, usually with a polymer epoxy. The process of lamination is normally achieved in one of two manners; through pressure lamination or rolling lamination. Pressure lamination involves the use of clamps to adhere the layers together whereas rolling lamination requires unwinding rolls of a material, the use of heat and an adhesive, and then rewinding the two rolls into one new laminated material.

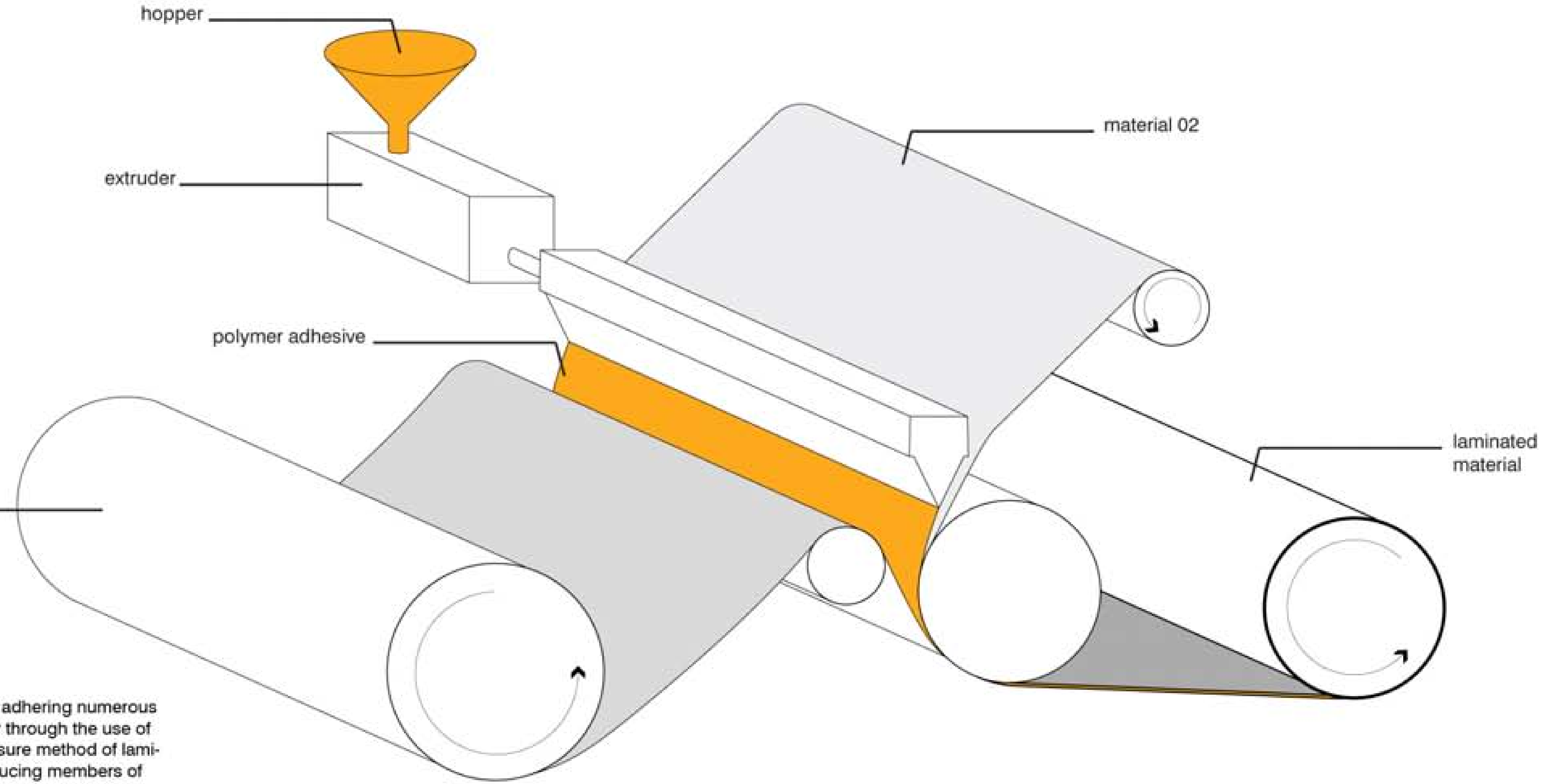
application

Laminations were traditionally used for stationery products and furniture. Recent developments in material innovations and lamination techniques have lead to uses for structural applications. Materials like carbon fiber and other types of polymer sheets have lead to new uses for laminates. When compounded with an additional technique such as forming, a versatile, light weight, and durable laminate is formed.

Certain "intelligent" laminates are currently in development. NASA in collaboration with DuPont created a technologically active laminate for the Mars Rover that could withstand the harsh climate of Mars. Laminates can now serve a technological purpose as well as a structural one.

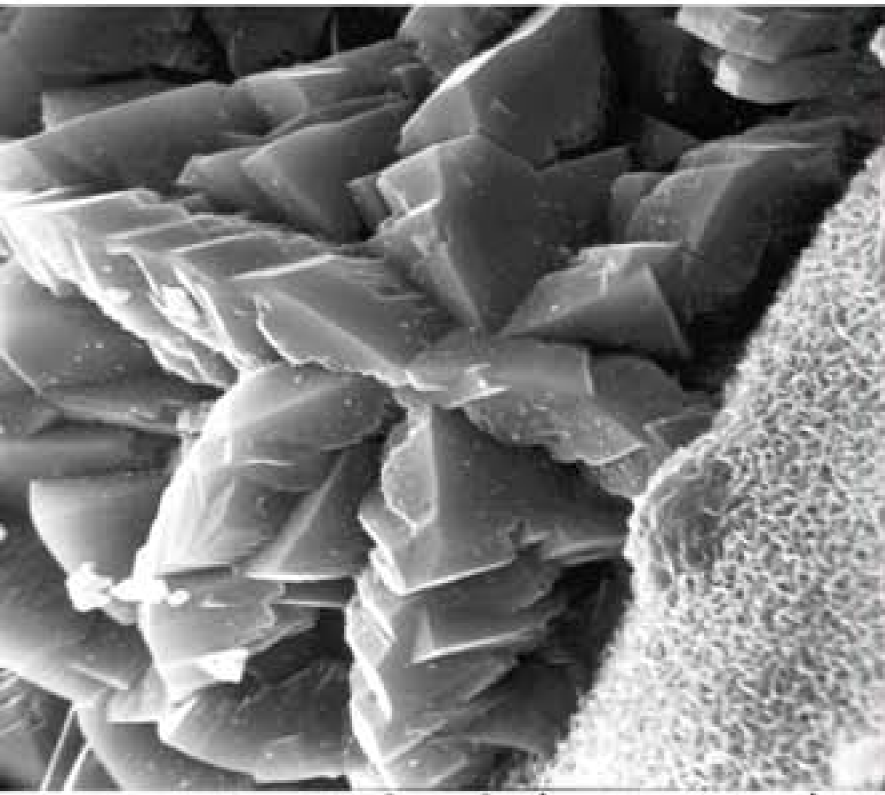
processlamination

 markbearak+**ben**howell+**patrick**oconnor+**kyuseon**hong+**kirk**tracy+**jordan**trachtenberg



lamination

Lamination can be accomplished by adhering numerous pieces of material under pressure, or through the use of machinery such as rollers. The pressure method of lamination production is effective in producing members of any size that can be assembled on site or shipped away. Rolling lamination is restricted to the size capabilities of the machinery. The process produces sheets that can be further manipulated by material hybridization and/or the use of compressive forms.

