How water wheels powered the mills

Mill Waters
Parks and Reservoir

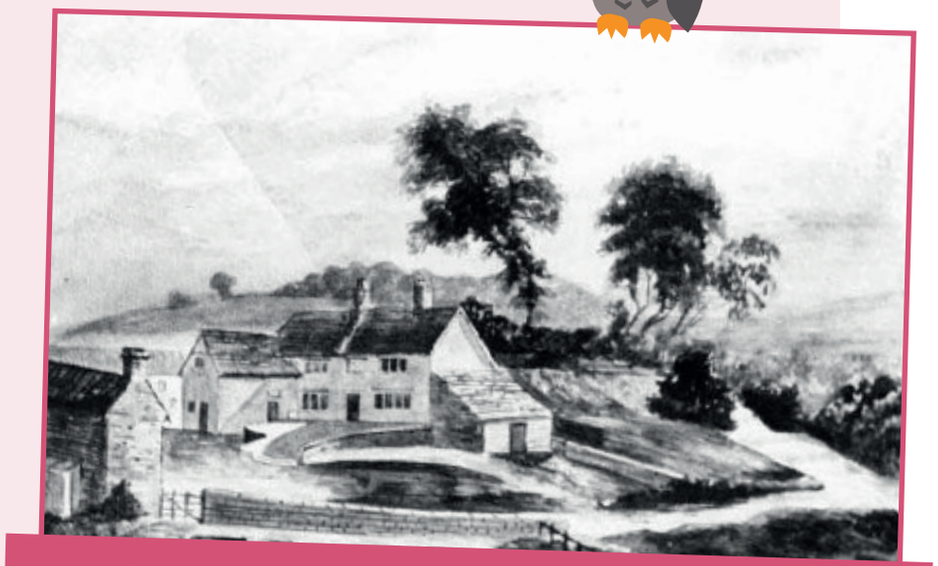
well read
informed communications

This education Pack developed by Kate Dawson at Well Read in consultation with local heritage groups and schools. Particular thanks to Denis Hill, Heritage Consultant for his help providing historic background.

at Mill Waters heritage site

History of the water wheel

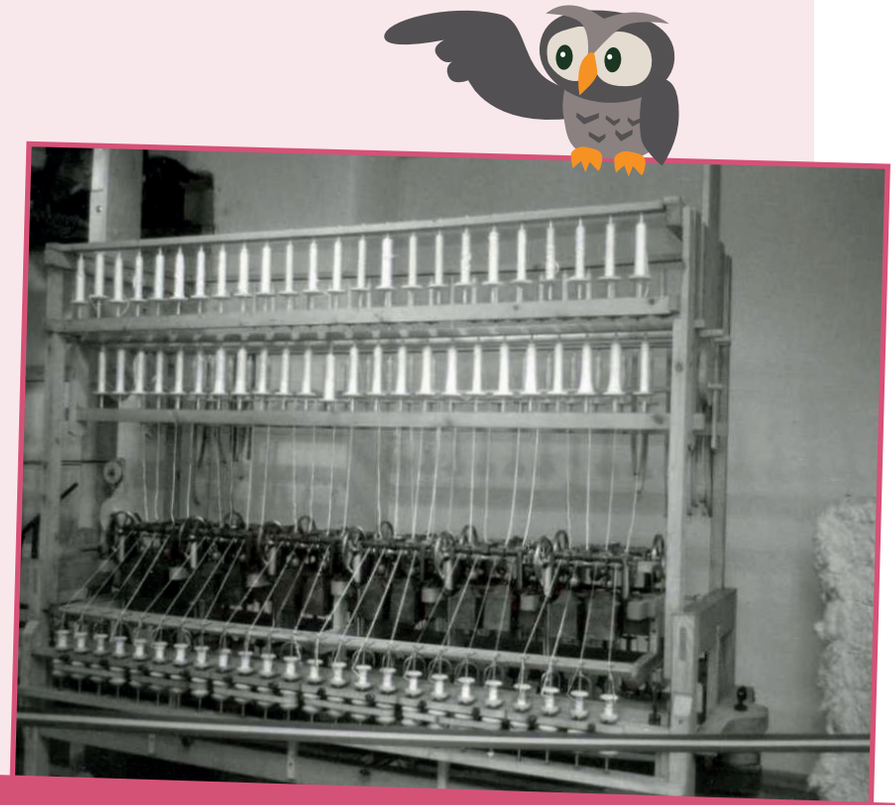
- The water wheel was brought to Britain by the Romans to mill corn.
- By the 16th century there were about 20,000 in the country.
- There are records of water mills at what is now King's Mill Reservoir for grinding corn and fulling – cleaning knitted wool or cloth, dating back to the 1200s.
- People also spun cotton in their homes during the winter months when work was short.



