Model waterwheel

For Pull-out Plans see P40

PHOTOGRAPHS BY JOHN HAWKSWELL

John Hawkswell constructs a waterwheel complete with a moving figure

Admiring a real waterwheel last year, I knew I had to attempt to build a model: I was struck by how little water was required to turn the giant wheel. It was obviously well balanced. Research revealed that waterwheels have been used since ancient times, representing an important source of power in a wide variety of industries. Designs were developed to achieve high efficiency. Unfortunately my investigation failed to produce plans for a model where the key components were turned on a lathe. I reasoned that if the sides and rim of the model were turned together there was every prospect of achieving a wheel that was finely balanced and would turn easily, provided the right bearings could be secured.

My first thought was to use the waterwheel to generate electricity and light a small bulb. But waterwheels excel at providing mechanical power so the idea of driving an automaton seemed like a plan. The work on the project was spread over several weekends and involved a good deal of experimentation.

I gave the waterwheel two coats of teak oil. The wheel had only minor eccentricity and a small plastic clip fixed on the edge of one wheel at 2 o'clock was sufficient to turn the whole assembly.The flow produced by the pump at full power was excessive but fortunately the pump had different power settings and the lowest setting proved sufficient. The waterwheel has now had several outing at shows and events where it attracts lots of attention. One side of the wheel is removable to facilitate spindle maintenance. It is best to take account of the capacity of the pump in the early stages of design. There is little point building a 1.5m waterwheel if the pump you are using will only raise the water by 1m.

Cutting list

- 2m of 150 x 40mm treated softwood
- 3 sheets of 6mm plywood sheet 60 x 60cm
- 1 sheet of 10mm plywood 40 x 30cm
- Short length of branch wood to make the 'logs'

Additional materials

- Small pump
- 500mm of 12mm garden hose
- 100mm M6 or M8 carriage bolt – partially threaded
- 2 x brackets to carry waterwheel spindle
- 2 x brackets to carry carriage bolt
- O-ring – or elastic band – for pulley drive
- 12 x 3mm nuts and bolts in stainless steel
- Various washers, screws, pins, nuts and bolts

1 Start this project by marking out the waterwheel on 10mm plywood. Since the diameter exceeded the range of my compass, I used a handy home-made jig for this. The diameter should be slightly oversize; this will allow for truing up on the lathe.

2 Drilling a small centre hole for the nail allows you to mark a suitable circle to rough cut with a bandsaw or jigsaw ready for turning. The nail hole provides a centre reference point.

3 Stick a paper template to one side to provide a guide to the diameter and angle of the paddles. Using PVA glue, stick the two plywood sides together as a sandwich using a sheet of newspaper as the 'filling' to allow the two sides to be separated later. Then use a bowl gouge to create the desired diameter and lightly sand the edge.

4 The spindle assembly needs to be accurately centred on each side. To facilitate this, fix a plywood circle to the centre and turn a recess to accept the spindle flange.

5 The construction of the inner rim provides an opportunity to practise some basic segmental turning. Glue 12 100mm lengths of 115 × 40mm pine on a circular piece of sacrificial MDF. I used Evo-stik weatherproof glue for this. Then mount the MDF board on the lathe using a faceplate and turn the inner rim to size using a bowl gouge. The inner rim then needs to be parted off slightly wider than required.

6 Before the two plywood sides are parted, you need to cut out the spokes with a jigsaw; this ensure that both sides will be the same. An odd number of spokes looks better in my view than an even number. You can then glue the edge of the inner rim to one of the sides.

7 Once the glue has set, remount the side onto the lathe. This picture shows how the assembly is held on the lathe. Screw a scroll chuck with a recess cut in MDF to the work. This recess was first turned with the assembly reversed and the chuck held in the spindle recess in the plywood insert.


