Go with the flow: conservation of a floating sculpture from 1961 made from glass fibre-reinforced polyester resin

Beerkens, L.; Stigter, S.; van Oosten, T.; van Keulen, H.

Publication date
2008

Document Version
Final published version

Published in
Plastics: looking at the future and learning from the past: papers from the conference held at the Victoria and Albert Museum, London, 23-25 May 2007

Go with the flow: conservation of a floating sculpture from 1961 made from glass fibre-reinforced polyester resin

Lydia Beerkens*, Sanneke Stigter, Thea van Oosten and Henk van Keulen

ABSTRACT Marta Pan's *Sculpture flottante, Otterlo* was commissioned by the Kröller-Müller Museum for a pond at the entrance of the new sculpture garden that opened in June 1961. The floating sculpture is made from glass fibre-reinforced polyester resin and is now coated with white paint layers. The top is connected to the base by a joint with a ball bearing, enabling it to rotate 360 degrees independently of the bottom part when activated by the wind. This smoothly shaped white lightweight water figure is a landmark for the public and an icon for the sculpture garden for generations of visitors to the Kröller-Müller Museum.

In 2004 research into the condition of the artwork was instigated as several problems were apparent: the rotation of the upper part had partly failed, the floating position appeared incorrect and the surface of the sculpture was covered with numerous paint layers. This paper deals with the investigation into the condition of the sculpture and research into practicalities of dealing with a heavy and large floating object. The interview with the artist is discussed as well as the conclusions for treatment and maintenance. The key element is the focus on the artwork as a whole, implying that the motion in combination with water and the outdoor environment are of equal importance as the material elements, the paint layer and the volume of the sculpture itself.

KEYWORDS glass fibre-reinforced polyester (GRP), outdoor water sculpture, poly vinylchloride coating, modern art, artist's interview, Marta Pan

Commission for a water sculpture

During the late 1950s the Kröller-Müller Museum designed a sculpture garden in the natural surroundings of the museum and sourced artworks that would suit the landscape and architecture in the park. The then director of the museum, A.M. Hammacher wanted a work that combined three elements: museum, garden and water. He proposed this to Marta Pan (b.1923) a young Parisian sculptor, who then designed *Sculpture flottante, Otterlo* in 1960–61, the first of many floating sculptures she would go on to produce (see Fig. 1).[1]

In an interview in 2005, Pan explained how she developed *Sculpture flottante, Otterlo* from a small-scale model to a work of over 2 metres high and wide (see Fig. 2).[2] In preparation for the actual work, Pan provided the museum with a photomontage of a scale model positioned in an image of a pond to give a first impression. She also provided technical drawings and a large wooden hand-cut sculpture similar in shape and size to the outdoor floating sculpture.[3] This sculpture served as the model for the work made from glass fibre-reinforced polyester resin (GRP) that was fabricated in cooperation with the professional firm Saint Gobain.

In February 1961 Pan informed Hammacher that the work was in progress and that she had ordered 350 kilos of lead bricks to ballast the bottom of the work.[4] She experimented with one opaque and four translucent layers in the build-up of a 5 mm thick GRP shell, a 'secret technique' she entrusted to Hammacher. She described the material as 'translucent'. The surface was reworked with pumice in order to achieve the right outline and shape of the sculpture. Pan also mentioned that the work would be given a *vernis incoloré*, a colourless varnish to protect against algae, dirt, bird excrements, etc. These notes are particularly important as from photographs and recollections the sculpture is only remembered as having an opaque white skin.

An engineering company was hired for the construction of the mechanical aspects: the ball joint that enables the top part to turn, the balance of the hood, the weight and the floating properties of the bottom part.[5] The actual balance was tested by trial and error in a basin near Paris by placing weights through a large hole in the front of the sculpture. The final balancing and positioning of the weights was carried out after its arrival at the museum and at this point the weights were secured permanently with a large quantity of polyester resin.

Figure 1 Marta Pan, *Sculpture flottante, Otterlo* (1960–1961) in the sculpture garden of the Kröller-Müller Museum in Otterlo (photo: Sanneke Stigter).

