Design Museum Gent

S.M.A.K.

Thesaurus for plastics: techniques

This thesaurus contains terms for indexing museum objects and works of art made from plastics. This thesaurus focuses on plastic processes and techniques and is in addition to the plastic materials thesaurus. Within the project 'Know, Name and Assess your plastics', two thesauri were developed on plastics in heritage institutions: one on techniques and another on materials. Both thesauri can be used separately, but complement each other when combined. The first version was published in May 2022 and is available as a pdf and on the website of Design Museum Gent. The thesaurus is available in Dutch, English and will in time also be available in German.

The project 'Know, Name and Assess your plastics' ran from October 2018 to June 2021 and focused on the identification and preventive conservation of plastics in the collections of Design Museum Gent and S.M.A.K. This project was made possible by funding from the Flemish government.

RELEVANCE IN A MUSEUM CONTEXT

In recent years, more and more museums have been paying attention to the plastics in their collections. Besides identifying the materials present in a collection, it may be of interest to know more about the fabrication or production techniques of plastics. A solid thesaurus to correctly name and describe these techniques is still lacking in many museums. An efficient thesaurus is, however, fundamental to writing down findings in a correct and structured way in a collection registration system.

Artists and designers, conservators, museum staff, conservation scientists, chemists, historians and engineers working in the field of plastics all use their own – sometimes very different- professional language, despite the common research topic. In order to facilitate communication between these different groups, as well as to provide a single, clear list of terms for registrars, standardized language is essential. This thesaurus brings together different sources into one clear and hierarchical glossary that enables museum staff to name techniques that occur in the plastics in their collection.

PURPOSE OF THE THESAURUS

This thesaurus is aimed at museum staff working with collection registration systems such as The Museum System (TMS) or Adlib/Axiell Collections, who want to further optimize and professionalize the registration of their plastics. The use of a correct thesaurus in a database is the starting point for proper workflows within museums, especially when there are very many pieces manufactured from plastic in the collection. The implementation of a thesaurus increases searchability, allows the user to categorize and create a sound and useful inventory. By combining certain terms, one can get a better understanding of the collection and it makes it possible to combine subgroups. In addition, the information about the manufacturing of objects and works of art made of plastic can also be of interest to the public and external researchers. The terminology chosen

is aimed in particular at supporting the workings in a museum, professionalizing the field and achieving an uniform (international) language.

SOURCES OF THE THESAURUS

The Art and Architecture Thesaurus of The Getty Research Institute (abbreviated AAT) is often considered the international standard for terminology within the field of cultural heritage and is therefore used by many institutions. The AAT is a compiled resource made by many contributions and is growing annually. As a result, the terminology is not always uniform, complete, or consistent. For example, there are several terms that apply to the manufacture of plastics but are only classified under other material types. The focus is often put on the traditional types of materials, which often leaves plastics out, while many techniques can also be applied to this group of materials. Many techniques were missing, especially the newer techniques such as specific methods of 3-D printing. In order to fill the voids - both in terms of terminology and completeness of descriptions - this thesaurus was created.

The starting point for this thesaurus were the terms already present in the AAT. In order to create a well-founded thesaurus, several sources were used. The International Organization for Standardization (ISO), proved to be an important source not only for the materials thesaurus but also for the techniques thesaurus. The ISO focuses on the industry and has several standardized lists of plastic and rubber terminology that are compiled by (international) committees and revised every five years[1]. A further source for this thesaurus was the information on the websites of the Plastics Historical Society[2] and Museum of Design in Plastics (MoDiP)[3], in addition, several polymer and plastic manuals were consulted.[4]

SCOPE OF THE THESAURUS

The terminology in this thesaurus was chosen based on literature research in conservation books, polymer manuals, other thesauri such as the AAT and from existing standards for chemists and industry such as the ISO standards. The choice has been made to limit the thesaurus to the relevant terminology within the heritage field and the techniques that can be encountered in museum objects. Terms that are too specific are not included, but are often named in a scope note of a broader term. It was also decided not to include patented names of techniques, but only generic names. Furthermore, the thesaurus focuses on fabrication techniques, not on post-processing techniques, such as polishing or sawing. The thesaurus table indicates which terms are considered as fundamental. The other terms can be considered supplemental, as they are closer terms that are linked to the broader terms that occur in the fundamental list. It is up to each collection (registrar) to decide whether to work with the fundamental list, or to add all available terms to the database.

These decisions do not exclude the possibility that in the future other techniques may be investigated and given a place in the thesaurus. The constant changes in fabrication techniques, especially in the field of 3-D printing techniques, presents an additional challenge for such a thesaurus. In particular, museums with design collections will need to keep an eye on these developments. Keeping the thesaurus up to date and updating the terms will continue to be necessary in the coming years. 7Design Museum Gent has the ambition to carry out such updates. The latest version will always be available on the website with an explanation of the adjustments that have been made.

1 The ISO 472:2013(en) Plastics - Vocabulary and the ISO/ASTM 52900:2015(en) Additive manufacturing - General principles - Terminology were very valuable for this project.
2 http://plastiquarian.com/
3 https://www.modip.ac.uk/
4 Harper, Charles, Plastics Materials and Processes. A Concise Encyclopedia (New Jersey: John Wiley & Sons, Inc., 2003); I Gibson, et al, Additive Manufacturing Technologies. Rapid Prototyping to Direct Digital Manufacturing (Springer Science Business Media, 2010); Tim A. Osswald et al., International Plastics Handbook. The Resource for Plastics Engineers. (Munich: Carl Hanser Verlag, 2006).

