AQUAPOUR™

Water soluble compound, easiliy mixed with water

Aquapour is a powdered mandrel material, which is easily mixed with water. Aquapour may be poured or injected into molds to form complex mandrels for composite lay-ups.

Aquapour is readily soluble in cold tap water and can easily be washed away from the finished part.

Aquapour saves time, labor and the wash-away feature minimizes the possibility of damaging fine details. Aquapour is formulated to minimize air bubbles and voids.

Benefits

- *Easily mixed with water*
- *Pourable and injectable*
- *Environmentally friendly, no special disposal procedures required*
- *Washes away in cold tap water*
- *Compatible with all commercial resins prepreg compounds*
- *Makes complex part manufacturing simple*
- *Easily dried in a convection oven*
- *Easily repaired and re-formed*
- *Reduces labor*
- *Saves money*
- *Saves time*

Aquaseal is recommended to seal the tool and prevent resin migration.

Instructions for using Aquapour™

Mix Aquapour™ well before beginning Step 1.

1. *Prepare mould. We recommend a Lecithin based mould release (e.g. rape oil / Rapsöl).*
Combine Aquapour™ with water.

a. Recommended mixing ratio is 55 % Aquapour™ powder material to 45 % water by weigth.
b. Small amounts of additional water may be added to improve pouring consistency; however, drying times will increase slightly if excess water is added.

2. *Pour Aquapour™ into mould.*

a. Working time is 5-10 minutes.
b. Vibrating the material while in wet form will help reduce bubbling. Pouring the material in a Vacuum will also reduce surface bubbling greatly.
c. Material will set up in approximately 1 hour.

3. *Remove mandrel from the mould.*

a. Mandrel must be removed from mould prior to being dried.
If you have problems to get the material out of the mold, before you put it in the oven. You can put the material with the mold in the freezer, to get the material very hard (frozen) and after it is freezed you can remove the mold without problems. The frozen material will then put in an oven and dried without the mold.

A

R&G Faserverbundwerkstoffe GmbH · Im Meissel 7 + 13 · D-71111 Waldenbuch
Tel. +49 (0) 7157 5304-60 • Fax +49 (0) 7157 5304-70 • e-Mail: info@r-g.de • www.r-g.de

4. *Dry in a convection oven. Fundamental Heating- / Cooling rate 3 °C /min.*

a. We recommend the material be dried at 135 °C (275 °F) at 1.5 hours per inch of mandrel thickness.
b. The material can also be dried at temperatures below 135 °C (275 °F). However, drying time will be increased. Aquapour™ is thermally stable and can withstand temperatures in excess of 200 °C (392 °F).
c. Drying times for Aquapour™ vary according to the part geometry and surface area. The more surface area that is exposed the shorter the drying time.
d. Drying times will increase exponentially as the part geometry increases.

5. *Remove mandrel from oven and seal it.*

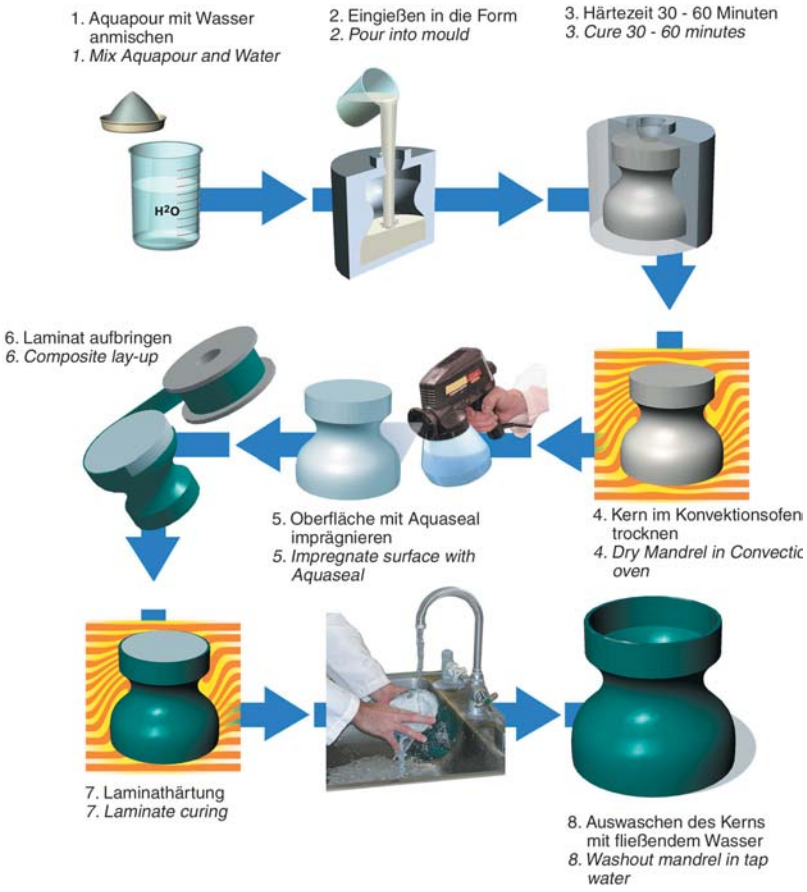
a. To avoid cracking, we recommend turning the oven off with the mandrel inside and letting the mandrel cool in the oven. This prevents thermal shock.
b. If tooling is necessary, using Aquafill™ to give the mandrel a smooth porcelain-like feel.
c. Aquafill™ can also be used to patch any defects or imperfections on mandrel.
d. We recommend Aquaseal™, a water-soluble sealer, compatible with Aquapour™.
e. Once dried, apply Release Agent or Release Wax on the Aquapour.