Figure 2 Marta Pan with Lydia Beerkens filmed by Frederike Breder during the interview held together with Sanneke Stigter, Marcel van der Sande and Toos van Kooten, 25 April 2005 in the presence of the artwork in the storage of the Kröller-Müller Museum in Apeldoorn (photo: Sanneke Stigter).

The opening in the 'belly' of the sculpture was then closed and sealed, the outline still visible in raking light. The sculpture was installed and loosely attached to a chain from the middle of the pond preventing it from straying onto the grass borders in windy conditions.

Commissioning a floating sculpture for a pond in the year 1960 was obviously a *tour de force*. Marta Pan succeeded in making an appealing modern sculpture – the first white sculpture in synthetic material in the museum garden.

Material history

Sculpture flottante, Otterlo has retained its functionality both in material form and artistic appearance for a long time. General maintenance has consisted of cleaning the surface, removing leaves and dirt by museum staff. The sculpture is stored between the months of November and April to protect it from the pressure of frozen water. For this purpose a custom-made pick-up trolley is used to lift the heavy sculpture from the water.

Recent investigation has provided an insight into the material history of *Sculpture flottante, Otterlo*. Old photographs show the sculpture in a bright and pristine condition. The floating position in the water and the turning of the top part, in combination with the free floating of the bottom part, accord with the artist's idea as shown from her drawings and the technical design. Remarkable is the shiny reflection of the glistening water on the white surface – today the matt surface does not reflect the light in the same manner. The original metal joint is visible on several of the early photographs, whereas now a large clamp is attached around the neck, its bolts altering the outlines of the sculpture. This clamp is an early repair to reinforce a serious crack in the GRP that spread upward along the 'neck' from the joint at the end of 1965.[6] The break was repaired with synthetic glue and a blacksmith added the clamp.[7] The new clamp and the bolts are painted white to match the rest of the sculpture.

Most information from the 1970s and 80s was collected from technical staff members as oral history. It is recalled that the joint had been replaced in 1971. In the same period lead weights were added to the hollow inner part of the hood to correct its horizontal position.[8] Several plugs in the lower edge of the top part, covered with a vinyl-based paint, were applied afterwards. The presence of water inside the sculpture is mentioned from time to time and repairs in both the polyester and the paint layers on top have taken place. The ball joint is greased regularly.

To retain a pristine white appearance, a clean and watertight recoating of the surface of the sculpture every few years seemed necessary. A special paint system developed by the Dutch firm Cocoon that was used in the museum was also thought suitable as a protective coating for *Sculpture flottante, Otterlo*. The sculpture was first coated with Cocoon around 1975 and several repeat applications followed at later dates.[9] On occasion paint was stripped off and the skin partially repaired before the whole sculpture was recoated. Previous repairs were neatly covered. The solvent-based paint system formulated around a polyvinyl-based copolymer is very convenient for recoating; it slightly dissolves the previous layer of paint giving it excellent adhesion properties. A disadvantage, however, is that as no other paint system adheres as well, only the firm of Cocoon can carry out this procedure.[10] The resulting paint layer measures between 0.2 and 0.4 mm. Frequent recoating has resulted in quite a mass of Cocoon on the sculpture, varying in thickness from 10 to 12 mm.[11] This has added weight to the sculpture and may have caused the imbalance in the floating position.[12] Poor adherence to the GRP and good bonding between the vinyl layers have resulted in areas with large bulges. The vinyl paint however has remained flexible, keeping the skin enclosed.

From the 1990s on, more detailed records were kept and condition reports became part of normal practice.[13] In 1991 we learn that the pond was cleaned and the sculpture repaired and sprayed; in 1992 another layer of Cocoon was applied and there were 'blurs on the surface through condensation'. In 1998 the underwater anchorage to the bottom of the pond was renewed with stainless steel and a new rope. In 2000 a hole was drilled in the bottom 'to let the water out' and closed with epoxy prior to recoating. In 2004 water had collected in large bulges in between the vinyl layers at the bottom of the sculpture. Loose paint layers were removed from the bottom and Cocoon's Vinylbond C was used for small fills. Cocoon 550 was sprayed on this lower part. It was further noted that the turning of the top part failed due to the ball joint and that as the position of the whole sculpture in the water had altered it was no longer upright.

