Ceramic Techniques

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When designing ceramic objects, it is necessary to consider what technique should be used to realize the object and shape in question. Various best-known techniques include e.g. hand-building, such as coiling and slab building, and techniques suitable for small-scale production, such as throwing, casting and molding, and 3D printing. Techniques can also be combined with each other, and many makers develop techniques of their own that differ from the above-mentioned, most commonly used techniques. Researching techniques can also be a starting point for doing so, and experiments can lead to new, surprising results.

Once the technique used in the making has been selected, the clay body best suited to it is considered. For example, it is good to have a chamotte or grog in hand-built clay, which stiffens and reduces the drying shrinkage of the object. The wheel throwing clay must be plastic and sturdy, but it must be kept in mind that too rough a chamotte can break the skin of the hands when throwing.

At the design stage, it must be remembered to anticipate firing shrinkage, as clay shrinks during firing depending on the clay quality; the firing shrinkage of porcelain is about 14-16% and that of stoneware about 13%.

Drying is an integral part of the making process. There is a risk of cracking if the work dries too quickly or unevenly. Therefore, it is a good idea to cover the work with plastic, newspaper or cloth in the early stages of drying, because when lightly covered, they dry more evenly. The thicker the object, the longer it takes to dry. Depending on the humidity, a large hand-built sculpture may need to be dried for up to several weeks. After bisque firing, the objects can be glazed, after which they are glaze fired according to the quality of clay used. After glazing, the objects can still be decorated with, for example, decals or painted with china paints. The decals and china paint colors must finally be fired onto the object, the temperature of the decorative firing depends on the decoration used.

The above techniques and, based on them, advanced, personal working methods are discussed in video interviews and demonstrations of artists and researchers working in the field. In addition to various techniques, the videos reveal the working philosophy of the authors more broadly. All videos can be found on the Aalto Open Learning website: Link

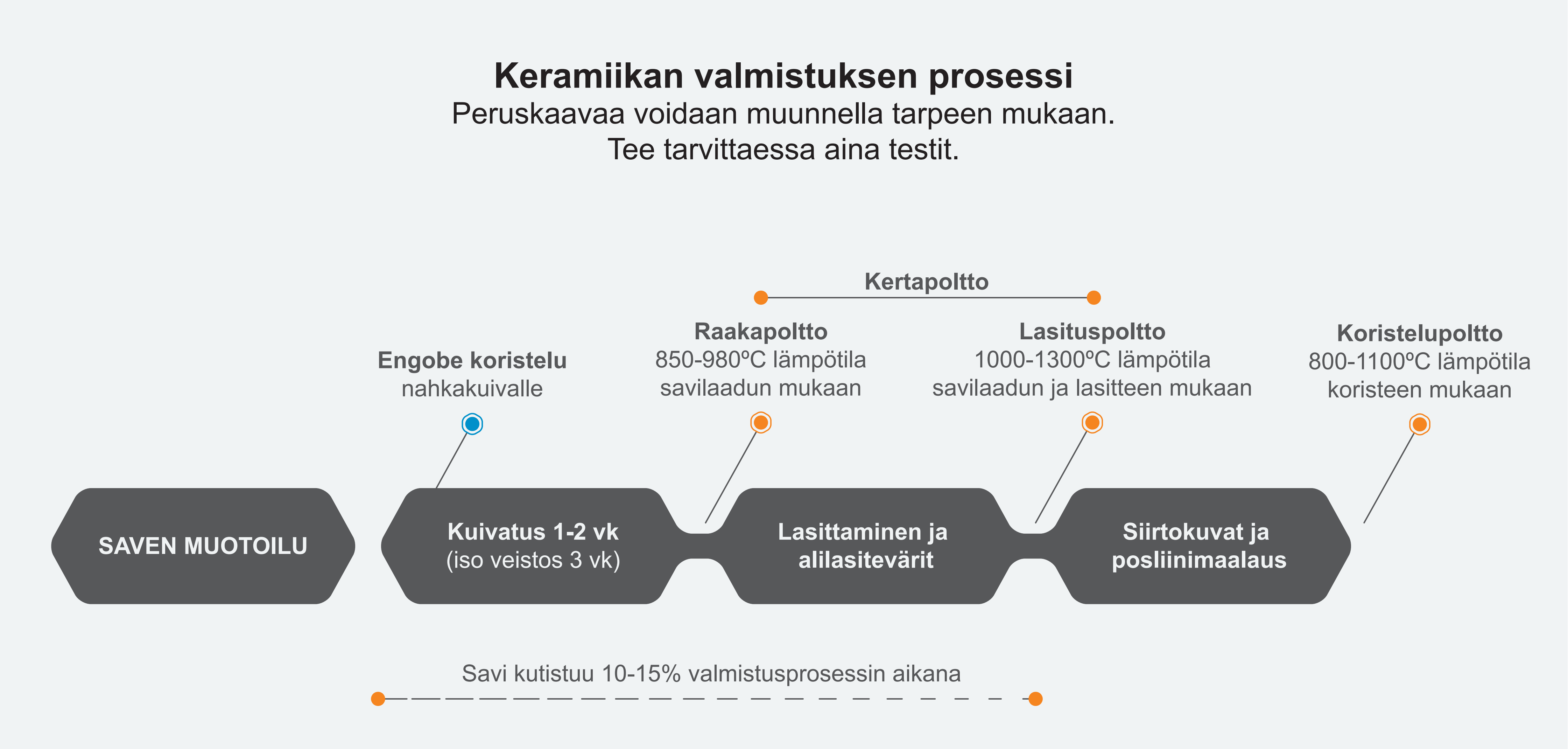

Figure 1. Ceramic making process

1. Hand-building

Hand-building is a method of making ceramics in which objects are made using fingers, hands, and simple tools. The most common hand-building techniques are the coiling technique and slab technique. Clay can also be machined without tools, for example with a pinching technique, in which an object is shaped from a clay ball by pinching with the thumb and forefinger. Different hand-building techniques can also be mixed together and combined in the same work.

In hand-building, it is good to use plastic and sturdy clay, which contains 0.5–2.0 mm chamotte 25–50%. The chamotte also facilitates large jobs, especially during construction, by solidifying and reducing the drying shrinkage of the object. Paper clay is also well suited for hand building, as the fibers brought in by paper make the clay durable in the unfired stage and can be used to build very thin and bulky walls.

Before hand-building and throwing, the clay must be carefully wedged. Wedging improves the workability of the clay and, for example, long-standing clay becomes softer when wedging. Wedging also removes any air bubbles from the clay, which complicates the work, easily splits the object during the drying phase and forms bubbles on the surface of the object during

Figure 2. Clay wedging

1.1 Coiling technique

The coiling technique is a very versatile hand-building method that is particularly well suited for large-scale sculptures and asymmetrical shapes. Elongated coils are formed from plastic clay by rolling the clay with light movements against the table with the help of palms. The clay coils are placed on top of each other as a wall and joined together. The surfaces to be joined must first be roughened, for example by scraping with a fork, after which a clay slurry or slip made of the same clay, which acts as an adhesive, can be applied to their surface.