A sketch of the old King's Mill by local artist A S Buxton

The Industrial Revolution

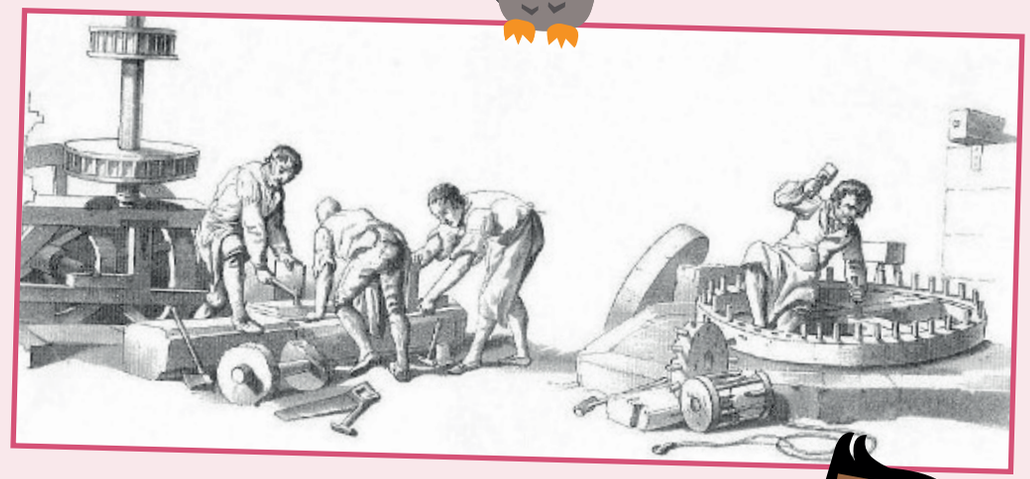
- When Richard Arkwright invented the water frame thousands of threads could be spun at once.
- The new machinery meant that the mills (or factories) could do the jobs which people used to do in their homes. This was part of the Industrial Revolution.
- By the 1830s the water wheels were powering a number of mills around Sutton and along the River Maun towards Mansfield.



One of the first water frames for spinning yarn

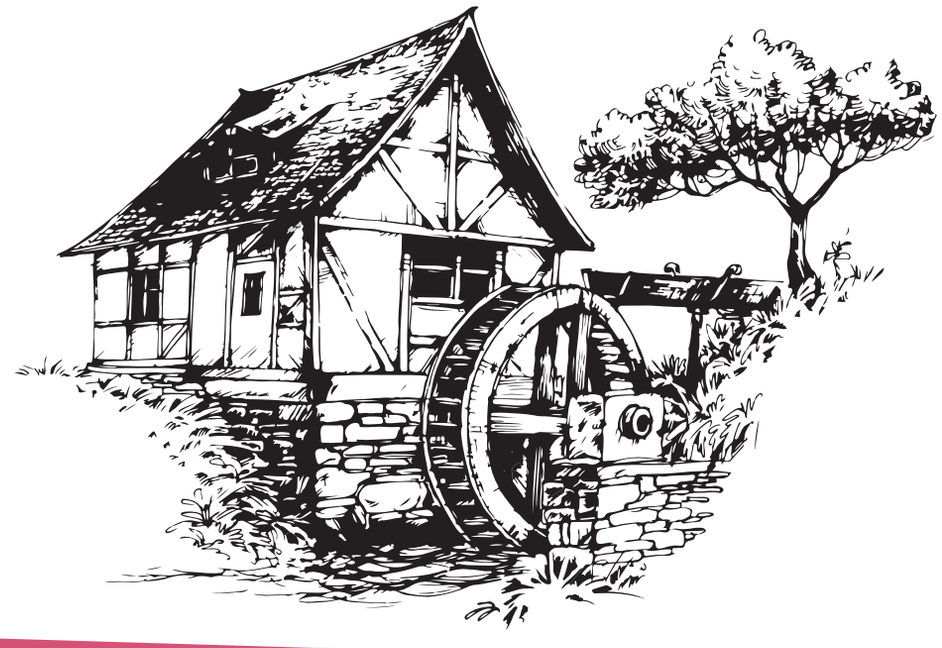
The art of the millwright

- The craftsmen who built the mills were known as millwrights.
- They were highly skilled and learnt their craft as apprentices, by watching their masters and following instructions.
- They would have dropped wood shavings into a river to estimate how fast it was flowing - and therefore its power to turn a water wheel.