USAGE OF THE THESAURUS

The terms are divided into preferred and alternative terms, which are linked to one concept and placed in a hierarchy, establishing relationships between broader and narrower terms. The hierarchical structure of the thesaurus not only helps in the search for a correct term, it also provides insight into the classification of techniques. This hierarchy is also available as a separate document in which the classification is visually represented. The two main sections for this thesaurus fall under the terms “3-D printing” and “forming (process). This classification is also consistent with the current hierarchy in the AAT. Therefore some scope notes, preference terms and guide terms were taken from the AAT.

Unlike the materials thesaurus, it may be less important to be very specific when registering techniques. It is also often difficult to tell from an object exactly what technique was used. If there is doubt whether it is indeed a particular technique, choose the broader term in the hierarchy. For example, when in doubt between “extrusion blow molding” and “injection blow molding”, choose the term “blow molding”[5], or when an object is clearly made in a mold, but it is not clear which technique, choose the broader term “molding (forming)”.

Each concept has a scope note in which more information about the technique can be found. The scope note briefly describes the technique and the materials to which it can be applied - to clarify, it is not about techniques that are exclusively applicable to plastics. It was decided not to add data on the development of techniques, because these can differ per country or continent.

As the terms and the corresponding scope notes are applicable to more materials than plastics alone, it was decided to also draw up a separate document with a specific explanation of the application of these techniques to plastics. In this document, the descriptions are more extensive than in the general thesaurus and specific examples of plastic applications are given. It is recommended to use the more ‘plastics-specific’ scope notes mainly as additional explanatory notes, but not to add them to the collection registration system, as conflicts will arise with technique thesauri on other materials (unless the collection in question consists exclusively of plastics). The specific technique thesaurus can be downloaded as pdf on the website of 𝒴Design Museum Gent.

The thesaurus contains several guide terms, these are general names for larger groups, which cannot be chosen as a term but act as guidance, it is necessary to choose one of the underlying terms. These guide terms are marked between < >.
The hierarchy of the thesaurus is also available as a separate document in which it is visually represented. The layout corresponds to the current hierarchy in the AAT, and several scope notes, preferred terms and guide terms have been taken from the AAT.

PARTNERS

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For more information on both projects, visit:
https://www.designmuseumgent.be/en/collection/project/plastics
https://www.th-koeln.de/en/terminology-for-conservation-of-plastics_73939.php

5 These are two similar techniques in which a hollow tube is blown up into a larger hollow form. The general name for this is 'blow molding'.

HIERARCHY

- <processes and techniques>
  - <processes and techniques by specific type>
    - <additive and joining processes and techniques>
      - 3-D printing
        - binder jetting
        - directed energy deposition
        - extrusion 3-D printing
        - material jetting
        - powder bed fusion
        - sheet lamination
        - vat photopolymerization
      - dip coating
    - forming (physical activity)
      - calendering
      - casting
        - film casting
        - slush casting
      - extrusion
        - extrusion coating
        - film extrusion
          - film blowing
      - filament winding
      - foaming (process)
        - structural foam molding
      - molding (forming)
        - bag molding
        - blow molding
          - extrusion blow molding
          - injection blow molding
        - compression molding
        - hand lay-up
        - injection molding
          - reaction injection molding
          - reinforced reaction injection molding
        - rotational molding
        - transfer molding
        - thermoforming
          - pressure thermoforming
          - twin-sheet thermoforming
          - vacuum thermoforming
        - pultrusion

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
<processes and techniques>		Note: <processes and techniques> is a hierarchical name within this thesaurus and that of the AAT, it cannot be used as a preferred or alternative term.	×
<processes and techniques by specific type>		Note: <processes and techniques by specific type> is a guide term within the hierarchy of the thesaurus and the AAT, it cannot be used as a preferred or alternative term.	×
<additive and joining processes and techniques>		Note: <additive and compounding processes and techniques > is a guide term within the hierarchy of the thesaurus and the AAT, it cannot be used as a preferred or alternative term.	×

