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Wood Tar Production Without the Use of Ceramic Vessels: Experimental Archaeology in Grodzisko Żmijowiska

Abstract

Several pits, the remains of wood tar production using the so-called 'vessel-less method', were discovered in the Lublin region. They contained objects related to the early Middle Ages. These discoveries were used as the base for experiments run in 2013 in the experimental archaeology centre at Grodzisko Żmijowiska. The first experiment involved the acquisition of wood tar from birch bark, while the other attempts were aimed at extracting tar from pine stumpwood. The experiments were conducted in a shallow pit that was plastered with clay and had a small depression at its bottom used as a container for the tar, separated from the pit by a clay strainer. The raw material gathered in the pit was covered with a clay dome. When the dome was dry, it was slowly heated up with burning wood to the right temperature which was checked inside the dome with a thermocouple. Both processes were conducted successfully. The results were compared with experiments focused on the production of wood tar using the two-vessel method known in the early Middle Ages. The comparison showed that the vessel-less method is less economical due to the amount of fuel used and almost three times less efficient in terms of the raw material to final product ratio. However, it is very simple technically and allows the effective production of wood tar.

Keywords: archaeological experiments, distillation of wood tar, tar production without the use of ceramic vessels

Introduction

In human history, the production of wood tar has been known since the Palaeolithic period and was widely practiced until the mid-20th century. Several methods were used for tar acquisition, beginning with the so-called vessel-less method where only an earthen cavity was used. In later periods, the one-vessel and two-vessel methods were employed.

In the western regions of the Lublin province, the oldest object related to the production of wood tar was discovered in 1998 in Las Stocki in a settlement of the Funnel Beaker culture. It comprised a large earthen pit containing pieces of charred birch bark, which seemingly served for the acquisition of wood tar using the vessel-less method.[1] Although a similar object had been discovered in 1981 in Wąwolnica in a settlement of the Volhyn-Lublin Painted Pottery culture, the research project authors deemed the object to be undated.[2] The first object of this kind discovered in the Lublin region and dated to the early Middle Ages was a wood tar pit found at Łopiennik Dolny, a find which we were directly interested in given that the chronological period was compatible with the archaeological experiments conducted at the branch of the Vistula River Museum in Kazimierz Dolny at Grodzisko Żmijowiska.[3] However, the immediate cause of our trials regarding the experimental acquisition of wood tar using the vessel-less method was the discovery, in 2011, of a group of fifteen wood tar pits

[1] Nogaj-Chachaj 2001.
[2] Zakościelna 1981.
[3] Zakościelna, Gurba 1997.

at the multi-cultural Site 6 in Bogucin.[4] These showed a characteristic cylindrical funnel shape and measured, on average, 1.5 metres in diameter and 1.4 metres in depth. They were dated to the 8th and 9th centuries AD. Due to the further discoveries at this site of characteristic pottery fragments with openings at the base, researchers have been inclined to interpret these pits as the remains of wood tar production using the two-vessel method. However, this does not exclude the possibility that, following the baking of the loess base, a vessel-less process could have been employed in such facilities.[5]

As part of the Experimental Archaeology Workshops which have been run at Grodzisko Żmijowiska since 2005, we have been dealing with the extraction of wood tar, i.e. the so-called 'dry distillation' of birch bark and wood tar using the two-vessel method. This method employs two vessels, one placed on top of the other. The upper vessel, filled with birch bark or pine stumpwood and equipped with a bottom with special openings, stands upon the lower vessel, which is dug into the bottom of the wood tar pit. By being heated with fire, the contents of the upper vessel char, thus producing tar and wood gas. The tar flows into the lower vessel which acts as a radiator, while the wood gas burns out through leaks in the upper vessel in the form of gas flames. Through numerous trials we were able to master this process to perfection, controlling its course via professional thermometers with a thermocouple which facilitated the rapid connection of emerging internal phenomena with the stages of firing and temperature management.[6]

The successful use of the two-vessel method encouraged trials employing other methods of acquiring wood tar and charcoal. The discovery in Bogucin as well as the earlier attempts to reconstruct the acquisition of wood tar using the vessel-less method, conducted by the Institute of Archaeology at the Nicolaus Copernicus University in Toruń[7] and Museumsdorf Düppel in Berlin,[8] have provided us with a foundation both in terms of the sources and methodology.