6. *Lay-up on mandrel to make finished part.*

a. Aquapour™ is compatible with the curing temperatures of all commercial pre-preg materials and resins.

7. *Wash away Aquapour™ from finished part.*

a. The material can be washed away under a faucet or with a standard garden hose.
b. Heated water is not necessary but will drastically increase the wash out of the mandrel.
c. Aquapour™ is environmentally friendly so no special disposal procedures are needed.



A

R&G Faserverbundwerkstoffe GmbH · Im Meissel 7 + 13 · D-71111 Waldenbuch
Tel. +49 (0) 7157 5304-60 • Fax +49 (0) 7157 5304-70 • e-Mail: info@r-g.de • www.r-g.de

Aquapour

Aquapour is a powdered mandrel material, which is easily mixed with water. Aquapour may be poured or injected into molds to form complex mandrels for composite lay-ups.

Aquapour is readily soluble in cold tap water and can easily be washed away from the finished part.

Aquapour saves time, labor and the wash-away feature minimizes the possibility of damaging fine details. Aquapour is formulated to minimize air bubbles and voids.

Benefits

- Easily mixed with water
- Pourable and injectable
- Environmentally friendly, no special disposal procedures required
- Washes away in cold tap water
- Compatible with all commercial resins prepreg compounds
- Makes complex part manufacturing simple
- Easily dried in a convection oven
- Easily repaired and re-formed
- Reduces labor
- Saves money
- Saves time

Aquapour is available in 5 to 55 gallon containers.

Aquaseal is recommended to seal the tool and prevent resin migration.

Call or fax Aero Consultants AG for assistance with your specific manufacturing requirements.

Aero Consultants AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
Email: info@aero-consultants.ch
Internet: www.aero-consultants.ch

Aero Consultants (UK) Ltd.
13/14 Clifton Road
GB-Huntingdon, Cambs PE29 7EJ
United Kingdom
Tel +44 (0) 1480 432 111
Fax +44 (0) 1480 412 910
Email: info@aero-consultants.co.uk
Internet: www.aero-consultants.ch

Instructions for using Aquapour

Note:
Remove the desiccant bag and mix the material in the pail with a blender very well before beginning Step 1.

1. Prepare mould. We recommend a Lecithin based mould release (e.g. rape oil) and apply the rape oil with a brush or use a Teflon foil or tape. *Never use release wax!*

2. Combine Aquapour™ with water.
    a. Recommended mixing ratio is 55% Aquapour™ powder material to 45% water by weigth.
    b. Small amounts of additional water may be added to improve pouring consistency; however, drying times will increase slightly if excess water is added.

3. Pour Aquapour™ into mould.
    a. Working time is 5-10 minutes.
    b. Vibrating the material while in wet form will help reduce bubbling. Pouring the material in a Vacuum will also reduce surface bubbling greatly.
    c. Material will set up in approximately 1 hour.

4. Remove mandrel from the mould.
    a. Mandrel must be removed from mould prior to being dried.
    If you have problems to demold the material, before you put it in the oven. You can put the material with the mold in the freezer, to get the material very hard (frozen) and after it is frozen you can remove the mold without problems. The frozen material will then put in an oven and dried without the mold.

