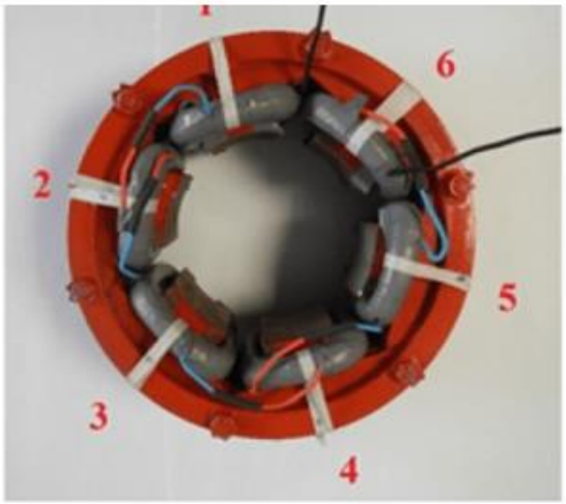
Assembly manual

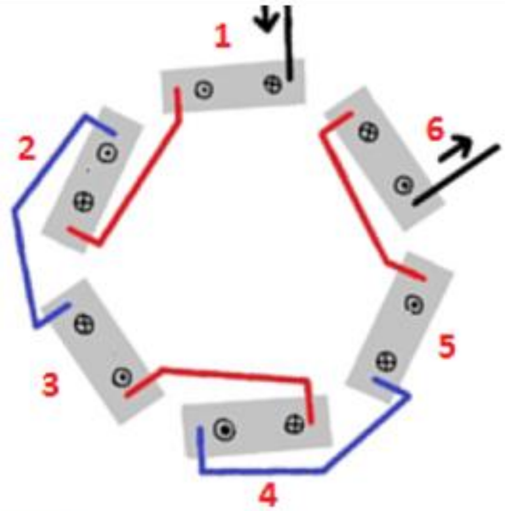
Blog posts about the project

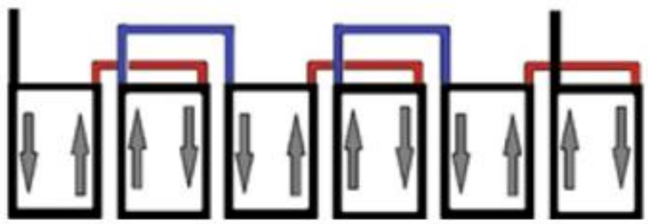
WIL Turbine construction 6: ELC construction October 12, 2022

So that the turbine can be used to supply power to devices, a little electronics is still required.

Therefore, after the mechanical work on the turbine and the generator, today we continue with the Electronic Load Controller (ELC).







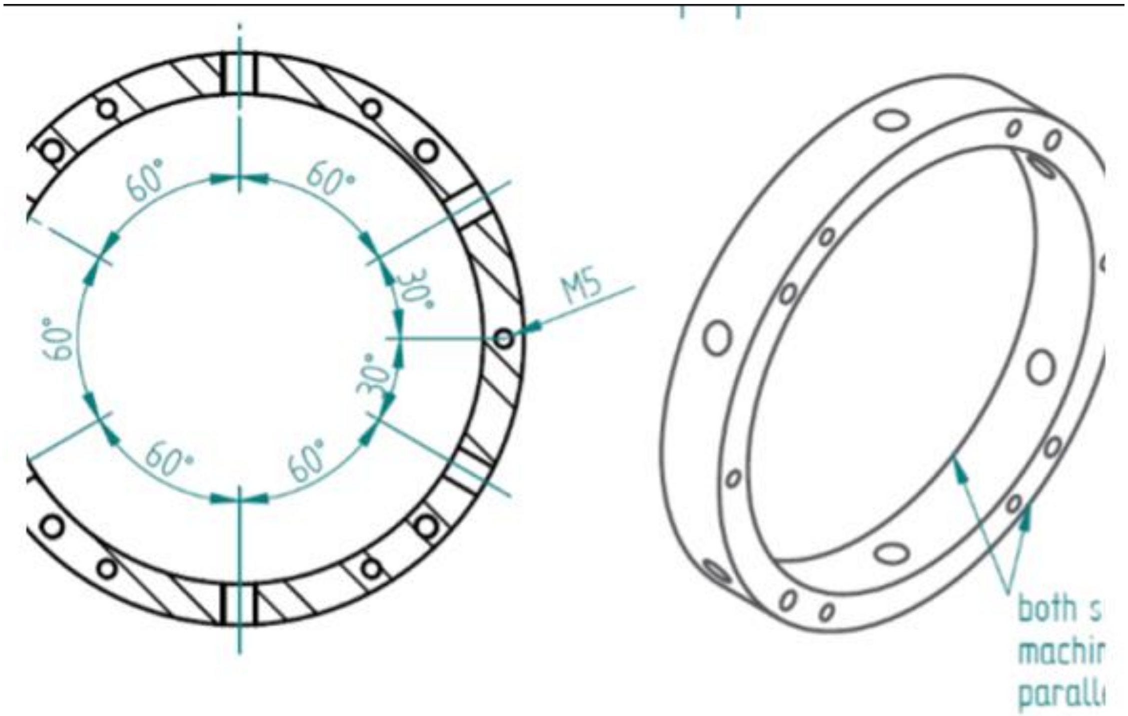
WIL Turbine construction 5: Coil assembly September 29, 2022

To start coil assembly, we need a finished stator and six finished coils. Our generator is called 3-pole because it consists of 3 pairs of coils, which are wound alternately left and right after assembly. 1000 revolutions per minute then means 3000 magnetic field reversals in 60 seconds i.e. 50 per second.

And already we have the 50Hz for our AC. But now to the assembly.