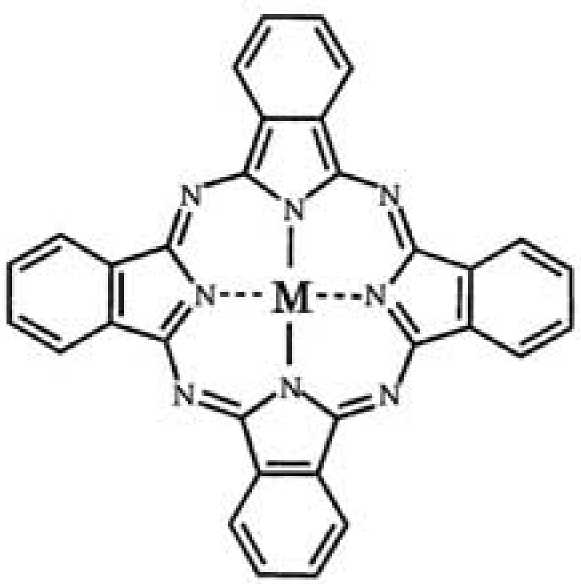


moleculariron-magnesium

pouringmetal

panelmetal

fieldmetal



properties

Some metals and metal alloys possess high structural strength per unit mass, making them useful materials for carrying large loads or resisting impact damage. Metal alloys can be engineered to have high resistance to shear, torque and deformation. However the same metal can also be vulnerable to fatigue damage through repeated use, or from sudden stress failure when a load capacity is exceeded. The strength and resilience of metals has led to their frequent use in high-rise building and bridge construction, as well as most vehicles, many appliances, tools, pipes, non-illuminated signs and railroad tracks.

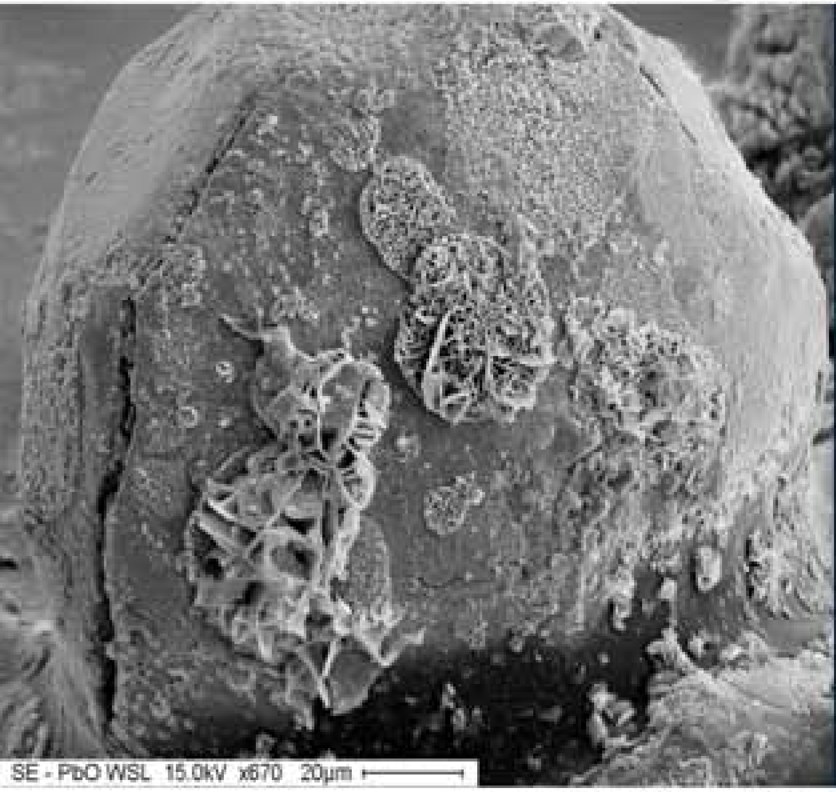
Metals are good conductors, making them valuable in electrical appliances and for carrying an electric current over a distance with little energy lost. Electrical power grids rely on metal cables to distribute electricity. Home electrical systems, for the most part, are wired with copper wire for its good conducting properties.

The thermal conductivity of metal is useful for containers to heat materials over a flame. Metal is also used for heat sinks to protect sensitive equipment from overheating.

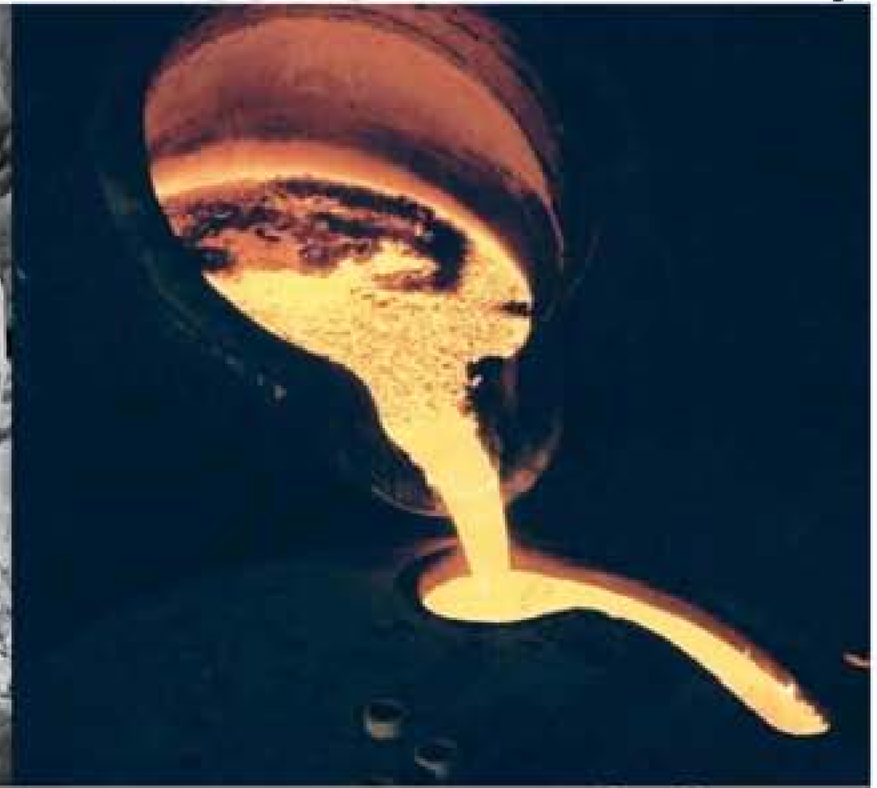
The high reflectivity of some metals is important in the construction of mirrors, including precision astronomical instruments. This last property can also make metallic jewelry aesthetically appealing.