5. Dry in a convection oven. Fundamental Heating- / Cooling rate 3°C /min.
    a. We recommend the material be dried at 135°C (275°F) at 1.5 hours per inch of mandrel thickness.
    b. The material can also be dried at temperatures below 135°C (275°F). However, drying time will be increased. Aquapour™ is thermally stable and can withstand temperatures in excess of 200°C (392°F).
    c. Drying times for Aquapour™ vary according to the part geometry and surface area. The more surface area that is exposed the shorter the drying time.
    d. Drying times will increase exponentially as the part geometry increases.

Aero Consultants AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
info@aero-consultants.ch
www.aero-consultants.ch

Aero Consultants (UK) Ltd.
13/14 Clifton Road
GB-Huntingdon, Cambs PE29 7EJ
United Kingdom
Email:
Internet:
Tel +44 (0) 1480 432 111
Fax +44 (0) 1480 412 910
info@aero-consultants.co.uk
www.aero-consultants.ch

Instructions for using Aquapour

6. Remove mandrel from oven.
    a. To avoid cracking, we recommend turning the oven off with the mandrel inside and letting the mandrel cool in the oven. This prevents thermal shock.
    b. If tooling is necessary, using Aquafill™ to give the mandrel a smooth porcelain-like feel.
    c. Aquafill™ can also be used to patch any defects or imperfections on mandrel.

7. Seal the mandrel.
    a. We recommend Aquaseal™, a water-soluble sealer, compatible with Aquapour™.
    b. Once dried, apply Release Agent or Release Wax on the Aquapour.

8. Lay-up on mandrel to make finished part.
    a. Aquapour™ is compatible with the curing temperatures of all commercial pre-preg materials and resins.

9. Wash away Aquapour™ from finished part.
    a. The material can be washed away under a faucet or with a standard garden hose.
    b. Heated water is not necessary but will drastically increase the wash out of the mandrel.
    c. Aquapour™ is environmentally friendly so no special disposal procedures are needed.

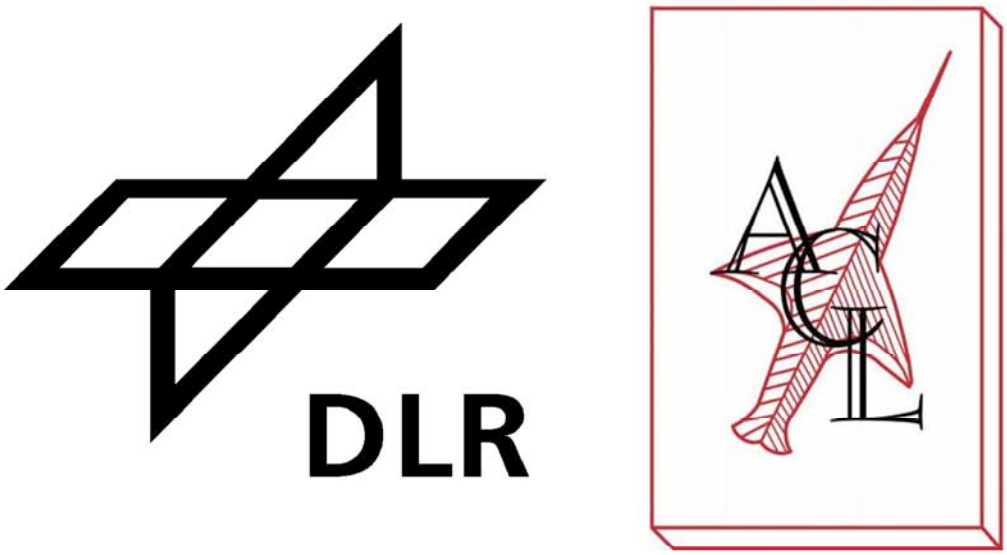
Call or fax Aero Consultants AG for assistance with your specific manufacturing requirements.

Aero Consultants AG
P.O. Box 35
CH-8606 Nänikon/Uster
Switzerland
Email:
Internet:
Tel +41 (0) 44 905 28 00
Fax +41 (0) 44 941 31 37
info@aero-consultants.ch
www.aero-consultants.ch

Aero Consultants (UK) Ltd.
13/14 Clifton Road
GB-Huntingdon, Cambs PE29 7EJ
United Kingdom
Email:
Internet:
Tel +44 (0) 1480 432 111
Fax +44 (0) 1480 412 910
info@aero-consultants.co.uk
www.aero-consultants.ch

Report

Microwave Drying of Aquacore, Aquapour and Aquaseal



Institute for Composite Structures and Adaptive Systems
DLR Braunschweig

Braunschweig, June 2005

Contents

1 Overview

This report discusses the findings of our analysis of the forming materials Aquapour and Aquacore as well as the releasing agent Aquaseal, produced by Aero Consultants Ltd. AG. The drying behaviour of said materials in a microwave oven was examined, especially with respect to possible acceleration of the drying process in comparison to conventional ovens.