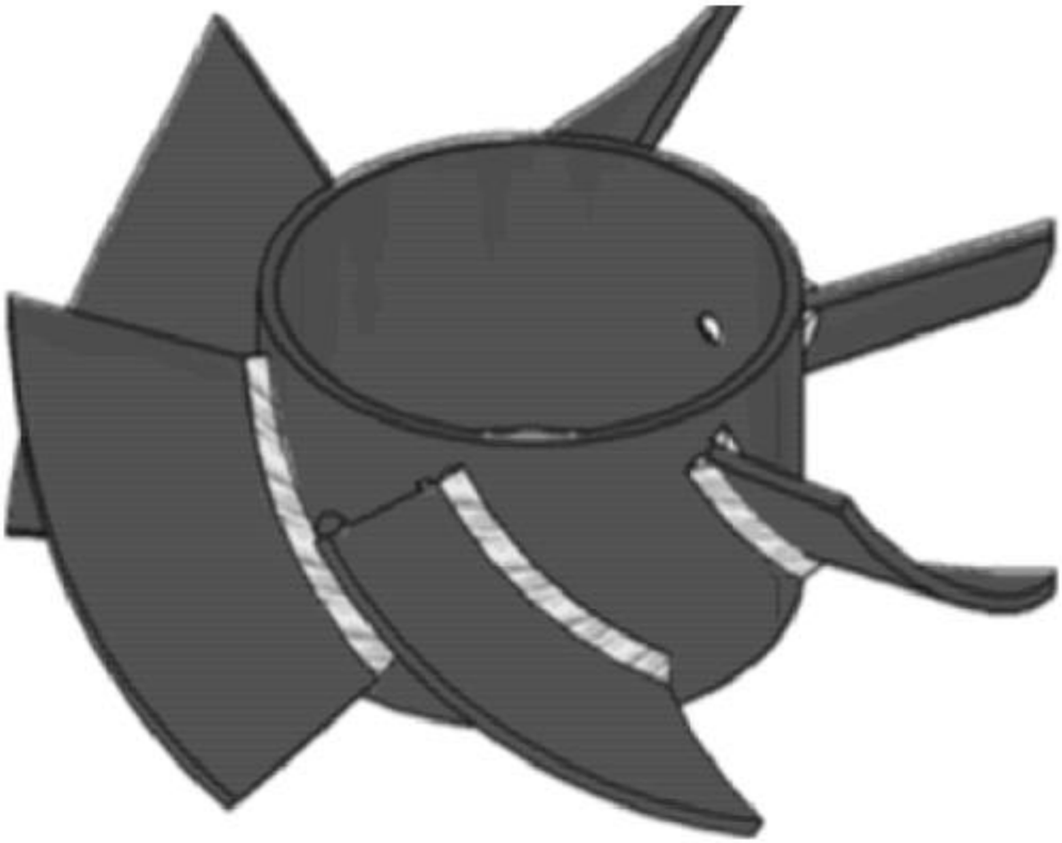

WIL Turbine construction 4: Sgulen winding August 20, 2022

After the mechanics, the electrics now come into play. Without coils, in which the magnetic field of the passing magnets of the rotor induces a current, no generator works. To ensure that the generator delivers the right voltage at the right frequency, the speed of the magnetic field change and the number of turns in the coils are crucial.



WIL Turbine construction 3: Stator July 31, 2022

Now it's the turn of the stator. What is it? To generate electric current, you need an electric field that changes and an electric conductor. In our generator, these are the stator with the coils, which is firmly connected to the turbine housing and does not move - hence the name stator - and the rotor with the magnets, which is connected to the propeller and thus rotates when the propeller is driven by the water.