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
3-D printing	3D printing 3D-printing three-dimensional printing 3DP additive manufacturing	Process of building three-dimensional parts or objects layer by layer, as opposed to formative or subtractive design techniques. Most of these additive design techniques are rapid-prototyping techniques in which a CAD (computer-aided design) is translated into a physical product. The materials and bonding methods differ for each 3-D printing technique. A powder, liquid, filament, pellets or sheets of plastic, metal, ceramic, wax, sand, paper, composite material, food or living cells can be used. 3-D printing is a rapidly changing technology and there are many different techniques that are patented or trademarked by companies under different names. Note: The general term 3-D printing is often used as a synonym for non-technical additive design techniques and is often associated with non-professional printers. Nevertheless, it was chosen as the preferred term because it is familiar to a wide audience. Use the term 3-D printing when in doubt between different 3-D printing techniques.	×
binder jetting		A 3-D printing process in which three-dimensional objects are made by dispersing a liquid binder over a powdered material. A layer of powder is spread on a platform and over certain areas a binder is spread using a print head. A second layer of powder is applied and the process is repeated until the final product is created. This technique can be used for metals, plastics and ceramics. Note: Use the general term 3-D printing when in doubt between different 3-D printing techniques.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
directed energy deposition	Beam Deposition (BD) metal deposition Laser Engineered Net Shaping (LENS) Directed Light Fabrication (DLF) Direct Metal Deposition (DMD) 3D Laser Cladding Laser Generation Laser-Based Metal Deposition (LBMD) Laser Freeform Fabrication (LFF) Laser Direct Casting LaserCast Laser Consolidation LasForm Laser-Based Metal Deposition (LBMD)	A general term for various 3-D printing techniques in which three-dimensional objects or additions to already existing parts are created by the fusion of material through a laser, electron beam or plasma beam. A powder or wire-like raw material is pushed through a nozzle and immediately melted in the process. A second layer is applied and the process is repeated until the final product is created. This technique can be applied to most plastics and ceramics, but is most commonly used on metals. Note: Directed energy deposition is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.	
extrusion 3-D printing	material extrusion (MEX) Fused Deposition Modeling (FDM) fused deposit modelling Fused Filament Fabrication (FFF) composite filament fabrication	A general term for various 3-D printing techniques in which three-dimensional objects are fabricated by building up material layer by layer in a given cross section. The material is applied to a platform via a nozzle under constant pressure and speed. The different layers are joined together by heating or a chemical. Most often this technique is applied to plastic filaments, but it is also possible with metal or wax. This 3-D printing technique is widespread and relatively inexpensive, and several simple DIY printers are available. Note: Extrusion 3-D printing is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
material jetting	Drop on demand (DOD) Multijet Modeling (MJM) Thermojet printing	A general term for various 3-D printing techniques in which three-dimensional objects are made by pouring material drop by drop onto a platform using a print head. When the material is cured, usually by the action of UV radiation, a second layer of droplets is added. The process is repeated until the final product is created. Support material is necessary in this technique and is removed after processing. This technique is applied to both plastics and waxes. Note: Material jetting is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.	
powder bed fusion	Selective Laser Sintering (SLS) Selective Laser Melting (SLM) Electron Beam Melting (EBM) Laser Sintering (LS) Laser Melting (LM) Selective Heat Sintering (SHS) Plaster-based 3D Printing (PP).	A general term for various 3-D printing techniques involving three-dimensional objects made by fusing several layers of powdered material through the action of a laser or electron beam. A layer of powder is spread over a surface and fused together, then a second layer of powder is applied, the process repeated until the final product is created. Unused powder is removed afterwards. This technique can be applied to most powdered materials but mainly metal and plastics are used. Note: Powder bed fusion is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
sheet lamination	Laminated Object Manufacturing (LOM) Selective Deposition Lamination (SDL) Selective Lamination Composite Object Manufacturing (SLCOM) Ultrasonic Additive Manufacturing (UAM) Plastic Sheet Lamination (PSL)	A general term for a 3-D printing technique in which parts are made by bonding layers of sheet material together. The sheet material is placed on a platform and bonded layer by layer using an adhesive, ultrasonic welding, thermal bonding or other techniques. The sheet material is trimmed before, during, or after joining using a laser or sharp knife. Laminates are usually combinations of different materials and it can be applied to paper, cardboard, plastic or metal. Fiber-reinforced composites can also be made in this way where carbon, aramid or glass fiber fabrics are bonded with a thermoplastic. Note: Sheet lamination is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.	
vat photopolymerization	Stereolithography (SLA or SL) Continuous Liquid Interface Production (CLIP) Daylight Polymer Printing (DPP) Digital Light Processing (DLP) Solid Free-form Fabrication (SFF).	A general term for various 3-D printing techniques in which three-dimensional objects are made by selectively curing a liquid photopolymer in a vat through the action of light-activated polymerization. The vat containing the liquid resin is placed on a platform that is gradually lowered where layer by layer, the material is cured using a laser or projector. Ultraviolet light and electron beams are most commonly used. At the end, the object can be removed from the drained vessel and supports removed. Note: Vat polymerization is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
dip coating	dip molding dip casting	An additive process in which hollow objects are created by (repeated) immersion of a mold in a liquid or paste. The end product can be either the coating removed from the mold or the mold itself with the added mass. Dip coating is mainly applied to waxes, metals, rubbers and thermoplastics.	
forming (physical activity)	formed (physical activity) forming processes shaping (physical activity)	Shaping, molding, or fashioning into a certain state or condition. Note: Forming is a general term for many techniques. Use the general term forming when in doubt between the narrower terms. The term and scope note is taken from the AAT.	×
calendering	calendered	Process in which material is passed under pressure and usually heat between a series of rolling mills in order to make the material thinner or smoother, or to apply a coating. The final roller determines the final appearance of the surface, which may be matt, glossy or embossed. Calendering can be applied to paper, fabric, rubbers and thermoplastics.	×
casting	casting (process) cast (process)	Process in which liquid material is poured into a mold without the application of external force or pressure, as opposed to processes in which material is pressed into a mold, for which the term molding (forming) applies. Casting can be applied to many different materials including metal, plaster and plastics.	×