Figure 3. Still-image from video, Kristina Riska

Figure 4. Still-image from video, Johanna Rytkölä

1.2 Slab-building technique

Like coiling technique, slab technique is a versatile hand-building method that is suitable, for example, for making tiles and sculptures. The slabs can be made by using a rolling pin or a clay slab-roller. They are cut to the desired size and shape and joined together, like with the coiling technique. With slab technique, it is possible to create large and uniform surfaces relatively quickly.

Figure 5. Still-image from video, Kirsi Kivivirta

All the videos can be found in Aalto Open Learning: https://openlearning.aalto.fi/course/view.php?id=110

2. Small series

Small-scale production is serial production, but its production volumes are considerably smaller compared to industrial serial production. The advantage of small-scale production is freer formulation and a more versatile applicability of different clay bodies as well as glazes and surface techniques, as production is often handcrafted. In small series production, especially arts and crafts, the product designer often also acts as the manufacturer. The most typical techniques used in small series production are wheel throwing, press-molding, jiggering and casting.

Figure 6. JØRÐ Material research, SaijaHalko

2.1 Wheel Throwing

Wheel throwing is a manufacturing method in which clay is shaped with a wheel. Turning creates regular, round shapes. The first wheels rotated at a kicking speed, but today most wheels are electrically operated, with the speed of rotation controlled by a pedal. Once the thrown object has dried to leather-hard, it can be placed back on the wheel and trimmed and finished by turning.

Good throwing clay is plastic and sturdy, which can withstand the stresses of spinning. Many natural clays, such as Finnish red clay, are well suited for throwing due to their high plasticity. Chamotte is also suitable for throwing clay, but too coarse chamotte wears and at worst breaks the skin of the hands. Throwing clay must be wedged well before use, as inconsistencies in the clay make it difficult to work the clay on the wheel.

Figure 7. Still-image from video, Camilla Groth

All the videos can be found in Aalto Open Learning: https://openlearning.aalto.fi/course/view.php?id=110

Steps for throwing:

- Centering
- Interior and base forming
- Wall pulling (lifting)
- Forming an object
- Finish

2.2 Pressing

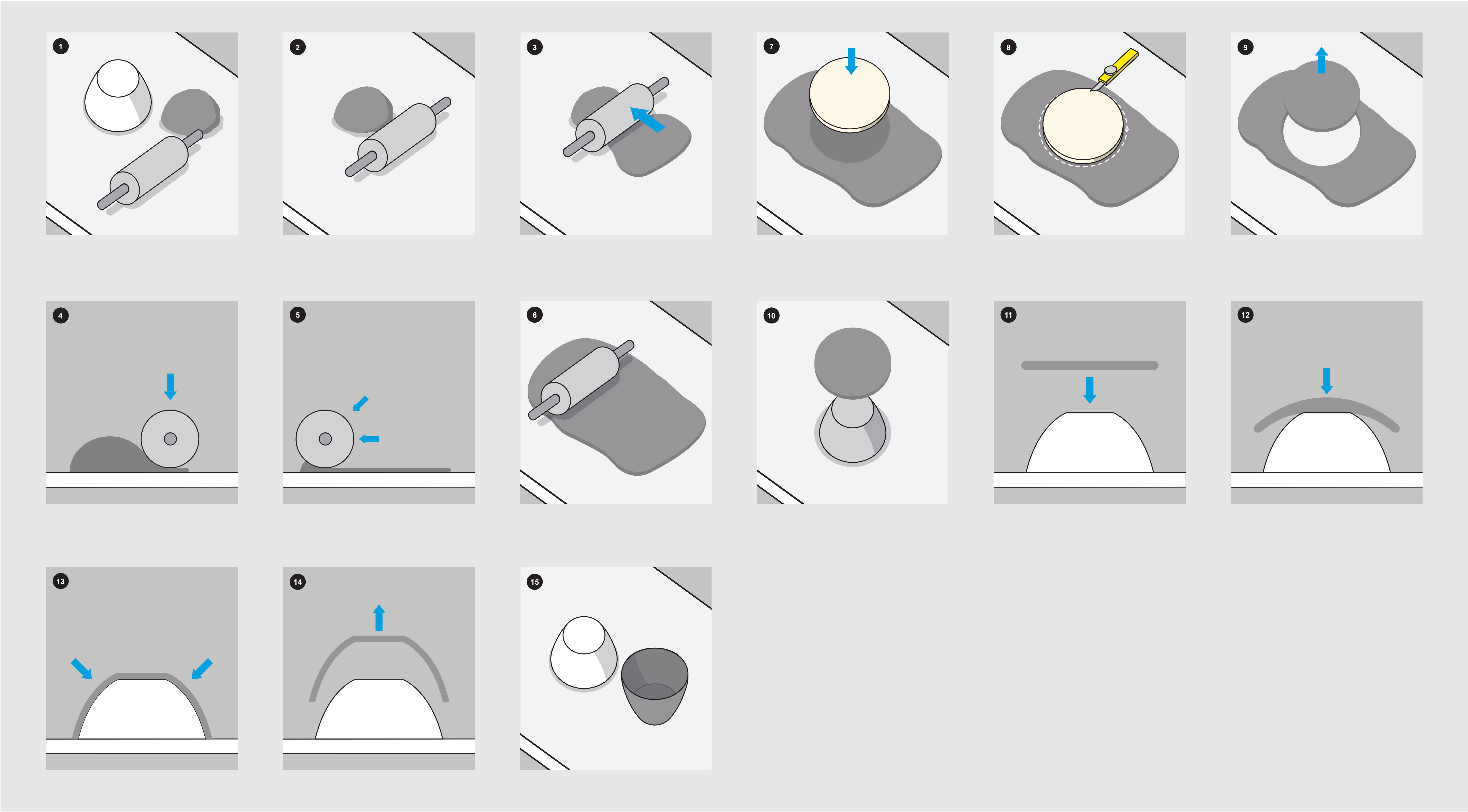

Figure 8. Image series on press molding:

1. Press-mold, clay, and rolling pin are found.

2. The clay must be made in a slab first.

3. A rolling pin or slab-roller can be used.

4.-6. Pressure is applied downwards as the rolling pin is rolled forward to make an even slab.

7.-9. Use a template the same size as press-mold to cut the right shape slab.

10.-13. Place slab on mold and press around plaster slump mold until desired shape is reached.

14.-15. After the clay has dried to leather-hard, it can safely be removed from the press-mold and finished.

Pressing combines different techniques; slab technique and molding technique. Press molds are usually made from plaster. The plastic clay is rolled into a slab, cut to the desired size and placed inside or on top of the mold. The clay is pressed along the mold and the clay left over the mold is cut off.