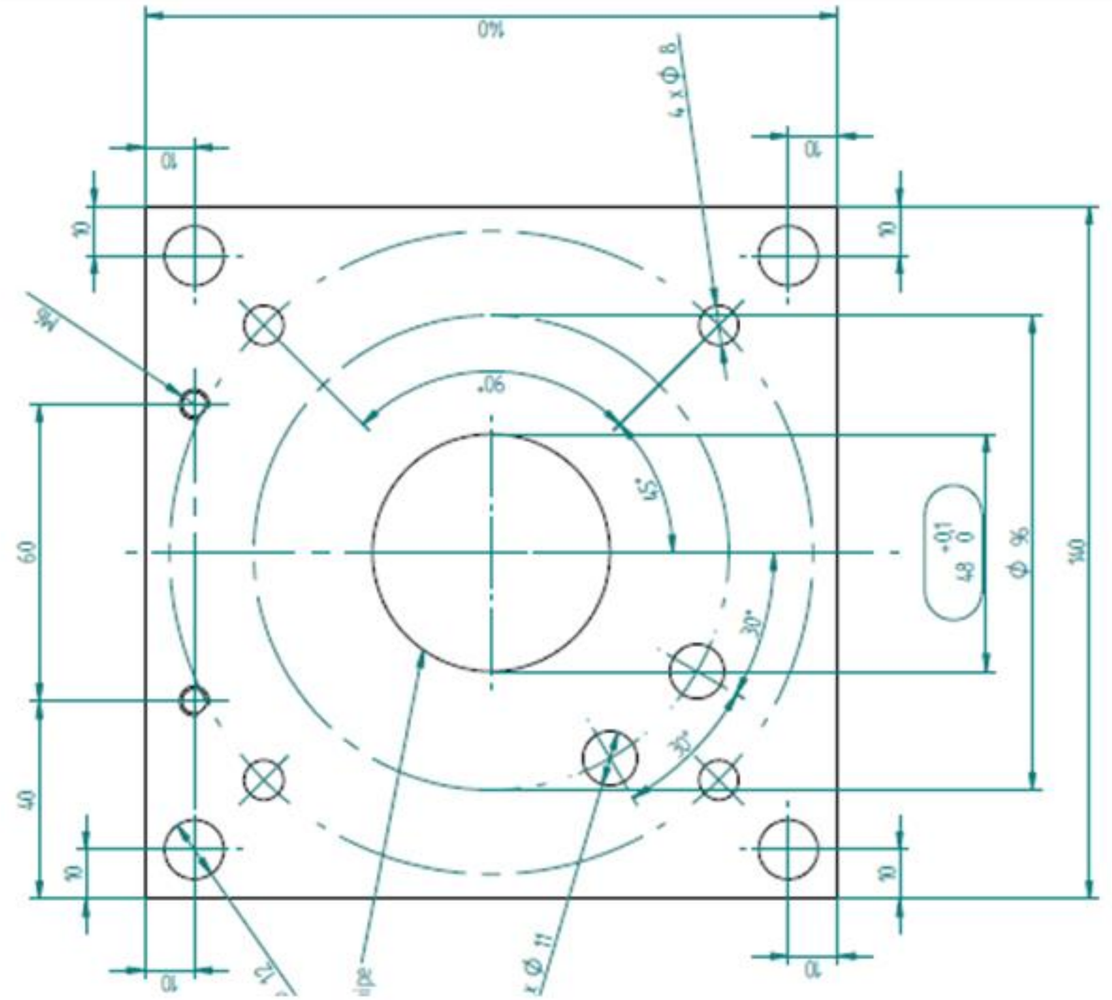


WIL Turbine construction 2: Propeller construction 09 July 2022

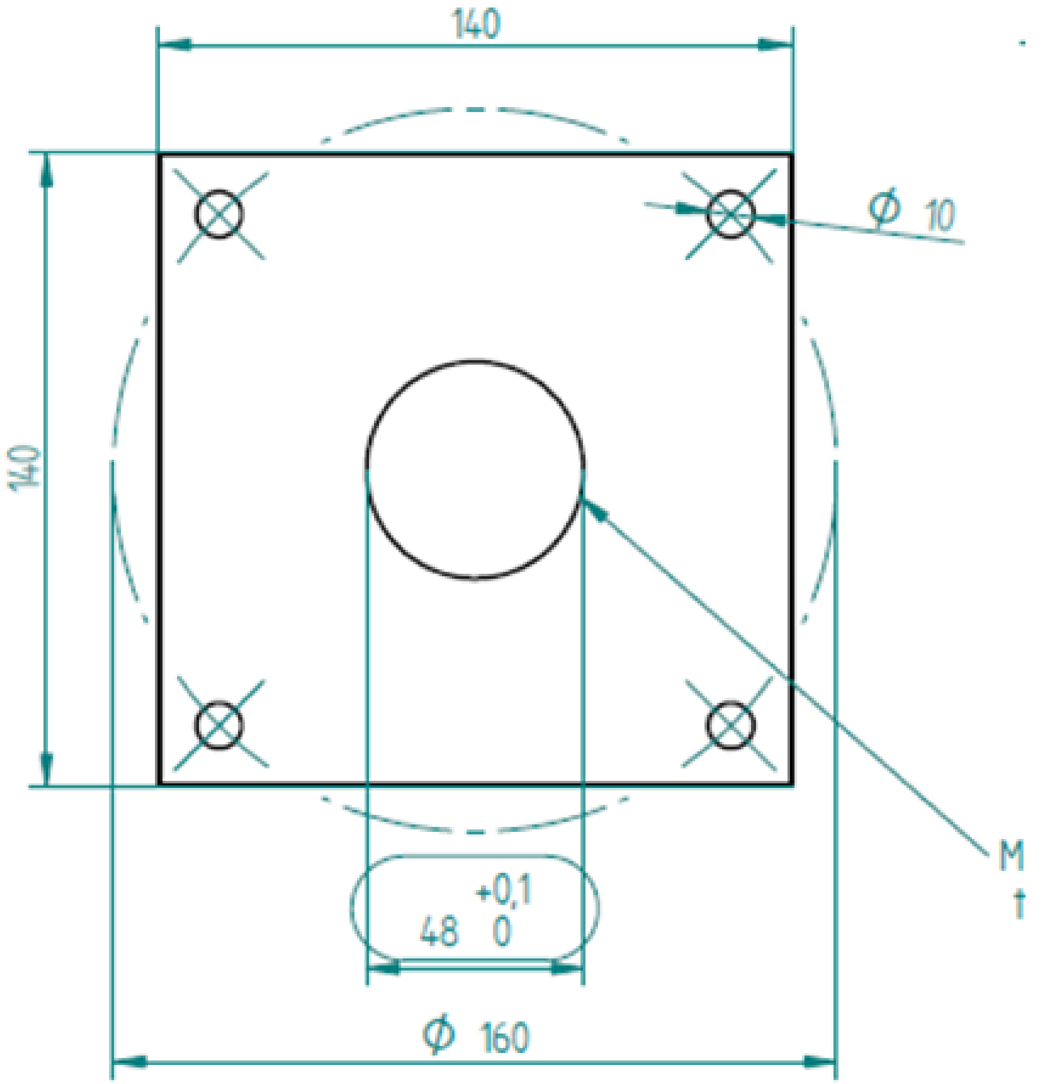
After the base plate for the turbine, the propeller is on the agenda today. Here we see that we can achieve technically high-quality things even with the simplest technology. The trick:

WIL Turbine construction 1: Base plate 08 July 2022

WIL Turbine construction 1: Base plate



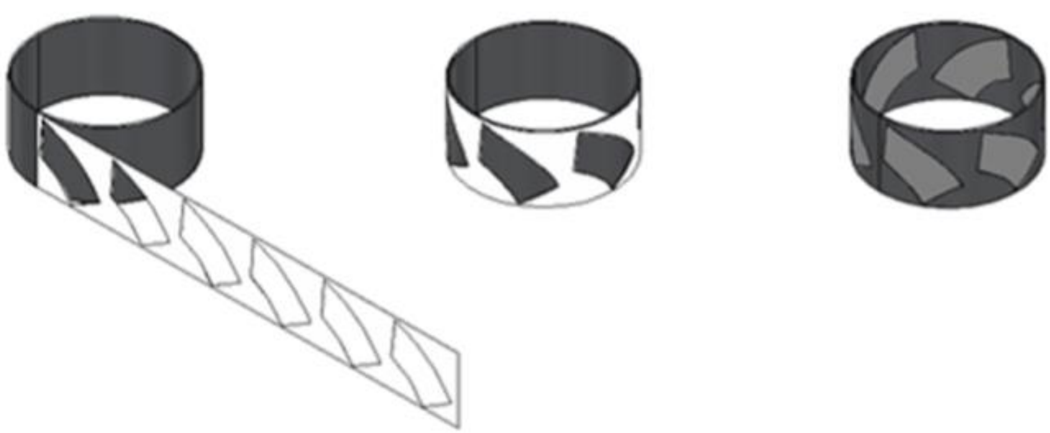
At some point, the corona work will be over. In order to be ready for the installation of the next turbine then, we have started with the construction of five turbines. It was not easy to find a workshop that would make its premises and machines available to us free of charge. But with Janner Waagen in Weiden we found a great & competent partner who is open-minded for our project. So we start with the material procurement. A stovepipe for the propeller, 8 mm thick steel plates for the upper and lower base plate, flat iron for the pole shoes …

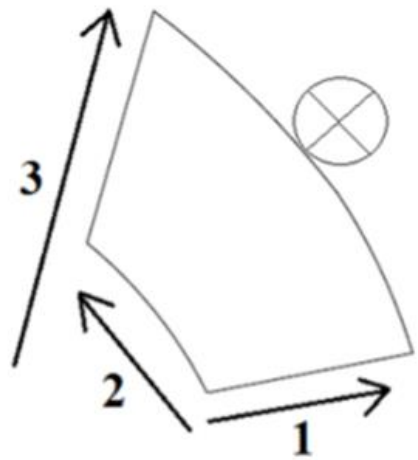


Let's start with the simpler things, the base plates. Square plates with a side length of 140 mm are sawn with the band saw. Then comes the scribing grains of the drill holes. What was that again? Four holes in the corners of the plate, four for the attachment of the stator of the generator, two more holes for the attachment of a retaining bracket, again two for the cable bushings and of course the large central hole for turning out to the correct size. With the scriber and the compass it is soon done. Now you have to make sure that the drill doesn't deviate and then you can start drilling. First pre-drill small, then drill larger and don't mix up the correct drill diameter. The drill chips fly. But after an hour, it's done. The lower base plate has fewer holes, so it goes faster.

WIL turbine construction 2: Propeller construction

After the base plate for the turbine, the propeller is on the agenda today. Here we see that even with the simplest technology, we can create technically high-quality things. The trick is to saw out almost all the contours of the propeller blades on the stovepipe, then bend the segments inward by 90 degrees, weld them to the inner tube, and then saw out the finished propeller from the stovepipe. But first things first: First, we need a stovepipe with 120mm inside diameter and our cutting template for the propeller blades from the manual. When printing out the template, a little fiddling is required until the template really comes out of the printer in 1:1 scale. The guide line on the print template serves as a check. After three attempts, it is done. How do we get the contours onto the stovepipe? Now it's time to cut out the template and glue it onto the stovepipe. Then the center punch is used and with many center punch dots it is easy to see where to cut.

