# Manual ceramic shell

System : Adbond Artcast/ Adbond Advantage

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Produkten : Nedform B.V /
Remet Uk Limited

## Introduction

This document is intended to introduce the ceramic shell casting process.
As you will discover the ceramic shell process depends a lot on your environment (temperature, humidity airflow) as well as on the moulds you want to cast (details, sharp edges etc). Therefore the advice and numbers given in this document are an average starting point and will have to be adjusted to your specific situation by experimenting. Please contact Nedform in case more questions remain/ arise.


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# 1. Introduction

This ceramic shell process aims to make a ceramic shell over a wax form by building the shell up layer by layer. After de-waxing (melting out the wax) this ceramic shell and in the same time baking it one remains with a ceramic mould usable for bronze/ art-casting. The shell normally consists out of 5-12 layers depending on the size of the casting.

## *1.1 Advantages and disadvantages of ceramic shell casting.*

Compared to the traditional method of lost wax casting with plaster/ chamotte the ceramic shell method offers the following advantages:

- √ The shell/ mould is easier to handle because of the lower weight/mass.
- √ The shell is porous which means that gas is able to escape and will not build up as quickly and rupture the shell. Of course this depends on the flour and stucco used and still requires a bit of practice.
- √ After de-waxing the shell is baked in 1-2 hours which compared to the long baking times for plaster saves energy.
- √ The quality of the casting is better and more consistent, which means less work on the finishing.
- √ Because less materials are used you will have less materials to throw away.

Unfortunately there are a few disadvantages:

- X One has to get familiar with the process (i.e. practice).
- X The dipping and drying of the layers sounds arduous and time consuming. Normally this is not a problem when one has become familiar with the process.
- X The removal of the ceramic shell from the final cast may be tougher because the shell is stronger. In part because of this we advise on using different flours and stuccos if one would like to cast in weaker materials than bronze 9like aluminum). Normally a high pressure water gun is an easy way to remove the shell.

## *1.2 Putting on the layers*

It is relatively easy to build a layer. One simply dips/ submerges the wax form in a dipping bath. This dipping bath is filled with a slurry made out of Adbond Advantage, fused silica powder (RP1 or RP2) and zircon powder.
Subsequently one puts stucco on the slurry covered wax. This stucco normally is of a coarser grind of fused silica or zircon (sand).
After each layer the mould should be left to dry. When the mould is dry enough one can start the dipping and covering with stucco again. This process is repeated as often as s necessary for the mould to reach the required strength.
Sometimes a form is too big to completely submerge. The remaining parts are covered by pouring slurry from the tank over the wax form. Please be careful to cover the complete surface with the slurry and avoid bubbles. We advice blowing away excess bubbles on the slurry skin before putting on the stucco.

Sometimes people use an air pressure gun to cover the model in slurry but this requires practice.

# 2. The Process

## *2.1 Items one should/ could use*

For the ceramic shell process to work we advice to use the following products or equivalents:

Required/ strongly adviced

- A bucket/ barrel/ tank used to make up the slurry and dip the wax form in:
  - Preferably a barrel that is easy to continuously mix the slurry in. Slurry that is not mixed for too long a time settles, gels and finally hardens and is often not usable anymore. It is possible to make the slurry fluid again but it loses much of its strength.
  - The opening/ diameter of the barrel has to be big enough to facilitate the dipping. The height of the barrel should be enough to cover all/ most of the wax form. Of course one should not make the diameter of the barrel too big as it would take too much slurry to fill up the tank. The sides of the barrel should be straight.
  - A cover to close the barrel after use so the remaining slurry will not dry out. Of course one may add the amount of water that evaporates, but care has to be taken to keep all values/ ratios of the slurry at the ideal level.
- Blender
  - The slurry should:
    - Be mixed for 4 hours up to a complete day when the slurry is made or when a lot of new ingredients are added. This is to ensure proper wetting of the flour in the slurry. As soon as the viscosity stops changing more than 1 seconds every 15 minutes the slurry is properly mixed.
    - Be continueously mixed, especially when left alone over long periods of time. Stirring may be stopped for short times if this makes the dipping easier.
  - The blender should not be a high shear blender (meaning over 2000 rpm). High shear blenders typically have saw tooth blades perpendicular to the rotating disc. This is because high shear mixing destroys the latex in the binder thus destroying the slurry.
- Sieve/ sifter
  - When dipping the mould will always loose a bit of stucco from the previous layer(s). It is recommended to periodically sieve the slurry(at the top of the barrel) with a hand sifter.
  - A sifter may also be used to put the stucco on the wet wax form. In this way one is sure not to drop/ throw the stucco on the wet skin too powerful. Stucco that hits the skin with too big a velocity may penetrate too far and thus destroy the contact layer with the wax form.
- Scale
  - To get the proper mixing ratios it is recommended to use a simple scale.