2.3 Jiggering

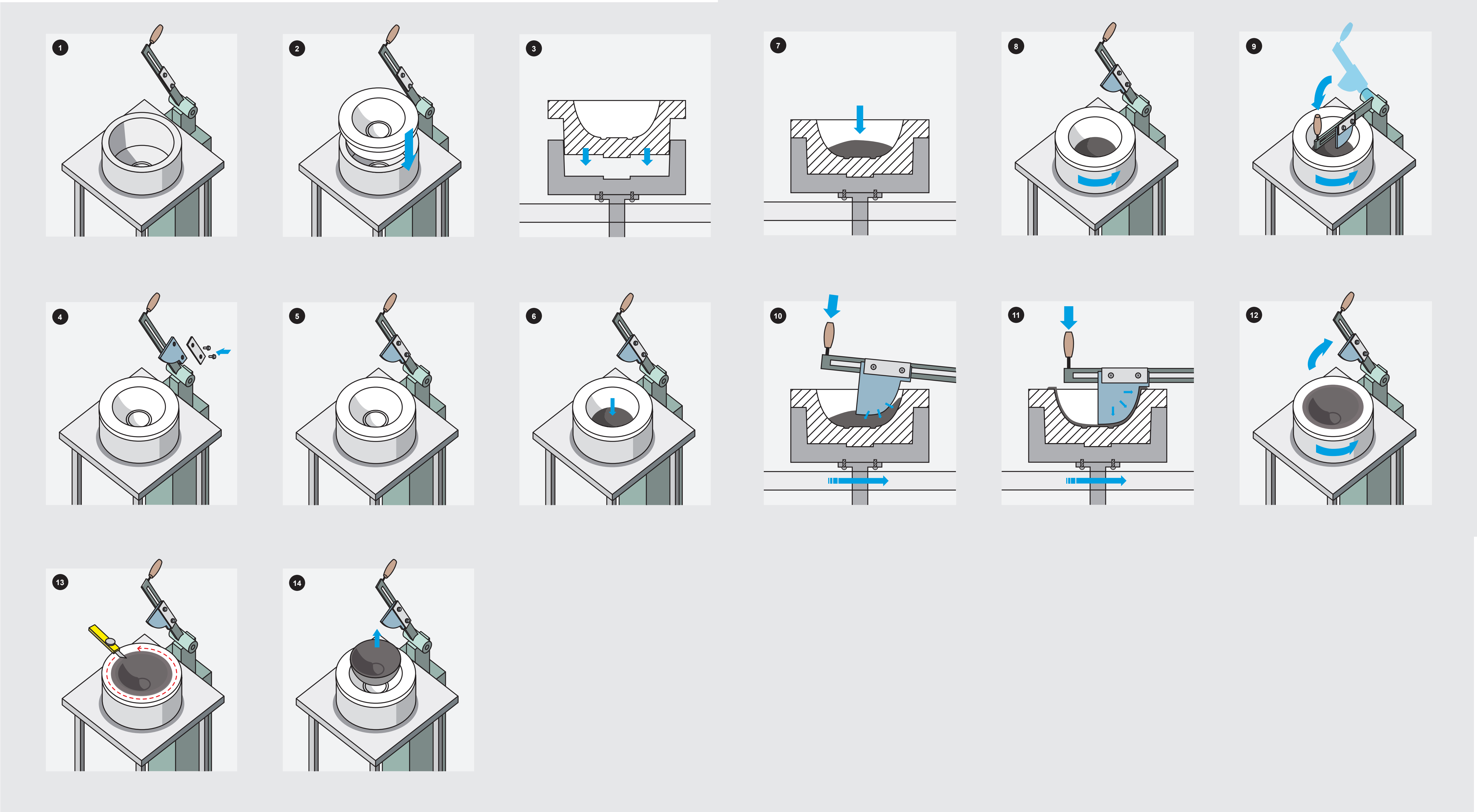

Figure 9. Image series of jiggering technique

1.-3. The plaster mold is placed into the metal chuck.

4.-5. The jiggering blade is fixed at the correct position on the arm. The left edge must meet the middle point exactly.

6.-7. A small piece of plastic clay is placed in the bottom of the mold.

8.-11. As the mold is spinning, the arm with the blade is lowered slowly in steps, each time removing a small amount of clay. The final shape is found when the arm is pushed all the way down to be horizontal.

12.-14. When the form is finished, any excess clay on the top rim of the mold can be cut away. The piece can then be removed from the mold after it has dried and shrunk a bit.

Jiggering is a manual molding method used in small series production as well as product development. In manual molding, the plaster mold is placed in a metal chuck that rotates during forming. The jiggering blade (wood, plastic, steel) is lowered by hand on the clay piece as the plaster mold rotates. By jiggering, both internal and external molding can be done.

