NOTIFICATION

INTRODUCTIONS

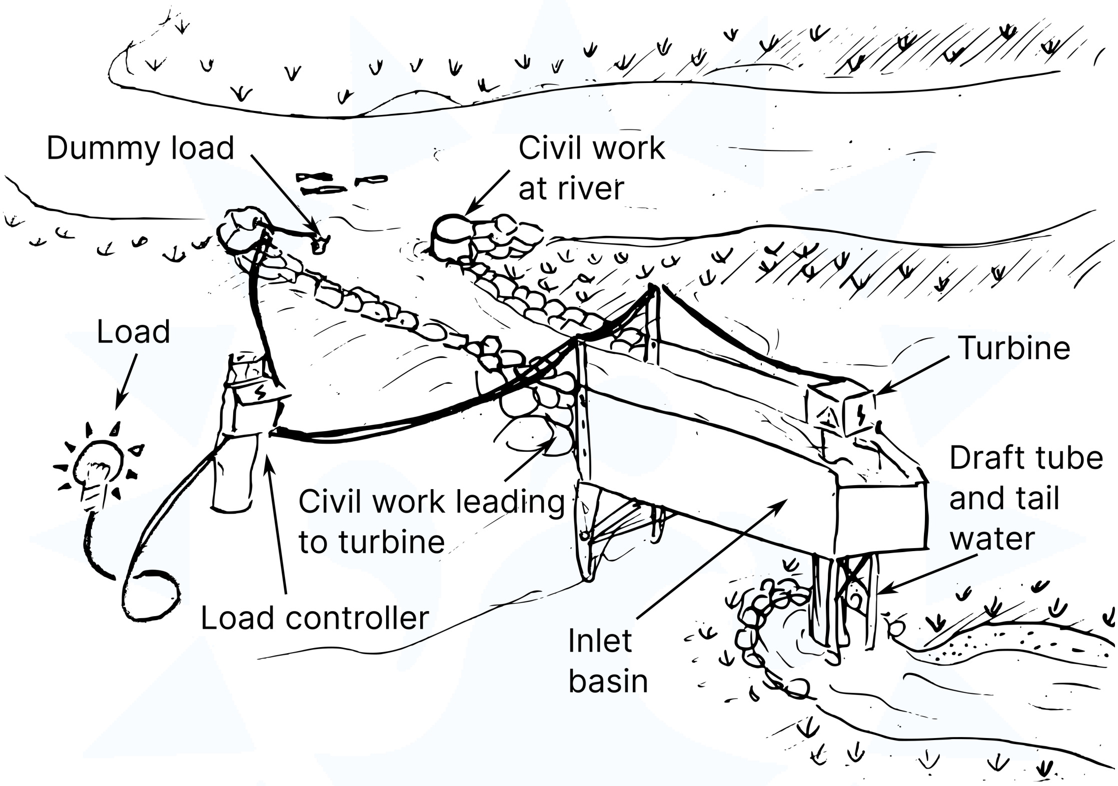

Fig. 1.: Overview of the WIL system: The turbine, civil works and electrical installation

This handbook is meant as a guideline on how to choose the right location, negotiate with potential costumers and build and maintain a turbine system that can bring electricity to rural areas. This chapter gives you basic information about the WIL project, this handbook and its authors.

Introduction of the WIL Project

The project name WIL means Water is Light and summaries the intention of Ingenieure ohne Grenzen e.V. to bring light into houses in less developed countries. The electrical energy is produced by a pico hydro turbine which is designed in a way, that it could be produced with mainly local material and technologies available in emerging countries. By improving the living conditions of the inhabitants by sustainable energy and an affordable solution this project should also enable some people to start a business by building, installing and maintaining pico hydro systems.

The WIL turbine system generates an equivalent of 50 standard 5 Watt LED Light Bulbs. Because of its small size and power range the turbine is preferred to be installed close to the consumer. For support you find contact information on the website.[1] Please do not hesitate to contact us at any time with any question.