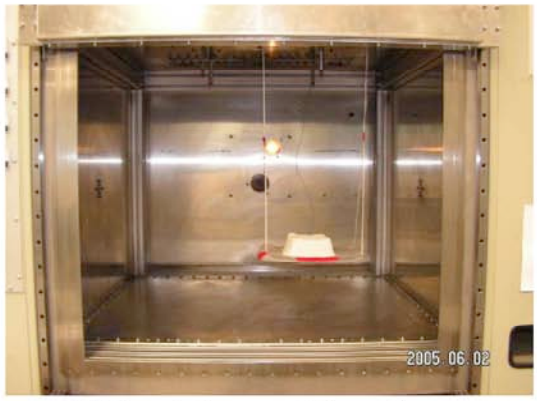


Abbildung 1: Gesamter Mikrowellenraum

2 Experiment Setup

The Institute of Composite Structures and Adaptive Systems uses a custom-built microwave oven equipped with four magnetrons. Each magnetron can be separately controlled to supply up to 2000W of microwave power at a frequency of 2.45GHz to a 1m^3 cavity. In order to examine the drying process it is necessary to continuously weigh the specimen.
Since it was not possible to install a scale within the microwave field a scale was placed above the microwave cavity, and cords of polypropylene (PP) routed through openings in the cavity wall were used to connect it to a polypropylene plate supporting the specimen (Fig. 2). To enable water to evaporate from the underside of the specimen, holes were drilled into the plate. Fig. 1 shows the microwave cavity with the specimen placed on the plate.

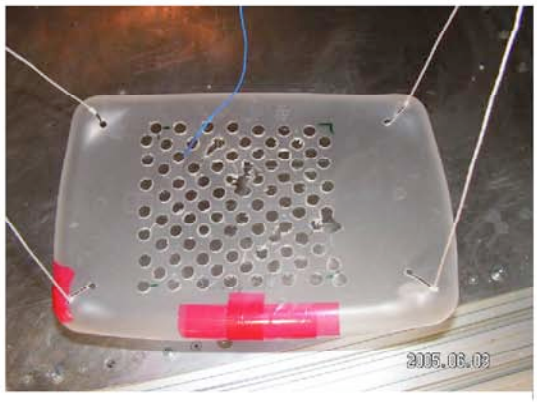


Abbildung 2: Gelochte Platte

3 Experiments

3.1 Aquacore and Aquapour

Aquacore and Aquapur are both delivered in form of a powder which was then shaped into a specimen. The shape was provided by small PP containers which were filled with Aquacore or a mixture of water and Aquapour. The dimensions of the specimens were about 4.5cm x 12.5cm x 12.5cm, resulting in a volume of about 700ml.
Aquacore is inserted into the PP mould without any further preparation. The whole process of forming is completed within 15 minutes.
Aquapour is mixed with 45% by weight of water and left to sit for one hour before it is demoulded.
The specimens are then placed on the plate inside the microwave cavity. The emitted microwave power is kept constant throughout the experiment. During its course temperature and weight of the specimen are recorded at regular intervals. When the weight of the specimen remains constant, the experiment is terminated.
The temperature is measured by means of thermocouples inserted 1cm into the specimen.

Figure 3: material in forms

3.2 Aquaseal

The releasing agent Aquaseal is delivered in liquid form. In order to examine the drying of Aquaseal the specimen, formed from Aquapour or Aquacore, it is weighed, covered in Aquaseal using a compressed-air spray gun and subsequently weighed again and placed inside the microwave oven. During the drying process the weight of the specimen is recorded at regular intervals until no further decrease in weight is noted.

Figure 4: applying Aquaseal

4 Results

4.1 Aquacore

4.1.1 400W/m³

The first experiment was conducted at a power density of 400W/m³, the measurements taken are displayed in Diagram 1. The weight settles after about 90 minutes, no defects were found on visual inspection.