2.4 Slip-casting

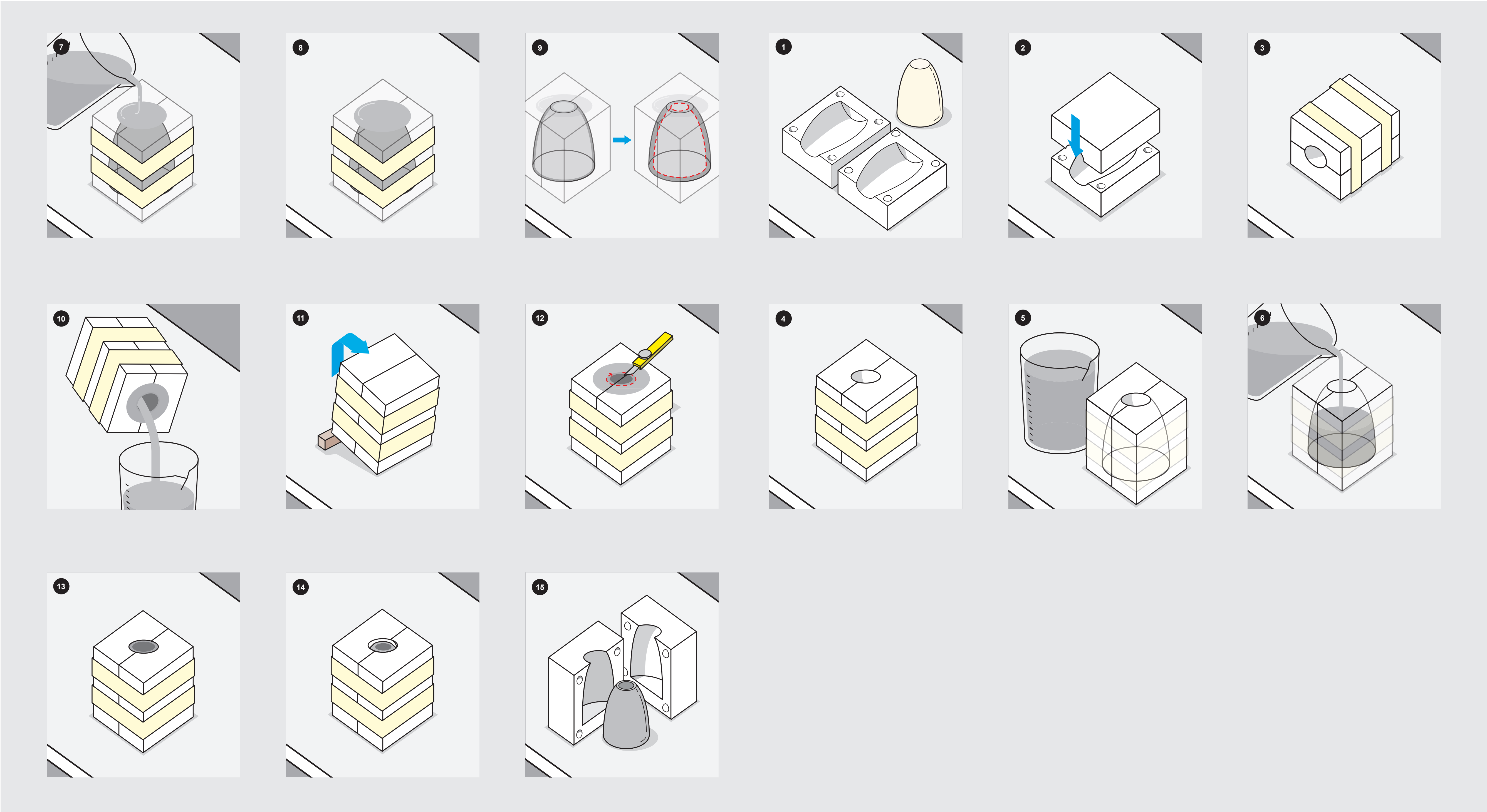

Figure 10. Casting with a plaster mold

1.-4. To cast, the mold must be totally dry, pieced together, and banded.

5. Make sure you have enough slip for the volume of the mold.

6. Fill mold in a controlled manner, splashing can create bubbles and inconsistencies.

7.-8. Fill mold completely to the top and make sure to top off if the slip level is sinking below the shape of the form.

9. The longer the slip sits in the mold, the thicker the wall becomes.

10. At the desired time/thickness, dump out the excess slip from the mold.

11. Flip the mold upside down and rest at an angle so the remaining drips don't form a nipple in the interior middle base.

12. Once the clay interior is no longer dripping or wet on the surface, the excess clay can be trimmed from the top of the mold.

13.-15. Depending on the thickness and size of the piece, after 30 minutes to a couple hours, the piece will dry and shrink to the leatherhard and can be removed from the mold.

Casting methods are divided into open casting and solid casting. Molds can be single or multi-piece. Casting techniques are used in both small series production and industrial production.

In open casting, the casting mass is poured into a mold where it is allowed to set for a certain period of time. During this time, a solid layer of clay gradually increases in thickness on the inner surface of the mold, as the plaster mold absorbs some of the water contained in the casting slip. The thickness of the clay layer is determined by the length of time of the casting slip in the mold, so that by extending the casting time, the thickness of the layer can be increased. When the desired wall thickness of the object has been reached, i.e. a certain casting time has elapsed, the mold is turned upside down, and the excess slip that is still wet is poured out and the already cast solid object remains inside the mold. The object is left to dry in the mold for some time, during which it solidifies due to the continuous absorbency of the mold. When the drying object shrinks slightly, it can be easily removed

In solid casting, both internal and external formation of the object takes place by means of a mold. The mold consists of two halves, inside which the shape of the object to be made is repeated. The molds are filled through the pouring openings in one half so that the space between the molds is filled. The water in the casting slip is absorbed into the mold on two sides and the wall thickness is determined by the mold and not by the casting time used as in open casting.

3. Industrial

From the designer's point of view, the industrial design of ceramics is a consistently advancing design process in which precise manufacturing frameworks are often defined for the design task from the outset. The design usually takes place in close cooperation with a company in the field, in which case the client first describes, for example, the intended use of the object or the group of users and the manufacturing methods available at any given time. In recent decades, the ceramics industry has mainly moved from Finland, as in Europe in general, to countries with cheaper labor. The manufacture of tableware and sanitary ware, as well as bricks and tiles used in construction, are still major industries worldwide. When designing for industry, it is beneficial for the designer to understand the possibilities and limitations of each manufacturing method.

3.1 Slip-casting

Irregularly shaped objects such as pitchers and jugs are mostly manufactured by casting.
Injection molding is a more modern casting method than traditional casting, which is able to produce considerably more pieces in turn than traditional casting methods. Injection molding is used to make fairly large batches and allows the manufacture of asymmetrical containers such as pots and pans. Injection casting molds can have a service life of up to 30,000 castings. Sanitary ware is made in both traditional casting and die casting.

3.2 Jiggering

In jiggering, the porous plaster mold absorbs moisture from the plastic clay while the steel blade shapes the other side of the object. Jiggering is used to make circular pieces such as cups, plates and flower pots. The life span of plaster molds is 70–250 molding times.

Jiggering capacity:

Hand held machines	75–200 pcs / h
Semi-automatic jiggering	400–475 pcs / h
Automatic roller machines	550–600 pcs / h

3.3 Compression

Industrial pressing techniques have largely replaced traditional casting and molding techniques in industrial production. Enabling production automation to produce large quantities with a small number of employees. Compression techniques are divided according to the moisture content of the clay used into wet compression, wet / semi-dry compression, and dry compression. Methods useful in making containers include wet compression and semi-isostatic image compression.

In wet compression, also commonly referred to as RAM compression, the mass used is in plastic form and has a moisture content of 19–21%.

Molds used in dry pressing are made of metal and often coated with polyurethane film. The pulp used is granulated and has a moisture content of 1.5–4%. The main reason for the popularity of the method is economy. The production of plates is fully automated and personnel are only needed for monitoring, changing molds and adding material. In traditional methods, the manufacture, processing and drying of plaster molds bind a lot of resources and worn or otherwise damaged molds cause defects in the products to be manufactured. Metal molds used in dry pressing can withstand tens of thousands of presses. The space requirement required by the pressing equipment is only a fraction of that required by a traditional production line with a corresponding production capacity. Although the production of an expensive mold requires large production quantities, it is not necessary to produce objects in stock, but by changing the mold, different models can be manufactured on the same machine during the same working day. Pieces can be made on demand and the shelf life of finished products is substantially reduced. When forming automatically with durable mold tools, the objects do not show quality differences caused by craft steps, as in traditional molding methods. The advantages of the manufacturing technology are the dimensional accuracy and good quality of the pressed parts. The production capacity of dry pressing can be up to 600 pcs / h.

4. 3D printing techniques

3D printing is a material-adding technique in which printing adds material, for example layer by layer or by continuous extrusion. The following is an example of one way to approach clay printing, but there are several different variations and ways. 3D printing is an evolving field and more and more new printers and suitable materials are entering the market.

Printing a piece of clay can be roughly divided into three different work steps. In the first step, a digital file is made of the format of the piece to be printed. For example, Rhinoceros 3D modeling software or other similar CAD software can be used for this. For example, the finished digital file is saved in STL format, after which the modeled format is sliced into layers by another software. The digital file gives the coordinates to the printer, as it moves and prints the media. The second step in the process is printing itself. For extrusion printing, a suitable soft clay must be made that is sufficiently pasty and of uniform quality.