Research and conservation set-up

The main goals of the conservation research were to enable the top part of the sculpture to rotate fully in the wind again and to re-establish the upright position of the sculpture in the water. Various questions needed to be addressed. Had the weights shifted causing the imbalance in the sculpture or had the hood or other areas of the sculpture become too heavy by the subsequent addition of paint layers? Had water entered the interior through micro cracks in the aged GRP or were there serious tears in the original material? Would it be possible to make the sculpture watertight again and how? Could a surface coating really provide a watertight protection? It was necessary to obtain more technical information in order to better understand the flotation issues and the best means of obtaining a view of the inside of the sculpture.

The first focus was the ball joint. With gripper tongs the joint was loosened carefully. The large hood was separated from the bottom part with a forklift and both parts of the connecting joint were examined. The joint is constructed from aluminium and stainless steel. Inside are two solid polyamide sockets that enclose a steel ball. The tapered shape of the housing of the sockets allows limited torsion of the top part while turning.[14] The ball was completely rusted; coarse grease, rust particles and dirt had added to the malfunctioning of this joint. The inner part of the joint only needed cleaning and some lubrication. The damaged ball was replaced by a new stainless steel ball.

The hood was weighed on a constructed balance and confirmed as 110 kg; the bottom part was estimated to weigh around 500 kg. These numbers illustrate the difficulty of handling this heavy object that is over 2 metres in width. During lifting this massive object with girdles, it became clear that completely different forces are introduced on the hollow GRP shell than when the water supports the sculpture with evenly distributed upward forces. Proper handling is paramount given the sculpture's aged and possibly deteriorated synthetic structure.

Figure 3 Collage of the X-ray photographs of both parts of the joint in *Sculpture flottante, Otterlo* (photo: Lydia Beerkens).

To obtain a better insight into the construction of the sculpture it was subjected to X-ray examination.[15] A test series was made on selected areas using a mobile X-ray machine after which a continuous series of X-rays was made of the bottom edge of the hood in order to locate the added weights. Both sides of the ball joint were X-rayed, revealing the inner construction of the joint with reinforcement, counterweight and the exact vertical positioning of the joint (see Fig. 3). Radiographs of the bottom part however were unsuccessful: the lead bricks absorbed all radiation and concealed the distribution of the bricks at the bottom. Some repair patches, visible as small distortions in the surface, were revealed. Throughout the investigation, the X-ray films were reassessed from time to time; these revealed more information offering a better understanding of the production process and the material history.

Forces, physics and mechanics

The next issue was how to calculate the amount of weight that would be needed to regain the correct floating position of the sculpture in the water. Consulting a physicist about the opposite forces of weight and upward pressure from the water made clear that the asymmetrical shape and ever-changing direction of forces by the turning of the hood made exact calculations about floating position and level impossible. The alternative was testing by trial and error. A large inflatable basin was set up as part of the first test (Fig. 4).[16] The sculpture could be placed in the basin by lifting it with a forklift and girdles. First the bottom part was lowered slowly into the water. This part floated perfectly in an upright position without the hood, implying that the hood could be responsible for the sculpture's imbalance. The hood was joined smoothly to the bottom section with the new ball bearing in the cleaned joint. At this point the front of the bottom part dropped too deeply into the water and the reason for the malfunctioning of the rotation immediately became clear. With the front too deep in the water, the lower half of the joint leans and actually blocks the turning point. When the tail side was pushed down, a more upright position was achieved and the joint was unblocked: the hood swayed smoothly on the wind.

It was estimated that a weight of 37 kg on the back side of the bottom part was needed to lift the front sufficiently from the water to rebalance the sculpture in its upright position, allowing a full rotation of the hood. It is possible that some of the lead bricks had become loose during handling or transport of the object and had shifted position, thereby causing the imbalance. Adding a counterweight of 37 kg to the sculpture would cause the whole object to drop by some 2 or 3 cm in the water. This was considered to be a reasonably good solution that would not result in too much of a visible change, assuming it would be possible to add the weight.