The introduction of iron

- By the early 1800s millwrights had started to use printed instructions and had begun to use maths to work out the best design of water wheel to get the most power.
- Thomas C Hewes was one of the most renowned millwrights at the end of the 1700s and early 1800s.
- He started using iron shafts instead of timber, to make them fire proof and also last longer.



A sketch of an undershot water mill

How a water wheel works

Water wheels use the power of water, usually from a flowing stream, to turn a wheel, which is connected to a shaft that powers machinery inside a mill or factory.

The water mills in Sutton-in-Ashfield were powered by the River Maun.

Water wheels work best with a good strong flow of water. Different works are designed to improve the water **volume** and direct water away from the wheel:

- **dams and reservoirs** build up a head (water supply).
- **mill races, sluices and weirs** help channel water, especially in the seasons when water levels are low.
- **tail races** carry water away from the wheel.

There are three common types of water wheel: the overshot, undershot and breastshot.

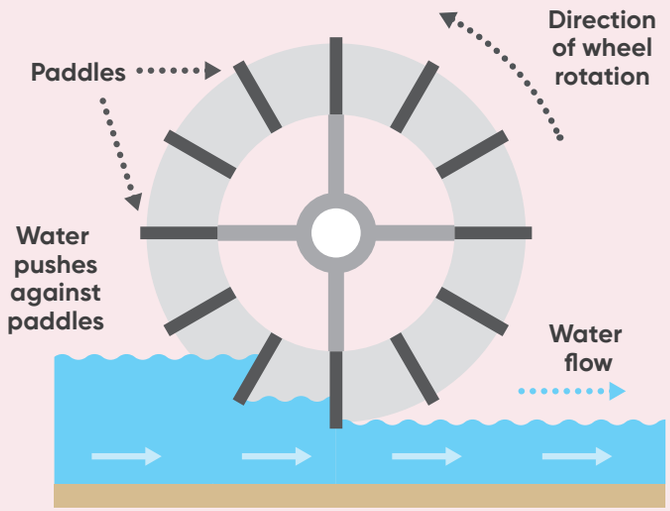
Undershot wheel

The undershot is the cheapest and easiest to make. The wheel is simply placed directly into a fast flowing river and supported from above.

The motion of the water below creates a pushing action against the paddles under the water making it turn.

This type of water wheel needs lots of fast moving water. Compared with the other types of water wheel it is very inefficient. It is only capable of converting 15-30% of the water power into mechanical power, only 20% of the water's potential energy is used.

The undershot water wheel rotates in a vertical plane and has a horizontal axle. This type of wheel works best in a stream with mill races.



How a water wheel works

Overshot wheel

The overshot wheel is the most common, but it is more complicated than the undershot wheel as it uses buckets to catch water.

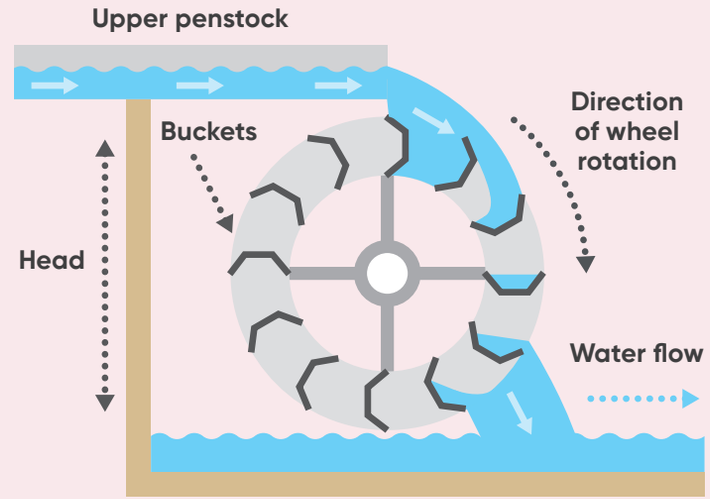
These buckets fill with water flowing in at the top of the wheel. The force of gravity makes the wheel spin around as the empty buckets on the other side of the wheel become lighter. The empty buckets go back up the top again ready to be filled with water and the cycle repeats.