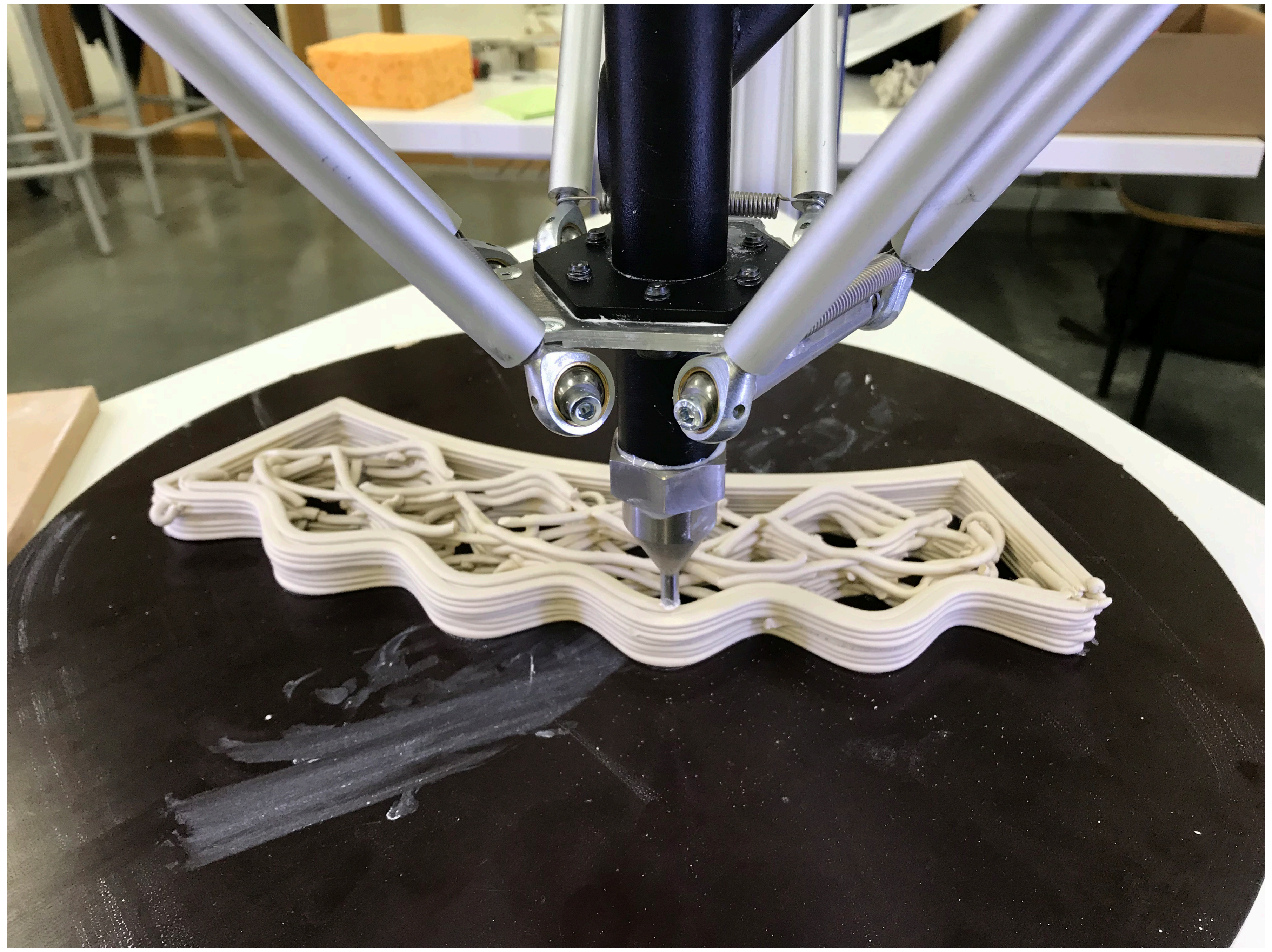

Figure 11. 3D printing ceramics

The clay can be prepared from start to finish itself or, for example, using ready-made fine clay, to which water is added by hand processing so that the pulp is suitably soft. Printing clay by the extrusion method often requires constant monitoring and, for example, adjustment of the air pressure. During printing, you can still influence the printing process itself, for example by changing the print speed or adjusting the air pressure. However, these possibilities depend on the type of printer you are using. The third step in the process is the finishing step of the printed part, in which the object is dried, finished and fired to the desired temperature in a manner familiar to ceramics.

3D printing involves a wide variety of printing techniques and the extrusion method is just one of them. The clay can also be printed, for example, with a powder printer, which prints the clay powder by layer. Different clay 3D printing methods allow for the application of clay material in dry powder or plastic form. In the stereolithography (SLA) method, the ceramic raw material can be blended with a photopolymer that is photoactive. In the SLA technique, the liquid mixture is added stepwise to the basin, after which the surface of the mixture is cured layer by layer by means of a laser beam.

The 3D printer for ceramics can be thought of as a new kind of tool for craftsmen, designers and artists, which enables e.g. the production of otherwise difficult shapes and the use of new types of material. As a digital tool, a 3D printer is very different from traditional tools in that it is programmed and requires not only knowledge of ceramics, but also different areas of expertise. 3D printing can be approached from a very technical point of view, as it enables, for example, the production of structurally demanding shapes. It can also be used as a handcrafted tool, and approached from an exploratory and experimental perspective.

Figure 12. 3D Poetry, Yi-Chiao Tien

5. Mold techniques

The production of molds is necessary when the objects are to be duplicated, for example in the production of molding, pressing or casting. Various auxiliary molds can also be used to support demanding molds by hand. plaster, which absorbs water from clay, is an excellent mold material.

Before making the mold, a sample of the object to be reproduced must be made. The specimen can be made of almost any material, such as clay, 3D-printed plastic, plaster, or wood. When using plaster as a model material, it is good to apply e.g. 1-3 thin layers of shellac to its surface, which hardens the plaster surface and closes the porosity of the material. When using other porous model materials, it is advisable to try different packages or fillers, if necessary, in order to make the surface of the model smooth and tight, so that the plaster of the mold comes off well. When making a specimen, it must be remembered to take into account the combustion shrinkage of the ceramic, ie to increase the specimen according

Figure 13. Mold example: multi-part jug mold. Mold Nathalie Lautenbacher

Molds used in ceramics are usually made of plaster. plaster is used as a mold material, as plaster absorbs and evaporates water efficiently due to its porosity. From the wall of the plaster mold, calcium sulphate dissolves in the moist clay, which has a flocculating effect. This prevents the clay from penetrating the pores of the plaster, and promotes the release of the mass from the mold. The plaster also reproduces the shapes of the specimen very accurately. A plaster cast can be used in the manufacture of molds as well as model pieces, but both can also be made without.

