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This paper provides a brief overview of some of the current knowledge concerning medieval fulling mills, drawing on archaeological finds and manuscript evidence from medieval and early modern England, Wales, France, Germany and other parts of Continental Europe. Illustrations of fulling mills from 1500s and 1600s are compared with medieval accounts of their construction, main tenance and repair. This evidence suggests that fulling mills were simply conventional watermills with the same waterfeed and drive mechanisms as grain mills, but which substituted right-angled gearing and millstones with cam-operated trip-hammers, walk stocks or stamps and fulling troughs. Although there were at least two different designs of fulling mill (an observation supported by the extant illustrations), it may well be the case that other designs of fulling mill existed in France and other parts of the Continent.

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Fulling Mills in Medieval Europe: comparing the manuscripts and archaeological evidence

Dr Adam Lucas*

Résumé

Ce travail est un bref aperçu des connaissances actuelles concernant des moulins à foin médiévaux. Il s'appuie sur des découvertes archéologiques, ainsi que sur des manuscrits conservés depuis la période médiévale jusqu'au début de l'époque moderne des moulins à foin des années 1550 et 1650 sont comparés aux textes médiévaux qui décrivent leur construction, exploitation et réparation. Ces témoignages suggèrent que les moulins à foin étaient tout simplement des moulins hydrauliques classiques à eau et que les moulins à grains ont été subtilisés par un système d’arbre à cime qui actionnait des maillets. Bien qu’il y ait au moins deux modèles différents de moulins à foin selon des illustrations existantes, on ne peut pas exclure que d’autres modèles existaient.

Abstract

This paper provides a brief overview of some of the current knowledge concerning medieval fulling mills, drawing on archaeological finds and manuscript evidence from medieval and early modern England, Wales, France, Germany and other parts of Continental Europe. Illustrations of fulling mills from the 1550s and 1650s are compared with medieval accounts of their construction, maintenance and repair. This evidence suggests that fulling mills were simply conventional watermills with the same waterfed and stone mechanisms as grain mills, but which substituted right-angled gearing and millstones with cam-operated trip-hammers, walk-stocks or stamps and fulling troughs. Although there were at least two different designs of fulling mill (as observation supported by the extant illustrations), it may well be the case that other designs of fulling mill existed in France and other parts of the Continent.

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INTRODUCTION

For those scholars working on early modern and medieval technology, the primary sources for study range from graphic depictions, such as paintings, engravings, church sculptures, relics, illuminated manuscript illustrations and graffiti, to original texts, such as technical treatises, law codes, charters, rentals, and account books (see, e.g., Holt 1998; Ashill and Langdon 1997;Bradford and Wolfe 1998; Langdon 2004; Lucas 2006; Walton 2006). For the pre-modern period, excavation data may offer additional sources. Some rich textual sources of information about topics on which the graphic and textual evidence has been either silent or vague (e.g., Ashill and Langdon 1997. Lewis 1997; Wikander 2006).

However, when it comes to understanding how individual machine technologies actually worked, and the materials from which they were made, the useful sources are far more restricted. For most of the ancient and medieval periods, the illuminating sources about machine design have been Hellenic, Roman and Arabic technical treatises, together with archaeological excavations of a range of sites, including towns and villages, public buildings, villas, monasteries, and military and industrial sites (e.g., White 1984; Wikander 1984; al-Hassan and Hill 1986; Greene 1990, 1994, 1984; al-Hassan and Hill 1986; Greene 1990, 1994, 1984; al-Hassan and Hill 1986; Greene 1990, 1994, 1984). However, there have been very little evidence about how fulling mills were designed and constructed, and at least amongst English language fulling mill scholars (see Langdon 2004; Lucas 2006). Over the last several years, however, some important primary sources have been made available online through the Max Planck's contribution to the Archaeological Project, and some of that material will be drawn upon to inform this discussion. It is hoped that French, German and other Continental scholars may be able to shed more light on this topic following the publication of this paper.

THE FULLING PROCESS AND THE HISTORY OF ITS MECHANIZATION

Fulling is a step in woolen cloth-making which involves two processes: scouring and 'milling' (or cleaning). The blackening process involves matting the wool (or cleaning) to add together strength and water resistance, whereas the scouring process involves cleaning the wool to eliminate oils, dirt and other impurities. Fulling shrinks the wool fibres of the cloth, drawing it together as a denser fabric. The best quality cloth was full, then dyed and brushed with teasels to raise the fabric's pile (hustles were used in the Middle Ages), and finally trimmed of loose threads to produce a high finish. Once the fulling process was completed, the wet cloth was stripped between two horizontal wooden poles and fastened at the top and bottom with iron tenterhooks in what was known in English as a tenteryard. At the end of this process, the cloth would shrunk in size by 10 to 20 per cent.