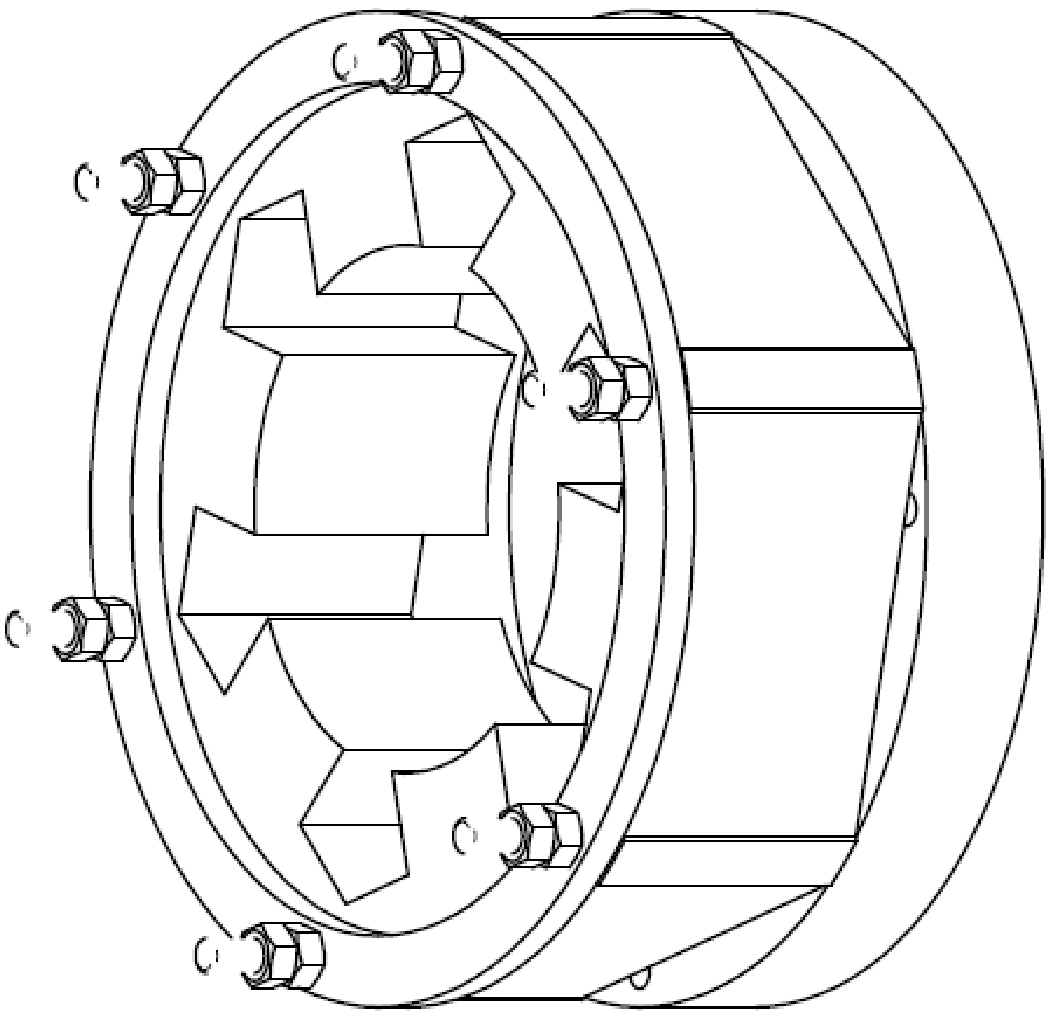


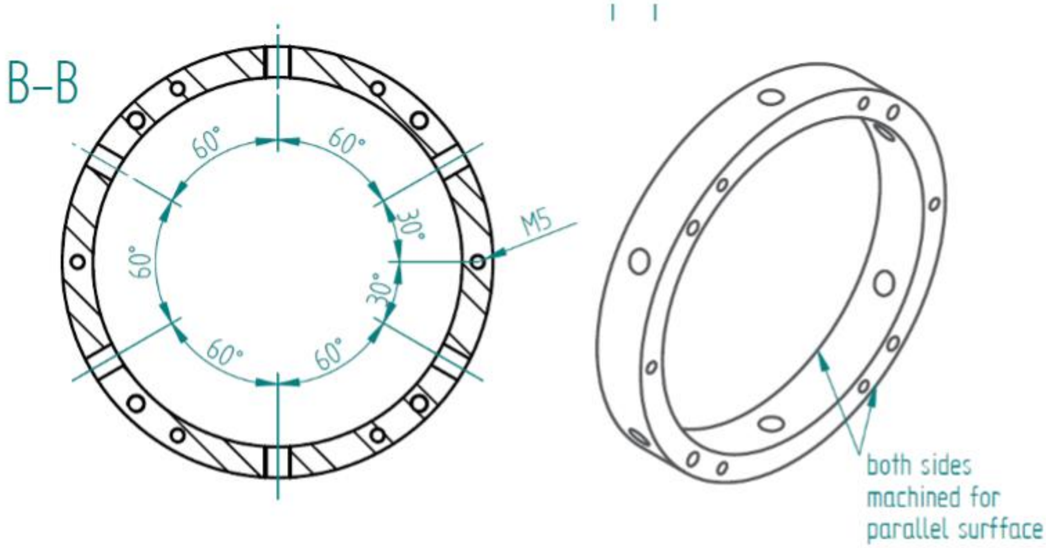


After drilling a hole for the jigsaw blade for each propeller blade, we start cutting. The round contours are real stress for the metal saw blade, but with a lot of patience we can do it without breaking the saw blade. In the end, the propeller blades hang only at 2 corner points. Now we just have to push them 90° inwards and weld them to the inner tube, and the finished propeller can be broken out of the stovepipe remnant. And what is the highlight? The stovepipe radius ensures the correct bending of the blades and the template with the pivot points at the end of the propeller blades guarantees the correct position and the optimum angle of attack. You can't tell by looking at the template that a lot of brainwork went into it.