Introduction of the turbine system

The WIL-System is designed to provide electricity in an off-grid environment, this means in areas, where no public electricity is available. It is designed for a power level of about 250 W. Therefor it is able to provide electricity for lighting and charging of mobile phones in some houses, when LED lighting is used. The system consists of the generator (turbine), which has to be placed in a location providing minimum 40 l/s of water flow and a drop of 2 m. To control the frequency and voltage level of the generator a control unit is necessary, which also provides a basic level of load management. After generating electricity and controlling of the voltage, electricity is transported to the houses via an electrical line, which ends at the protection box near the houses to be connected. As electricity always includes the danger of electrical shock, this device is mandatory to avoid danger for the people using electrical energy. From that protection box, which has to have a connection to ground (grounding) the electric energy is fed to the houses.

Introduction of the authors

This handbook has been created by Ingenieure ohne Grenzen e.V. Regensburg and GreenStep e.V.

GREEN STEP e.V. is a Non-Profit German NGO, founded in 2007. Focus is set in the field of renewable energy technologies to improve electrification in remote areas in Africa. In this context the design of the WIL turbine system was initiated for production in a vocational school in Cameroon. In addition projects to promote and support sustainable agriculture were implemented to raise living standard of the rural population. GREEN STEP's policy is to support and empower individuals and groups to build their own business. For more information visit green-step.org.

Ingenieure ohne Grenzen e.V. is a non-profit private aid organisation. We are independent of political, religious or ethnic aspects. Ingenieure ohne Grenzen was founded in 2003. More than 3000 members in Germany support about 50 projects in more than 30 countries. We cooperate with corresponding partners within the worldwide Engineers without Borders organisation. For more information visit ingenieure-ohne-grenzen.org. Our goal is to build and expand basic infrastructure. We work together with local partners and people. The focus is on the supply of clean water, sanitary facilities and energy, e.g. for schools and health centres.

The Regensburg regional group was founded in 2009 and focused on water supply by solar pumps. Soon the topic of energy supply was added. This led to the development of the small hydropower turbine WIL in cooperation with Ostbayrische Technische Hochschule Regensburg (OTH), a local university of applied sciences. This turbine was optimised for use and production in less developed countries. Its goal is to promote the development of local training and employment.

[1] waterislight.de
ingenieure-ohne-grenzen.org

How to use this manual

This handbook contains all information for building, installing and maintaining a complete WIL pico hydro turbine system. Additionally, information to basic theory of hydropower, installation site evaluation and tool usage is provided. Advanced technical skills in mechanics and electronics are required. This document is open source of information and available for everyone. It cannot be copyright protected or sold for its content. If the digital version or an update of the same is required, please see contact information below.

It is supported to use this manual for your needs but it is also strongly advised to take care of personal safety and environmental issues at any time! As defined in the NOTIFICATION on top of this document, all warranty on using this document is declined. This handbook is designed for three different levels of users. All chapters are marked with level A, B or C at the bottom of the page.

Level A includes the basics how to use the system. The content should be known by a user of a completely installed system. This means the usage of the electricity in his house but not the installation or maintenance of components of the system and also not the building of the electrical or mechanical components.

Level B includes the information, how to install and maintain a system by the usage of already build components. It does not include the production e.g. of the turbine, the electronic control unit or the protection box. It also includes safety hints for the installation. The user of the handbook at Level B also has to know the content of level A.

Level C includes all information, how to build the components e.g. turbine, electronic control unit, protection box and charging box. The user of this level also has to know the content of level A and B.

On the bottom right of every page is the date of validation. Please make sure to check online, if your handbook is up to date. Additionally, the table below shows you the oldest date of validation per chapter. If you have a physical copy of this handbook, and an update is released, all you have to do is check and replace the chapters that are older then the dates given below:

ATTENTION: **If your chapter is older than the following date, please replace it. An update might also change the annex, depending on the levels you use. You might also need to update the table of contents on the following page.**

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CHAPTER A

MECHANICAL PRODUCTION

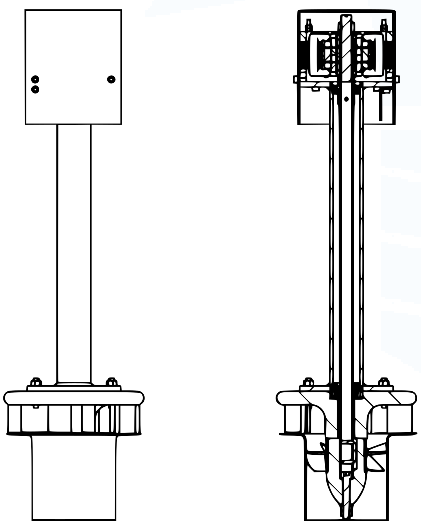


Fig. A.1.: Excerpt of the drawings

ATTENTION: You will need all the tools listed on the tool list and the parts listed on the object list. Make sure you have Version 2.0 of the CAD-Drawings.