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
film casting	film cast	Process in which films are made by pouring a liquid polymer, polymer dispersion, or solution onto a flat surface and allowing it to cure. This technique is typically applied to thermoplastic materials and is often used to produce photographic films or regenerated cellulose films.	
slush casting	slush molding slush-casting slush cast	Process of casting hollow objects in which a liquid material is poured into a two-part mold and immediately inverted, allowing the excess material to drain away, leaving only a thin layer of material on the inside wall of the mold. The material can be removed from the mold once it has hardened. This technique is mostly used on metals, thermoplastics and rubbers.	
extrusion	extruded extruding extrusion process Related term: extrusion blow molding	Process in which products with a fixed cross-section such as pipes, tubes, films or sheets are made. A rotating screw pushes a heated or unheated mass through a mold to make one continuous shape. Extrusion is applied to metals, rubbers, thermoplastics, ceramics, clay, and in some cases concrete.	×
extrusion coating	extrusion coated extruded coating	Coatings process in which a thermoplastic is continuously extruded over a moving substrate and pressed into it by cooled metal rollers. This technique can be applied to paper, metal foils or fabrics.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
film extrusion	film extruded	Process in which film is made by extruding a thermoplastic. There are several variations on film extrusion, depending on the next step in the process. In chill roll extrusion and cast film extrusion, the plastic is extruded over metal rollers; in film blowing, an extruded tube is blown into a thin film. Note: Chill roll extrusion and cast film extrusion are placed under the term film extrusion. For film blowing, there is a specific term.	
film blowing		Process of making films, in which a thermoplastic is extruded through a circular mold to create a narrow tube. This tube is then inflated under high air or gas pressure to expand into a film that is wrapped around a roll. This technique is mainly used to produce plastic bags.	×
filament winding		Process of creating reinforced plastic composites in which a wire or loose fibers are coated with a resin and wound around a rotating spindle or are placed in a certain pattern in a mold. After the resin has cured, the product can be removed from the mold.	
foaming (process)	foam molding foamed	General term for various processes in which cellular plastics, also called foams, are formed. A foaming agent is added, often under high temperature, to a liquid plastic. The foaming agent can be a physical additive such as a gas or air. A chemical foaming agent can also be used whereby a gas is created after a reaction with the components present in the material itself.	×

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
structural foam molding	Related term: injection molding	Process of creating products with a cellular (foamed) core and a non-cellular skin. A liquid plastic is injected into a cold mold using an injection molding technique. A foaming agent causes the core of the mass to become a foam and the cold mold creates a skin on the outside.	
molding (forming)	molded moulding (forming) moulded	Process of shaping materials in a mold under the application of pressure and often heat, as distinguished from casting where the material is poured into a mold without the application of external pressure or force. Molding (forming) can be applied to many different materials including metal, glass and plastic. Note: Molding (forming) is a general term for many techniques. Use the general term molding (forming) when in doubt between the more narrow terms. The term molding (forming) was taken from the AAT.	×
bag molding	vacuum bag molding	Process in which a flexible or liquid material is placed in or over a rigid mold and pressed together under pressure or vacuum with a flexible film, membrane or cloth. Reinforced plastic composites and plywood can be manufactured using this technique. Products with sharp corners are difficult to achieve with this technique. Bag molding is the general term for various techniques in which forms are manufactured by pressure or a vacuum in a bag.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
blow molding	mold-blowing blow moulding mould-blowing blow-molded	Process to manufacture hollow objects, primarily from thermoplastics. A plastic tube (also called preform) is inflated in a two-part metal mold using hot air or gas at high pressure to create a hollow form. After the mold cools, the product is ejected and finished. This technique is widely used for high-volume productions. Note: Blow molding is the general term for various forming techniques. Choose this term when in doubt between extrusion blow molding and injection blow molding.	×
extrusion blow molding	extrusion blow moulding	Process to manufacture hollow objects, primarily from thermoplastics. A granulate or powder is melted in the heated cylinder of an extruder and pushed through a mold to form one continuous hollow tube. This tube is then placed in a two-part metal mold into which hot air is blown at high pressure via a pin. In this way, a hollow object is created with a (narrow) opening. After the mold has cooled, the object is ejected and can be further finished. Extrusion blow molding is the most widely used blow molding technique to produce relatively large objects in high quantities. Note: When in doubt between extrusion blow molding and injection blow molding, choose the broader term blow molding.	×

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
injection blow molding	injection blow moulding Related term: injection molding	Process to manufacture hollow objects with a narrower opening, mainly from thermoplastics. A granulate or powder is melted in the heated cylinder of an injection molding machine and pushed through a narrow channel at high speed and pressure into a mold. This preform, a hollow shape sealed at one end (like a test tube), is then placed in a two-part metal mold, through a pin hot air is injected into the mold at high pressure. Injection blow molding is applicable for the production of small, precise and complex shapes with uniform wall thickness. Note: When in doubt between extrusion blow molding and injection blow molding, choose the broader term blow molding.	×
compression molding	compression moulding	Process in which a plastic granulate or powder is inserted into the cavity of an opened two-part mold. The mold is then closed and put under pressure and often heated. It is not possible with this technique to create complex shapes with tiered constructions or edges, however, simple shapes can be created. This technique is mainly used on thermosets and in some cases on thermoplastic composites. Note: The term compression molding is a general term for different forming techniques.	×