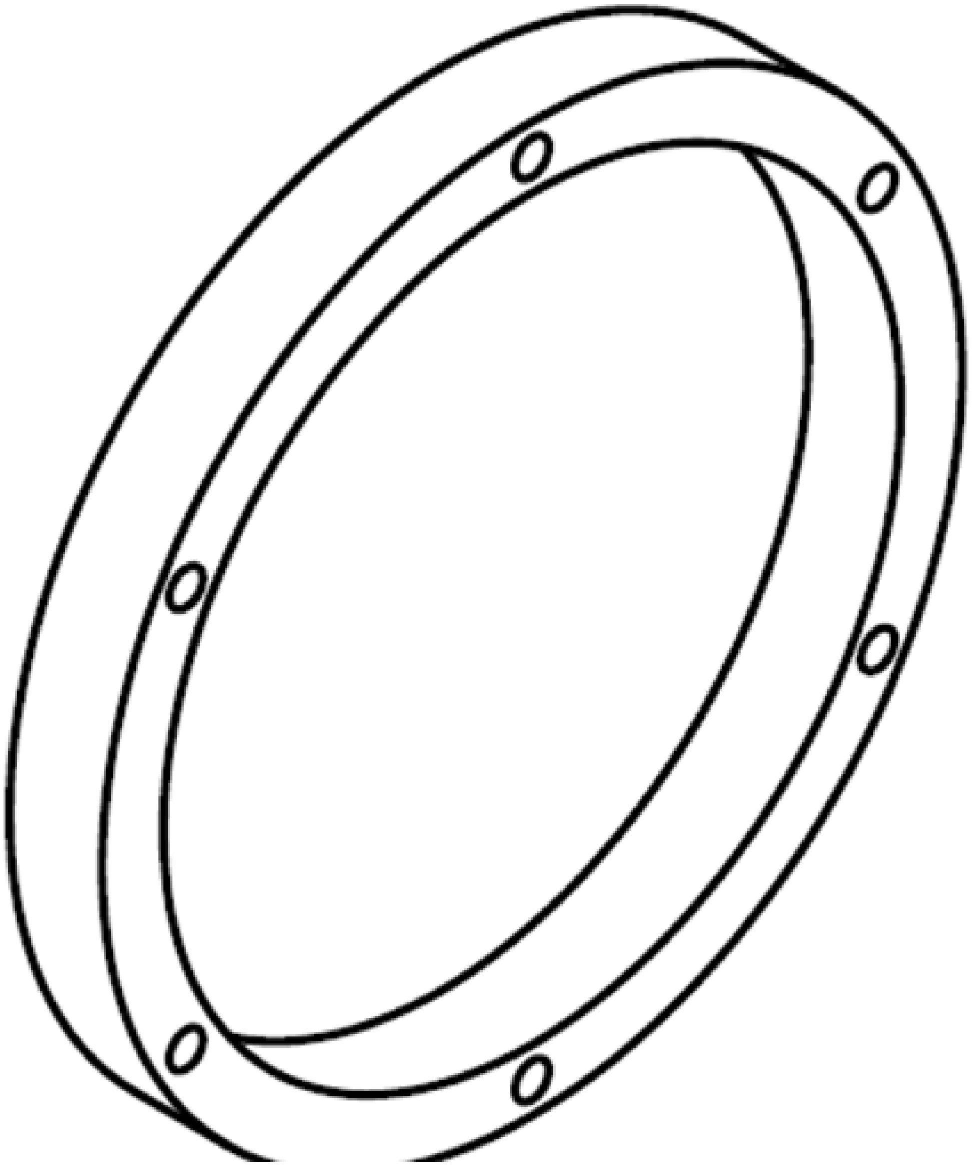
WIL turbine construction 3: Stator

Now it's the turn of the stator. What is it? To generate electric current, you need an electric field that changes and an electric conductor. In our generator, these are the stator with the coils, which is firmly connected to the turbine housing and does not move - hence the name stator - and the rotor with the magnets, which is connected to the propeller and thus turns when the propeller is driven by the water. As the magnets whiz past the coils, they see a changing magnetic field and therefore produce current, as Maxwell's equations promise in theory. If then the number of turns and the speed fits, our generator produces at 1000 revolutions per minute a voltage of 230V with a frequency of 50 Hz, as we know it from the socket. But now to the construction of the stator. It consists of four parts. An upper and a lower clamping ring, the transformer plates and the coils.





We’ll deal with coil winding next time. The upper and lower clamping rings are connected with threaded rods and ensure that the transformer plates sit where they belong and are pressed together to form a good magnetic conductor for the magnetic flux. So first it’s a matter of sawing the rings off a solid steel tube and then turning them flat on the lathe. The pressure on the transformer plates should be evenly distributed.



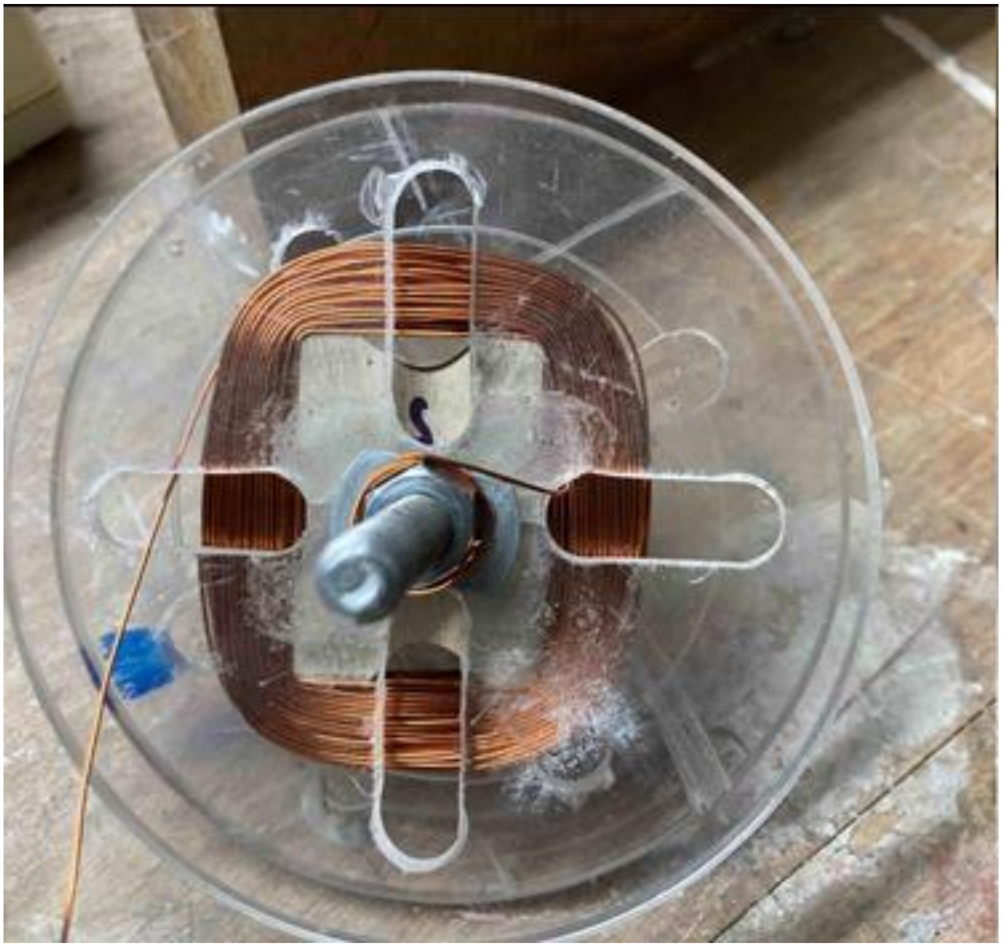
Before drilling, however, there is a lot of work to be done with compass and pencil. For the lower ring, we need two hexagons and a square to distribute the drill holes correctly. What was that again about the hexagon? Draw a circle with the compass and then pierce on the circle and apply the radius 6 times in a row. Once for the side holes and then offset by 30° for the holes in the threaded rods that connect the top and bottom rings. And then the four holes to be able to screw the stator to the base plate later. So first mark out all the positions and then re-size them so the drill doesn't slip. 6 holes in 20mm thick steel have to be drilled first. And don't mix up the diameters. 4mm for M5, 4,8 for M6 and 8mm for the side holes. Then cut the threads and the lower clamping ring is ready. After this exercise the upper clamping ring is a piece of cake. Even more so where only 6 holes with 60° spacing have to be drilled for the threaded rods. But this time with 5,5mm, because the threaded rods should pass loosely through the ring to be screwed with nuts.