When making a mold, it must first be determined how many parts of the mold are required by the shape of the specimen. If the shape is permeable, i.e. the shape opens outwards, the mold can be made in one piece. If the shape is inaccessible, the mold must be constructed of several parts so that each part can be detached from the specimen.

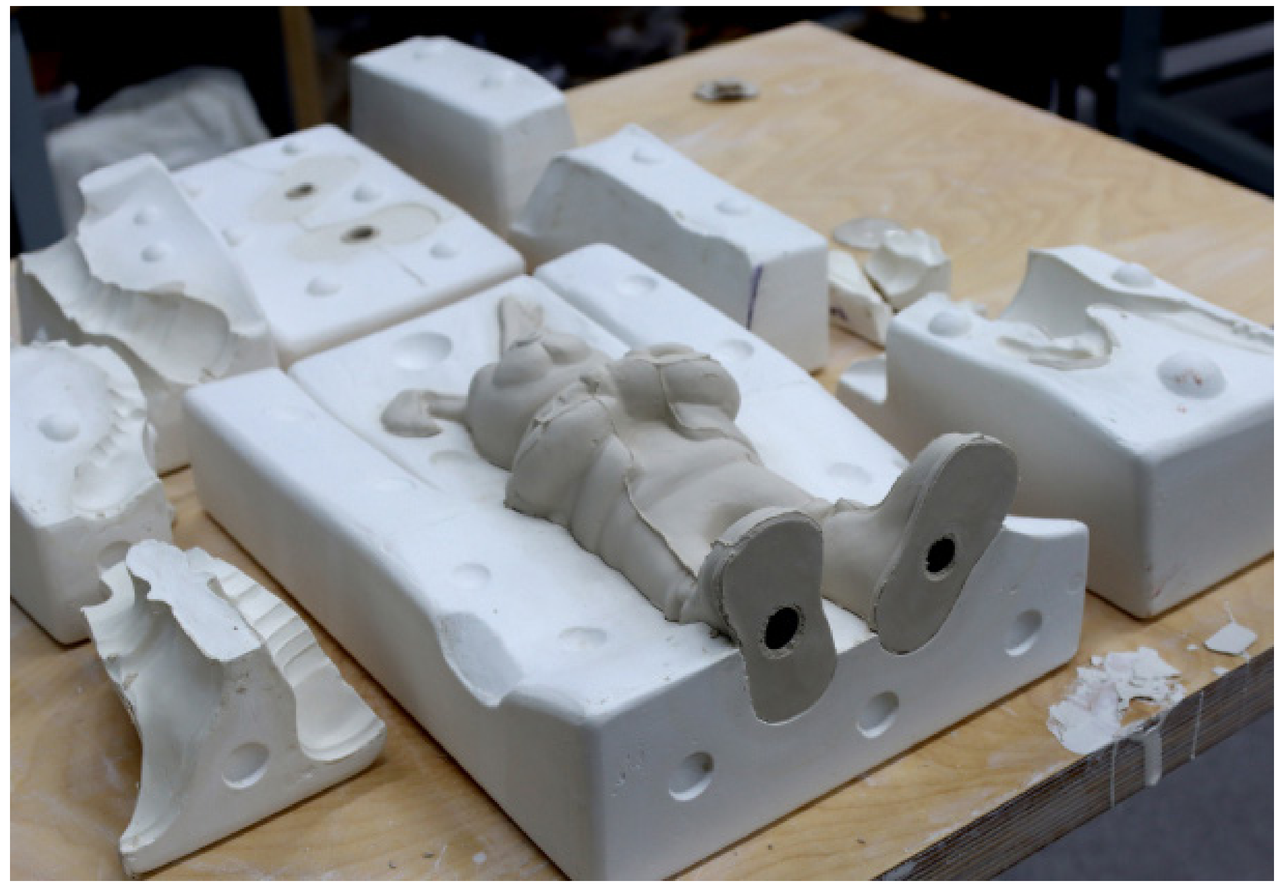

Figure 14. Mold example: multi-part sculpture mold. Mold Liisa Kaunisvirta

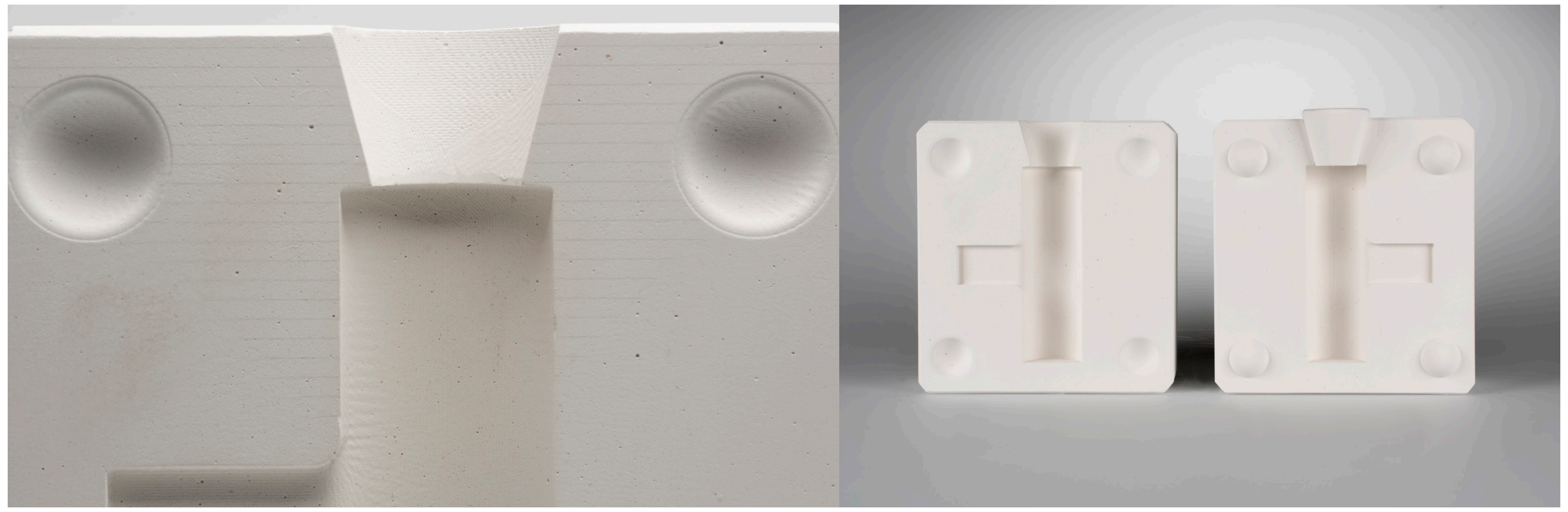

Figure 15. Mold example: Handle mold molded with a CNC milling cutter. Mold Piia Jalkanen