- Viscosity cup
  - To prevent having to guess if the slurry is at the right viscosity we advice to use a viscosity cup (e.g. Ford cup B or Zahn cup). As soon as you are happy with the viscosity of the slurry, measure it using a cup. When making a new slurry or adding new materials one will have a viscosity to aim for. This will speed up slurry making.
- Thermometer and humidity meter.
  - The temperature and relative humidity influence the drying time of the layers. Although these measuring devices are not absolutely necessary they facilitate the estimation of the drying time. They are normally used in combination with an air-conditioning device to make sure the room is kept at a constant temperature of 20 degrees and a humidity of about 50%.
- Fan/ blower:
  - Most people keep their drying moulds in a room with a wind speed of about 1 m/s. Please note: DO NOT use fans on primary layers!!!
- Oven:
  - Used for the de-waxing of the ceramic shell (i.e. melting the wax out of the shell). The wax should easily flow out of the oven to prevent fire or explosian risks.
  - After de-waxing one leaves the shell in the oven and increases the temperature to about 900 ºC to bake the ceramic shell.
- Dust mask: One should use dusk masks when handling sand, flour and stucco.
- Safety glasses.
- Waterproof gloves.
- The ceramic shell products as described in this manual in section 3.1.

Optional

- Sander. A container that pours stucco from the top collected from the bottom by a conveyor belt. It is also possible to use a fluidized bed sander. Normally though one throws on the stucco manually or by using a sieve. Be careful not to throw the stucco on too forcefully so as not to puncture the skin (also called sand bite).
- Crane or leverage to maneuver heavy wax forms while dipping. (larger forms get heavy after the first few layers of stucco).
- pH measuring device. The pH of the slurry should always be above 9.0 otherwise it will go off and an irreversible gelation of the slurry will occur. Unfortunately it is not possible to use pH paper.
- Wetting agent. A product to improve wetting of the form by the slurry. A common product is Wet- in or Victawet 12. This product is normally only required for precision casting.
- Antifoam. This product reduces bubbling of the slurry by reducing the surface tension. This product is already pre-blended in the Adbond Advantage so one normally does not need to add this unless there still is excess bubbling.
- Degreasing product. Patternwash or citric acid is used to make the wax surface less greasy and thus facilitate adhesion of slurry to the wax.

## *2.2 The making of the slurry*

The most important property of a good slurry is the viscosity. The right viscosity however is the viscosity one likes to work with. There is no real standard value. Other factors are important too. If the wax form has sharp edges the viscosity should be high to help cover these edges. If the was form has fine details the viscosity should be lower.

Please note that every new slurry or filled up slurry should be mixed for four hours (preferably 24 hours). Mixing of the slurry is ok as soon as the viscosity does not change too much over time. Please do not use high shear mixing (>2000 rpm) for this will destroy the latex in the binder. A normal kitchen blender or mixing drill should do fine.

The first layer is the most important one as this one determines the surface quality of the casting. It is therefore important that this layer covers the complete wax mould perfectly without any air bubbles. The flour used in the slurry for the first layer is very fine so as to be able to get all the details. The smaller grain of the flour causes this “primary” slurry to be slightly more viscose than the “back-up” slurry.

