

Scanning the 19th Century

ÉCOLE CENTRALE DE NANTES

École Centrale de Nantes is a topnotch science and technology school. Over the years, it has acquired a solid reputation and has become a *grande École* for general engineering, as demonstrated by its 11,000 graduates' current positions and by their esteemed credentials in the business world.

Centrale Nantes offers engineer training and boasts a center for research and industrial studies. These studies are carried out by student-engineers in research laboratories under the tutelage of research directors. Its research units include nearly 2,000 researchers with experimental facilities.

ADVANCED INDUSTRIAL ARCHAEOLOGY AND VIRTUAL MUSEOGRAPHY

In the past years, the field of digital museography has been growing fast, but the current evolution is directed towards ancient industrial systems and assemblies in order to increase the accessibility of the techniques' history through virtual simulations of the visitors. Consequently, the science tools for engineers can be "deflected" from their primary use and used for the redesign of physical machines. As such, 3D scanning and surface reconstruction methods can play a role in relating the machine within its environment.



THE EDUCATIONAL PROJECT

A team from ÉCN conducted the study of an ancient industrial machine, in which a reverse engineering methodology was used for capturing technical characteristics of industrial objects, and acquiring knowledge and know-how, which are essential to contextualize life cycles.

Understanding an old technical machine can be an easy deal for former workers, but it can be difficult and highly delicate for museum curators or visitors of the museum. Besides, using old technical knowledge can be a solution for creating new products. It is in this way of «thinking the future» that the team performed its research. However, instead of working on objects of the present time, the starting point is technical objects belonging to the past.

STUDY HYPOTHESIS

Considering that saving and maintaining physical objects are very costly for museums, and considering that dismantling of the piece is sometimes nearly impossible as the machine crumbles to dust, the team approach proposes a new kind of finality: the preservation of the machine as a numerical object.

Consequently, using virtual technologies can be a real benefit for visitors and curators. Virtual Reality is a new mediation tool: unlike in videos and thanks to interactivity, the operating process becomes easier to understand. The visitor is no longer a spectator of an exhibit, but an actual actor. As he is immersed in the system, it is possible for him to test the virtual machine to its limits. Moreover, the mediation-tool detail level can be adapted to the targeted public and thus make the machines come alive.

3D DIGITALIZATION

In order to resolve the problem of patrimonial object conservation, we have to capture physical data if it exists. Compared to the basic tools, 3D digitalization has proven to be very effective for the optimization of costs and time for measuring complex machines. Moreover, as archaeology usually deals with old objects, "contact" is sometimes impossible or even forbidden, which is not a problem when using 3D scanning devices.