5.1 Mold-making

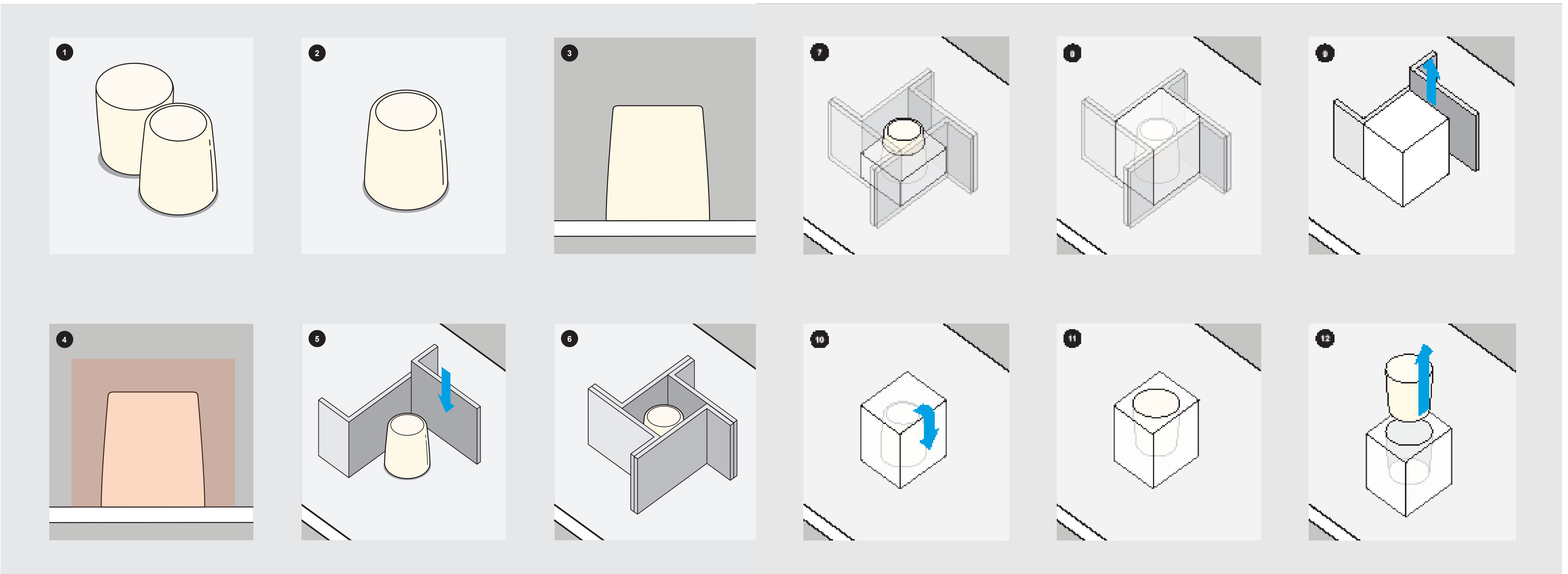

Figure 16. Making a 1-part mold

1.-4. With a model, the orientation of the final object needs to be determined to know where the pour hole of the mold will be. In open casting, the open side will be placed down on the surface of the table. This mold can be one part since it is possible for the object to fall straight out of the mold, or it is draftable.

Make sure to apply a mold release agent, such as soap and oil.

5.-6. Choose how to contain the liquid plaster around the model, here cottle boards are used with clamps.

7.-8. Plaster is poured over the model to cover the base and sides equally.

9.-12. After the plaster has fully set, cottle boards can be removed, mold flipped, and model removed. With one part open-casting molds, the model might need coaxing out, such as with compressed air. The mold is left to dry.

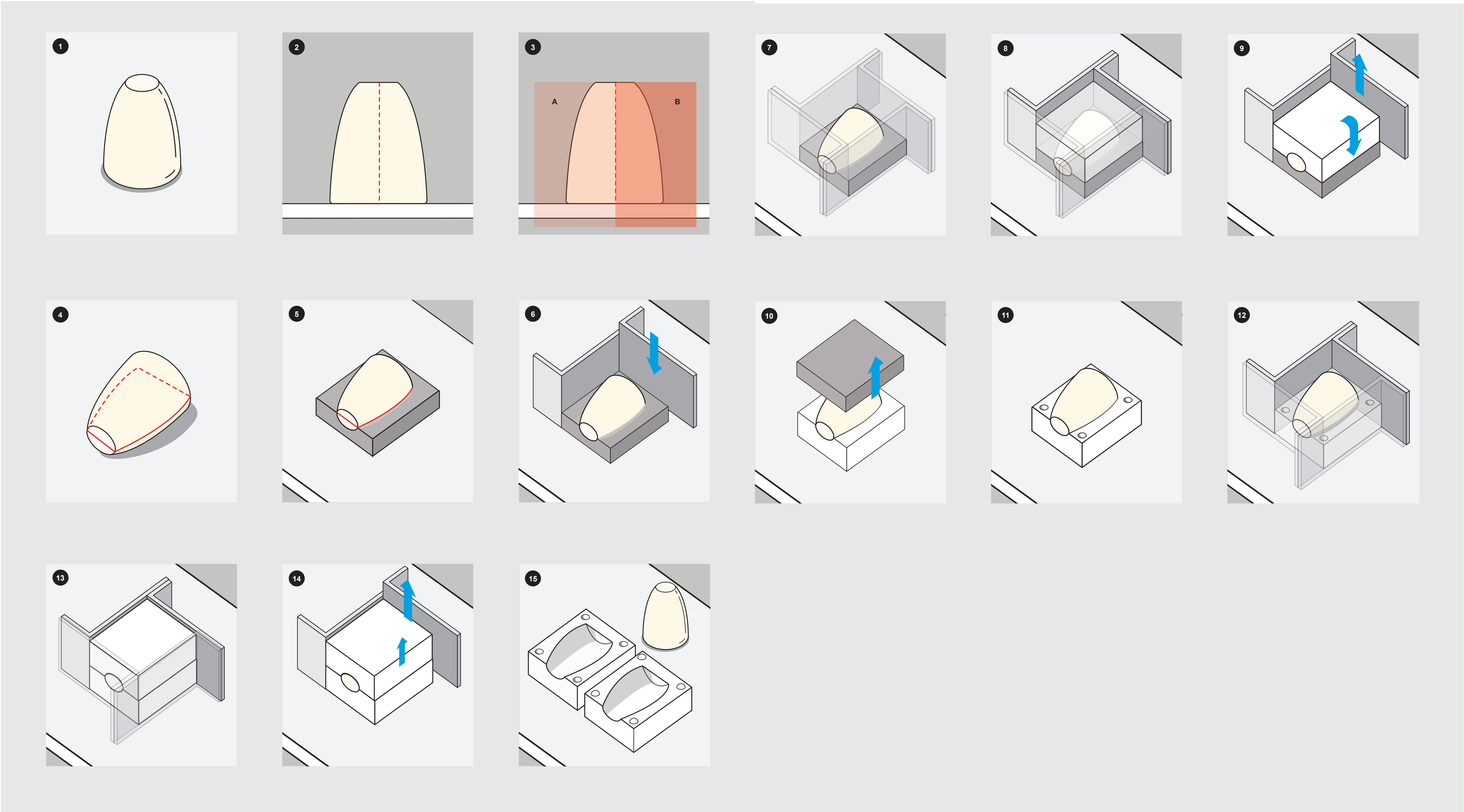

Figure 17. Making a 2-part mold

1.-4. The model has a small curve under on the lip of the form. Because of this small curve, the mold must be two parts and a middle or separating line is drawn where the mold seam will be.