For centuries, human urine provided a convenient and accessible source of lye in the form of ammonia, produced when the urine becomes stale. This ammonia solution, known as 'wash' in English, not only cleanses but whitens the cloth, and was traded (and sometimes taxed) as a commodity during the Roman, medieval and early modern periods (see, e.g., C. Suetonius Tranquillus, De Vita Caesarum, 'Divus Vespasianus', 549, 599). By late medieval period, fuller’s earth was also used in the process. Mined since Roman times, this extremely versatile mineral clay is still deployed for various purposes. In the fulling process, it served as a degreasing and decolorizing medium due to its ability to bind with oils, grease and other organic matter. Plant known in England for fuller’s herbs, scowerworht, scourwart or soapwort, was also used for scouring. This plant contains soap-like chemicals known as saponins which act as natural detergents, turning into a foamy lather when mixed with water (Martin 2002).

Before mechanical fulling was introduced to the Mediterranean Basin and Europe, fulling was done by foot, by hand, or with clubs wielded manually inside a large trough. The trough contained the cloth and a sufficient quantity of urine to fully immerse it (usually about ankle depth). The fullers would stand in the trough with bare legs, and if fulling by foot, support their weight on the rim of the trough as they trampled the cloth underfoot. The cloth was then taken out of the trough and rubbed across a corrugated surface and rinsed with water to remove the foul smelling liquor. Fulling was most suited to long, heavy broadcloth used for such things as carpets, rugs and winter clothing.

The following passage from William Langland's Piers the Plowman (c.1400) notes the physical discomfort caused by wearing cloth that had not been fulling and the processes involved in fulling:

"Cloth that cometh fro the wraying is not good to wore.

Til it be fulled under foot or in fulling stotes,

Wasshen wel with water and with teasles cruched in natche
den yanked and yepted and under taullours haned."

The earliest unambiguous evidence for mecha

nical fulling comes from Islamic North Africa and Spain in the tenth and eleventh centuries, although recent work by Roman-era archaeologists suggests that fulling mills may well have been in use during the Roman period and, at the very least, by Byzantine times (Lewis 1997; Wikander 2008). Although mechanical fulling had spread throughput...
Throughout Western Europe by the end of the thirteenth century, a variety of manual methods of fulling continued to be used in many countries until the nineteenth and twentieth centuries (fig. 1).

The mechanization of the fulling process involved the substitution of two or more wooden stamps or trip-hammers for the beating of the cloth by hand, foot or clubs. These stamps or trip-hammers were supported in a heavy wooden framework and moved by water-power in a step-wise sequence through the action of a set of rotating cams mounted either directly on the axle of the water-wheel, or on a separate axle attached to what was called a ‘tappet wheel’ in English. The hammers would alternately rise and fall upon the cloth as it lay in the trough, the frequency of their blows regulated by the number of cams attached to the rotating axle, by the gearing which connected the water wheel to the tappet wheel, or by waterworks which controlled the velocity and volume of water directed to the water-wheel (fig. 2).

Whether the cloth in question was being fully manually or mechanically, care had to be taken by the fuller that the whole cloth was beaten evenly and consistently. In mechanical fulling, the trough was rounded at one end so that the cloth would turn gradually with each blow of the trip-hammer. Inattention in managing this process and judging when the cloth had been sufficiently fulled could result in holes in the fabric, thereby ruining a whole bolt of cloth (Martin 2002).

The earliest illustration of a fulling mill that I have been able to locate is this crude working drawing by Antonio da Sangallo the Younger, dated to c. 1526 (75–20), which is accompanied by the following text: ‘gualchiera dove sta lo panne; Gualchierlo lo fusó alza chulle / traverse le manganelle dove / e lo maglio che da lo panno la ruota [...] la chassetta’ (fig. 3).

What is interesting about this and several other working drawings of fulling mills by the German engineer Heinrich Schickhardt from the early 1600s is that the fulling mechanisms which they represent are of a different kind to those in mechanical treatises of the seventeenth century. If we compare the upper left hand side of the drawing of the fulling mill by da Sangallo with the best known representation of a fulling mill by Vittorio Zonca from a century later (fig. 4), we see that whereas Da Sangallo’s trip-hammer is moving up and down in a hammering motion, Zonca’s trip-hammers are moving in a step-wise, back-and-forth fashion.

In the text accompanying Zonca’s illustration, he explicitly acknowledges the existence of other designs of fulling mill. The text explains the advan-

Fig. 2. Operation of fulling mill. Courtesy of Old Fulling Mill Museum of Archaeology, Durham.