Mechanical production is the act of building and creating parts for this turbine. You may use machines like lathes, but the design allows manufacturing in all metal workshops. The design choices allow maximal performance with the least requirements. You should still work as precise as possible. Reduced quality will result in lower performance and efficiency. The following part of the manual shows exactly how to build the WIL water turbine. In order to avoid any injury and to be able to produce a device that is actually operational, you have to follow every step of the manual very carefully. Please do take your time and do not rush or make any compromises.

Choose good quality material in order to get the best efficiency, durability and maximum safety! It is advisable to organise all of the parts before you start working. Follow the instructions of the handbook step by step! If you have any question regarding parts or manufacturing steps, please contact us at:

https://www.ingenieure-ohne-grenzen.org/de/mitmachen/regionalgruppe-regensburg#kontakt

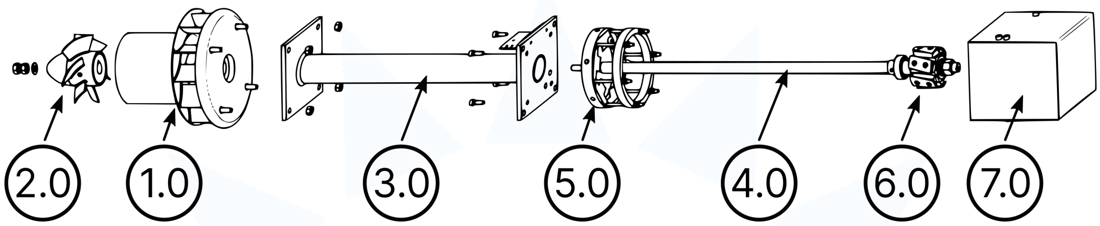


Fig. A.2.: Overview of the main parts and their corresponding number in the technical drawings

1.0 Flow channel
- 1.1 Lead ring
- 1.2 Upper feed stream ring
- 1.3 Outflow pipe
- 1.4 Thread shaft
- 1.5 Vane

2.0 Propeller
- 2.1 Propeller hub

3.0 Housing
- 3.1 Connection pipe
- 3.2 Stator receiver
- 3.3 Terminal bracket
- 3.4 Upper feed stream sheet

4.0 Turbine shaft
- 4.1 Shaft
- 4.2 Distance bushing
- 4.3 Thread shaft
- 4.6 Safety catch
- 4.7 Bearing seat
- 4.8 Safety bolt

5.0 Stator
- 5.1 Lower lamination ring
- 5.2 Upper lamination ring
- 5.3 Transformer sheet
- 5.4 Alt. transformer sheet
- 5.5 Thread shaft

6.0 Rotor
- 6.1 Pole shoe
- 6.2 Thread shaft
- 6.3 Magnet dummy

7.0 Generator cover
- 7.1 Main sheet
- 7.2 Side sheet

8.0 Downpipe (not shown)
- 8.1 Flange
- 8.2 Draft tube

A.1. Working with a lathe

WARNING:

Do not try to work with it without a training by an experienced teacher.

A lathe is a very dangerous machine. It is better to find some experienced person to do the works described below instead of being badly injured.

You will find hints, how to work with the lathe machine in the attachments. These are only hints and can not replace a training with an experienced person. The workpieces for lathe machine The description below gives you hints for the production of the workpieces with a lathe machine. The parameters are proposals for good working quality.

A.2. Working with wood

WARNING:
The wood grain has to be parallel to the rotation axis of the lathe.

- The cutting parameters need to be adjusted to the type of wood used
- Hardwood must be used e.g. ash, beech, elm, oak, mahogany, maple or poplar
- To make wood more durable in water applications, it has to be sealed. Treat all wooden parts with wood finish, like mineral oils, natural oils or resin. Please closely follow the instructions given by your treatment product.