Some metals have specialized uses; Radioactive metals such as Uranium and Plutonium are used in nuclear power plants to produce energy via nuclear fission. Mercury is a liquid at room temperature and is used in switches to complete a circuit when it flows over the switch contacts. Shape memory alloy is used for applications such as pipes, fasteners and vascular stents.

applicationmetal

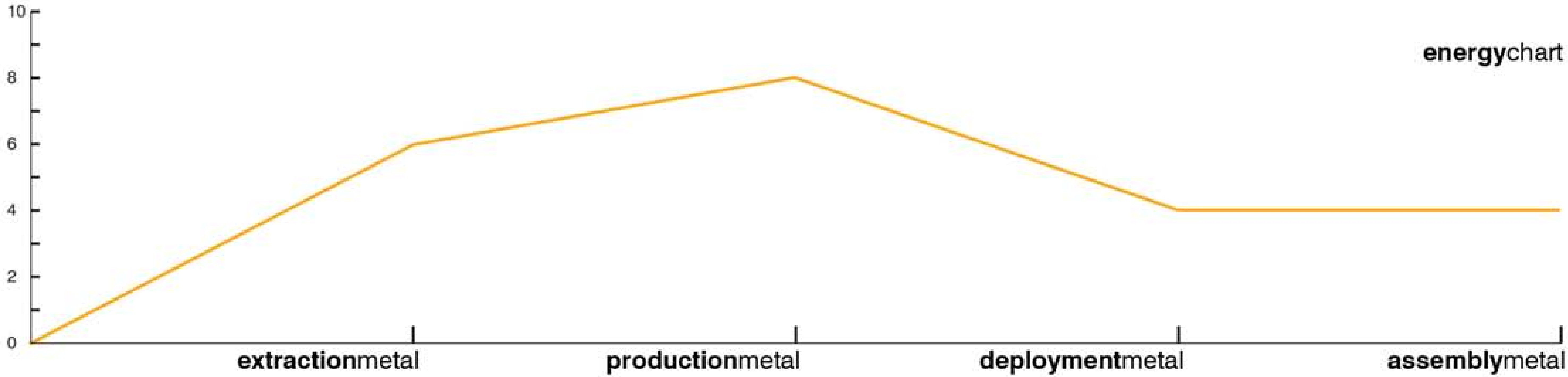


extractionmetal

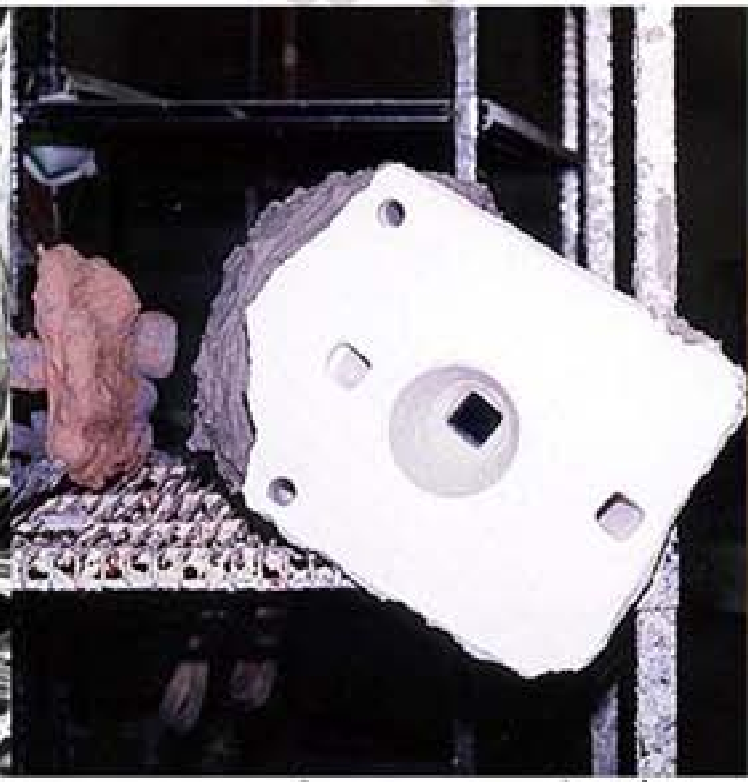

productionmetal


deploymentmetal

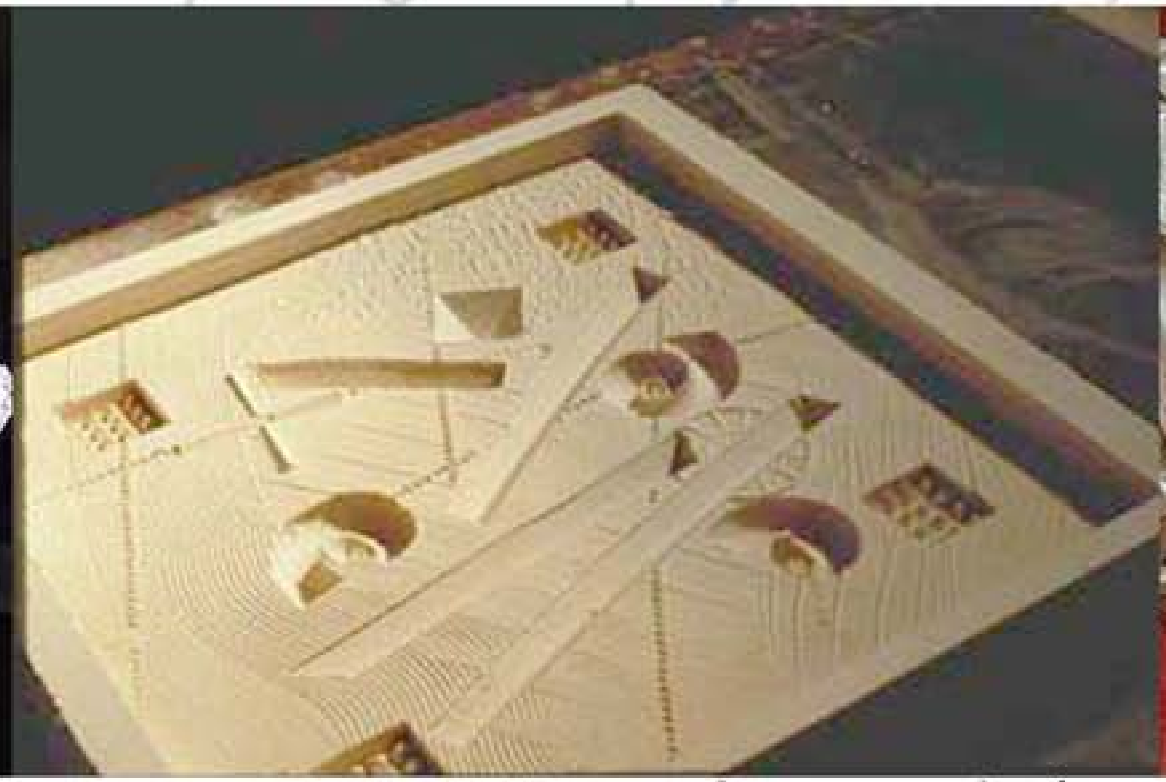

assemblymetal



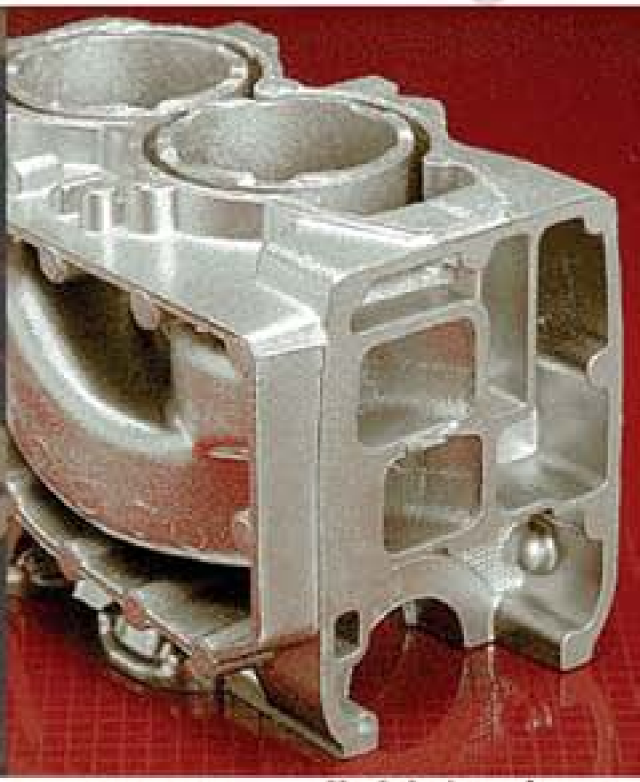
molecularaluminum



plaster castaluminum



plaster castaluminum



fieldaluminum

plaster castaluminum

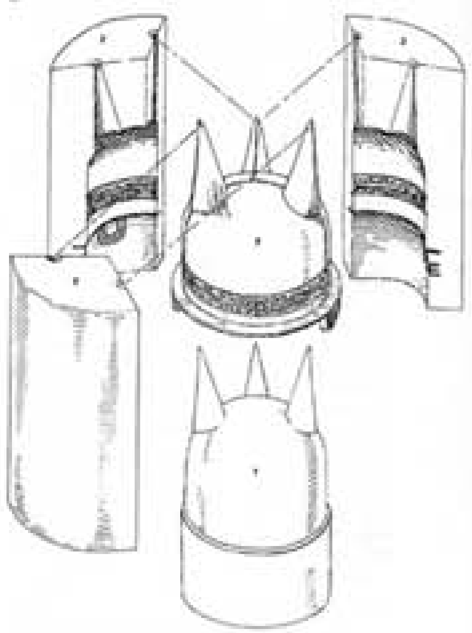


Diagram showing how early Chinese bronzes were formed: the model or core (1), the sections of the mold (2), and the completed vessel (3—the cauldron no. 4)

properties

In plaster mold casting, a plaster, usually gypsum or calcium sulfate, is mixed with talc, sand, asbestos, and sodium silicate and water to form a slurry. This slurry is sprayed on the polished surfaces