Fig. 3. Fulling mill, Antonio da Sangallo the Younger, 1526 75–20. Courtesy of Gabinetto dei Disegni e Stampe, Uffizi, Florence Su concessione del Ministero dei Beni e le Attività Culturali.

Fig. 4. Fulling mill, Vittorio Zonca, Novo Teatro di Macine e Edifici (New Theatre of Machines and Buildings), 1607. 1621.
tages of this design in comparison to others used, for example, in Padsa. It also tells readers that the machines’ measures can easily be deduced from the wheel’s semi-diameter, as shown in the illustration.

While Zonca’s design may well have had advantages over others, it is interesting to see that a number of working drawings for fulling mill installations by Heinrich Schickhart that are roughly contemporaneous with Zonca’s Nero Teatro di Machini e Edificii (New Theatre of Machines and Buildings) are more similar to the design portrayed in da Sangallo’s working drawing from a century earlier (fig. 5, 6, 7, 8, 9). In the top right hand corner of fig. 8, we can see a plan drawing of the fulling stocks and their troughs, as well as the axle bearing four cams for each stock. The sketch reproduced in figure 9 was probably produced as part of a project to renovate an existing site at which a fulling mill and grinding mill (Reib Mühl) were driven by a single waterwheel. Some of the notes are concerned with the wishes of a carpenter about reimbursement for his labour.

In this drawing by the Pseudo-Juanelo Turriano (fig. 10), from c.1595, we have a simpler variation on Zonca’s design, in which a step-wise motion is likewise being imparted to the trip-hammers rather than an up and down motion as in da Sangallo’s and Schickhart’s designs. The accompanying text also explicitly tells us that not much water is needed to drive the device because of the small weight of the stamps to be moved. What is difficult to understand about this design is how the troughs could have held sufficient liquid to assist in the cleansing process. Although it may simply be a fiction for illustrative purposes, the motion of the trip-hammers sideways into a trough without sides would presumably result in any liquid quickly emptying from it. Given the detail of the trough and pounding mechanism represented in this illustration of another step-wise fulling mill by Georg Andreas Böcker from 1661 (fig. 11), it would appear that the trough normally did have sides and a top which enabled the fuller to rotate the cloth using a two-pronged fork. The heated cauldron, bucket and ladle in front of the trough suggest that the cleansing liquor poured onto the cloth may have drained back into the cauldron for re-use.
Fig. 8. Working drawing for a fulling mill in Berg (Stuttgart), Heinrich Schickhart, c. 1615. (Courtesy of Hauptstaatsarchiv Stuttgart)

Fig. 9. Working drawing for a fulling mill and grinding mill (Reib Mühle) in Wil, Heinrich Schickhart, c. 1610. (Courtesy of Hauptstaatsarchiv Stuttgart)
Before moving on to the issue of the size of the waterwheels and the types of waterfed mechanisms used to power these different designs, two issues require comment. The first is that Schickhardt’s drawings in particular make it very clear how the various moving parts worked, what were the shapes of the fulling troughs, and the very characteristic shape of the mallets. Second is that it is useful at this point to start developing some of the evidence from managerial documentation to gain some insights into the vernacular and regional names given the various parts of a fulling mill, and the relative significance of those parts in the design and construction of fulling mills in different contexts and locations. As will soon become clear, the primary texts provide information that is complementary to that contained in the illustrations.

FULLING MILL TERMINOLOGY

Fulling mills are mentioned in the charters and account books of many lay and ecclesiastical estates throughout medieval Europe. The conventional Latin term for a fulling mill is molendinum fullerorum or a cognate such as molendinum fullenum, molendinum fullarium, or molendinum fullatorum (all from the late twelfth century). The term molendinum fullerorum or fullerorum (also late 12th century) can similarly be found in various parts of France. However, the term molendinum panator or paratorum (cloth or apparel mill) also appears from as early as c.1040 from Provence, and is regularly recorded from the twelfth and thirteenth centuries in the Hérault and Toulouse regions of southern France. The term molendinum draperium (drapery or cloth mill) is also recorded from the early twelfth century throughout to the fourteenth century, again predominantly in the southern provinces of France (Lucas 2006).

The vernacular terms for fulling mills varied considerably. In England, two cognate terms for a fulling mill were “tucking-mill” and “walkmyle”. In Wales, the vernacular term was “pandy”. In some Germanic and Scandinavian countries, the term “walkmyle” or “walkemalla” was also used. These terms were presumably transference of the process of fulling by foot to the mechanical process of fulling with water-powered trip-hammers. In Spain and Italy, the vernacular term was “gualchiera” or “gualchiera” (Lucas 2006).