A.3. Tool List

Tools

Standard tools:
- Hammer
- File
- Screw clamp
- Shears
- Manual deburring tool
- Grains
- Ruler
- Corner
- Compass
- Calliper
- Scribing needle
- Silicone sealant
- Drilling machine
- Welding device

Saws:
- Handsaw
- Jigsaw
- Saw blade
- Angle grinder
- Angle grinder blade

Lathe:
- Lathe tool
- Cutting insert

Soldering:
- Rod electrode
- Solder

Drills:
- HSS: 23; 20; 18; 16; 14; 12; 11; 10; 9; 8; 6.4; 6.0; 5.5; 4.5; 4.2; 4.0; 3.5; 3.3; 3.0
- Tread cutter: M6; M5; M4
- Piloted counterbore: M4
- Countersink: 24; 15; 12; 10; 8; 6; 4;

A.4. Turbine Crafting Tools

All tools described in this chapter are mandatory for the turbine building process. Once crafted, they can be reused for all following turbines. It is mandatory to craft them very precise and in high quality. Do not save money on them and be sure the dimensions are precise! While working, please refer to the drawings on Drawing set V2.0!

ATTENTION: All dimensions are given in millimetre [mm]!

A.4.1. Dummy Magnets

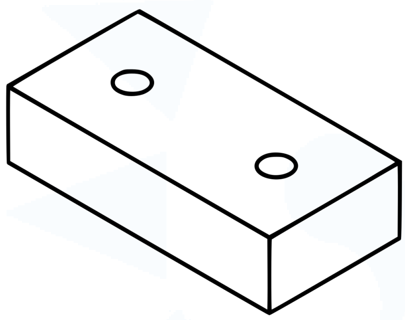


Fig. A.3.: Magnet Placeholder

- Quantity: 6
- Material: Metal or Hardwood
- Drawings: Pos. 6.3

Description: The dummy magnets are used as substitute of the real magnets while crafting the rotor. If the real magnets are used, e.g. for turning the rotor, metallic waste will stuck to them and may lead to damage. The dimensions and position of the borings must be the same as the real magnets which can be used as reference.

A.4.2. Coiling Tool

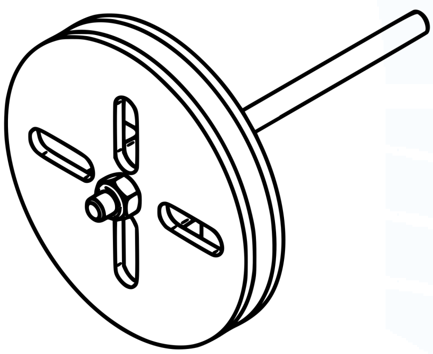


Fig. A.4.: Coiling tool assembly

- Quantity: 1
- Material: Hardwood, metal or durable plastic
- 2x Ø110 x 4 mm side piece sheet
- 1x middle piece material
- Thread bar M6 to M10 x 100 mm
- 2x fitting screw nuts

Description: The coil tool is required to wind the 6 coils for the generator. The copper wire will be fixated at the centre part of the tool, which then can be attached to a (battery) drill. By carefully guiding the wire into the tool, a homogeneous coil is produced.

After coiling up a certain number of windings, the coil can be fixated by wrapping it with insulation tape using the four big slot holes of the side bits of the tool. The edges of the two side plates need to be smooth so the wire cannot be damaged. The dimensions of the middle part are also very important and need to be precise, otherwise the coils won't fit the generator. The two side bits can have different dimensions. Solely the four holes have to fit to the holes of the middle part.

A.4.3. Flanging Tool

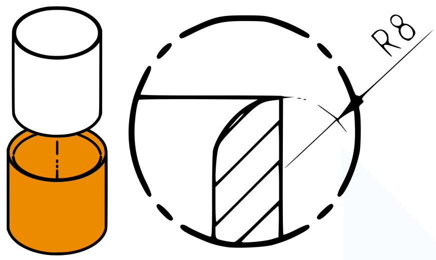


Fig. A.5.: Radius on the tool

- Quantity: 1
- Material: Steel
- Pipe Ø140 x 7.5 mm

Description: This tool is required for bending the upper edge of the outflow pipe. The 8 mm radius is important to get a plan surface for the upper feed stream ring and a floating transition for the water stream. If it is not possible to turn the R8 radius on the upper edge, a smaller radius can be applied by hand.

