Non-destructive lock-picking

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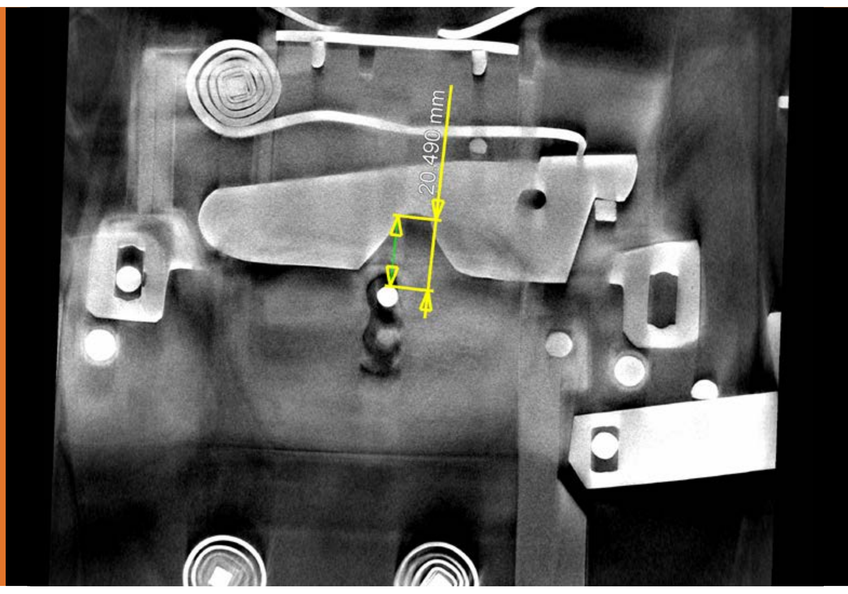
Abstract

One of the challenges in restoration work is to restore locked treasure chests which are missing the key. There exists a considerable amount of historical chests which served as city or guild treasure chests about 200 hundred years ago. The aim of the restoration work is to open the chest for the purpose of its further conservation, the recovery of lock mechanism and a subsequent manufacture of a key. The opening of such locks is complicated if not impossible without damaging the object because these chests have been made in a way that they could be open only with the key. X-ray computed tomography (CT) brings a detailed exploration of lock mechanism and enables to manufacture a copy of the key.



Introduction

In museum depositories there are a considerable number of locked chests or possibly other lockable objects which are missing the key. The inside of chests usually includes dust contamination, moulds and condensation of air humidity. These factors support corrosion of the internal space of the chests and damage other objects inside (for instance paper, documents, fabric, metal dishes). The aim of the restoration work is to open the chest for the purpose of a complete conservation considering the preservation of the authenticity and informative value (without the damage of surface workings); furthermore, the goal is to restore the function of the lock mechanism and to manufacture the missing key.

The request for the CT analysis came from the restoration team of The Secondary School of Applied Arts and the College of Craft Turnov, whose aim was to restore the historical treasure chest. This treasure chest is currently a property of the South Moravian Museum in Znojmo (Czech Republic). There is no record about the chest except the admission into the depository of the museum after the World War II. This indicates the chest comes from an evicted German population of the Znojmo region. It was most likely used as a city or guild treasury since the second quarter of the 19th century. This was determined by the comparison to other chest which has a similar ironwork style. [1]

The easiest and also non-destructive way of opening a locked treasure chest is to make a false key based on the imprint of the lock mechanism. However, this opening method usually doesn't work because the locks often include secret mechanisms against lock-picking. Moreover, the lock can be also damaged from past opening attempts. In this case, it is necessary to resort to a destructive method. That means to cut out some part of the chest, mostly it is the bottom of the chest, and unlock the chest from the inside. This created hole is consequently re-attached to simulate the original surface. However, this invasive and destructive method damages the chest forever and degrades its historical value.

We introduce the use of X-ray micro computed tomography (microCT) as a new non-destructive method to open the locked historical objects which are missing the key. The microCT shows the inner structure of the lock very precisely and can reveal any hidden mechanism or damage. [2] After this detailed exploration of the lock mechanism it is very easy to make a copy of the key and open the lock.