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
hand lay-up	hand lay up contact lay-up contact lay up	Process of manually creating a reinforced plastic composite in a male or female mold. A release agent, such as a wax layer, is applied in the mold, followed by a gel coating, which provides the final product with a colored smooth outer layer. A reinforcing material, usually a fiberglass mat, is placed in the mold after which a thermoset is sprayed or applied with a brush. To ensure adhesion between the different layers and to remove any air bubbles present, a roller is used.	×
injection molding	injection moulding injection molding of plastics Related term: injection blow molding	Process in which a granular or powdered thermoplastic is melted in a heated cylinder and injected into a mold through a narrow channel (sprue pin) at high pressure and speed. Once the material has hardened in the cold mold, it can be released using ejector pins. Injection molding of thermosets, where a cold resin is injected into a heated mold, is less common. Injection molding allows mass production of highly detailed, three-dimensional parts, from small to large sizes. Note: Injection molding is the general term for various forming techniques. Choose this term when in doubt between the narrower terms.	×
reaction injection molding	reaction injection moulding reactive injection molding RIM	Injection molding process in which rapidly curing, low-viscosity thermosetting resins are pressed into a mixing chamber and then injected into a closed mold, where polymerization occurs. Note: When in doubt between reaction injection molding and reinforced reaction injection molding, choose the broader term injection molding.	×

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
reinforced reaction injection molding	structural reaction injection moulding RRIM SRIM resin- transfer molding	Injection molding process to make reinforced plastic composites. It is a variant of reaction injection molding. Fast-curing, low-viscosity thermosetting resins are pressed into a mixing chamber and then injected into a closed mold where polymerization takes place. Before the resin is pushed into the mold, the reinforcement material (glass, polyester, carbon or aramid fiber) is placed into the mold. Note: When in doubt between reaction injection molding and reinforced reaction injection molding, choose the broader term injection molding.	
rotational molding	rotational moulding rotoforming rotomolding rotational casting rotation sintering centrifugal moulding	Process of making (cylindrical) hollow objects by rotating the mold on one or more axes during the curing of the material. Inside the mold is a granulate, powdered or liquid material, which is pressed against the sides by rotating the mold. This technique can be used to manufacture larger objects with uniform wall thickness, closed hollow parts and complicated shapes. This technique can be applied to plastics as well as metals.	×
transfer molding	transfer moulding plunger molding Related term: compression molding	Process in which thermosetting materials are preheated in a reservoir and then pushed into a closed mold. The heated mold causes the material to harden.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
thermoforming	thermoforming moulding sheet molding air-assist forming	Process in which thin sheets of thermoplastics are heated until they become flexible after which they are pressed against a mold using a vacuum, air or mechanical pressure. The object is cooled and can then be removed from the mold, after which excess material can be cut away. Note: When in doubt between different thermoforming methods such as pressure thermoforming, twin-sheet thermoforming and vacuum thermoforming use the general term thermoforming.	×
pressure thermoforming	pressure forming	Process in which thin sheets of thermoplastics are heated until they become flexible after which they are pressed against a mold under high air pressure. The object is cooled and can then be removed from the mold, after which excess material can be cut away. Note: When in doubt between pressure thermoforming and thermovacuum forming, use the general term thermoforming.	
twin-sheet thermoforming	twin sheet thermoforming	Process for making hollow objects. Two heated thermoplastic thin sheets are placed in a two-part mold. Air is blown between the sheets at high pressure, combined with a vacuum on the outside, thus pushing the sheets into all the cavities of the mold. Due to the heat, both sheets melt together at the edges. This technique is generally used to make large, double-walled parts with flat panels.	

PREFERENCE TERM	ALTERNATIVE TERM	SCOPE NOTE	FUNDAMENTAL
vacuum thermoforming	vacuum forming	Process in which thin sheets of thermoplastics are heated until they become flexible after which they are pressed against a mold under a vacuum. The object is cooled and can then be removed from the mold, after which excess material can be cut away. Note: When in doubt between pressure thermoforming and vacuum thermoforming, use the general term thermoforming.	
pultrusion		Process in which continuous reinforced plastic product is created with a fixed cross section. Bundled fibers are pulled through a layer of viscous resin and then pulled through a heated mold where the resin cures.	×

ADDITIONAL GUIDE

3-D printing

Process of building three-dimensional parts or objects layer by layer, as opposed to formative or subtractive design techniques. Most of these additive design techniques are rapid-prototyping techniques in which a CAD (computer-aided design) is translated into a physical product. The materials and bonding methods differ for each 3-D printing technique. According to the ISO/ASTM standards, seven main categories in 3-D printing techniques, or additive manufacturing techniques, can be distinguished: binder jetting, direct energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat polymerization. A powder, liquid, filament, pellets or sheets of plastic, metal, ceramic, wax, sand, paper, composite material, food or living cells can be used. Polyamide, acrylonitrile-butadiene-styrene and poly(lactic acid) are most commonly used. 3-D printing is a rapidly changing technology and there are many different techniques that are patented or trademarked by companies under different names.

Note: The general term 3-D printing is often used as a synonym for non-technical additive design techniques and is often associated with non-professional printers. Nevertheless, it was chosen as the preferred term because it is familiar to a wide audience. Use the term 3-D printing when in doubt between different 3-D printing techniques.

binder jetting

A 3-D printing process in which three-dimensional objects are made by dispersing a liquid binder over a powdered material. A layer of powder is spread on a platform and over certain areas a binder is spread using a print head. A second layer of powder is applied and the process is repeated until the final product is created. This technique can be used for metals, plastics and ceramics. Regarding plastics, this technique is mainly used for acrylonitrile-butadiene-styrene, polyamide and polycarbonate.