The balance of the top part was tested separately. It needed some 750 g of additional weight on the short end in order to achieve perfect horizontal alignment again. The extra weight was added by inserting a line of fishing lead weights through a small hole drilled in a disguised area in the hood. The line was fixed in the hole to allow easy removal should this be necessary. The material that was removed to accommodate the addition of weight provided a good opportunity to study the condition of the shell of the sculpture: it measured 7 mm thick and was solid and whitish in colour. The independent layers of coating measured some 2 mm each.

Figure 4 Balancing out *Sculpture flottante, Otterlo* in the inflatable basin (photo: Lydia Beerkens).

To investigate the interior of the bottom part it was decided to drill a small hole to enable access for an endoscope. The hole (approx. 9 mm diameter) was located at the bottom of the back above the water level. The first view of the interior showed a yellow-white surface with glass fibre cloth. It is clearly the last of the layers that were positioned in a mould formed from the wooden model. Looking lower down in the large hollow space was quite disappointing – total darkness. When moving the camera lower, however, a glimmering brownish blurry surface appeared. It was not a clear sight of the lead bricks for which we had hoped – the bottom was dirty with mud and sand obviously leftover from the period when water had entered the sculpture. It could be concluded that weight should only be added when the sculpture is empty of water and the GRP structure is watertight.

Analyses of the synthetic materials

The exact condition of the polyester is unknown but the general impression gained from the drilling of small holes is that of a thick, solid and strong material. At the bottom a steel plate is attached where the hook is positioned to connect to the chain in the pond; this may be the weak spot from which small cracks might have emanated. This area cannot be reached to investigate the state of the polyester without stripping off the paint layers. Although this has been done previously, this raises the question of what should be applied after repairing the polyester. Cocoon is still an option as it has functioned previously as protective layers with the result that the sculpture is still in reasonably good condition. The polyester sculpture survived 45 years in the water under climatic fluctuations, sun, wind and rain, protected by the coating. However, the subsequent and unevenly distributed weight might have disturbed the balance of the sculpture.