There were local and regional terms for the various working parts of a fulling mill in different European countries. The following discussion will focus on the English evidence, as John Langdon’s research has shed the most light to date on this issue. For those interested in the French terminology, an illustration of the parts of a fulling mill contained in a paper by Levesque et al. (2002) provides the relevant information.

In Mills in the Medieval Economy (2004), Langdon devotes several pages to discussing the material on fulling mills revealed through his extensive examination of the mill records pertaining to more than 300 manors across England between 1300 and 1540 (Langdon 2004). The relevant information on the terminology for fulling mill parts is contained in documents from the 1350s to 1420s, a period during which a considerable number of conventional water-powered grain mills were converted to fulling mills.

The term fulling stock or “walk-stock” appears to have been used to indicate the whole unit of a single trip-hammer, with its hinges, arm, and mallet. The term “betel” or “beetle” was used to indicate the head of the trip-hammer: the wooden mallet. The terms “dagshoe” and “foot” were also used, which is very understandable given the characteristic shape of the mallet, which looks as though it has toes on the business end, as we can clearly see in the illustrations by Schickhardt. The term “shank” was used to indicate the arm of the trip-hammer: again not surprising given that the motion of the walk-stocks was intended to imitate the treading motion of manual fulling. The terms “le perrou”, “trunk”, and “fuller’s block” were some of the terms used for the trough in which the cloth was beaten, the term “trunk” being used presumably because the trough was often made from a hollowed out tree-trunk. Interestingly, the term “hinge” is used to denote a part replaced in many late medieval fulling mills in England, which presumably indicates that there was an iron hinge connecting each shank to the walk-stock. Another interesting detail that Langdon uncovered was that prefabricated walk-stock units were being manufactured in the town of Saffron Walden in Essex in the early 1400s.

GRAIN MILLS AND FULLING MILLS: FUNCTIONALLY CONVERTIBLE MACHINERY?

There has been some debate about whether fulling mills were very similar to conventional grain mills, except that the millstones and the right-angled gearing mechanism used to drive the millstones in grain mills were substituted by a directly driven cam mechanism, trip-hammers and troughs for
Before concluding, it is worthwhile briefly examining the designs of extant fulling mills in Britain and France for comparative purposes. Most of these were originally built in the eighteenth or nineteenth century. Some have been restored and operate as tourist attractions. The higher mill at Helmshore Mills Textile Museum at Rossendale in Lancashire, as well as the Armley Woollen Mill at Leeds, features recumbent trip-hammers, rather than walk-stocks, as does Diderot’s Encyclopédie illustration of a fulling mill from the late eighteenth century. However, the reconstructed fulling mills at Petit Gaumier in Cugand and at Arguegat in the Pyrénées Orientales feature walk-stocks.

Interestingly, Plate X from Duhemel de Lomme’s 1765 manuscript Art de la drapérie principalement pour ce qui regarde les draps fins describes the recumbent trip-hammer as a “moulin à foulon à la façon de Hollande”, whereas the walk-stock design is described as a “moulin à foulon traditionnel ou moulin de France” (Levesque et al. 2002).

CONCLUSION

The evidence reviewed reveals that there were at least two designs of fulling mill: recumbent trip-hammers and upright walk-stocks. A third variant, vertical stamps, has been reported by Rouillard (personal communication 2011), but I have not been able to confirm their use for fulling. Nevertheless, all three variants imitate the repetitive movements of human beings and can be thought of as early forms of robotics.

The fact that English and Welsh grain mills were commonly converted to fulling mills in the wake of the Black Death provides clear evidence that the waterfed and waterwheel mechanisms for fulling mills were in no significant way different from those for conventional grain mills, as no such works are described in any of the relevant accounts (Langdon 2004, Lucas 2006). Indeed, we can see from Schickhardt’s designs for multiple mills (fig. 12) that one waterwheel could power a number of grain mills, fulling mills, and other kinds of industrial mill, and we know of other instances of such combinations in late medieval England.

From the very limited information available, it is not clear whether the different designs of stocks, hammers, and troughs were regional or widely adopted variants, although it is hoped that future archaeological research may provide some insights. The fact that reconstructed fulling mills from the eighteenth and nineteenth centuries appear to be quite uniform in design is more likely a result of standardization through industrialization and probably does not reflect earlier construction traditions.

While I am confident that there is much more useful material to be uncovered from late medieval French, Spanish, Italian and German sources than that which I have been able to assess here, the material presented hopefully provides researchers in ancient, medieval and early modern technology a framework for future inquiry.

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