WIL turbine construction 4: Coil winding

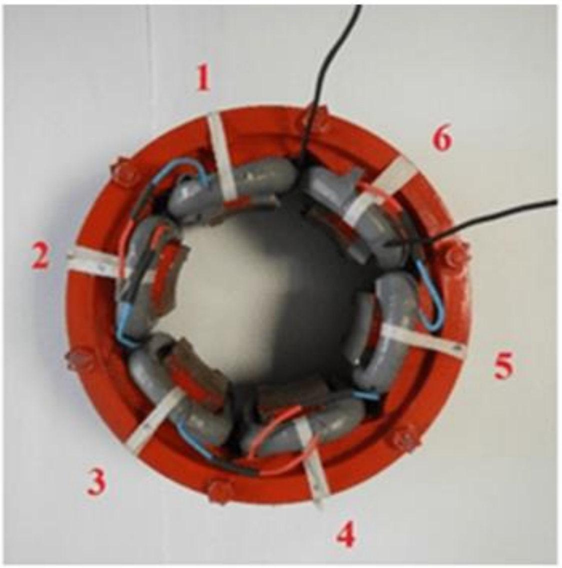
To ensure that the generator delivers the right voltage at the right frequency, the speed of the magnetic field change and the number of turns of the coils are crucial. Our generator is supposed to deliver 230V with 50Hz, just like the current comes from the socket in our house. At 1000 rpm and 3 pole generator we need 222 turns. The coils are wound from 0.6mm thick enameled copper wire. There is an auxiliary tool for this: it consists of a coil core around which the wire is wound and two discs so that the wire does not disappear left and right. The coil core is slightly beveled so that the finished coil can be removed from the core. In addition, it contains recesses on the four sides so that you can tie the spools together with wire or cable ties before taking them down so that they don't end up in a ball of wire. Now you can simply start winding by hand and count along. If counting gets on your nerves, a primitive winding machine made of a drill and a counter will help. Let's get started. We need 6 coils for one generator. After winding, the coils are still wrapped with temperature-resistant tape, so that the coils do not rub against the poles of the stator during assembly and operation and the enameled wire is worn through. That would mean a winding short circuit and the coil would no longer be usable. We leave the ends of the enameled wire sticking out on one side on the left and right so that we can still see the direction of rotation for mounting on the stator. The next step is the assembly on the stator and the soldering to the finished coil system. That will come next time.