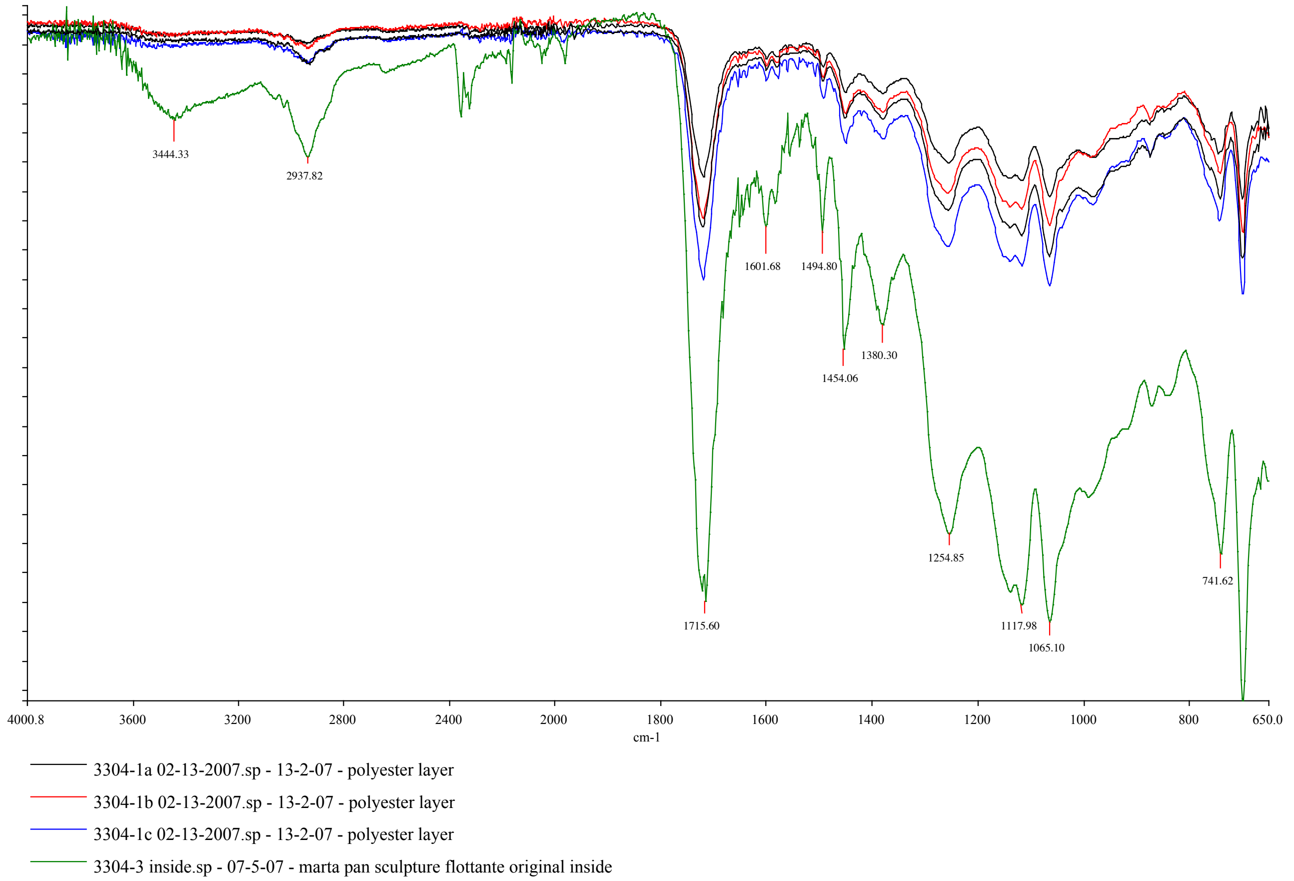

Figure 5 FTIR spectrum of polyester layers and first white layer from Marta Pan's *Sculpture flottante, Otterlo* (green spectrum) (Thea van Oosten, ICN).

Fourier transform infrared (FTIR) analysis of the polyester and the (later) paint layers was performed on sample material derived from a drilled hole made for the endoscopic investigation. To determine the components of the Cocoon layer, the first white layer and the GRP resin, about eight samples were taken while exploring the sculpture with the endoscope (see Fig. 5). FTIR analysis was carried out while the sculpture was in winter storage using a portable Smith Detection Identifier instrument. The Identifier is a miniaturised analysis system that is fast, easy to use and accurate. Its small footprint, sturdy all-metal construction and sealed housing make it ideal for on-site use. All samples were recorded using an attenuated total reflectance (ATR) sampling device and a microscope to examine their colour, size and structure.

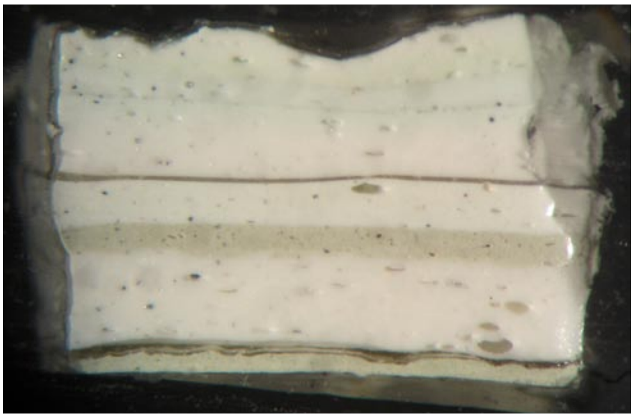

Figure 6 Sample 1A: cross-section from the spot where a small hole was drilled for examination of the interior with the endoscope. Stereomicroscope photograph (optical magnification 64×) shows several layers of coating, probably seven layers of Cocoon with slightly different tones of white. The thicker layers contain numerous air pockets (sample preparation and photo: Evelyne Snijders, SRAL).

Results

The first white layer consists of adipic acid and a polyurethane, referring to an alkyd paint (a kind of polyester resin) modified with urethane linkages. The condition of this polyester paint layer is more degraded than the other polyester resin samples, as can be seen by an increase in C–OH functional groups at 3444 cm^{-1}, resulting in more oxidised and hydrolysed groups (see Fig. 5, green spectrum). The Cocoon layer consists of a polyvinyl chloride which, according to the manufacturer, is a polyvinyl chloride (PVC) polymer (see Fig. 6).