Note: Use the general term 3-D printing when in doubt between different 3-D printing techniques.

directed energy deposition

A general term for various 3-D printing techniques in which three-dimensional objects or additions to already existing parts are created by the fusion of material through a laser, electron beam or plasma beam. A powder or wire-like raw material is pushed through a nozzle and immediately melted in the process. A second layer is applied and the process is repeated until the final product is created. This technique can be applied to most plastics and ceramics, but is most commonly used on metals.

Note: Directed energy deposition is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.

extrusion 3-D printing

A general term for various 3-D printing techniques in which three-dimensional objects are fabricated by building up material layer by layer in a given cross section. The material is applied to a platform via a nozzle under constant pressure and speed. The different layers are joined together by heating or a chemical. Most often this technique is applied to plastic filaments, but it is also possible with metal or wax. acrylonitrile-butadiene-styrene, polyamide, poly(lactic acid), polycarbonate and polycarbonate blends are mainly used. This 3-D printing technique is widespread and relatively inexpensive, and several simple DIY printers are available.

Note: Extrusion 3-D printing is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.

material jetting

A general term for various 3-D printing techniques in which three-dimensional objects are made by pouring material drop by drop onto a platform using a print head. When the material is cured, usually by the action of UV radiation, a second layer of droplets is added. The process is repeated until the final product is created. Support material is necessary in this technique and is removed after processing. It is applied to both plastics and waxes. This technique can be applied to polypropylene, polyethylene, polystyrene, poly(methyl methacrylate), polycarbonate and poly(lactic acid).

Note: Material jetting is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.

powder bed fusion

A general term for various 3--D printing techniques involving three-dimensional objects made by fusing several layers of powdered material through the action of a laser or electron beam. A layer of powder is spread over a surface and fused together, then a second layer of powder is applied, the process repeated until the final product is created. Unused powder is removed afterwards. This technique can be applied to most powdered materials but metal and plastics are most used. This technique is mainly applied to polyamide.

Note: Powder bed fusion is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.

sheet lamination

A general term for a 3-D printing technique in which parts are made by bonding layers of sheet material together. The sheet material is placed on a platform and bonded layer by layer using an adhesive, ultrasonic welding, thermal bonding or other techniques. The sheet material is trimmed before, during, or after joining using a laser or sharp knife. Laminates are usually combinations of different materials and it can be applied to paper, cardboard, plastic or metal. Fiber-reinforced composites can also be made in this way where carbon, aramid or glass fiber fabrics are bonded with a thermoplastic. Polyamide, polyetheretherketone and polyethylene are commonly used for these techniques

Note: Sheet lamination is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.

vat photopolymerization

A general term for various 3-D printing techniques in which three-dimensional objects are made by selectively curing a liquid photopolymer in a vat through the action of light-activated polymerization. The vat containing the liquid resin is placed on a platform that is gradually lowered where layer by layer, the material is cured using a laser or projector. Ultraviolet light and electron beams are most commonly used. At the end, the object can be removed from the drained vessel and supports removed. This technique is mainly applied to polyacrylates, epoxies and polyethers.

Note: Vat polymerization is a general term for many techniques, a selection of which are included as alternative terms. Use the general term 3-D printing when in doubt between different 3-D printing techniques.

dip coating

An additive process in which hollow objects are created by (repeated) immersion of a mold in a liquid or a paste. The end product can be either the coating removed from the mold or the mold itself with the added mass. Dip coating is mainly applied to waxes, metals, rubbers and thermoplastics.

forming (physical activity)

Shaping, molding, or fashioning into a certain state or condition.
Note: Forming is a general term for many techniques. Use the general term forming when in doubt between the narrower terms. The term and scope note is taken from the AAT.

calendering

Process in which material is passed under pressure and usually heat between a series of rolling mills in order to make the material thinner or smoother, or to apply a coating. The final roller determines the final appearance of the surface, which may be matte, glossy or embossed. Calendering can be applied to paper, fabric, rubbers and thermoplastics. Calendaring can be used to add a plastic film or coating to textile or paper carrier by adding it to the last two rollers.

casting

Process in which a liquid material is poured into a mold without the application of external force or pressure, as opposed to processes in which material is pressed into a mold, for which the term molding (forming) applies. Thermosetting plastics commonly used for molding are epoxy, unsaturated polyester, polyurethane, and phenol-formaldehyde. These cure chemically at room temperature or in an oven. Molded thermoplastics, such as poly(methyl methacrylate), polyamide and cellulose acetate harden after the mold is cooled. Molded objects can sometimes be recognized by trapped air bubbles. Three-dimensional objects as well as sheet materials and films can be cast.

film casting

Process in which films are made by pouring a liquid polymer, polymer dispersion or solution onto a flat surface and allowing it to cure. This technique is typically applied to thermoplastic materials and is often used to produce photographic films.

slush casting

Process of casting hollow objects in which a liquid material is poured into a two-part mold and immediately inverted, allowing the excess material to drain away, leaving only a thin layer of material on the inside wall of the mold. The material can be removed from the mold once it has hardened. This technique is mostly used on metals, thermoplastics and rubbers. Slush casting is used to create open, hollow objects such as doll heads or rain boots. Poly(vinyl chloride) or rubbers are commonly used in this technique.