The slurry for the back-up layers (third layer and further) has a coarser flour and therefore a slightly lower viscosity.

Most customers use two dipping tanks. One for the primary and one for the back-up slurry. It is however also possible to make up a primary slurry and dip all wax forms in this slurry and make the first or first two layers. Then one adds material to make the primary bath turn into the secondary one (adding Adbond Advantage and the coarser flour). In this way one only needs to use 1 dipping tank and normally has less left over material.

For beginners using the ceramic shell method for bronze castings we normally advice to make up slurries with fused silica flour. The adding of zircon flour makes the shell a lot tougher but the mixing ratios are a bit more precise.

Properties of zircon:

- Very fine material resulting in a high detailed surface.
- Stronger ceramic shell
- The resulting shell is less porous. Gas has more difficulty escaping from this shell which makes it more prone to cracking.
- Easier to de-shell the final casting, but only if the mixing ratio is done accurately enough.

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**Making of the primary slurry:**

- Fill the dipping tank with the right amount of Adbond Advantage/ Adbond Artcast.
- Add fused silica flour to the Adbond. Either use RP1 or RP2. RP1 is a bit finer than RP2 and used for better details but normally only for precision castings. Mixing ration is Adbond: Flour = 1 Kg: 2Kg

- If one has the necessary experience it is possible to add zircon flour 200 mesh too. This should be done in the mixing ratio Adbond: zircon flour 200 mesh = 5 Kg: 2 Kg. If one prefers to use RP2 instead of zircon one should use the ratio Adbond: extra RP2 = 5Kg :1Kg.

e.g. Bad 1 (Primary slurry):

| | | | |
|---|---|---|---|
| | 60 kg | Binder Adbond Advantage or Adbond Artcast | |
| | 120 kg | RP 2 | |
| + | 24 kg | Zirkon flour ECG (200 mesh) | ← Optional |
| = | 204 kg | Primary slurry | |

Or

| | | | |
|---|---|---|---|
| | 60 kg | Binder Adbond Advantage oder Adbond Artcast | |
| | 120 kg | RP 2 | |
| + | 12 kg | RP 2 (extra RP2 instead of zircon) | |
| = | 192 kg | Primary slurry | |

The viscosity should be around 85-95 seconds (measured with a Ford B4 cup).

**Making of the back-up slurry (secondary slurry):**

One can make the back-up slurry by adding Adbond Advantage/ Artcast and the necessary flours to the primary slurry or one just starts from scratch.

Please see example below for a possible mixing ratio.

e.g. dipping tank 2 (back-up slurry):

| | | |
|---|---|---|
| 90 | kg | Binder Adbond Advantage or Adbond Artcast |
| 120 | kg | RP 2 |
| + 24 | kg | Zircon flour ECG (200mesh) or 12 Kg RP2 extra instead of zircon |
| =234 | kg | Back-up slurry (also known as secondary slurry) |

Viscosity should be around 50-60 seconds (measured with a Ford B4 cup)

These examples are a good starting point for most casting ideas. We recommend starting with these values and to adjust later as seen fit. A good guidline for the density of the slurry is about 1,7 gramm/cm3.

### *2.3 The making of the layers/ dipping*

As described the layers are built by dipping the wax form in the slurry and putting stucco on the wet wax surface. One should be careful to cover the complete surface with the slurry. After the stucco has been stuck on there should be no wet surface visible. For the stucco it is best to use fused silica coarse ground (RG1, RG2 or RG3). This material is more coarse than the fused silica flour (RP1, RP2).

RG1 is used as stucco for the first or first two layers. RG2 is used for the next three layers and RG3 is used for the remaining layers. Of course one is free to make alterations to this suggestion.
ALWAYS put on stucco. Never make a layer without stucco as this causes the layer to attach itself poorly to the earlier layers. The layer might come loose during casting or de-waxing, destroying the final casting.