A.4.4. Bore Appliance

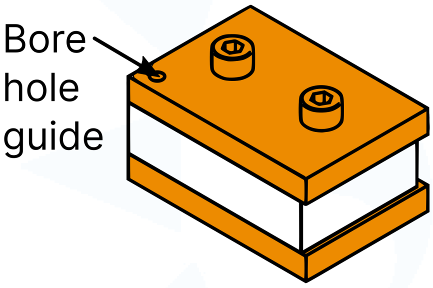


Fig. A.6.: The tool ensures uniform holes

- Quantity: 1
- Material: Steel (high strength preferably)
- 2x Bore sheet
- 2x screws/thread bars M8 x 50 - 60 mm
- Nuts M8

Description: The bore appliance is used to drill a uniform hole into the transformer sheets.

A.4.5. Angle Grinder Appliances

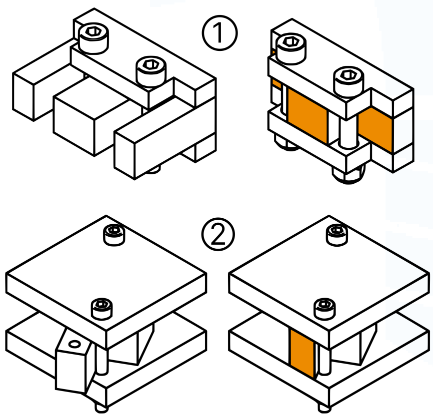


Fig. A.7.: The orange surface is wrought with an angle grinder, to fit inside the generator.

- Quantity: 1
- Material: Steel (high strength preferably)
- 4x angle grinder sheets
- For tool 1: 2x screws/thread bars M8 x 50 - 60 mm and fitting nuts
- For tool 2: 2x screws/thread bars M5 x 50 - 60 mm and fitting nuts

Description: These are the two tools for cutting the transformer lamination sheets to the required shape. The correct dimensioning and the placement of the top and bottom borings is very important. If the sheets do not fit the generator properly, the efficiency of the generator will decrease significantly.

A.4.6. Stator Lathe Appliance

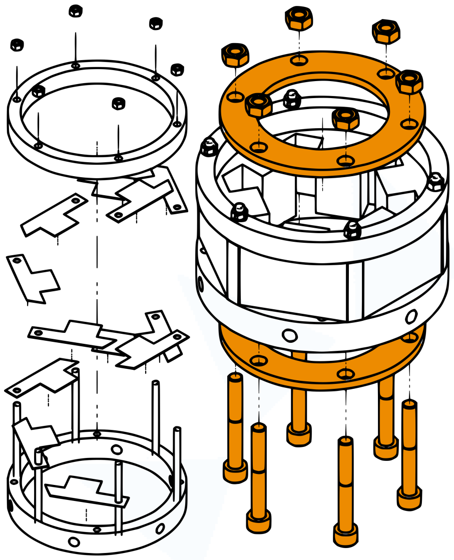


Fig. A.8.: Assembled Lathe Appliance

- Quantity: 1
- Material: Metal
- 2x Ø114 x 5 mm sheet
- 6x screws/thread bars M8 x 60 mm
- 6x screw nuts M8

Description: Do not try to use the lathe on the assembled stator without this tool, because otherwise its stator can be damaged. The two metal rings with 6 borings are placed onbottom and top of the laminations. By using screws and screw nuts, this tool fixes the stator and allows machining on the lathe. The dimensions of both top and bottom ring, which are crafted identically, need to be applied very precisely. The thickness of the two rings may be varied between 5 mm and 10 mm. The boring diameter may vary between 8 and 9 mm. For assembling, use at least 60 mm long M8 screws or M8 thread bars.

A.4.7. Rotor Lathe Appliance

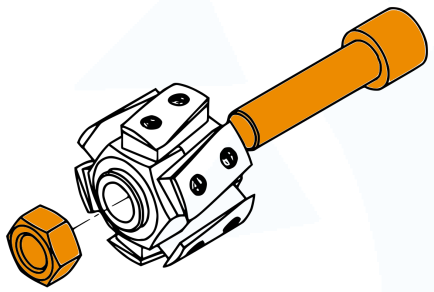


Fig. A.9.: The finished tool

- Quantity: 1
- Material: Steel (high strength preferably)
- Shaft Ø30 x 115 mm
- Nut M20

Description: This tool is required for trimming the pole shoes to a cylindrical shape.

