WASC 2130

Commentary on
John Smeaton
'Water Power'

2010

Water Power
John Smeaton at Waltham Abbey

William Walton purchased the Waltham Abbey Mills from Peter Hudson in 1701. This coincided with the steady rise of the nation states bringing with it growing rivalry in trade and territorial expansion, leading to a succession of conflicts. In Britain's case particularly war with France, in Europe, India, North America and at sea. Consequently there was a constantly rising demand pressure on the Mills and this was reflected in a progression of demolition of out of date buildings, adaptation and new builds, particularly of incorporating mills. The object of incorporation was to produce as intimate as possible a mix of the three ingredients of gunpowder. Incorporation had originally been done by hand in mortar and pestle. Later this was adapted to a system of spring loaded pestles operated by hand or power. The mills in which this took place were termed stamp mills. In Britain on the grounds of safety stamp mills were banned from 1772 and new incorporating mills incorporated the alternative edge runners. Edge runners were circular heavy stones mounted vertically and revolving slowly on a bed of the gunpowder ingredients exerting a twisting pulverising action to achieve the requisite closeness of mix.

The Waltons constructed a series of seven incorporating mills at the southern end of the Millhead Stream moving up from the site of the original Millhead mill. In 1771 for design of a new incorporating mill they turned to an engineer who had established himself as pre eminent in mill design - John Smeaton.
Smeaton has been best recognised for his outstanding civil engineering work on canals, bridges and harbours and of course the first stone Eddystone Lighthouse and he has been termed the 'Father of English Civil Engineering'. This has tended to eclipse the importance of his work on water and wind power.
A generalised image of the Industrial Revolution is one of an economy steadily transformed by the use of abundant reserves of coal and iron backed up by an extensive transport system based originally on the canals and powered by the steam engine. What is less generally recognised is that in the earlier part of the Industrial Revolution the core power source was not steam but water. One of the foremost developers and innovators in water power at this time was John Smeaton.
In 1772 Smeaton carried out a major scientific study of water power. He was a highly capable experimenter and employed elaborate models to test his theories. In 1775 he published the result of his research- ' An Experimental Enquiry concerning the Natural Powers of Water and Wind to turn Mills '. This became a bible for millwrights.
Waterwheels were the medium for creation of water power for mills. They were in four configurations - overshot, medium breastshot, low breast shot and undershot., with the latter the most common. Smeaton demonstrated conclusively that in fact a considerable amount of useable energy was lost when the jet of water struck the flat paddles of the undershot wheel and a significantly increased output with less water useage could be obtained by filling the buckets of overshot or the heel of breastshot wheels and letting gravity do the work.
Fundamental to power is its transmission. Smeaton established principles for optimum design of gear wheels and arrangement of gears, wheel, shaft etc. Power is negated if the machinery does not have

enough

strength to cope with the demands of higher power output. Smeaton played a vital part in propagating the use of cast iron in place of wood in the water wheel and transmission components, at a time when this material was still regarded with some scepticism, producing greater strength and smoother running. In 1769 he was the first to fit a cast iron shaft to a water wheel, replacing a broken wooden one. The wheel powered a blowing engine at the great Carron Ironworks and it is possible that Smeaton's confidence in cast iron lay partly in the knowledge that he could obtain quality castings from Carron. He was similarly in the forefront
of iron utilisation when in 1780 he introduced the use of wrought iron for wheel buckets.

At Waltham Abbey after material preparation it passed through successive manufacturing stages, all water powered, supplemented by horse at a time of peak demand - incorporation, corning, glazing, dusting. Smeaton executed water wheels and machinery for 44 mills, three of them gunpowder. The Waltham Abbey incorporating mill was the twenty first, in 1771. By then his design ideas would have been refined and developed. The available head of water on the Millhead at 6ft. Was not high enough to sustain overshot and he installed a low breastshot mill. Fortunately a series of Smeaton's drawings for mills at Waltham Abbey have survived. Of these the following appear to reflect the mill which was executed, if it is taken that the design specified for the ' West Side of the Mill Pond ' ultimately became the basis for the mill built on the east side.
Figures 5-7 show the configuration of a central wheel of 14ft. Diameter 6ft. Width driving two sets of runners with underdriven shafting and gearing.

Figure	Folio	
5	36v	' Plan of the Building for Mr. Walton's Powder Mill at Waltham Abbey, on the West Side of the Mill Pond ' 1771
6	37	' Plan for Mr. Walton's Powder Mill at Waltham Abbey ' 1771
7	38v	' Upright for Mr. Walton's Powder Mill at Waltham Abbey ' 1771
8	39	' Water Wheel for Mr. Walton's new Powder Mill at Waltham Abbey 1771on the West Side of the Mill Pond ' This illustrates the importance which Smeaton placed, in low breast wheels, on the design of the masonry construction termed fall immediately upstream of the wheel to reduce to a minimum the leakage past the tips of the floats (paddles). Further to obtain maximum efficiency in water utilisation the cast iron plate at the upper part of the water entry should be carefully matched to the shape of the shuttle (sluice) so that only a thin sheet of water is admitted to flow over on to the wheel.
9	39v	' Design for connecting the Water Wheel Axis with the Tumbling Shaft for Mr. Walton's Powder Mill at Waltham Abbey ' 1771 This is important for componemt design and material, showing the gudgeon fixing

at the end of the Axis (shaft) and the use of cast iron for the Tumbling Shaft Box.
This was possibly the first use of cast iron in Essex for a mechanical purpose.

Smeaton's Mill at Waltham Abbey is part of the rich industrial archaeological heritage of the GunpowdeMills. It is significant on three counts :-

Firstly it was an important indicator of the Mills' employment of the leading exponents in spheres of engineering and technology other than explosives - Smeaton in water power, Fairbairn for millwork, Armstrong for hydraulics, Hick Hargreaves for machinery.
Secondly it has left important evidence of Smeaton's design work in the in the configuration of water wheels and machinery in the shape of drawings .
Thirdly it symbolises Smeaton's critical role in development and innovation in water power when water was
the core prime mover in the earlier stages of the Industrial Revolution.

The Millhead To-day
The 18th.century mills were of flimsy weatherboard construction and none of the structures has survived. However two important aspects of Millhead water power can still be seen.
1. The Head Mills
These were on the site of the original fulling mill at the southern end of the Millhead. Unusually they were side driven rather than the more common centre driven. The extensive below ground vaulting for under driven shafting, and gearing, post base, wheel pits, water channels etc have been preserved. Figs. 10, 11.

2. Smeaton's Mill
The substantial cast iron plate at the crown of the fall has survived as a reminder of this 18th century mill designer par excellence. Fig. 12.

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