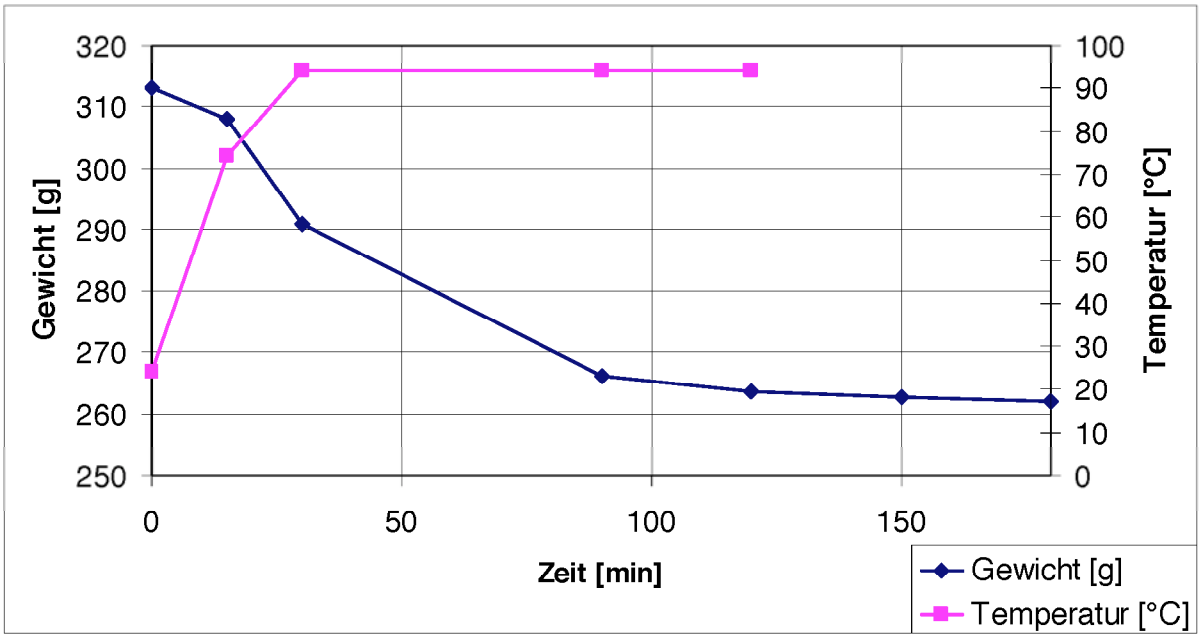


Diagram 1: Aquacore dried at 400W/m³

4.1.2 1000W/m³

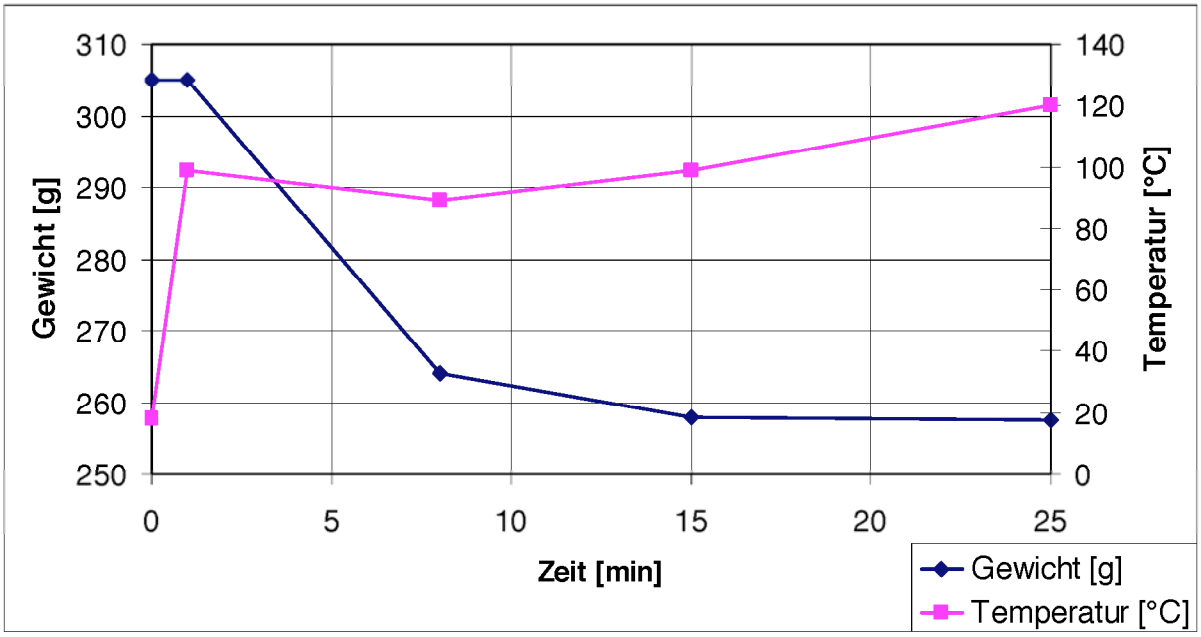


Diagram 2: Aquacore dried at 1000W/m³

At 1000W/m^3 the specimen had completely dried after 15 minutes. Measurements can be found in Diagram 2. No defects could be found on visual inspection.