A.4.8. Wood Lathe Appliance

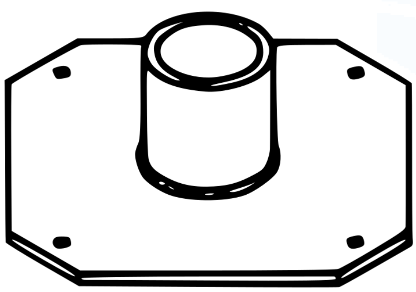


Fig. A.10.: The finished tool

- Quantity: 1
- Material: Metal
- Sheet 180 x 180 x 5 mm
- Pipe outer Ø50 mm, inner Ø40 mm, Length 50 mm

Description: The Wood fixation tool is used for turning the wooden lead ring. It makes it possible to mount the unmachined wood to the lathe machine.

1. Mark the centre of the ground plate.
2. Mark a line at each corner of the ground plate as shown in the technical drawings.
3. Mark a diameter of 40 mm around the centre of the ground plate.
4. Place the pipe over the 40 mm marking, so that it is centred on the ground plate.
5. Fasten the pipe onto the ground plate with some clamps. It is essential, that the pipe is cut in a 90° angle, so that the turning will be correct later on! In case of doubt, put the pipe in a lathe and turn off one mm of the front side.
6. Weld the pipe onto the ground plate.
7. After cooling down, put the welded tool into the lathe and turn a 40 mm hole in the centre of the ground plate (later, this hole will match with the boring of the lead ring).
8. Keep the tool mounted to the lathe and double-check if the surface, that would contact the raw wood, is at a perfect 90° angle to the main axis of the lathe. If not, rework this surface with the lathe.
9. Mark a 160 mm diameter with a pen on the ground plate. (The easiest way is to put a ruler over the 40 mm hole and add 60 mm from the edge of the boring, then put the tool back into the lathe and hold a pen to that exact point. Now turn the lathe one rotation by hand. Now you have marked the diameter)
10. Bore four holes with diameter 4,5 mm which are 90° displaced to one another. These are for fastening the raw wood with a wood screw.

A.4.9. Centring Tool

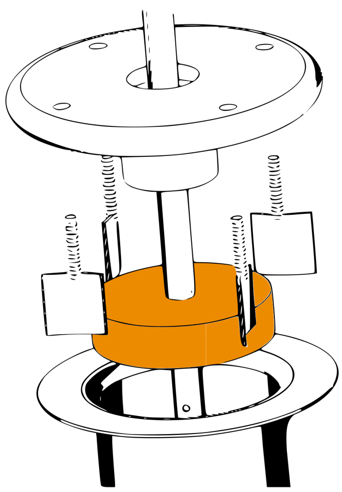


Fig. A.11.: Proper fit of the turbine shaft

- Quantity: 1
- Material: Steel or plastic
- Sheet Ø121 x 30 mm

Description: This tool is used to position the shaft perfectly centre to the outflow pipe. The propeller blades should have a constant gap of 0.5 to 1 mm to the outflow pipe, so the right position of the shaft is important. The smaller the gap, the higher the efficiency of the turbine. Please refer to the drawings in the annex for the exact measurements.

A.4.10. Stator Adjustment Tool

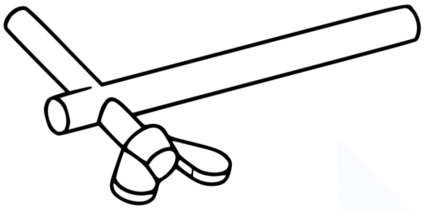


Fig. A.12.: The finished tool

- Quantity: 1
- Material: Steel
- Bolt Ø10 mm
- Screw M6 x 60 mm

Description: This tool is used to align stator and rotor.