Fig. 1. The treasure chest before the restoration work

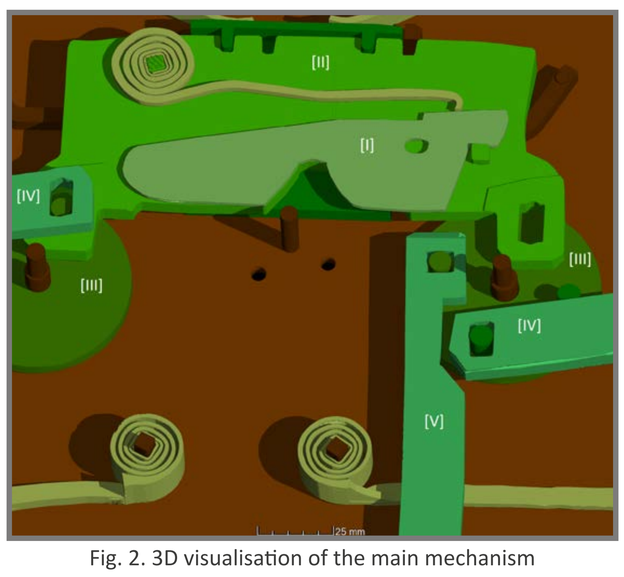


Fig. 2. 3D visualisation of the main mechanism

Mechanisms

The main mechanism operated by the key is shown in a photo recording the restoration work. The key has to go through the unusually shaped keyhole and turning the key lifts the lever [I] and moves the part II. This movement is transferred on guiding wheels [III] and two arms which cause the insertion of bolts [IV][V].

There are other two secret mechanisms which are making the opening of the lock trickier. The first protecting mechanism is related to the X-shaped cover. This cover closes the keyhole when it is in the basic position. It is necessary to push the button hidden in the decorative ornament around the lock (yellow colour) to turn the X-shaped cover up and uncover the keyhole. Moreover, when the main mechanism is opened by the key the lid can be open only in case the X-shaped cover is in the basic position.

Fig. 3. Front view of the lock, the model and real photo

The last mechanism shown in blue is also based on pushing a button. By pushing the button the bar is raised. On the other side of the bar there is a little peg, which by its insertion through the hole, secures the lever. This peg is thought to have blocked the unlocking, but due to its current state its main purpose is still unclear.

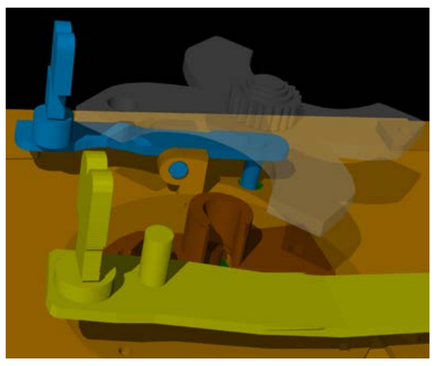


Fig. 4. The inside of the mechanisms related to the secret buttons.

Methods

We conducted CT analysis of the 60 kg heavy steel treasure chest with dimensions 580 x 392 x 410 mm (Fig. 1). The CT measurement of the lock mechanism was performed using an industrial system GE phoenix v|tome|x L 240 equipped with a 240 kV/300W maximum power X-ray micro focus tube and high contrast flat panel detector DXR250 with 2048 × 2048 pixel, 200 × 200 µm pixel size. [3]

The exposure time was 850 ms in every of 1800 positions. The position detector for each X-ray image was randomly shifted to eliminate the ring artefacts. The microCT scan was carried out at 240 kV and 270 µA acceleration voltage and X-ray tube current, respectively. The X-ray spectrum of tungsten target was modified by filters 0.5 mm Cu and 0.5 mm Sn. The tomographic measurement was performed at the temperature of 21 °C and the isotropic linear voxel size of obtained volume was 102 µm.

The tomographic reconstruction was realized using GE phoenix datos|x 2.0 3D computed tomography software. Within this software the object shifting correction and the beam hardening correction in the different material mode (number 8.5) was applied. [4]

The software VG Studio MAX 2.2 was used for all visualization of CT data and the measurement of the key dimensions. [5] The parts of the mechanism were manually segmented by drawing polygonal region.

Fig. 5. The manufactured key

Discussion and Conclusion

Many historical objects from museum collections are locked and their keys are lost forever. As it was long time ago when these objects were made, the used mechanisms of the locks are unknown to these-days locksmiths. The restorers use the "thieving" methods like picklocks, imprints or other tools to open the lock, but the opening of such a lock is usually tricky and mostly impossible because of secret mechanisms which protect the lock before any lock picking. Therefore, they use a destructive method which degrade the value of the historical object.

In this paper we show the microCT technique as new tool for the non-destructive opening of a locked historical object. This technique gives complete view into the inner structure of the lock and shows all difficulties with opening (hidden mechanism, damages).

We demonstrate this approach on the treasure chest from the second quarter of the 19th century coming probably from Znojmo region (south Czech Republic). The microCT system GE phoenix v|tome|x L240 was able to measure such a big object because of the great space inside of the machine. Despite the massive amount of metal parts which caused the beam hardening and artefacts scattering in the microCT data we were able to distinguish all components of the lock mechanism.

The microCT analysis revealed three separate mechanisms of the lock which have to be used in the specific order to unlock the door. Moreover one of those mechanisms was damaged and stuck. It is obvious that the non-destructive opening of the chest would be impossible without the microCT data. On the basis of the CT data the key was designed, manufactured and used for unlocking the treasure chest.

Acknowlegment

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