5. Solid clay is built up to the seam line, masking off one half of the form.

6.-7. Cottle boards are used to contain the plaster.

8. Plaster is poured over the form so the walls will be equal on each side.

9.-10. After the plaster sets and hardens, it can be flipped over and the clay is removed.

11. Keys are made in the first half so that the second half registers in place perfectly. Soap new plaster.

12.-13. Cottle boards are placed again and the second half of the mold is poured, keeping the halves equal in width.

14.-15. Plaster sets and the second half and model are removed. The mold is left to dry.

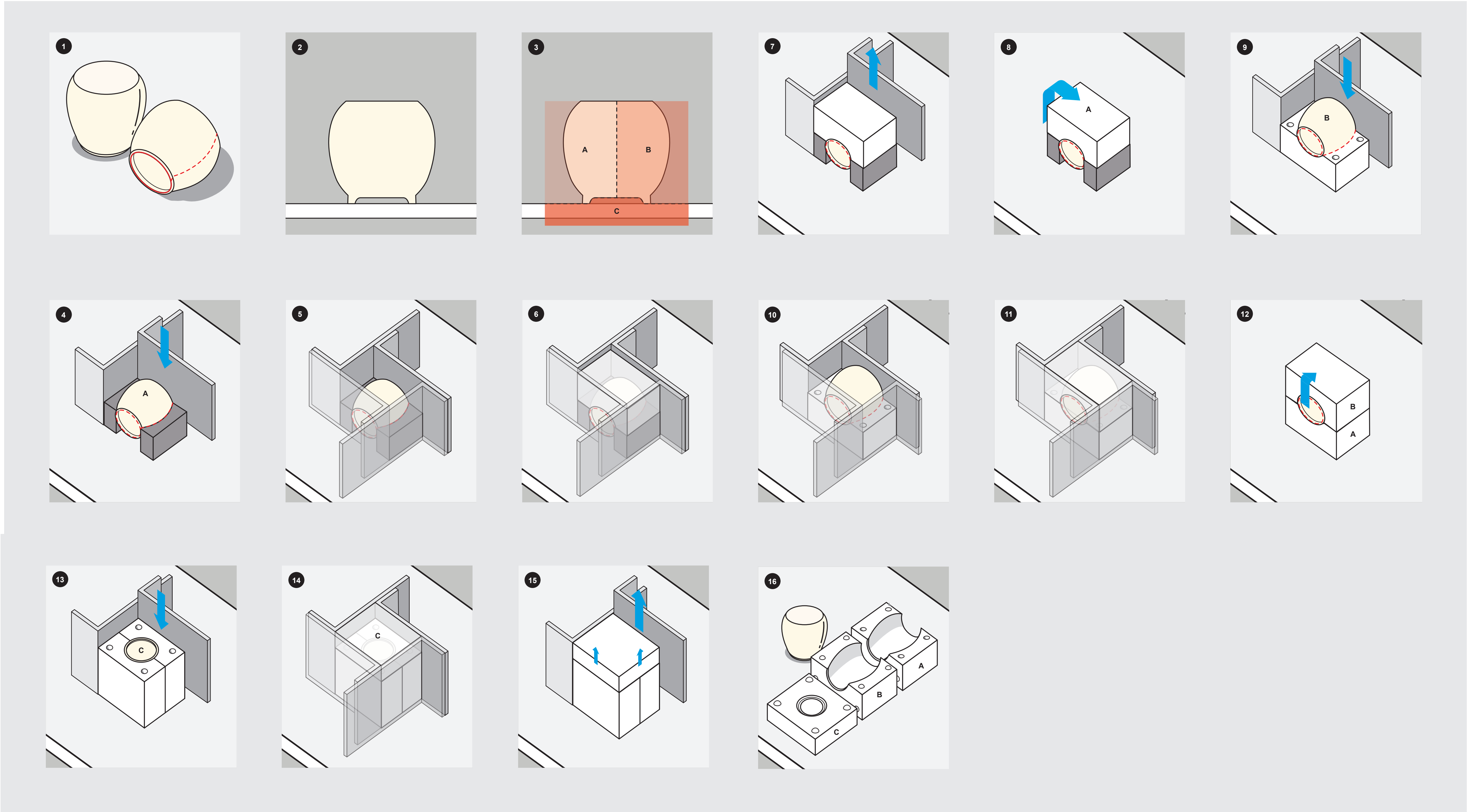

Figure 18. 3-part mold making

1.-3. Seam lines are found on the form. The solid mold pieces must be imagined as pulling away from another solid form.

4. Solid clay is built up to the seam line, masking off one half of the form.

5. Cottle boards are used to contain the plaster. Notice the board is flat against the foot of the form to mask where the 3rd part will be.

6. Plaster is poured over the form so the walls will be equal on each side.

7.-8. After the plaster sets and hardens, it can be flipped over and the clay is removed.

9. Keys are made in the first part so that the second part registers in place perfectly. In multiple part molds, special attention must be made to keys and how mold pieces move away from each other directionally. Soap new plaster.

10.-11. Cottle boards are placed again and the next part of the mold is poured, keeping the parts equal in width.

12. Plaster sets and the mold is flipped to make the last piece. 13. Keys are made, plaster is soaped.

14. Cottle boards are used again, the plaster is poured to the saem wall thickness.

15.-16. The mold is disassembled and left to dry.

When building a mold on top of a model, the model must first be treated with a release agent. As a separating agent, for example, a mixture of oil and soap can be used, which is prepared by mixing about half rapeseed oil and half soap (pine soap). It is also possible to buy the release agent as a ready-mix. Carefully add a thin layer of release agent to the surface of the specimen.

The mold is made by pouring liquid plaster on top of a model. Walls must be built around the model to keep the liquid plaster in place. The walls can be built of wooden boards, plastic or metal pieces, which are tightened together with, for example, clamps. Finally, the cracks are patched with soft clay.

Calculating the mold volume:

Cylinder volume:
$\pi r^2 h$ or 3.14 x radius^2 x height.

Volume of a rectangular triangle:
length x width x height.

The mixing ratio of plaster and water is about 1: 5 (water: plaster). plaster is made by first measuring cold water in a clean container. The pre-weighed plaster powder is sprinkled into the water. The mixture is allowed to sit for about 5-10 minutes, after which the mixture is stirred vigorously under water, either by hand or with a drill. When mixed, air bubbles are removed. When the plaster mixture begins to thicken, it is ready to be poured. As the plaster hardens, it heats up and expands slightly. Once the plaster has hardened and cooled, it can be removed from around the model.

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Images and illustrations

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Figure 19. Work by Marjut Alitalo