With the use of pyrolysis combined with gas chromatography–mass spectrometry (Py-GC–MS), cured polyester resin will pyrolyse into styrene, styrene dimer and trimer, fumaric acid, benzoic acid, phthalic acid, glycol and cinnamic acid. Most of these are related to the original building blocks of the unsaturated polyester. The presence of cinnamic acid in the chromatogram is pyrolitic proof of the existence of the cured polymer network, the linkage between the reactive double bonds (fumaric acid) and styrene.

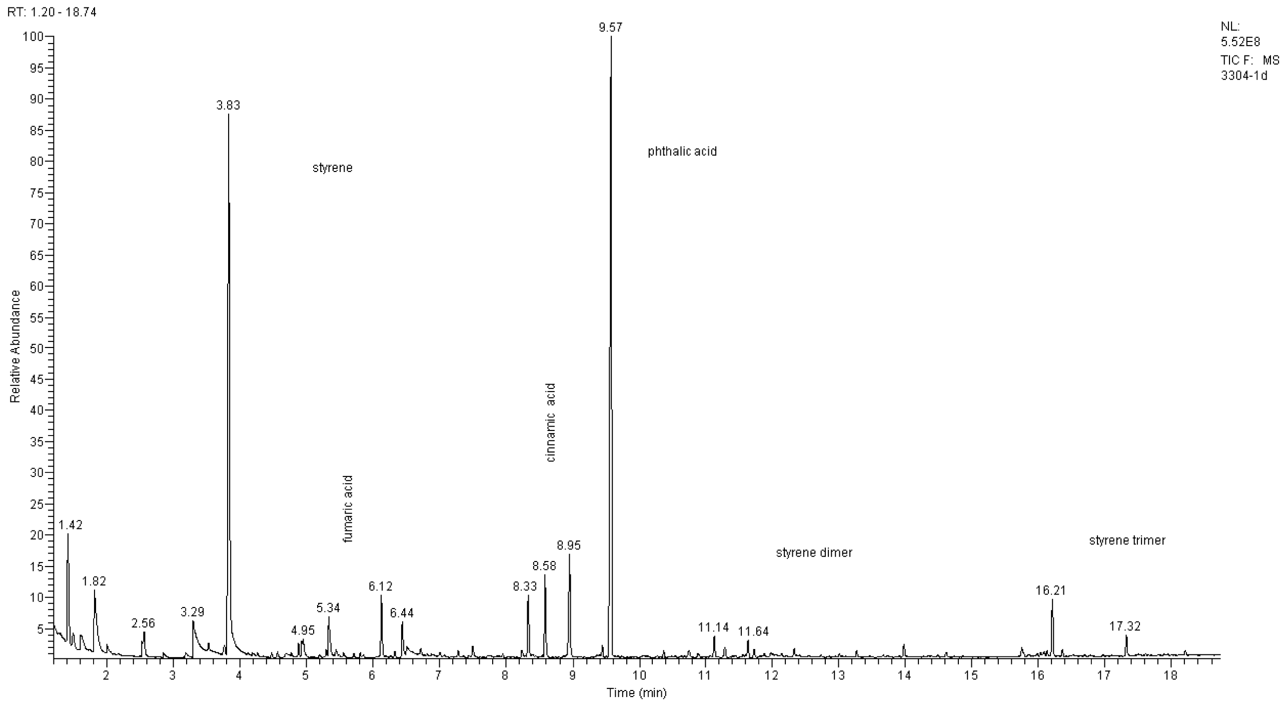

Figure 7 GC–MS spectrum of the glass fibre-reinforced polyester.

According to Py-GC–MS, the components or 'building blocks' of the polyester samples of the inside of *Sculpture flottante, Otterlo* are all similar and consist of fumaric acid, ethylene glycol and o-phthalic acid.[17] The presence and peak height of fumaric acid, cinnamic acid and styrene dimer and trimer confirm that the GRP sample is in good condition (Fig. 7). No serious amount of degradation was established on the polyester samples due to the fact that the polyester was protected by the various Cocoon layers.