This type of water wheel is much more efficient than undershot designs because almost all of the water and its weight is being used to produce output power.

Overshot water wheels are suspended above a river or stream and are usually built on the side of a hill providing a water supply from above, or a dam is created to direct water to the top of the wheel. It is capable of operating with an efficiency of 50-70% – so twice as much power as the undershot wheel, from the same amount of water.

Sometimes a dam is created to channel and increase the speed of the water to the top of the wheel, giving it more energy. It is the volume of water rather than its speed which helps rotate the wheel.

Overshot water wheels are usually very big so that there is a good distance for the gravitational weight of the water to rotate the wheel.



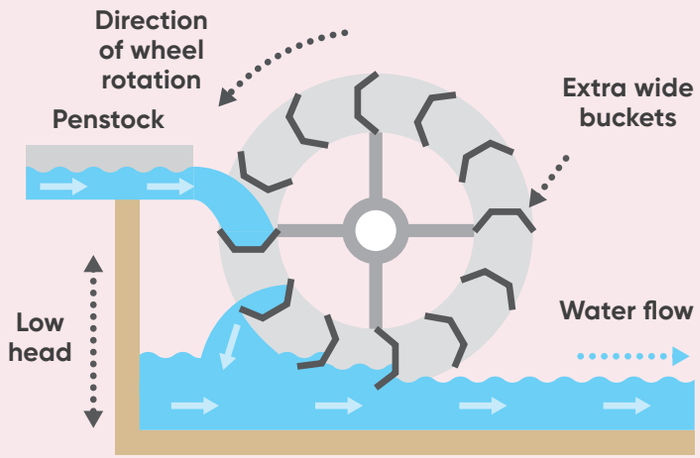
How a water wheel works

Breastshot wheel

The breastshot water wheel is designed so that the water enters the buckets about half way up at axle height, or just above it, and then flows out at the bottom.

This type is generally used in situations where the head of water is insufficient to power an overshot water wheel design from above.

As the gravitational weight of the water is lower there is less power, so to overcome this the buckets are made wider to make the buckets heavier, increasing the potential energy.



Index of terms

Volume – the amount of space that a substance takes up; in the case of a water wheel - how much water is used.

Dam – a barrier constructed to hold back water (across a river or lake) to raise its level, creating a supply of water to power the water wheel.

Reservoir – a large natural or artificial lake used as a source of water supply.

Mill Race – the channel carrying the swift current of water that drives a mill wheel.

Sluice – a gate for controlling the flow of water; it can also carry away surplus water.

Weir – a low dam built across a river to raise the level of water upstream or regulate its flow.

Gravity – the force that attracts a body towards the centre of the earth, or towards any other physical body with mass.

How a water wheel works

The parts of a water wheel

The traditional water wheel (whether undershot or overshot) had five parts:

1. The Axle

Before 1750 these were usually made from tree trunks cut down to 40-60cm diameter.

The axle had to be strong enough to support the weight of the wheel, usually between 2000 – 4000kg, plus the force of the water.

2. The spokes

These came out from the axle in the middle to support the rim of the wheel.

They were usually 7.6 x 22.9cm or 10.2 x 15.2cm planks.

3. The rims and shrouds

These were planks for about 5-10cm think, cut and set around the wheel to form a ring.

They could be pinned on; or notches put in them so the spoked slotted in; or holes made in them so the spokes could be slotted in (called mortising – which is the strongest joint).

4. The soling

The sole was layer of planks pinned onto the rims to stop water splashing out of an overshot wheel, and stop water getting out of an undershot wheel.

It also made the wheel more stable.

5. The float boards (undershot) and bucket boards (overshot)

In an undershot wheel the floatboards are set around the outside of the wheel. The wheel turns as the water strikes these boards.

In an overshot wheel bucket shaped boards carry water, the weight of the water turning the wheel. These were more expensive to make.

How a water wheel works