Experiments

During the Experimental Archaeology Workshops run in 2013, attempts were made at reconstructing this type of earthen pit and using it to distil wood tar. Due to the limited access to the required raw material (birch bark), the experimental pit was significantly reduced in size compared to those discovered in Bogucin. After a hollow with a diameter of 65 to 70 and depth of 30 centimetres was dug in a sandy bottom, the cavity was plastered with thin clay which had been mixed with sand especially for this purpose. Inside the hollow, a cylindrical depression with a diameter of 12 and depth of 20 centimetres was made. This created a container for the tar to flow into. In order to separate the pit from the flowing tar, as well as to prevent its contamination, a clay 'strainer' with four openings was made, thus separating the earthen pit from the container. The edges of the pit were surrounded by stones (Fig. 1). It was necessary to dry and heat the prepared structure by burning a large fire over it. However, despite almost 20 hours of drying and 2.5 hours of heating, the container still remained moist at the bottom. Minor cracks in the hollow were filled in with clay and baked once again. This time, the fire was started by lighting small pieces of wood within the container. The embers fell into the bottom of the hollow and into the container and remained there until the following day. This allowed to achieve the effect of baking the pit's surface layer which prevented the absorption of the produced tar into the pugging of the cavity itself.

After the hollow was cleaned from ash and charcoal, the separately dried and baked clay 'strainer' was set into it before birch bark was placed. Along with another layer of bark, a clay dome was formed which tightly sealed the whole pile of bark. This task was conducted in such a way that the contents of the pit simultaneously served as a support for the still-soft dome. Tightly wound strips of birch bark were placed inside while large pieces of bark were laid on the outside, i.e. in contact with the clay. This way, the layer of clay could be thinner (Fig. 2). The ring of stones on the perimeter of the pit greatly facilitated our work by preventing the movement of the still-fresh dome. When the cavity was ready, the lighting of the fire began with the careful drying of the dome, which took approximately 2.5 hours. The temperature within the pit reached 80 °C. Following the sealing of any remaining cracks, fire intensity was increased. The dome was entirely covered by the fire in which pine wood was used as fuel. Despite a large fire being maintained, the rise in temperature was slow. After another two hours, the thermocouple indicated a temperature of just 100 °C, which is too low for the distillation of wood tar. However, there was a strong smell of wood tar around the pit which may have indicated uneven heating of the contents. Moreover, no flames of wood gas coming from the surface were observed, which are highly characteristic of the two-vessel method and whose production accompanies the dry distillation of wood.

[4] Matyaszewski 2012.
[5] Matyaszewski 2012, 22.
[6] Wasilczyk 2014.
[7] Osipowicz 2004.
[8] Todtenhaupt, Kurzweil 1996.

Fig. 1. Wood tar earthen pit before drying (photo by K. Wasilczyk).

Fig. 2. Wood tar earthen pit during the filling and building of the dome (photo by K. Wasilczyk).

The very slow increase in temperature prompted a change in the wood used as fuel, which was initiated by the placement of thick dry pieces of oak bark. This was followed by a sudden increase in temperature which rose to 300 °C within one hour. However, we would be cautious about drawing the conclusion that it was the change in fuel that sped up the process. We are rather inclined to believe that the thermocouple had been put in the wrong place: just where the thickest and most tightly-packed pieces of birch bark were found. Perhaps these pieces could have caused the uneven course of charring. After 5.5 hours of burning, the temperature reached 405.2 °C; after 6 hours we ceased adding any more fuel to the fire and left the whole pit to cool down. The course of the rise in temperature is shown by the 'wood tar from birch bark' curve (Fig. 3).

The next day, the dome over the pit was still slightly warm. With the aim of acquiring a cross section, the cavity, along with the dome, was cut through and dismantled, followed by an examination of half of the structure. Charred bark occupied one third of the capacity of the pit. While extracting the charcoal, we found out that