of the pattern halves (usually brass). The slurry sets in less than 15 minutes to form the mold. The mold halves are extracted carefully from the pattern, and then dried in an oven.

process

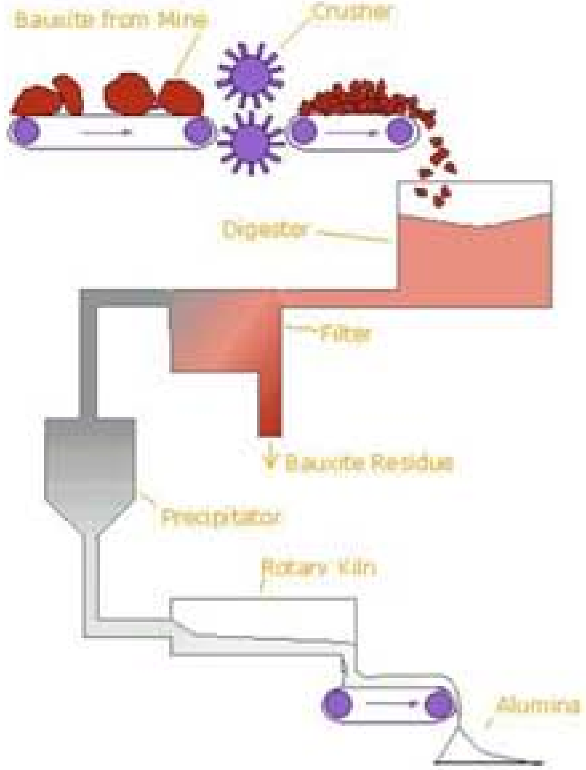
The mold halves are carefully assembled, along with the cores. The molten metal is poured in the molds. After the metals cools down, the plaster is broken and the cores washed out. Low temperature melting materials such as aluminum, copper, magnesium and zinc can be cast using this process. This process is used to make quick prototype parts as well as limited production parts.

application

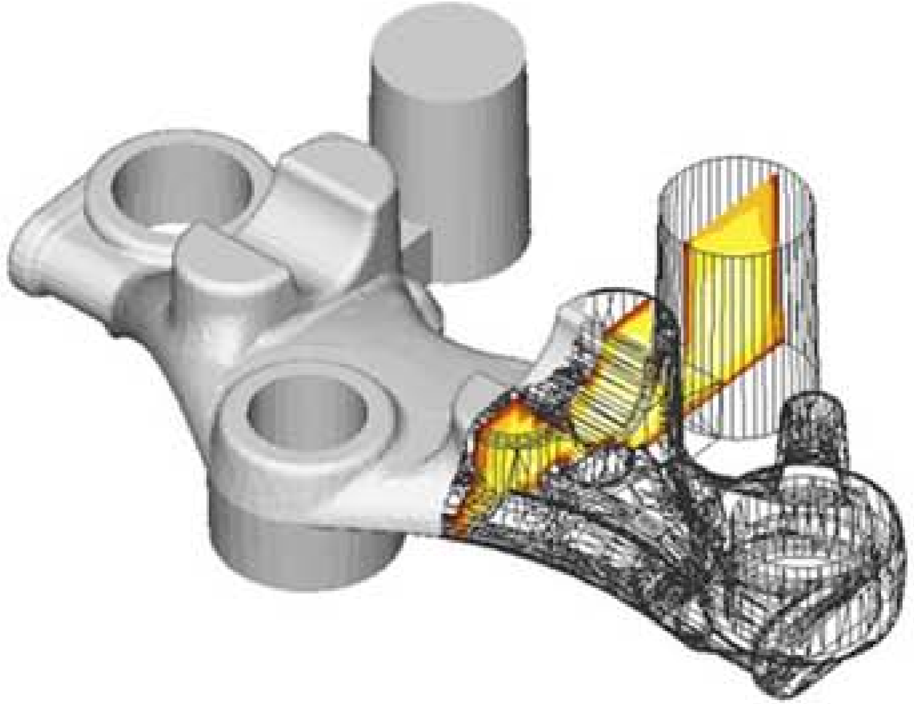
The volatiles are removed using a flame torch or in a low temperature oven. It is then baked in a furnace at about 1000 °C (1832 °F) yielding a ceramic mold, capable of high temperature pours. Additionally, the pour can take place while the mold is until hot. This process is expensive, but can eliminate secondary machining operations. Typical parts made from this process include impellers made from stainless steel, bronze, complex cutting tools, plastic mold tooling.