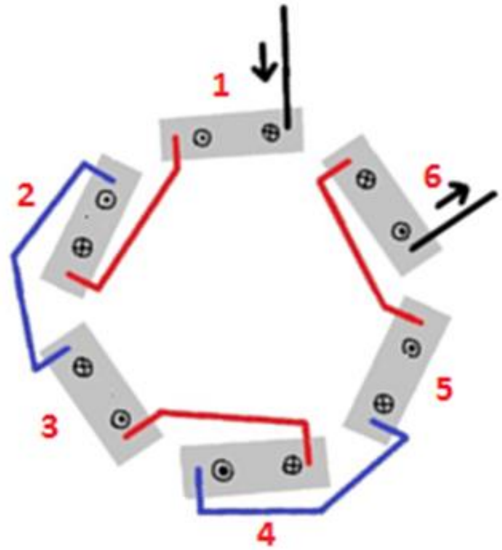

Power
USB
Ext

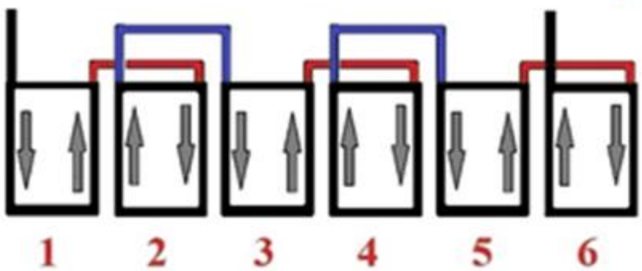

RECORD



WIL turbine construction 5: Coil assembly



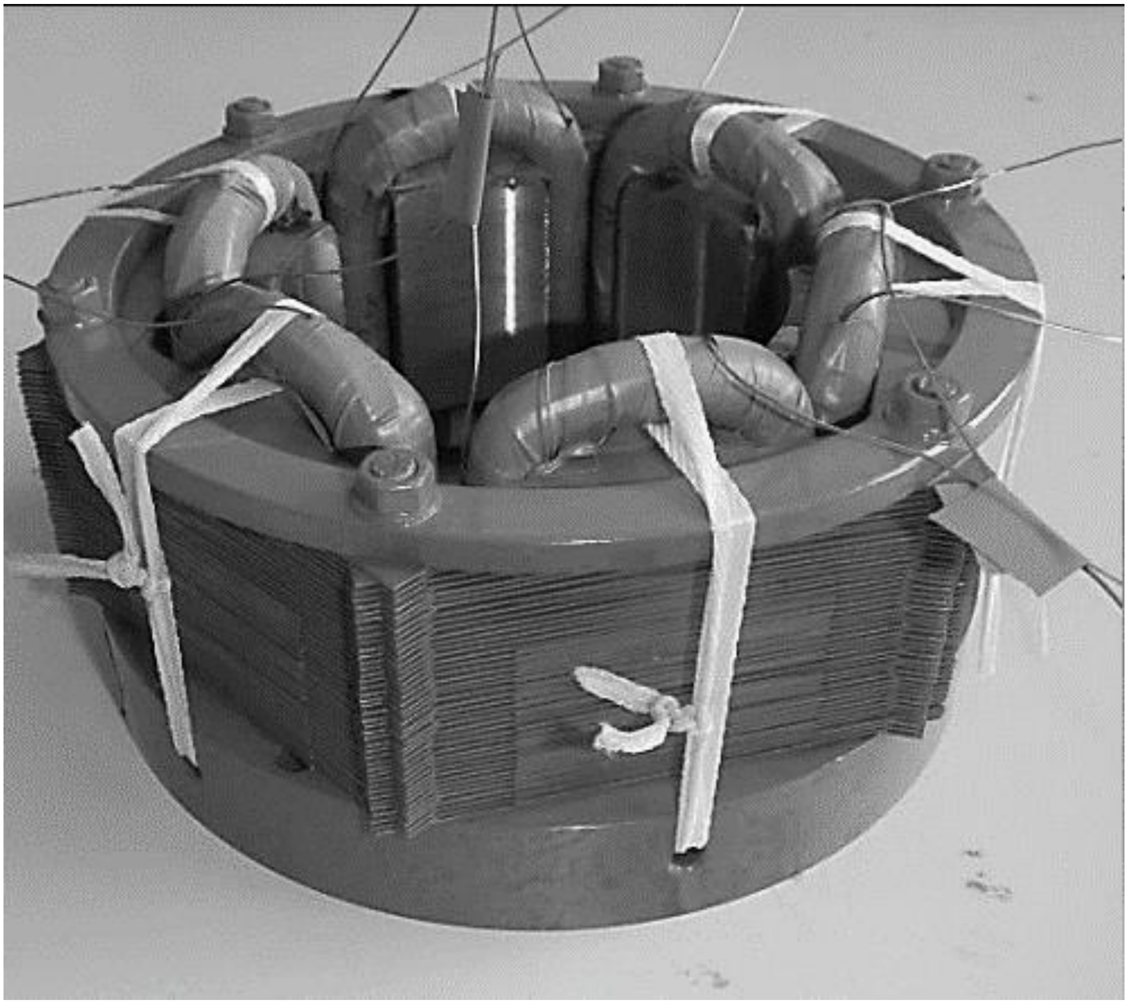




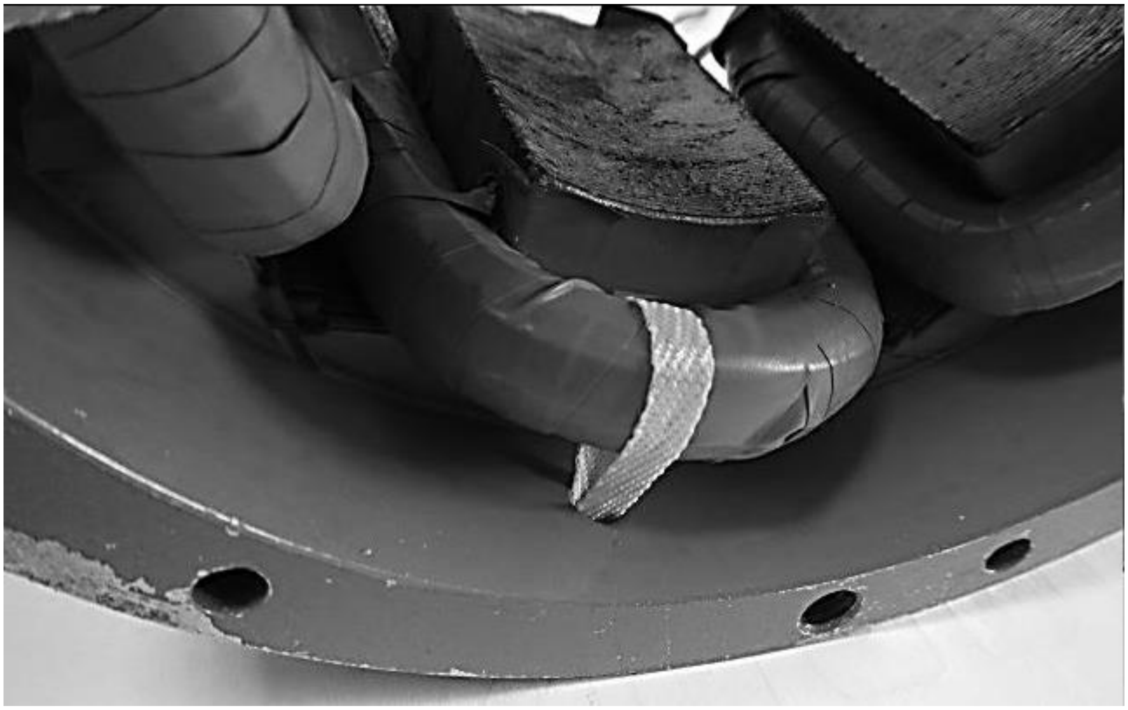
To start coil assembly, we need a finished stator and six finished coils. Our generator is called 3-pole because it consists of 3 pairs of coils, alternately wound left and right after assembly. 1000 revolutions per minute means then 3000 magnetic field reversals in 60 seconds thus 50 per second. And already we have the 50Hz for our alternating current. But now to the assembly.

The most important thing is to avoid shorted turns by damaging the lacquer on the copper wire. Therefore, the edges of the poles are slightly rounded and, for safety, the poles of the stator are also wrapped with temperature-resistant insulating tape. The coils themselves are also protected by insulating tape. Now the coils are pushed over the poles with feeling. It may be necessary to adjust the coil a bit.

Sliding the first coil over a pole is still easy. Some pressure may be necessary on the neighboring coils so that they sit neatly next to the other coil in the pole slot. The wire ends of the coils must always point upwards out of the stator so that they can then be soldered correctly. Then it just keeps going in circles until the last coil sits neatly in the pole slot.



Now comes the moment of truth. With the resistance meter all coils are measured. Between 2 and 3 ohms, the resistance is okay. If the enamelled wire has been damaged and turns are short-circuited via the metal stator, this is noticeable in this measurement. Everything in the green range? Then it’s a matter of fixing the coils. They should not slip out of the slot during operation. The coils have to be fastened to the stud bolts at the top with cable ties or string, and two coils at a time have to be pulled outward through the holes in the lower stator ring. This is a patience task, because the gap between coil and pole is narrow and the insulating tape, around the stator pole also disturbs.