The analyses of the first paint layer, or layers, on the polyester are difficult to interpret; styrene and phthalic acid might be from the polyester underneath. The presence of pentaerythritol together with the phthalic acid suggests the presence of an alkyd resin applied as a binder for 'alkyd paint'. Alkyds are sometimes modified with styrene and/or urethane. Adipic acid and toluene diisocyanate (TDI) are pyrolytic components of a polyester urethane resin applied as a binder for 'urethane paint'.

Multiple layers of alkyd and/or urethane might be possible.

The artist's involvement

An interview was arranged with the artist, Marta Pan to discuss the problems. When she first saw *Sculpture flottante, Otterlo* she immediately focused on the shape and volume of her work. She had a remarkably detailed recollection of the sculpture and it became clear how closely she had been involved in the development of the technical issues of getting the right balance. She suggested that the answer to the problem would be to simply cut a hole again, rearrange the lead bricks and close and repair the hole afterwards. When asked about the original appearance and whether to peel off the Cocoon layers, the artist focused on a different matter. She proposed sanding some of the polyester down in order to regain the original shape – the original outline and sharp contours of the sculpture had apparently been lost. The interview is a valuable source of both verbal and non-verbal information that can be reconsidered from time to time.

The complex conservation issues surrounding *Sculpture flottante, Otterlo* were discussed with a study group coordinated by the Foundation for the Conservation of Modern Art involving curators and conservators who assess and validate what is gained and what is lost after the decision-making process in the conservation of modern art.[18] The idea of a replica sculpture was suggested in order to allow the 'original' sculpture to be placed indoors and saved from further decay but it was decided that *Sculpture flottante, Otterlo* 'still performs well' and is in too good a condition to require replacement.

Conclusion

The complex choices about how to maintain Marta Pan's *Sculpture flottante, Otterlo* lie not only in material matters or physical implications, but also in perception, i.e. how one experiences the artwork. While the changed surface into opaque white layers of Cocoon was of great concern, the artist was mostly interested in the shape of her work. To achieve good results in this sense the choices might veer in the direction of more elaborate interventions and repairs than the generally minimalist approach that is now adopted in conservation. This should be a carefully weighed choice given the needs of an outdoor but very aged sculpture that must be able to withstand severe climatic conditions that are in total contrast to more stable indoor museum conditions.

Research into the conservation of Marta Pan's *Sculpture flottante, Otterlo* was undertaken by analysing the production process and the material history using various analytical techniques. Not all the questions have been answered. However the optical, radiographic and endoscopic investigation, combined with paint layer and GRP analysis have given a good insight into the behaviour of the material and the construction of the sculpture. Despite early technical defects followed by repairs and interventions, *Sculpture flottante, Otterlo* has survived almost half a century rather well. At the same time it is clear that the layers of Cocoon are now very thick and that delamination takes place occasionally, especially on the part of the sculpture that remains underwater. A point will be reached where recoating is no longer sufficient. Although the idea of peeling off the PVC paint layers is tempting, it is countered by the fact that we are uncertain about the condition of the glass fibre-reinforced polyester resin structure. The numerous layers of Cocoon have protected the material over the years from deterioration by light, UV, fluctuating temperatures and a continuous exposure to water. The main goal in the conservation treatment of *Sculpture flottante, Otterlo* is to maintain the lightweight impression of this floating and dancing white sculpture for future generations.

Acknowledgements

We would like to thank Marta Pan for her kind cooperation in the filmed interview, her interest and friendly replies on all further queries in this matter; Evelyne Snijders, student in the Modern Art Conservation program at SRAL for the cross-sections of the paint layers and her kind assistance with the endoscopic research; Arnold Truyen for the X-ray photography and interpretations; Rob van Heyster for being instrumental in demounting the hood, ordering hardware for the joint, taking charge of the lifting and diving into the pool in bad weather; Dr P. Huisman for her kind help with the calculations of the forces, weight and balance of the floating sculpture.