plaster castaluminum

extractionaluminum



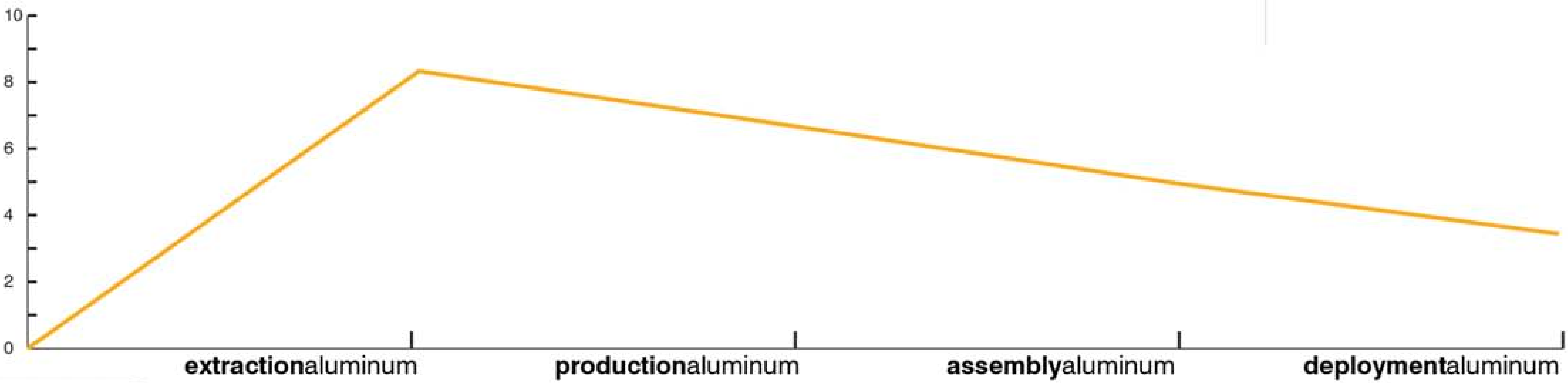
productionaluminum



assemblyaluminum

deploymentaluminum

energychart



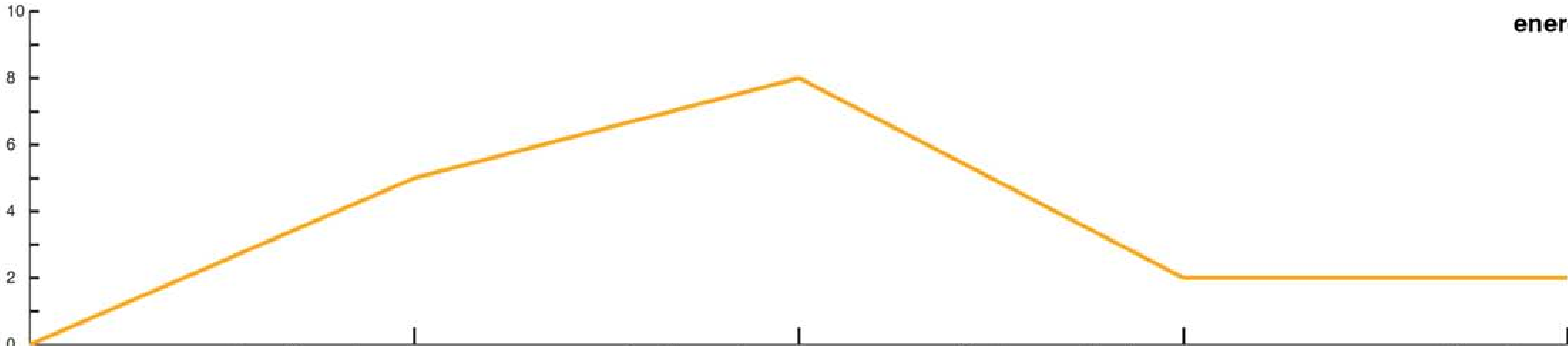
extractionpolymer

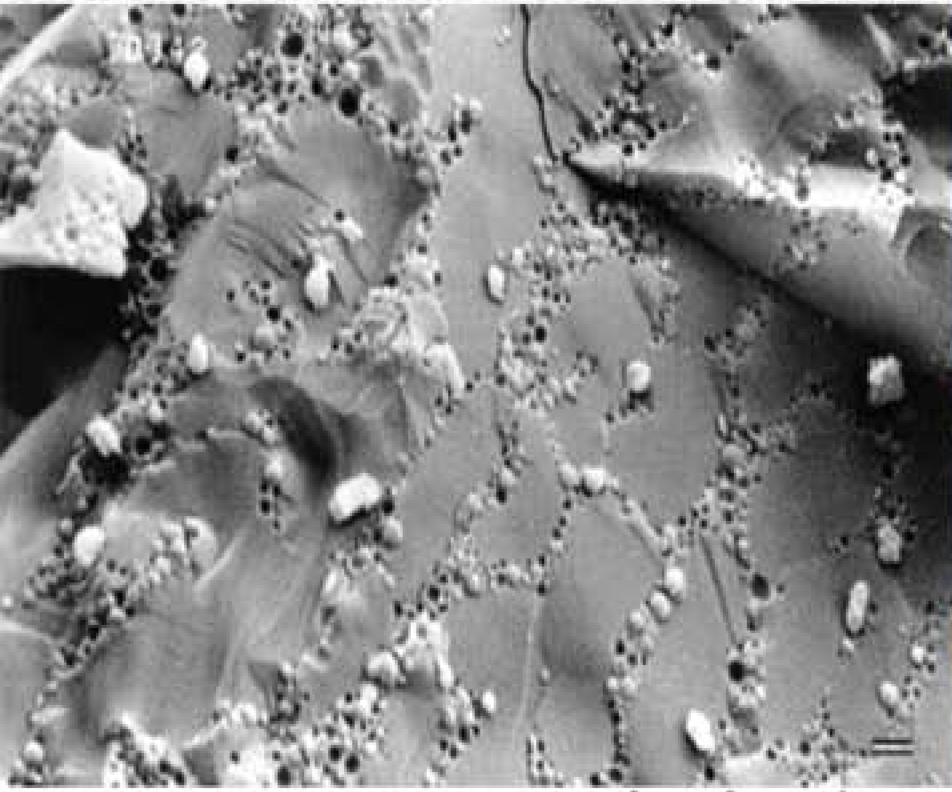
productionpolymer

deploymentpolymer

assemblypolymer

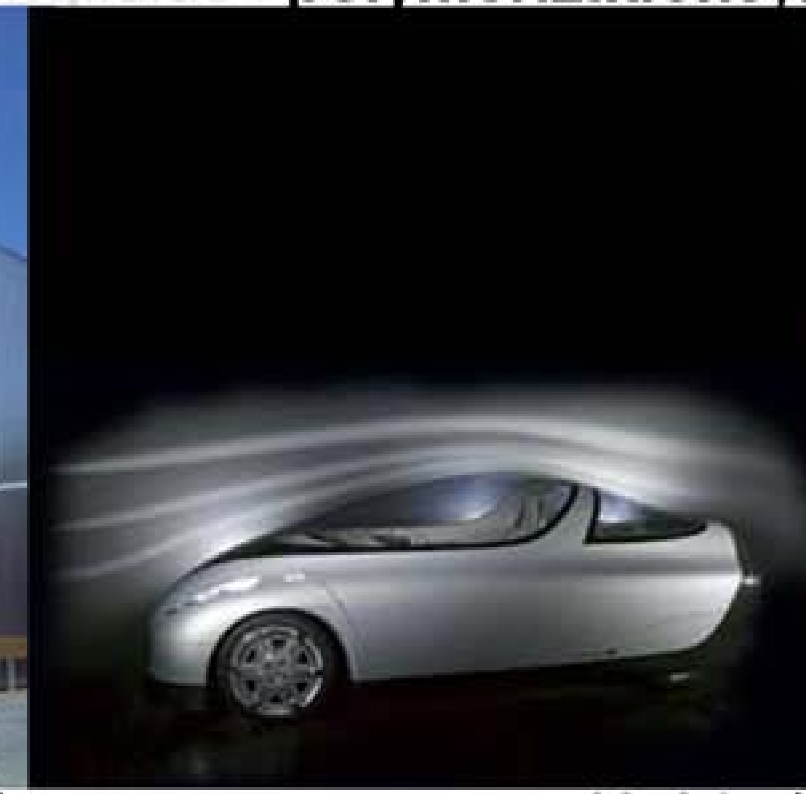
energychart





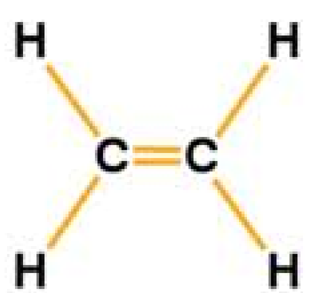
molecularpolymer

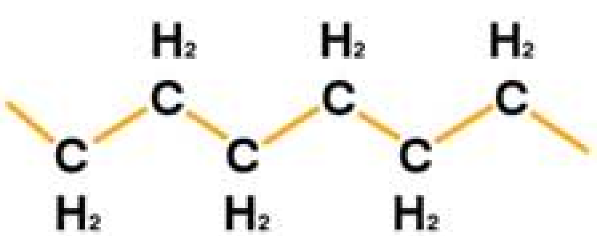
panelplastic



moldedplastic

high-strengthpolymer





properties

Polymers gain their strength through the process that bonds molecules together in chains. Polymers are used for their high strength, light weight, durability, and thermal properties