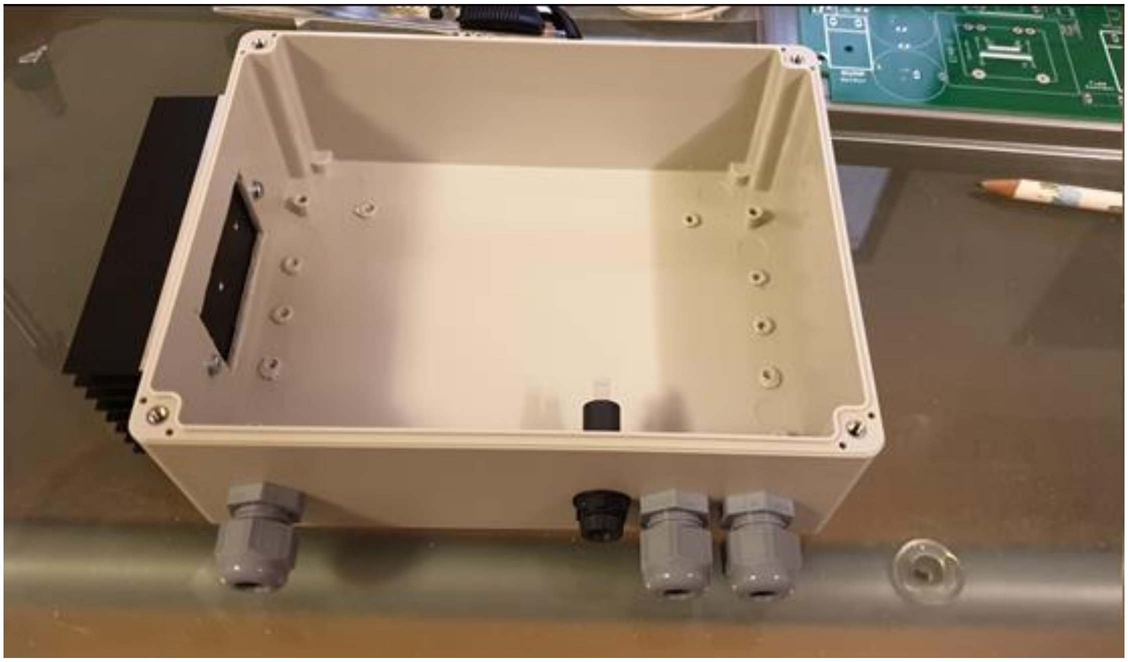


Now only the last step is missing, the soldering of the coils to the finished generator. Thank God, there is the wiring diagram in the manual. Then it is done. Now comes the final test with the compass. With the power supply a current of about 1A is fed into the series connection of the coils. Now the needle in the compass must show alternately a north and a south pole when moving from one coil to the next. If it does, we've finally done it. The stator is loaded with the coils and we are done. Hooray.

WIL turbine construction 6: ELC construction

In order for the turbine to be able to be used to power devices, a little electronics is required. Therefore, after the mechanical work on the turbine and the generator, today we continue with the Electronic Load Controller (ELC). Why is it needed? The turbine always delivers more or less the same power. However, depending on which and how many electrical consumers are connected, they do not require the entire power generated. Then the voltage and frequency would increase and the connected devices would be damaged. To prevent this from happening, the voltage must be regulated. The generator of the turbine is designed in such a way that a frequency of 50 Hz is set at a voltage of 230 V. If the voltage is right, the frequency is also right. The ELC thus ensures a constant voltage for the consumers. To do this, a load resistor (can also be an immersion heater, for example) is switched on in short pulses many thousands of times per second, where the excess power is converted into heat. This is done with a power transistor that is controlled by a microcontroller. The power at the load resistance and thus the voltage can then be regulated via the length of the pulses.

But now we can start with the construction of the ELC: We start with the housing, in which the electronics are installed to protect against wind and weather. To do this, we drill holes in a plastic housing for the lines that connect the electronics to the outside world. To ensure that everything is tight again later, cable glands are screwed into the holes. On one side of the case we cut out a section with the jigsaw onto which a heat sink is glued. Components that would overheat without cooling are later screwed onto the heat sink. We also use a fuse that can later be changed from the outside without opening the housing. This completes the preparations on the housing and we can turn our attention to the actual electronics board.

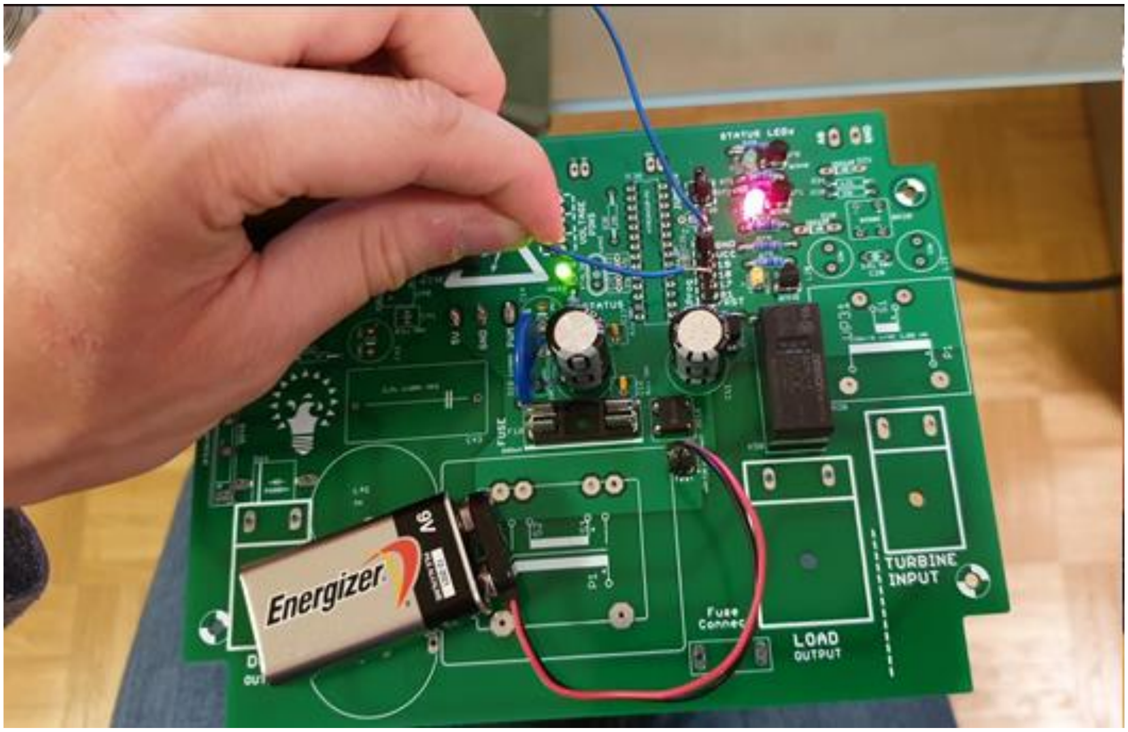


Prepared ELC housing

In addition to the circuit boards, all required electronic components have been ordered in the last few weeks, which are now being soldered onto the circuit board. We proceed in such a way that we solder functionally related assemblies one after the other, which we can then test directly. A small 9-volt battery is connected for the tests and sometimes a small tester with an LED that we built especially for the tests. A separate test procedure was devised for each assembly. This ensures that in the end the electronics work as they should and that all components have been soldered in correctly.

We start with the assembly that takes over the power supply for the electronics. It starts straight away with the most difficult component, a voltage regulator using SMD technology. Soldering this filigree component requires a certain amount of finesse. After that it gets easier. After a successful test, it continues with the next assembly.

Each module is soldered one after the other and then tested: LEDs for signaling errors, the power transistor that switches the load resistance with control components, components for voltage measurement, filters, etc. Finally, the heart of the electronics is used - an ATmega- Microcontroller on which a program will run during operation that controls all components.



LED assembly test

After we have finished soldering, the circuit board is inserted into the prepared housing and screwed tight. But we're not quite done with that yet. The intelligence to control the ELC is still missing, namely the software on the microcontroller. To do this, we wrote an Arduino program that takes care of the voltage regulation. In addition, it also monitors the network status and, in the event of a fault, switches off the consumers before they are damaged. In this case, the cause of the error is displayed with the LEDs until the problem has been rectified. The program is now loaded onto our microcontroller with the help of another Arduino. If this step has also been carried out successfully, the Electronic Load Controller is ready for use after approx. 10 hours of construction!

The software is loaded onto the microcontroller