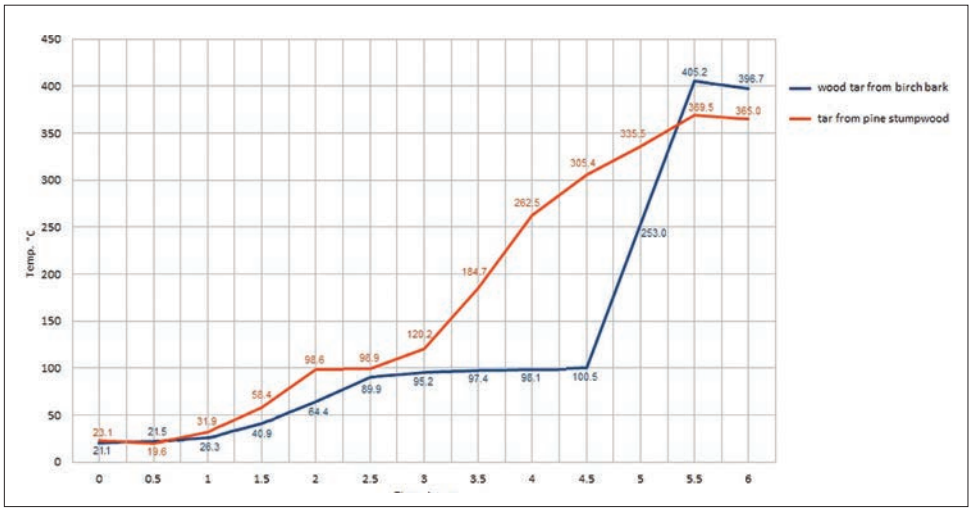

Fig. 3. Graph of temperature during the process of distilling wood tar (compiled by P. Lis).

Fig. 4. Wood tar earthen pit after emptying (photo by K. Wasilczyk).

Fig. 5. Filling of the inside of the pit and dome with pine stumpwood (photo by K. Wasilczyk).

some of the birch bark (approx. 5 to 10%), which had been placed lowest on the grate, was not charred but covered in wood tar with the consistency of soft modelling clay. With the help of a spoon, the tar was extracted from the container (Fig. 4). The wood tar possessed a uniform, soft, plastic consistency, without any distinguishable cracking of the pitch or any wood tar 'water'. Since the amount of bark used was 3.6 kg while the amount of tar acquired was 0.39 kg, the efficiency rate of the process amounted to 11.3%.

After three days, the experimental distillation of wood tar was repeated with one difference: the contents comprised so-called pine stumpwood, i.e. pieces of dried pine roots saturated with resin (Fig. 5). Birch bark was only used to cover the surface of the stumpwood to make sure that pieces of wood didn't stick to the pugging and that the thickness of the pugging matched that of the remaining half of the dome. The course of the process was very similar to the previous experiment. Following the drying of the dome, a large fire was continually fuelled with pieces of oak bark, i.e. waste wood but of high calorific value. The duration of the fire was the same, namely 6 hours. The change in temperature is shown by the 'tar from pine stumpwood' curve (Fig. 3). The increase in temperature was gradual, without sudden spurts, hence the optimal conditions for the distillation of wood tar were created. In both curves, the slowdown in temperature increase at about 100 °C is related to the evaporation of water contained within the contents of the pit.

Regarding external manifestations, the smell of tar appeared during the third hour of firing. Although in neither process was the appearance of gas flames observed, during the time when these potentially could have appeared the entire dome was covered by a large fire. This not only hindered such observations but even made them impossible. In order to judge the course and progress of the process, based on external indications alone and without the use of a thermocouple, the appearance of the smell of tar needs to be taken into account. However, this is not enough to control the process efficiently. In the vessel method, the indications are more numerous and include: the blackening of the pugging of the upper vessel; the burning of the mound; the smell of tar being distilled; as well as the appearance and disappearance of gas flames. These indications allow for sufficiently precise control and assessment of the course of the process while the disappearance of gas flames is a sign that the distillation has come to an end.

Conclusions

The two-vessel method for the distillation of wood tar appeared later and is undoubtedly more economical. It uses far less fuel while the process is significantly more efficient. The more primitive method of acquiring tar in wood tar earthen pits without the use of ceramic vessels does not enable precise control of the process. It is also less economical, uses more wood while the efficiency of the process (11%) is worse than that of the vessel method (30%). However, it, too, is effective in that quite an impressive amount of wood tar was acquired. Perhaps with time, by further repeating the experiment, it would be possible to observe other indications of the process occurring within the pit and relate these to process stages.

It is our hope that the continually developing activities in the field of experimental archaeology conducted at the branch of the Vistula River Museum in Kazimierz Dolny at Grodzisko Żmijowiska will allow us, with time, to gain greater control and better knowledge of the processes involved, as well as to answer many more questions regarding the technology of historical tar production.

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