process

Many polymer materials are synthesized from natural resources. One example is a South American tree that extracts latex when its bark is removed. Other examples of polymers derived from natural resources include silk, lacquer, and nylon.

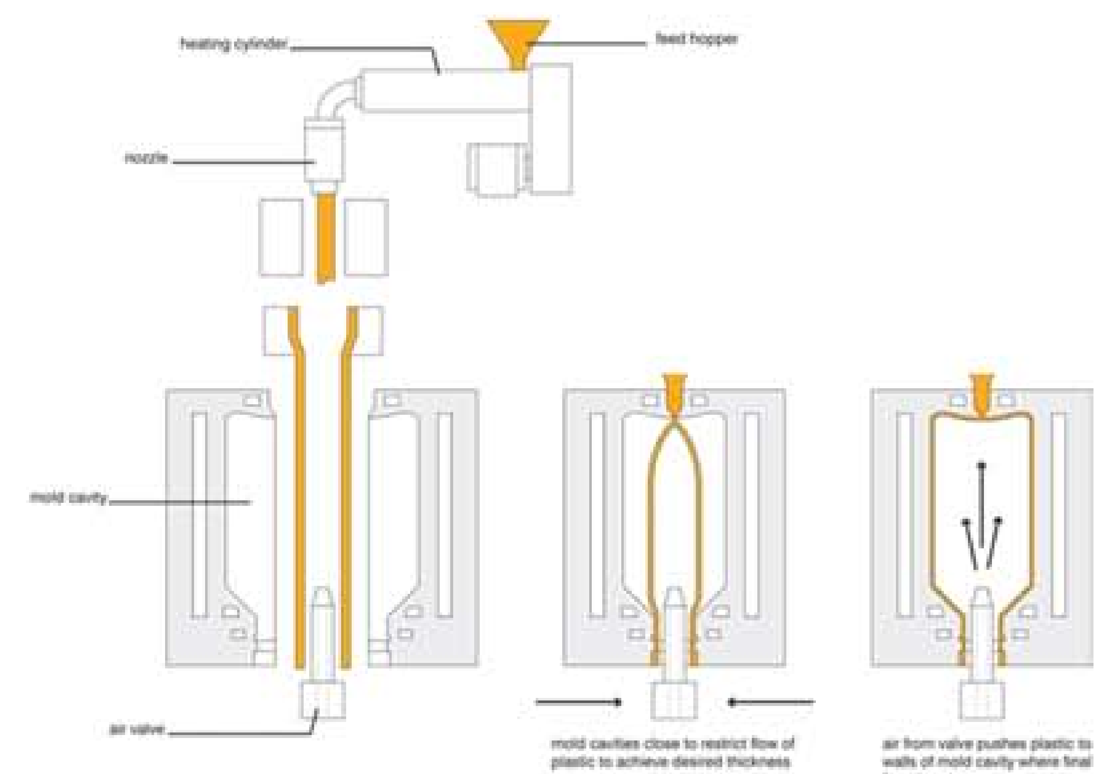
The Polymerization process is achieved by one of two processes; addition or condensation. Molecules become chains gaining significant strength by eliminating or adding water or alcohol.

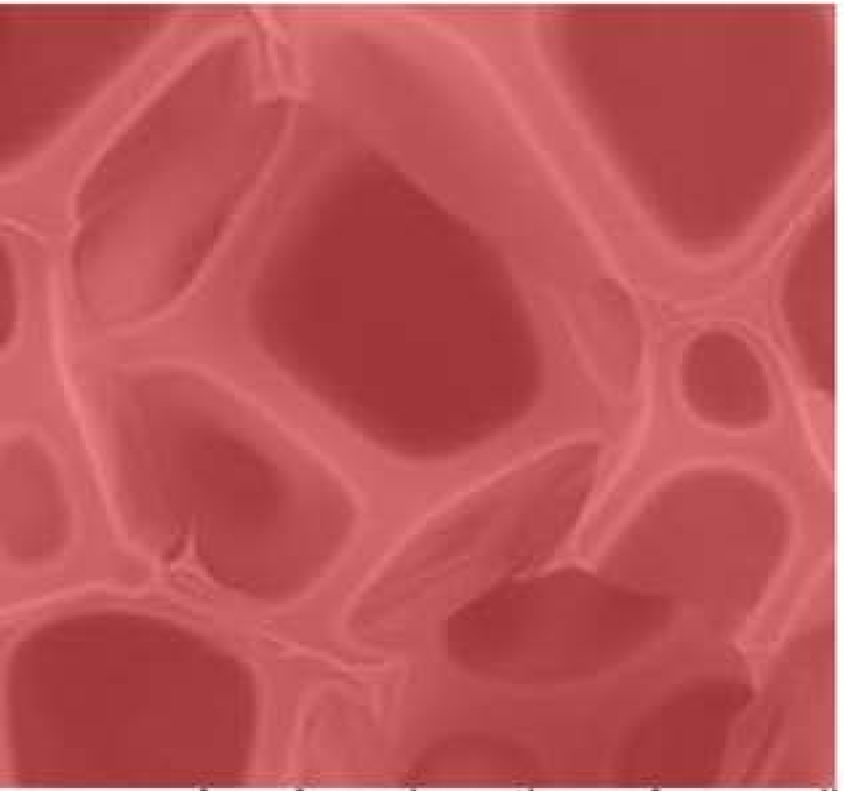
Once polymerized, traditional methods of production include blow moulding, injection moulding, spinning into fibers, or extrusion. All methods involve heating the solid polymerized bits to a liquid state where it then further manipulated into its final form.

application

Applications of Polymers range from the micro to the macro scale. Products at the smaller end of the spectrum include bottles, containers, parts for larger objects,and industrial design objects. Large scale applications of Polymers include sheets, structural members, and automotive, nautical, aviation, and architectural uses.