Please make sure the slurry is mixed constantly or at least periodically to prevent sedimentation/ unmixing of the materials and gelling.

It is important to let the shell dry after every new layer. The drying time depends ont temperature, relative humidity and air flow. Good drying is very important on parts with (sink) holes or were the ceramic shell bridges a gap.

**Applying the first layer:**

Dip the wax in the primary slurry and make sure the whole part is perfectly covered in slurry. Let excess slurry run off and make sure there are no air bubbles.
Put on RG1 stucco. Please be careful not to throw the stucco on too forcefully. The stucco should not penetrate the slurry skin completely as it might be possible it will damage the contact layer between slurry and wax which will be seen as small dents in the final casting. One could use a sieve to put on the stucco gently and evenly. Please make sure the total shape is covered with stucco.

Let the layer dry for more than 4 hours (relative humidity 50%, temperature 20-25 ºC and no to minimum air flow if possible). We recommend to let the first layer dry for about 12-24 hours (e.g. overnight).

**Applying the second layer:**

Dip the wax in the primary or secondary slurry (depending on the required detail and strength) and make sure the whole part is perfectly covered in slurry. Let excess slurry run off and make sure there are no air bubbles.
Put on RG2 stucco. Please be careful not to throw the stucco on too forcefully. The stucco should not penetrate the slurry skin completely as it might be possible it will damage the contact layer between slurry and wax which will be seen as small dents in the final casting. One could use a sieve to put on the stucco gently and evenly. Please make sure the total shape is covered with stucco.

Let the layer dry for about 4 – 6 hours (relative humidity 50%, temperature 20-25 ºC and air flow 1 m/s if possible).

**Applying the third and further layers:**

Dip the wax in the secondary slurry and make sure the whole part is perfectly covered in slurry. Let excess slurry run off and make sure there are no air bubbles.
Put on RG3 stucco. One could use a sieve to put on the stucco gently and evenly. Please make sure the total shape is covered with stucco.

Let the layer dry for about 4 – 6 hours (relative humidity 50%, temperature 20-25 ºC and air flow 1 m/s if possible).

One should repeat this last process as often as necessary to get the right number of back-up layers. Normally one uses 5 to 6 layers in total for small moulds and up to 10 or 12 layers in total for big moulds.

### *2.4 The drying of the shell:*

After applying the last layer the complete shell should be left to dry for about 24 hours. Ideal temperature would be 20-25 ºC , relative humidity is 50% and air flow is 0 m/s. Do not heat the shells to hasten drying as this causes uneven expansions and cracking.

### *2.5 De-waxing and baking of the ceramic shell*

The de-waxing and baking of the ceramic shell is done in a de-waxing oven at about 900 ºC (de-waxing might also be done with an autoclave or boiler clave). It is strongly advised to use an oven were the wax can flow away freely so as to prevent fire or explosion hazards.

Note that the oven should be at a high temperature so as not to give the wax time to expand and crack the shell. A high temperature also burns away possible ash residue.

It is also possible to melt the wax out using a heating gun/ burner. This requires a bit of practice. It is important to melt the wax near the ceramic surface first (and let this run away) so the remaining wax has space to expand. Often this is done prior to baking when the oven is slow to reach the thermal peak. This way the remaining wax has space to expand.

### *2.6 The casting*

The casting of the metal is normally done soon after de-waxing and baking oft he shell.
Small shells with a lot of small runners should be at about 600 ºC at the moment the metal is cast. Larger shells with larger runners may be at a temperature as low as 400 ºC. The high temperature of the shell prevents cracking because of heat shock when the hot metal is cast.
The heating of the shell also prevents cooling of the cast metal and thus increases fluidity of the metal (important for parts with small openings or high detail).

*Note: Silicium-Copper alloy (Cu 95,8%, Si 3%, Mg 1%) normally give the best results.*

### *2.7 The removal of the ceramic shell*

When the casting has cooled down enough the shell may be removed. Removal is easiest when the shell is placed on a flexible or sandy underground and the runners are hit with a hammer. The remaining parts may be removed with a chisel or even

with a high pressure water gun/ sand gun (about 300 bar). Be careful not to damage the casting especially with weaker materials like Aluminum.