4.1.3 2000W/m³

The measurements of Aquacore dried at 2000W/m³ can be found in Table 1 as well as Diagram 3. According to these the specimen dried within 7 minutes. The weight decreased exponentially while temperature increases at a rate of 120°C/min up to the boiling point of water and remains at this level for about 4 minutes. As the water content decreases the temperature rises further. Visual inspection reveals no grave defects, only the surface of the supporting plate has left a small imprint in the specimen. The dried specimen can be seen in Fig. 5.

Figure 5: Aquacore specimen at 2000W/m³

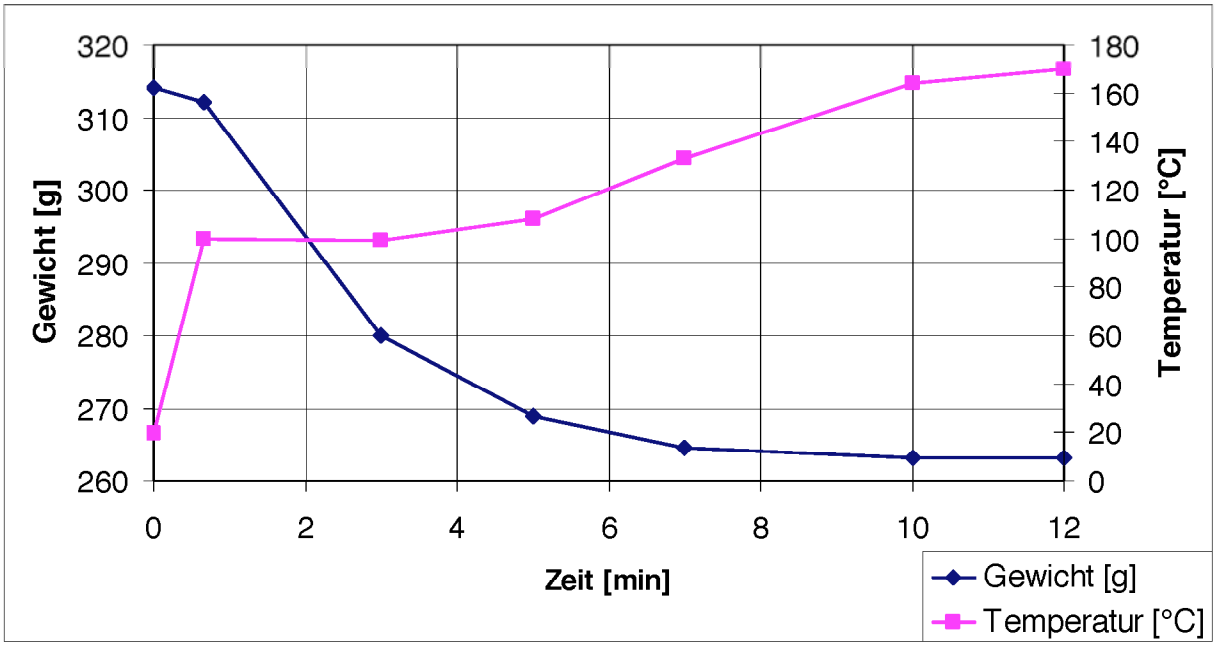


Diagram 3: Aquacore dried at 2000W/m³

Zeit [min]	0	0,66	3	5	7	10	12
Gewicht [g]	314	312	280	269	264	263	263
Temperatur[°C]	20	99	99	108	133	164	172

Tabelle 1: Aquacore dried at 2000 W/m³

4.1.4 Conclusion

Drying of Aquacore can be greatly accelerated by using a microwave oven instead of a conventional following the manufacturer's specifications. Since Aquacore is very porous the generated steam can escape at a sufficient rate.The drying time is presumably limited because of temporary softening in the border regions. This behaviour remains subject to further investigation.