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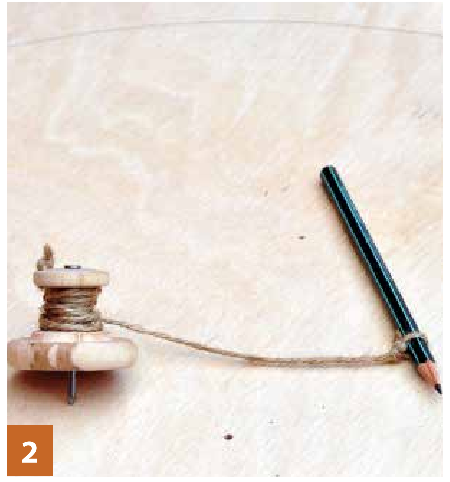
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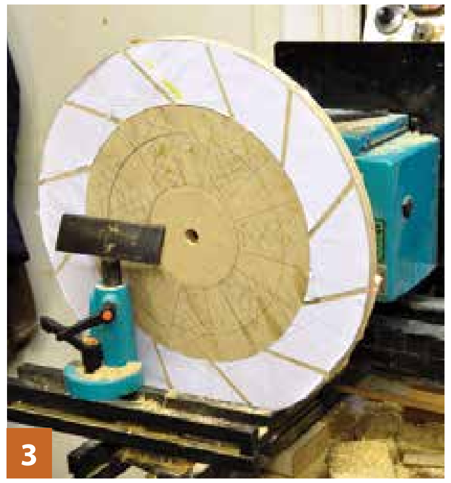
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8 Attach the cycle spindle to one side using M3 stainless steel nuts and bolts. The width of the inner rim now needs to be refined to ensure it is the same as the spindle. Attaching the cycle spindle to one side provides a direct guide to the desired width.

9 Cut the 12 paddles from 6mm plywood. This size allows 3mm to slot into a rebate on one side. Make a chamfer of 66° on the end of each paddle to ensure a snug fit.

10 Rout 12 rebates 6mm wide in one side to accept the paddles. This helps each paddle to slide into the correct position. The simple home-made routing jig shown in 10a provided a rebate which had a consistent angle and length. Step 10b shows the side after the grooves or rebates had been cut. The wheel was then lightly sanded prior to further assembly and I made sure the paddles could slide into the rebates.

11 A 22mm hole in the centre of the wheel provides sufficient clearance for the axle to rotate freely. The six stainless steel bolts securing the wheel to the spindle flange give it a bit of character. With both sides of the wheel bolted to the spindle and screwed or glued to the inner rim, the paddles can be fixed in position. Do not put glue in the rebate if you wish to access the spindle in the future.

12 The water 'tank' for the wheel is a plastic storage box. The bearers are made from pressure-treated timber and are cut to span the length of the tank. Four turned columns are required to raise the bearers so that the wheel can clear the level of the water in the tank. The columns are bolted to the bearers using nylon butterfly nuts.

13 Brackets are bolted to the bearers to fix the wheel in position. Check the wheel turns easily and make any adjustments. Make sure that the paddles are facing the right way round so as to retain the water as long as possible as the wheel rotates.

14 Pressure-treated timber is used to make the first tank end. This has to be long enough to span the width of the tank. This provides a shelf on which to fix the bearers.


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10a


10b


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15 The second tank end has a width of 250mm. This provides a base for the water tower. Drill a 25mm hole through the centre to accommodate the water hose. In operation, it was found that water collected on the surface and did not return to the tank. I rectified this by dishing the leading edge.

16 The components of the chute consist of plywood sides with a base of 12mm-thick pressure-treated wood. The shaped pieces at the end minimise the loss of water by keeping the water within the width of the cell.

17 Screw the chute directly to the tower. The wooden block provides a convenient base to build the rest of the tower, which is constructed from plywood. Here the back has been removed to show the water hose in position. The chute is angled downwards by about 5°. Experience suggests that the discharge end of the chute should be close, say 30mm, to the top of the wheel.