processesplastic



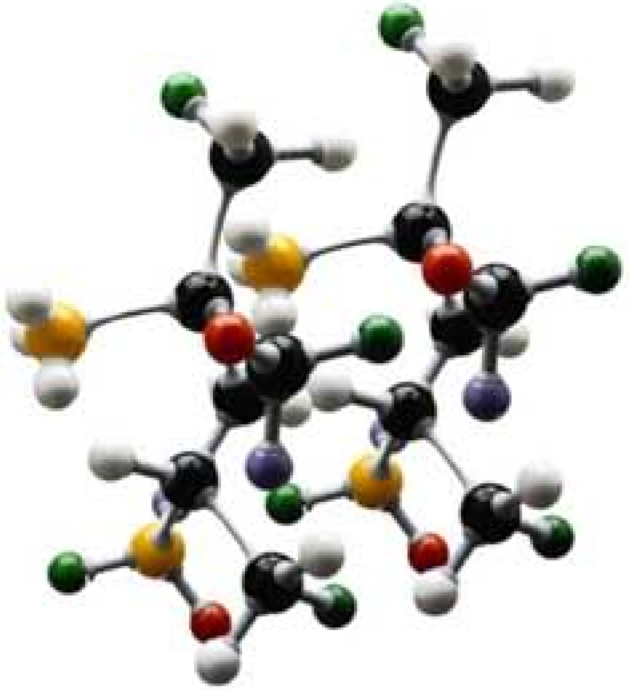


molecularpolyurethane foam cell

polyurethane foam

polyurethane columns

heavy duty polyurethane floor



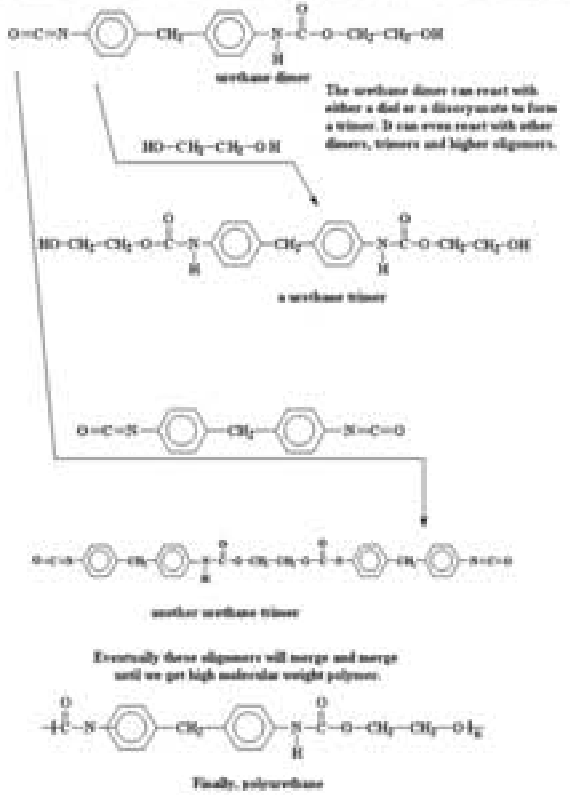
properties

Polyurethane is the mixing of two components, namely Polyol and Isocyanite, and belongs to the greater family of plastics. Contrary to the usual plastic materials, polyurethane has countless applications and uses in several areas. Today, polyurethane is one of the most important and unstable members of the family of plastics, and its structure is exactly what makes it so useable. Polyurethane can be applied to a very wide spectrum of products, from making special molds, to being used as an insulation material and to creating machinery and furniture.

foamcrete

applicationpolyurethane

substances+processes **ben**howell+**kirk**tracy+**kyuseon**hong+**jordan**trachtenberg+**mark**bearak+**patrick**oconnor