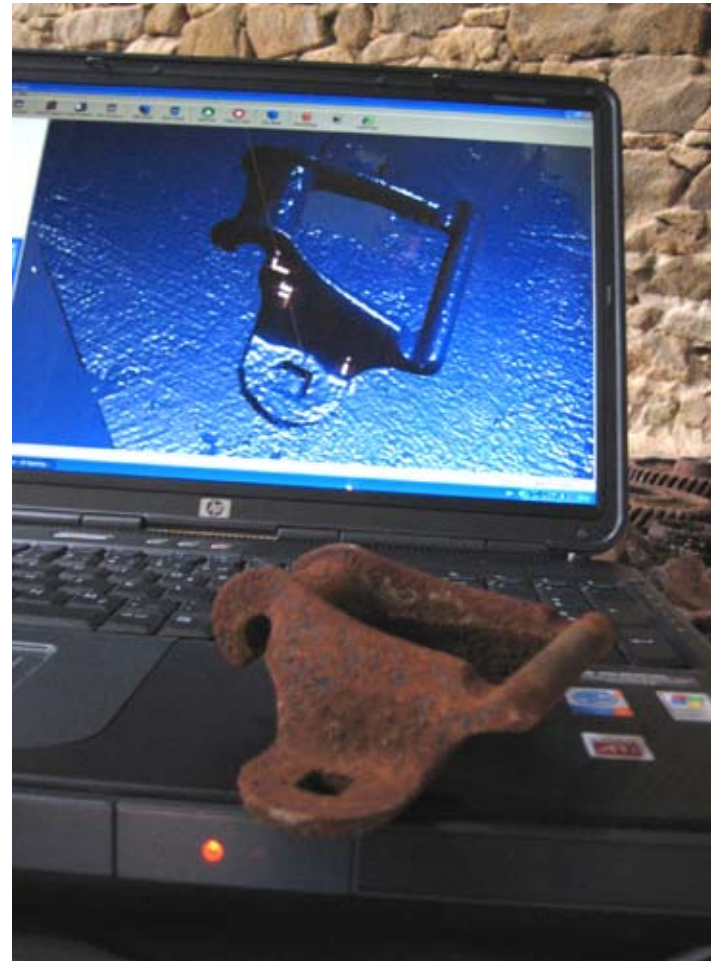
THE AMAZING DISCOVERY

The story depicted here is about a study that began 20 years ago, and which is the result of an encounter with an industrial technical object: a handcrafted machine of the 20th century.

In 1984, the Salt Marsh Museum opened in Batz-sur-Mer, France. Three years later, the Museum went looking for new buildings on the Museum premises. The search led to the discovery of a 31,200 ft² architectural unit, built in local granite and equipped

with a wooden floor and a slate roof, that was previously used for storing salt. Inside the main building was discovered a large machine made of wood and metal, which preliminary analysis indicated that the machine had been in contact with a product that had caused it to deteriorate over time: salt.

A primary health status revealed that the object disintegration was inexorable and that the machine was deteriorating very quickly, making it urgent to immortalize the machine. To do this, numerous photographs of the huge installation (215 ft² base and 11 ft height) were taken.



That aside, there was yet to understand how the machine worked and how it was built 90 years ago. To do so, other technical intermediary sketches were done. Moreover, a 3-dimensional photograph was produced in order to contextualize the machine in its architectural framework at a precise date.

SALT-WASHING MACHINE: FROM 3D DIGITALIZATION TO TECHNICAL AND HISTORICAL STUDIES

After thorough reflection and having taken into consideration the various factors implied, the team came to the conclusion that 3D digitalization technology was the most suitable technique to carry on the remaining steps of the project.

Obviously, the laser device chosen had to be transportable. The global digitalization was carried out by the Morel Mapping Workshop architectural firm, with a Leica laser scanner, while the parts hard to reach or requiring more care were scanned using a self-positioning handheld and truly portable laser scanner from the Handyscan 3D line-up.

At the end of this first mechanical study, and thanks to dynamic 3D modeling, the team was able to validate the historical hypothesis suggesting that it was a handcrafted machine. Indeed, even if the trays seem to be similar at first sight, they are in fact all different from each other. The virtual model takes this mainframe and authenticity into account, otherwise the machine could not be operated virtually in the CAD software. In addition, some of the elements were found on the ground around the machine, pretty much in ruins. Because of that, they have been designed virtually, based on the form of components that they were in contact with, and also based on the mechanism study.

The team also succeeded in validating the objective of this industrial artifact: washing the salt by dissolving it in a saturated saline solution.

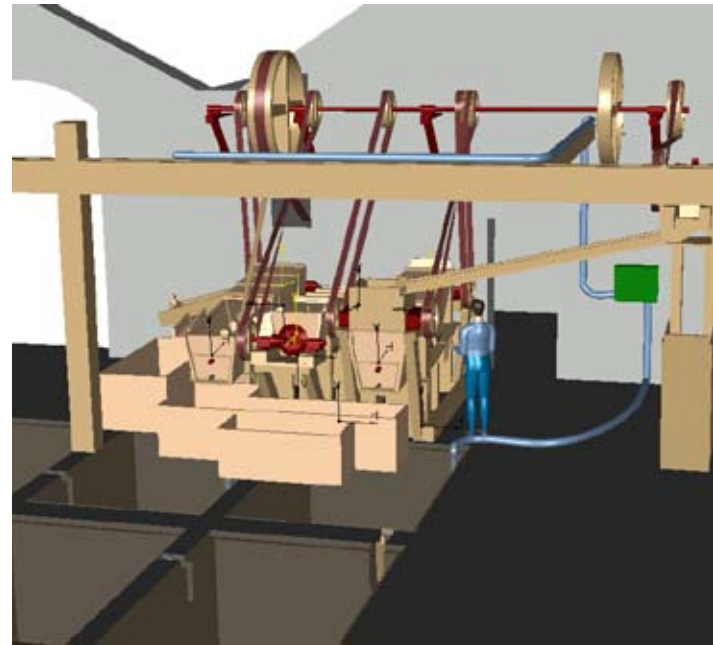
And why do that?