18 To turn the annulus or ring pulley, bolt a roughly circular piece of plywood to a piece of MDF, which is gripped in a scroll chuck. Turn the plywood circle with a bowl gouge so that it runs true to a final diameter of 120mm. Cut a groove in the edge with a 10mm spindle gouge. The centre is then cut away.

19 Screw the ring pulley to the wheel with brass screws. Several washers are required to allow the wheel to clear the bracket and turn freely.

20 This second pulley – 70mm diameter – picks up the drive from the ring pulley. Drive a coach bolt with a square section under the cap into the plywood so that the drive can be transmitted to the next pulley. After truing up a suitably sized disc, cut a groove in the edge with a 10mm spindle gouge to accept the belt running from the drive pulley.

21 To make the wooden man chop, a third pulley is required to transfer the movement to the hinged figure. The amount of movement is controlled by the diameter of the disc. Attach a bolt at right angles close to the outside edge.


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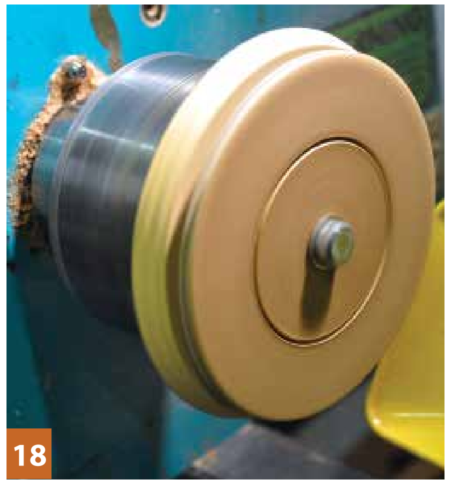
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22 An M8 coach bolt threaded at one end connects the second and third pulleys. Washers are required to assist smooth running when the brackets are added.

23 Draw both the legs and the body of the automaton. Glue the paper template to the wood and carefully cut out the pieces. Once the pieces are cut, sand, then paint the figure with acrylic paint.

24 Prepare the plywood base and fix the brackets so that the pulley assembly can turn freely. Then fix the half-moon anchor plate. The legs are then stuck to the anchor plate and the body is bolted to the legs ensuring that it is free to move.

25 Wrap some wire around the carriage bolt and attach the other end of the wire to the elbow so that the figure moves. Some adjustments may be necessary to get the correct length of wire. I also added some 'logs'.

26 I decided to add a turret to the top of the tower. The base of the turret fits snugly in the top of the tower, using a piece of square section timber attached to the base. The turret is screwed to the plywood tower so that it is removable.

27 Provided the completed waterwheel turns freely when light hand pressure is applied, you are now ready for the first water test. Some adjustments may be required. Leaks can be fixed by applying some more silicone sealer.

28 I used an Aquarius Universal 2000 water pump. This model allows adjustment to the flow rate. An adaptor allows garden hose to be fitted to the outlet pipe. An elbow joint at the other end of the hose directs the water flow along the chute.

29 A 200mm-long rubber band forms the pulley chain and the whole setup can run happily all day. Although the tank is quite small it is more than adequate and with the pump at a low speed setting water loss from spray and splashes is minimal. However, water in the tank can disappear in unexpected ways – I saw one little boy drinking it! ■


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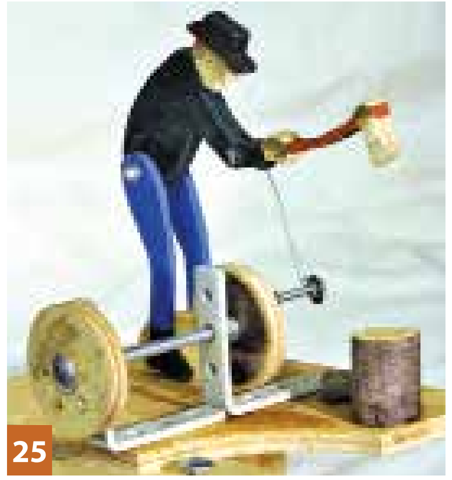
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