4.2 Aquapour

4.2.1 400W/m³ und 300W/m³

The first experiment with Aquapour is conducted at a power density of 400W/m³. Upon application of microwave energy the temperature rises almost linearly to 79°C within 26 minutes. At that point the specimen is destroyed in an explosion. Its remains can be seen in Fig. 6. Application of 300W/m³ also results in a somewhat less violent destruction of the specimen.

Figure 6: destroyed specimen at 400 W/m³

4.2.2 200W/m³

Safe drying of Aquapour was achieved at 200W/m³. The results of this experiment can be seen in Diagram 4 and Table 2. Measurements indicate that the specimen has completely dried after 180 minutes. Up to that point weight, and consequently water content, decrease linearly. Temperature increases up to the boiling point of water after 45 minutes. 105 minutes into the experiment the temperature starts to decrease again.

Figure 7: destroyed specimen at 300W/m³

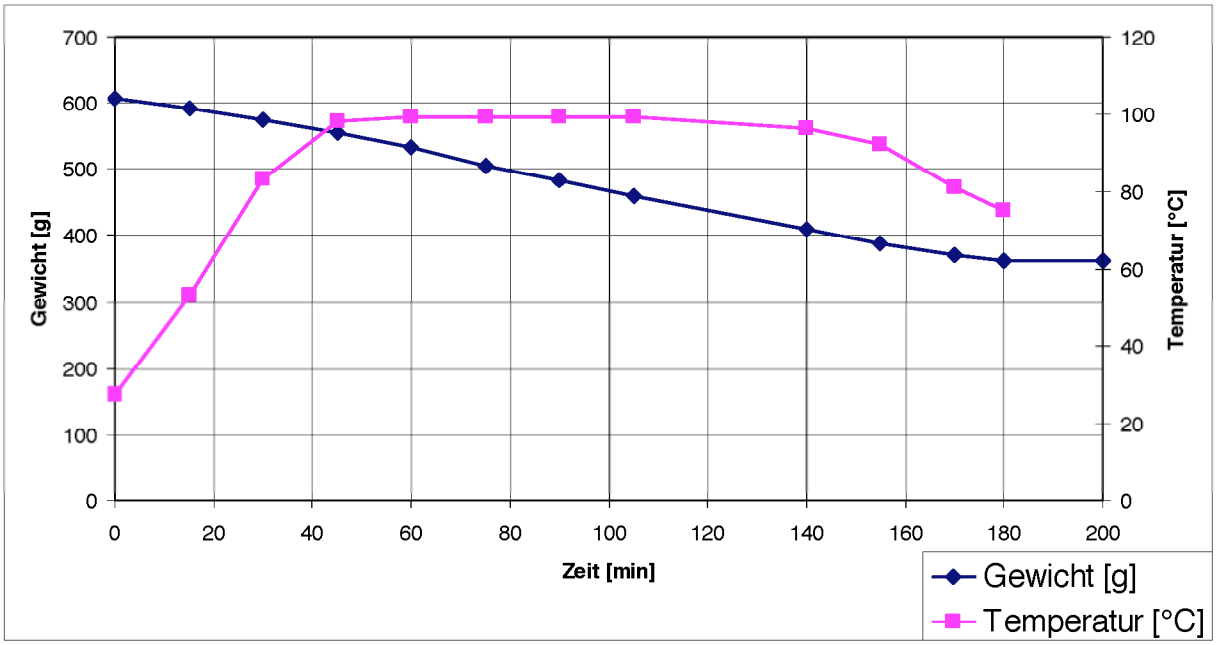


Diagram 4: Aquapour dried at 200W/m³

Zeit [min]	0	15	30	45	60	75	90	105	140	155	170	180	200
Gewicht [g]	607	592	574	555	533	506	483	460	409	388	369	362	362
Temperatur[°C]	27	53	83	98	99	99	99	99	96	92	81	75	

Table 2: Aquapour dried at 200 W/m³

4.2.3 Conclusion

Specifications for Aquapour state a drying time of about 1,5 hours per inch of thickness. These drying speeds can also be achieved using microwave heating.
Drying time is limited by the material's low porosity. Since the developing steam can not escape quickly enough, resulting in an explosion.
It should be noted that the microwave oven used was not designed for drying processes. It is possible that e.g. a different atmosphere inside the cavity could accelerate drying.

4.3 Aquaseal

The drying of Aquaseal using microwave heating was examined at different powers and using different substrates. The results obtained from the experiments can be found in Table 5. The diagram shows that the drying time depends on sealant thickness as well as applied power.
Bad results were obtained only for thick coats and using a power density of 2000W/m³. This experiment resulted in a rough surface interspersed with bubbles as can be seen in Fig. 8.