extrusion

Process in which products with a fixed cross-section such as pipes, tubes, films or sheets are made. A rotating screw pushes a heated or unheated mass through a mold to make one continuous shape. This technique is also used to provide electrical wiring with an insulation layer. This technique is mainly applied to rubber or thermoplastics, such as polyethylene, polypropylene and poly(ethylene terephthalate).

extrusion coating

Coatings process in which a thermoplastic is continuously extruded over a moving substrate and pressed into it by cooled metal rollers. This technique can be applied to paper, metal foils or fabrics.

film extrusion

Process in which film is made by extruding a thermoplastic. There are several variations on film extrusion, depending on the next step in the process. In chill roll extrusion and cast film extrusion, the plastic is extruded over metal rollers; in film blowing, an extruded tube is blown into a thin film.

Note: Chill roll extrusion and cast film extrusion are placed under the term film extrusion. For film blowing, there is a specific term.

film blowing

Process of making films, in which a thermoplastic is extruded through a circular mold to create a narrow tube. This tube is then inflated under high air or gas pressure to expand into a film that is wrapped around a roll. This technique is mainly used to produce plastic bags. Plastics that are primarily used are polyethylene and polypropylene.

filament winding

Process of creating reinforced plastic composites in which a wire or loose fibers are coated with a resin and wound around a rotating spindle or are placed in a certain pattern in a mold. After the resin has cured, the product can be removed from the mold. This process can be applied to both thermoplastics and thermosets.

foaming (process)

General term for various processes in which cellular plastics, also called foams, are formed. A foaming agent is added, often under high temperature, to a liquid plastic. The foaming agent can be a physical additive such as a gas or air. This technique is mainly applied to natural rubber and urea-formaldehyde. A chemical foaming agent can also be used whereby a gas is created after a reaction with the components present in the material itself. This technique is mostly applied to polyethylene, polypropylene and polyurethane.

structural foam molding

Process of creating products with a cellular (foamed) core and a non-cellular skin. A liquid plastic is injected into a cold mold using an injection molding technique. A foaming agent causes the core of the mass to become a foam and the cold mold creates a skin on the outside. Products made with this technique may have a swirled surface pattern. Polyurethane is widely used for this technique.

molding (forming)

Process of shaping materials in a mold under the application of pressure and often heat, as distinguished from casting where the material is poured into a mold without the application of external pressure or force. Molding (forming) applies to various methods of forming thermoplastics, thermosets or rubbers.

Note: Molding (forming) is a general term for many techniques. Use the general term molding (forming) when in doubt between the more narrow terms. The term molding (forming) was taken from the AAT.

bag molding

Process in which a flexible or liquid material is placed in or over a rigid mold and pressed together under pressure or vacuum with a flexible film, membrane or cloth. Reinforced plastic composites and plywood can be manufactured using this technique. Products with sharp corners are difficult to achieve with this technique. Usually the finished product has one smooth side and on the other side the folds of the bag are visible. Thermosets are generally used in this technique.

Note: Bag forming is the general term for various techniques in which forms are manufactured by pressure or a vacuum in a bag.

blow molding

Process to manufacture hollow objects, primarily from thermoplastics. A plastic tube (also called preform) is inflated in a two-part metal mold using hot air or gas at high pressure to create a hollow form. After the mold cools, the product is ejected and finished. This technique is widely used for high-volume productions. Sometimes objects can be recognized by a mold line.

Note: Blow molding is the general term for various forming techniques. Choose this term when in doubt between extrusion blow molding and injection blow molding.

extrusion blow molding

Process to manufacture hollow objects, primarily from thermoplastics. A granulate or powder is melted in the heated cylinder of an extruder and pushed through a mold to form one continuous hollow tube. This tube is then placed in a two-part metal mold into which hot air is blown at high pressure via a pin. In this way, a hollow object is created with a (narrow) opening. After the mold has cooled, the object is ejected and can be further finished. Extrusion blow molding is the most widely used blow molding technique to produce relatively large objects in high quantities. Products produced with extrusion blow molds can often be recognized by a marking that occurs when one side of the tube is squeezed shut, as sometimes seen on the bottom of bottles.

Note: When in doubt between extrusion blow molding and injection blow molding, choose the broader term blow molding.

injection blow molding

Process to manufacture hollow objects with a narrower opening, mainly from thermoplastics. A granulate or powder is melted in the heated cylinder of an injection molding machine and pushed through a narrow channel at high speed and pressure into a mold. This preform, a hollow shape sealed at one end (like a test tube), is then placed in a two-part metal mold, through a pin hot air is injected into the mold at high pressure. In this way, a hollow mold with a narrow opening is created. After the mold is ejected from the mold, it does not need to be touched up, so no pinch or cut marks can be found, as is the case with extrusion blow molds. Injection blow molding is applicable for the production of small, precise and complex shapes with uniform wall thickness.

Note: When in doubt between extrusion blow molding and injection blow molding, choose the broader term blow molding.

compression molding

Process in which a plastic granulate or powder is inserted into the cavity of an opened two-part mold. The mold is then closed and put under pressure and often heated. It is not possible with this technique to create complex shapes with tiered constructions or edges, however, simple shapes can be created. This technique is mainly used on thermosets and in some cases on thermoplastic composites.