Notes

1. Marta Pan, *Sculpture flottante, Otterlo*, 1960–1961, glass fibre-reinforced polyester resin, aluminium, pond, 216 × 226 × 185 cm (object), 3200 × 1400 cm (pond), KM 115.762, Kröller-Müller Museum.
2. Interview with Marta Pan 25 April 2005 by Lydia Beerkens and Sanneke Stigter, attended by Marcel van der Sande and Toos van Kooten, filmed by Frederike Breder with a camcorder in the presence of *Sculpture flottante, Otterlo* as well as the wooden sculpture in storage in Apeldoorn.
3. Marta Pan, wooden model of *Sculpture flottante*, 1960, 183 × 226 × 216 cm, KM 118.667, Kröller-Müller Museum. In order to enable the wooden model to exist as a freestanding sculpture, Pan had made an additional flat bottom part that could replace the original part that was designed to be largely under water. This artwork can be exhibited as a freestanding sculpture in the museum space. The lower half of the bottom part can be exchanged with an extra piece of the same size and shape as the 'underwater' part from the water sculpture.
4. Letter dated 28 February 1961 from Marta Pan to former director Hammacher.
5. Conversation between Marta Pan, Evert van Straaten and Sanneke Stigter, 10 October 2006, Kröller-Müller Museum, Otterlo.
6. The conservation archive of the Kröller-Müller Museum holds photographs of this damage dated December 1965.
7. Kees Sukkel (blacksmith) and Steven van Beek (head of the technical department of the Kröller-Müller Museum) at a meeting on 25 April 2005.
8. Kees Teunissen and Steven van Beek, 25 April 2005.
9. Cocoon is manufactured by Andek Specialty Surface Products (http://www.cocoon-holland.nl).
10. Steven van Beek, pers. comm.
11. Layer thickness measured at cross-sections from drilled hole in 2007.
12. Cocoon has a density of 0.92–93 kg/dm^3.
13. Information from the archive of the Kröller-Müller Museum.
14. Comparison with the wooden sculpture shows that the joint is similar to the ball joint in the wooden sculpture, where a glass marble is used as the ball.
15. X-rays taken with a mobile X-ray machine by Arnold Truyen, sculpture conservator at the Limburg Conservation Institute (SRAL), 27 June 2005 in storage of the Kröller-Müller Museum, Apeldoorn.
16. 27 September 2005 with the assistance of Rob van Heijster and Hennie Hendriks.
17. Binding media, resins, waxes and modern materials were analysed with thermally assisted hydrolysis and methylation gas chromatography–mass spectrometry (THM–GC–MS) in combination with Curie point pyrolysis. Where possible, sample material is made into a suspension with a few drops of a 2.5% solution of tetra methyl ammonium hydroxide (TMAH) in methanol. The suspension was applied to the pyrolysis wire. For the analyses of polymers, the tip of the wire is flattened and bent into a V-shape, in which the polymer material is placed. One drop of 25% TMAH in methanol is added. The wires are pyrolysed at 625 °C. By the combination of the heat and the reagent, hydrolysis, methylation and pyrolysis takes place of the fatty acids, the resin acids and the polymer fraction of the sample. The total component mixture is separated on a DB 5 ms column by gas chromatography and the separated components are detected and identified with mass spectrometry.
18. See www.sbmk.nl

Materials and supplier

Vinylbond C, described as 'vinyl paint' with as main additional products methyl ethyl keton (70–75%), plasticiser DIDP (8–10%); Cocoon 550 white/grey, described as 'vinyl paint' with as main additional products methyl ethyl keton (65–67%), and plasticiser DIDP (8–10%): Cocoon Holland B.V., PO Box 1090, NL 1300 BB Almere, The Netherlands.

Bibliography

Jianou, I. and Pely, A. (1974) *Marta Pan*. Paris: Arted, Éditions d'Art.

Lambert, J.C. (1994) *Marta Pan de la sculpture au paysage*. Paris: Éditions Cercle d'Art.

van Kooten, T. and Bloemheuvel, M. (eds) (2007) *Beeldentuin Kröller-Müller Museum*. Rotterdam: Kröller-Müller Museum, Otterlo, NAi Publishers.

Author's address

*Author for correspondence: Lydia Beerkens, Woordsesteeg 11, NL 6605 JB, Wijchen, The Netherlands (lydia.beerkens@planet.nl).