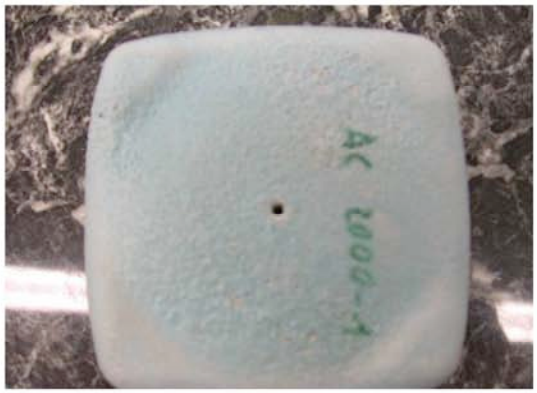


Figure 8: drying at 2000W/m³

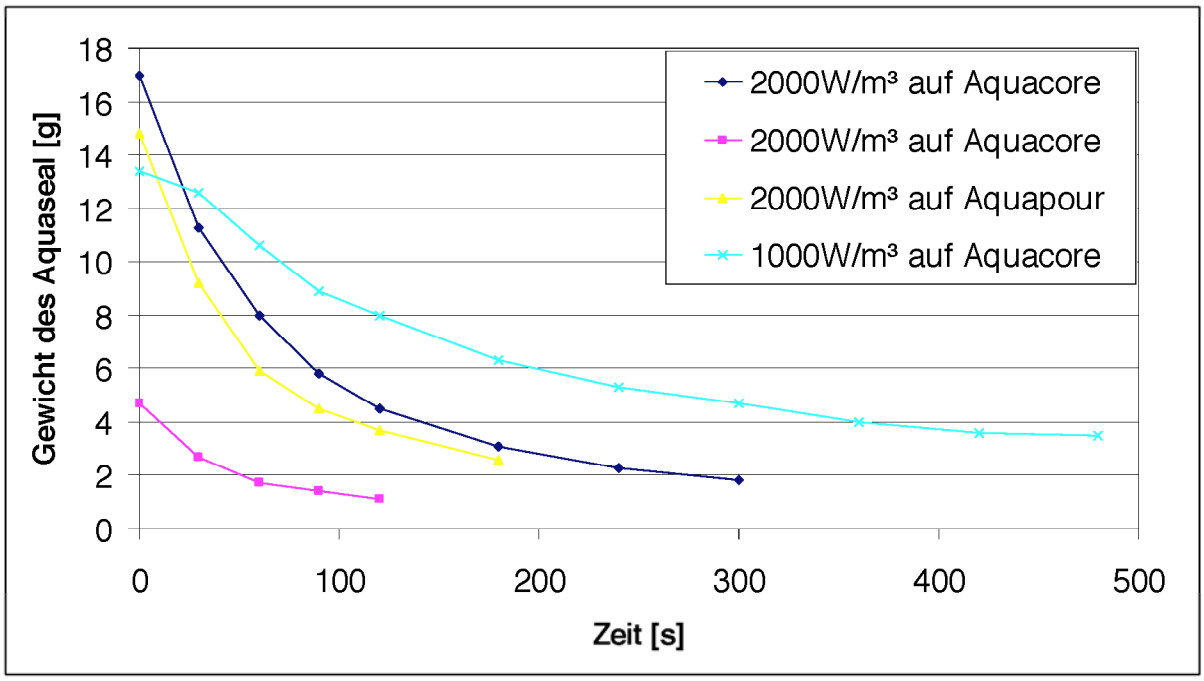


Diagram 5: drying of Aquaseal

4.3.1 Conclusion

The higher the radiated power, the shorter the drying time, as can be seen by comparing the drying process of Aquaseal on Aquacore at 1000W/m³ versus 2000W/m³.
The lower the amount of Aquaseal used, the thinner the layer. Thinner layers result in decreased drying time, although the drying time does not quite decrease at the same rate as the thickness.
Drying time is limited because for thick layers the radiated power has to be reduced, e.g. at 2000W/m³ a 17g coat of Aquacore will blister while 5g of Aquacore will dry at the same power without adverse effect.
A comparison shows that the same amount of releasing agent applied to Aquacore or Aquapour and then dried at the same power level will induce blistering with Aquacore but not with Aquacore. In general Aquaseal will dry slightly quicker on Aquacore.