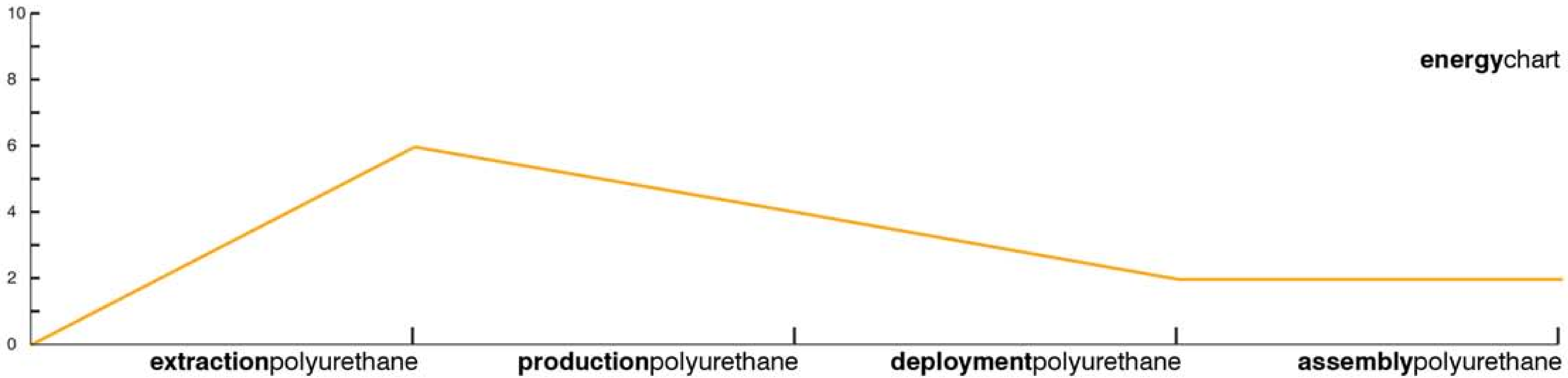


extractionpolyurethane

productionpolyurethane

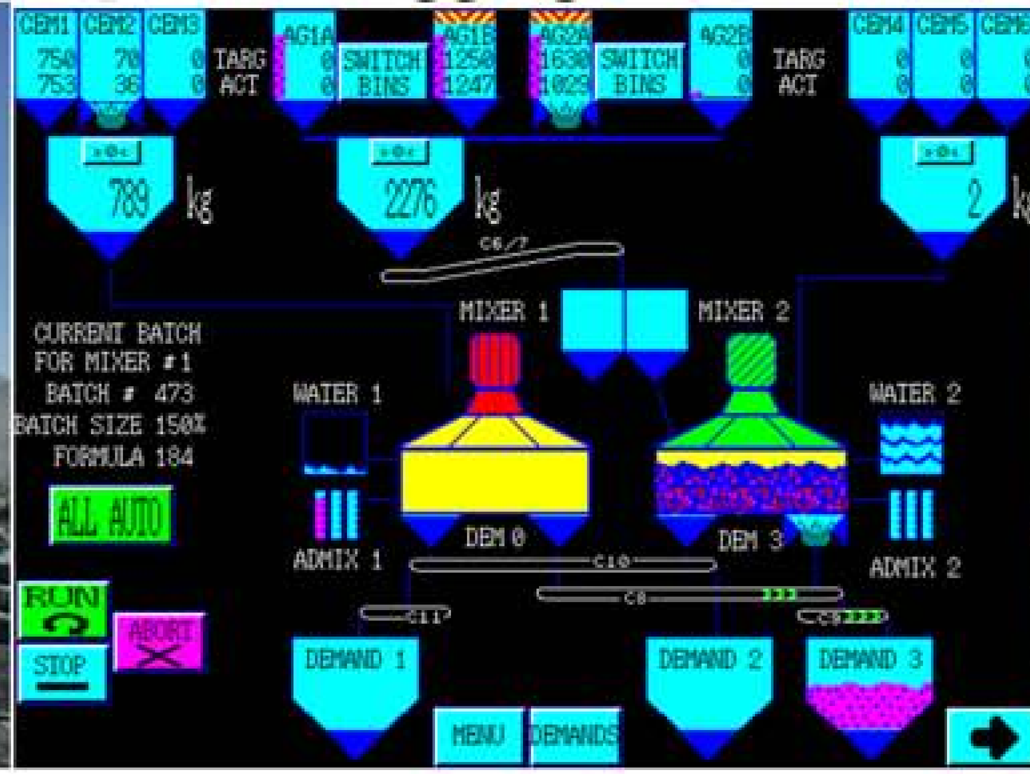
deploymentpolyurethane

assemblypolyurethane



Pour something to get solidity

extractionconcrete

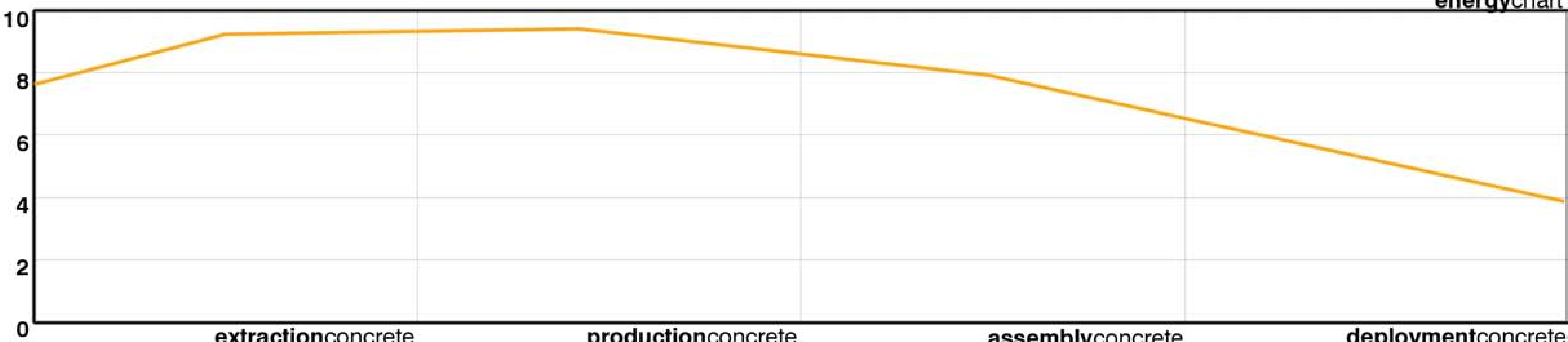


productionconcrete

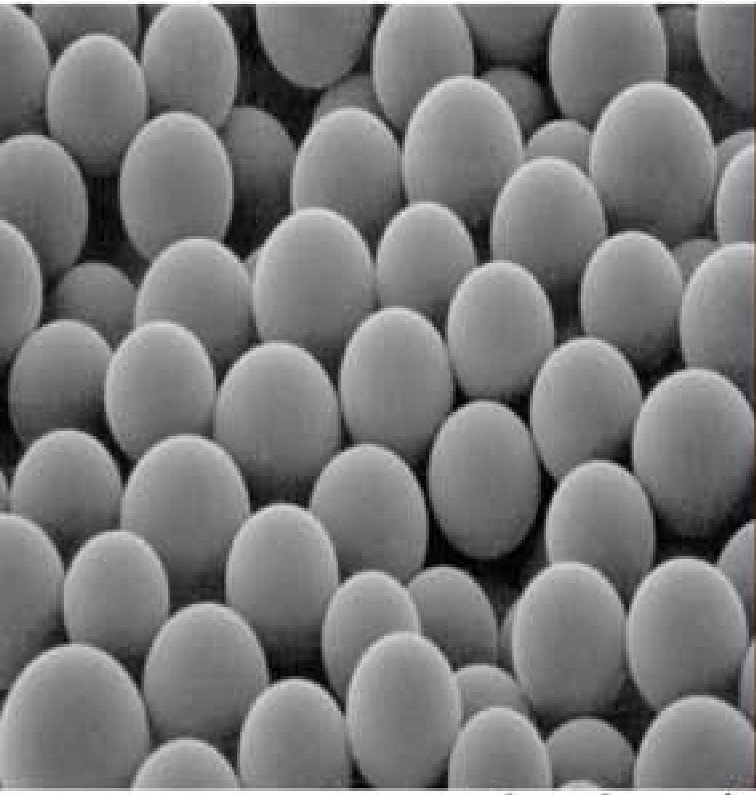
assemblyconcrete

deploymentzinc

energychart



substances + processes **mark**bearak + **ben**howell + **patrick**oconnor + **kyuseon**hong + **kirk**tracy + **jordan**trachtenberg



molecularresin

naturalresin

castresin

resin product

properties

Resin or Rosin (Oxford dictionary) is a hydrocarbon secretion of many plants, particularly coniferous trees, valued for its chemical constituents and uses such as varnishes, adhesives, as an important source of raw materials for organic synthesis, or for incense and perfume. Fossilized resins are the source of amber. The term is also used for synthetic substances of similar properties.

properties

The hard transparent resins, such as the copals, dammars, mastic and sandarac, are principally used for varnishes and cement, while the softer odoriferous oleo-resins (frankincense, elemi, turpentine, copaiba) and gum resins containing essential oils (ammoniacum, asafoetida, gamboge, myrrh, and scammony) are more largely used for therapeutic purposes and incense.

Resin in the form of rosin is used for the upkeep of bows for stringed instruments (i.e. violin, viola, cello, double bass), because of its quality for adding friction to the hair.

Resin has also been used as a medium for sculpture by artists such as Eva Hesse, and in other types of artwork.

Also, resin is used in some skateboard decks. It makes the skateboard more durable, making it less likely to get pressure cracks, chippings, or break in half.

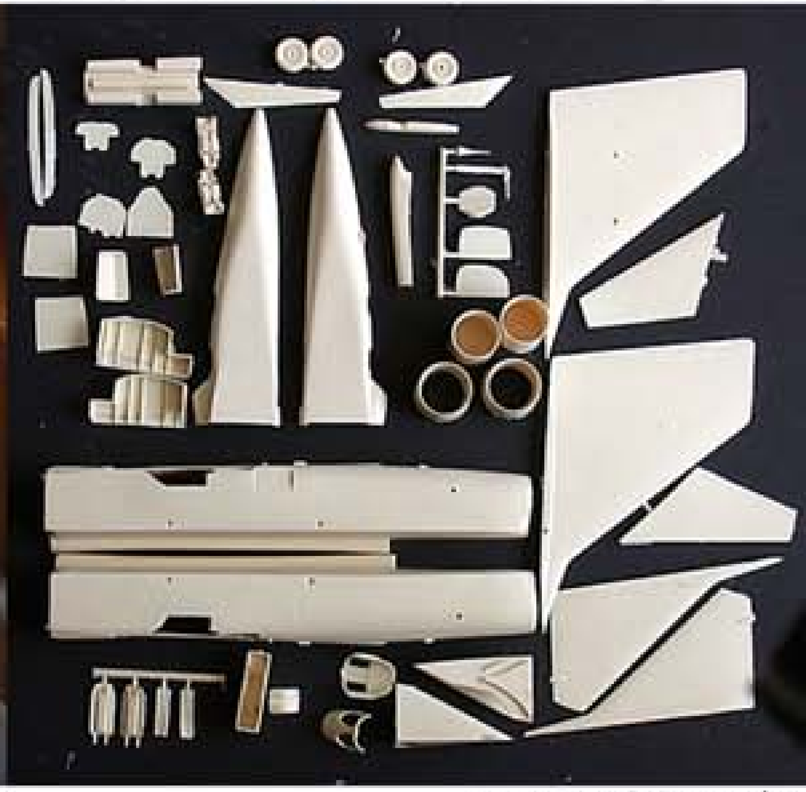
applicationresin

Permeable Resin Mortar System

extractionresin

productionresin

deploymentresin



assemblyresin