Note: The term compression molding is a general term for different forming techniques.

hand lay-up

Process of manually creating a reinforced plastic composite in a male or female mold. A release agent, such as a wax layer, is applied in the mold, followed by a gel coating, which provides the final product with a colored smooth outer layer. A reinforcing material, usually a fiberglass mat, is placed in the mold after which a thermoset is sprayed or applied with a brush. To ensure adhesion between the different layers and to remove any air bubbles present, a roller is used. Hand lamination is a relatively easy and inexpensive technique often used by artists to create sculptures, mainly from fiberglass reinforced unsaturated polyester.

injection molding

Process in which a granular or powdered thermoplastic is melted in a heated cylinder and injected into a mold through a narrow channel (sprue pin) at high pressure and speed. Once the material has hardened in the cold mold, it can be released using ejector pins. Injection molding of thermosets, where a cold resin is injected into a heated mold, is less common. Injection molding allows mass production of highly detailed, three-dimensional parts, from small to large sizes. Characteristic features of products manufactured using this technique is the sprue (this is where the mass of the sprue pin is pinched off), round markings (created by the ejector pins) and mold lines that in some cases remain visible.

Note: Injection molding is the general term for various forming techniques. Choose this term when in doubt between the narrower terms.

reaction injection molding

Injection molding process in which rapidly curing, low-viscosity thermosetting resins are pressed into a mixing chamber and then injected into a closed mold, where polymerization occurs. Rigid polyurethane foam is manufactured using this technique.

Note: When in doubt between reaction injection molding and reinforced reaction injection molding, choose the broader term injection molding.

reinforced reaction injection molding

Injection molding process to make reinforced plastic composites. It is a variant of reaction injection molding. Fast-curing, low-viscosity thermosetting resins are pressed into a mixing chamber and then injected into a closed mold where polymerization takes place. Before the resin is pushed into the mold, the reinforcement material (glass, polyester, carbon or aramid fiber) is placed into the mold. Unsaturated polyester, epoxy and polyurethane can be used for this process.

Note: When in doubt between reaction injection molding and reinforced reaction injection molding, choose the broader term injection molding.

rotational molding

Process of making (cylindrical) hollow objects by rotating the mold on one or more axes during the curing of the material. Inside the mold is a granulate, powdered or liquid material, which is pressed against the sides by rotating the mold. This technique can be used to manufacture larger objects with uniform wall thickness, closed hollow parts and complicated shapes. Mold lines may be visible if necessary, but can also be polished away. Polyethylene is the most commonly used material in this technique.

Note: There are several terms for this technique, depending on the axis as well as the speed at which the mold is rotated: "centrifugal" for cylindrical objects rotated around one axis at a high speed, "rotational" for hollow objects rotated around several axes at a rather low speed. Centrifugal and rotational casting use a liquid plastic, while centrifugal and rotational molding use a powder or granulate. These techniques are both placed under the umbrella term rotational molding.

transfer molding

Process in which thermosetting materials are preheated in a reservoir and then pushed into a closed mold. The heated mold causes the material to harden. This technique is similar to compression molding, but allows for the creation of more complex parts or the use of metal or ceramic inserts. Another difference is the absence of mold lines since the mold is closed when the material is inserted into the cavity.

thermoforming

Process in which thin sheets of thermoplastics are heated until they become flexible after which they are pressed against a mold using a vacuum, air or mechanical pressure. The object is cooled and can then be removed from the mold, after which excess material can be cut away. Products made by thermoforming have shallow shapes such as bowls, bathtubs or yogurt pots. Nevertheless, rods or tubes can also be manufactured in this way. Often the technique is applied to acrylonitrile-butadiene-styrene, polystyrene and polycarbonate.

Note: When in doubt between different thermoforming methods such as pressure thermoforming, twin-sheet thermoforming and vacuum thermoforming use the general term thermoforming.

pressure thermoforming

Process in which thin sheets of thermoplastics are heated until they become flexible after which they are pressed against a mold under high air pressure. The object is cooled and can then be removed from the mold, after which excess material can be cut away.

Note: When in doubt between pressure thermoforming and vacuum thermoforming, use the general term thermoforming.

twin-sheet thermoforming

Process for making hollow objects. Two heated thermoplastic thin sheets are placed in a two-part mold. Air is blown between the sheets at high pressure, combined with a vacuum on the outside, thus pushing the sheets into all the cavities of the mold. Due to the heat, both sheets melt together at the edges. This technique is generally used to make large, double-walled parts with flat panels. All thermoplastic sheet materials can be used, but mainly acrylonitrile-butadiene-styrene is used, given its lower melting point.

vacuum thermoforming

Process in which thin sheets of thermoplastics are heated until they become flexible after which they are pressed against a mold under a vacuum. The object is cooled and can then be removed from the mold, after which excess material can be cut away.

Note: When in doubt between pressure thermoforming and vacuum thermoforming, use the general term thermoforming.

pultrusion

Process in which continuous reinforced plastic product is created with a fixed cross section. Bundled fibers are pulled through a layer of viscous resin and then pulled through a heated mold where the resin cures. Epoxies, unsaturated polyesters and silicones are commonly used in this technique.