# 3. Product information

All products in this manual are obtainable via Nedform BV. We also give advice about machines and tools.

A short description of the products:

## *3.1 Standard Products*

**Adbond Advantage:** This is the binder based on water and Latex. This binder is a pre-blend meaning it already contains the right amounts of water, latex, antifoam and wetting agent for all basic ceramic shell usages. In the past all these products were only separately obtainable which made the ceramic process more arduous. Adbond Artcast/ Adbond Advantage is ready to use. One only has to add flour in the required amounts. Because the latex is already in this product should not be high shear mixed (>2000 RPM).

**RP1 (Fused Silica Flour):**
This is the fused silica flour to add to the primary slurry for higher detailed castings. RP1 is a finer ground flour than RP2.
This product is mostly used for precision casting

**RP2 (Fused Silica Flour):**
This is the fused silica flour to add to the primary and/or secondary slurry. RP2 is a coarser ground flour than RP1.
This product is mostly used for art casting.

**Zircon ECG (-200):** Coarse zircon flour. This zircon flour may be added as flour to the slurry for a stronger shell and more details. It makes the shell less porous too which might cause cracking during de-waxing.

**RG1 (Fused Silica stucco):**
Stucco (more coarse than the flour RP). Seize 50/100 used for the primary layer(s).

**RG2 (Fused Silica stucco):**
Stucco (more coarse than the flour RP and stucco RG1). Seize 30/50 used for the second and third layer up layer(s).

**RG3 (Fused Silica stucco):**
Stucco (more coarse than the flour RP and stucco RG2). Seize 10/20 used for the back up layer(s).

**Starters kit:**
**2 bags RP1 or RP2**

**1 bag RG 1**
**1 bag RG 2**
**1 bag RG 3**
**30 Kg Adbond Advantage/ Adbond Artcast**
These quantities should suffice for a primary slurry of about 20 Ltr and a back up slurry of about 20 Ltr.

### *3.2 Alternatives to the products mentioned above*

RP1 / RP2/Zircon : Alternatives are: Cerametal (Flour), Valerite (Flour) and Molochite(Flour). Zircon is normally used when one wants to cast at higher temperatures (e.g. stainless steel). The alternatives are cheaper.

RG1 /RG2/RG3 : Alternatives are: Cerametal (Stucco), Valerite(Stucco) en Molochite (Stucco). Zircon is normally used when one wants to cast at higher temperatures (e.g. stainless steel). The alternatives are cheaper. Cerametal consists for 42% out of Aluminium, the grain has edges and is therofer more suited for art casting than investment casting. Molochite and Valerite consist for 44% out of Aluminium. The grain is more round which makes the material better suited for investment casting than the Cerametal.

Ifo ne uses Cerametal this will facilitate the removal oft he final shell.
Zircon de-mixes a bit easier than the other products in the slurry.
Molochite strengthens the shell and is therefore not suited for aluminium casting.

### *3.3 Possible additions*

The Adbond Advantage/ Artcast is ready to use mixture containing water, Latex, colloidal silica, antifoam and a wet in product. One only has to add the reuired amount of flour to make up the slurry. All ingredients are of course separately obtainable if need be.

Coloured dry time indicator. Sometimes it is hard to see whether the shell/ layer has dried enough for dipping. To facilitate this Nedform also offers a dye that changes colour when the shell is drying.
Shellspen a product that makes continues mixing of the slurry a thing of the past. This product will be obtainable over Nedform in the near future. For now. Please check out http://shellspen.com/

### *3.4 Further information*

Instead of fused silica one can use aluminosilicate materials (flours and stucco). These are cheaper and result in a stronger shell. However fused silica shells suffer less from thermal expansion and the castings are easier to knock out off the shell. Of course combinations of materials are also possible.

To further soften the ceramic shell one can add calcined coal and / or dilute the slurry with water.