Mainly to meet the requirements of the hygienist clientele of the 19th century, and to save on taxes. Until 1945, salt producers were indeed charged a weight-based tax

on the salt they sold. By washing out the impurities, they would make salt lighter and pay less taxes.

CHARACTERIZATION OF THE SALT-WASHING MACHINE COMPONENTS USING ARCHAEOLOGICAL EXCAVATIONS AND 3D DIGITALIZATION

Some parts essential for the machine to operate could not be scanned by the Leica scanner: the worm blades of the trays because they are inside the machine, and the salt production flow (links and buckets). Both elements were in an advanced state of deterioration, but needed to be scanned because the geometric and structural characteristics of these components were essential in determining the production capacity of the salt-washing machine.



The bucket chain was almost completely destroyed by the salt: it was not suspended anymore and its components formed a pile of rusty material that had to be investigated. Since it was impossible to measure them with traditional tools - it would have caused too much damage - the new measures were acquired using a new and revolutionary 3D technology: a self-positioning handheld and contactless Handyscan 3D laser scanner.

This laser scanner, developed and manufactured by the company Creaform, offers a much higher accuracy than the Leica scanner, in addition to being handheld, lightweight, non sensitive to variations in the environment and 360° scanning enabling.

The Handyscan 3D scanners calculate their position in space by triangulation, using reflecting targets that are affixed to the part itself or to an external reference support, thus creating a single and independent reference system.

In this case in particular, the parts could not be removed from the wetness-saturated atmosphere, for the reaction caused by a hydrometric change would have been so great that the parts would have deteriorated even faster. So, the parts were digitized under optimal conditions preservation-wise, but extreme conditions for the 3D scanner. Even if the links were completely rusty and no more complete buckets existed, 3D scanning has enabled the team to obtain multiple virtual representations. The generic dimensions were calculated by average iterations over all scans.

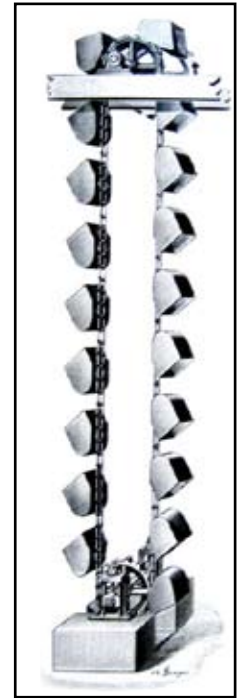
Moreover, blades were found inside holes of the workbench, hidden under a pile of sand, salt and dust. The fact that the blades' edges were sharp and the presence of a file on the workbench confirmed that they had been manufactured directly on site and that minor repairs directly on the salt-washing machine were done.

All these original components were also scanned and compared to those installed on the machine, which allowed for the validation of their original dimensions while the machine was in operation. Then, the whole of the information gathered could be compared to the data from the 1893 Ewart catalogue in order to match the parts.

During the course of this study, the Handyscan 3D laser scanner enabled the team to gather critical data and information.



Actual Bucket Chain



Burton Son catalogue, Ewart chain (1893)

Without the availability of such advanced and accurate technology, the project successful completion and accurate conclusion would have been seriously impaired, as large areas of precious knowledge would have been missing. Thanks to the Handyscan 3D contactless technology, the specific difficulties encountered during the course of this project, such as the impossibility to move the machine and tooling or their confined location, could easily be overcome.