

From washing machine motor to micro hydro generator

Bryan Leyland MSc, FIEE, FIMechE, FIPENZ

My wife and I are part owners of a 1000 kW hydropower scheme in New Zealand. The dam and intake need a supply of electricity for a radio transmitter and PLC and infrequent operation of valves and the screen cleaner. The main load is the electronic equipment that takes a continuous 6 W. It was too expensive to bring a cable from the powerhouse 1400 m away so a 120 W solar cell installation costing about \$US 2500 was installed. In spite of having several days of battery backup it failed to keep the batteries charged in the winter when it can be cloudy for many days.

We decided that at least 360 W of cells would be needed to solve the problem. This was going to be expensive so I started looking for alternatives and came upon Michael Lawley, a New Zealand engineer who has developed a range of micro hydro units and wind generators based on permanent magnet electric motors recycled from scrapped "smart drive" washing machines developed by Fisher and Paykel, a New Zealand company.



Dam, intake and solar cell

(Photo of intake and solar

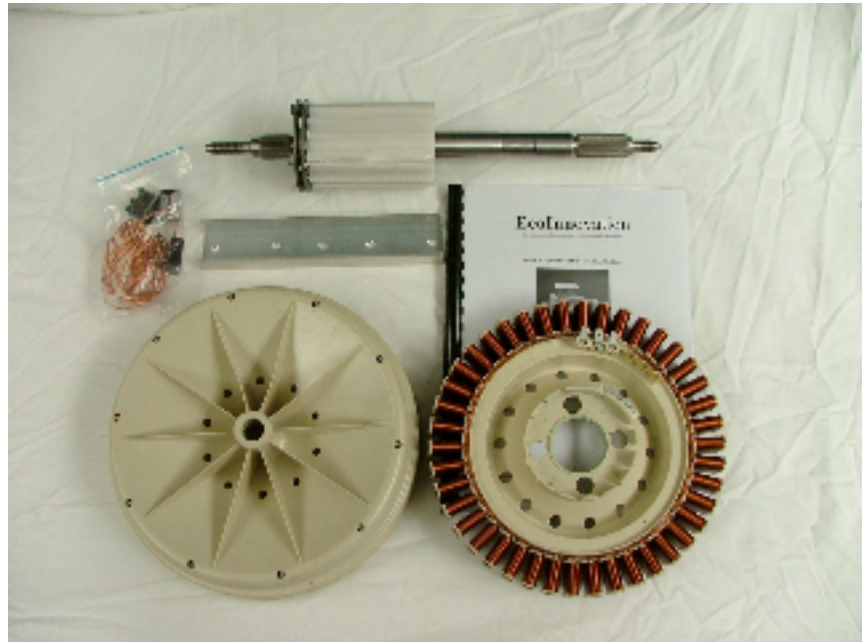
cell)

(Picture of sectioned washing machine)

About fifteen years ago, Fisher and Paykel developed a revolutionary new washing machine that avoided the cost and reliability problems of the gearboxes used to drive the agitator and to spin the bowl for drying. They developed the first washing machine that would agitate and also spin at a speed of more than 1000 rpm using one direct drive motor. This was a very difficult call, because it required that the motor be able to go forward and reverse every second or so for maybe twenty minutes while washing and then be able to spin at more than 1000 rpm. The permanent magnet motor has 42 three phase AC stator poles. The motor is built "inside out" (like the motor of a ceiling fan) with a ring of permanent magnets placed around the inside of the umbrella shaped rotor. The stationary alternating current winding fits inside the ring and is connected to a variable frequency supply from a three phase inverter.

(Picture of stator, rotor and shaft)

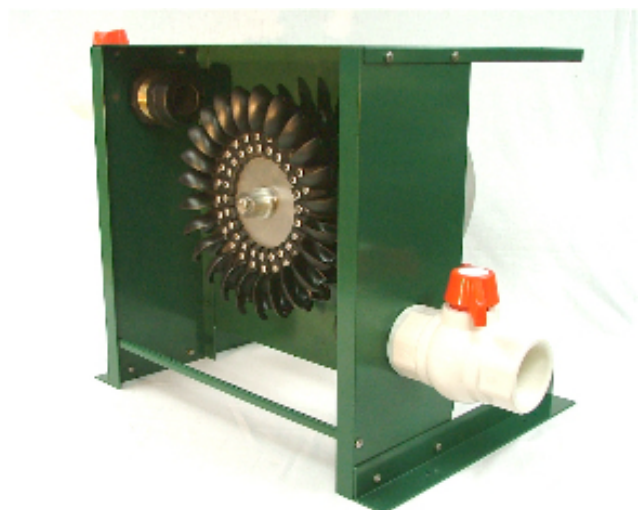
Michael Lawley found one of these washing machines on a rubbish dump a few years ago and took it home. He found that the unique characteristics of its motor made it ideal for generating electricity over the wide range of conditions that can be expected in the micro hydro and small windpower field. He developed a small Pelton turbine comprising a number of plastic buckets bolted to a disk to drive the generator. The standard runner diameter is 240 mm but it can range from 160 to 500 mm and there can be up to 4 jets. The bearing assembly is the same one that is used in the washing machine. It is robust and is well sealed against water ingress.



By re-connecting the three windings in star or delta and by connecting the poles in series, or in series/parallel, or all in parallel, the unit can generate anything from 12 to 560 volts over a range of outputs and speeds from about 150 W at 150 rpm and 5 m head to over 1kW at 1300 rpm and 120 m head. When it is operating on high heads at a low power Michael discovered that its efficiency and output can be improved by the rather extreme solution of cutting off most of the poles.



The high voltage that it can generate with all the windings in series is useful if the power needs to be transmitted a considerable distance from the generating unit to where it is needed. As the three phase current is less than 2 amps, a transmission distance of more than 2 km is entirely feasible with quite small conductors. The frequency is well above 50 Herz, so the AC output cannot be used directly. Step down transformers are needed to give a voltage suitable for battery charging. If the load is nearby, the windings can be re-connected to reduce the voltage to a level suitable for battery charging. Most systems have



shunt regulators on the DC system to stop the batteries being overcharged when the load is low.

If more than 1 kW is needed, I suspect that installing 2 - 10 of these units alongside each other would be cheaper than buying a single unit designed to match the site conditions. They would all feed into a DC system with an inverter to provide an AC supply. Where there is more than one unit – or jet - the low cost plastic solenoid operated diaphragm valves developed for irrigation schemes can be used to limit the water consumption when the full power is not needed.

I was so impressed with this unit that I purchased one to replace the solar cell installation at the intake of our small hydro scheme. For an installed cost of about \$US700, it now supplies 60 W of continuous battery charging power. It is driven by a two jet Pelton turbine operating at about 200 rpm on 4.5 metres head and generating 60 watts at 24 volts DC. We now have more than enough power.



The units can be purchased from Michael's firm¹ fully assembled and complete with a housing and a rectifier. It is also possible to purchase the motors, the Pelton buckets and an instruction book on how to build the unit and re-connect the windings as individual items. (Photo)

Michael also markets a wind turbine packaged based on the same generator with the same versatility. The unit has also been driven by a waterwheel and by a prototype propeller turbine.

This versatile and low cost unit could lead to a major reduction in the cost and complexity of micro hydro schemes all over the world.



¹ Ecolnn " www.ecoinn.co.nz