A.5. Turbine Subassemblies

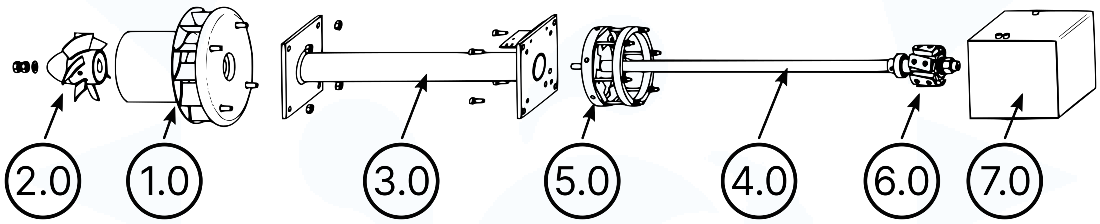


Fig. A.13.: Overview of the main parts and their corresponding number in the technical drawings

This chapter describes how to build the parts that make up the turbine. Please take the time to read the instructions carefully. While working, please refer to the drawings on Drawing set V2.0!

ATTENTION: All dimensions are given in millimetre [mm]!

A.5.1. Flow channel

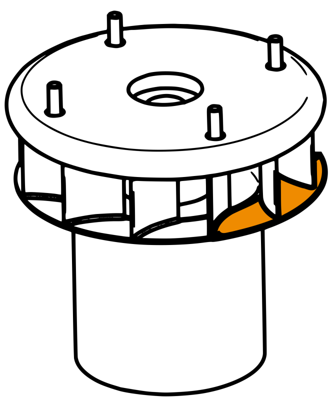


Fig. A.14.: Finished flow channel with vane template

Requirements

Tools:

- Welding equipment
- Lathe equipment
- Hammer
- Saw
- Rasp
- Vane template
- Centring tool
- Shaft (4.0) or Ø20 mm tube

Material:

- 12x Vanes
- 1x Lead ring
- 1x Upper feed stream ring
- 1x Outflow pipe
- 4x Thread shaft M8x40

Turning the lead ring on a lathe

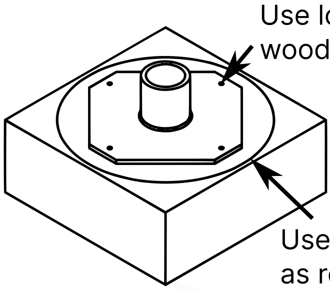


Fig. A.15.: Wood fixation tool with marked wood block

Requirements			
Tools:	• Wood lathe appliance		• Lathe • Screwdriver • Oil
Material:	1x Hardwood 230 x 230 x 90 mm		4x Wood screw M4 x 50 mm 4x Wood screw M4 x 25 mm

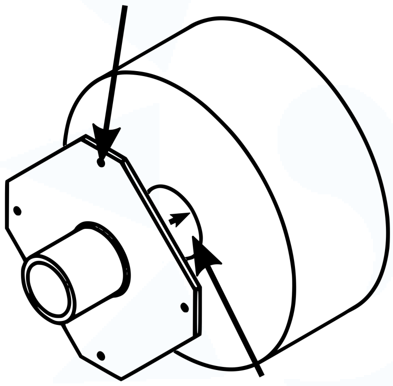


Fig. A.16.: Fixating the lathe appliance on the other side

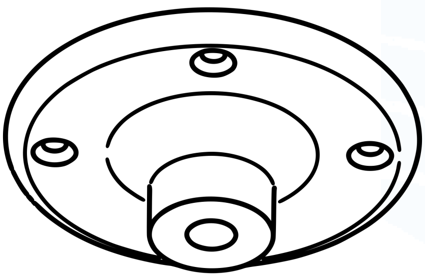


Fig. A.17.: Finished lead ring

1. Chose for the side which seems to be the flattest and mark on this surface the outer diameter of the lead ring. Mark the centre point of that circle. Now put on the wood fixation tool. Be careful that it is in the centre of the marked circle. Fasten it with the long wood screws.
2. Turn the cylindrical surface to Ø230 mm. Start slowly, because there can be an imbalance of the weight distribution because of the shape of the wood.
3. Turn the plane surface so that it is in a 90° angle to the cylindrical surface.
4. Bore a 49 mm hole into the plane surface.
5. Unscrew the wood fixation tool and put it back on the plane surface of the other side that has just been cut. Be careful that the fixation tool is centred properly, it is important for the following steps. You can orientate yourself on the 50 mm bore hole and the outer diameter. To fixate the wood now, you have to use the short 25 mm wood screws.
6. Now turn the lead ring according to the drawings.
7. When finished with turning the part, the holes of the wood screws can be used for the borings in the plane surface.

Sawing the vanes

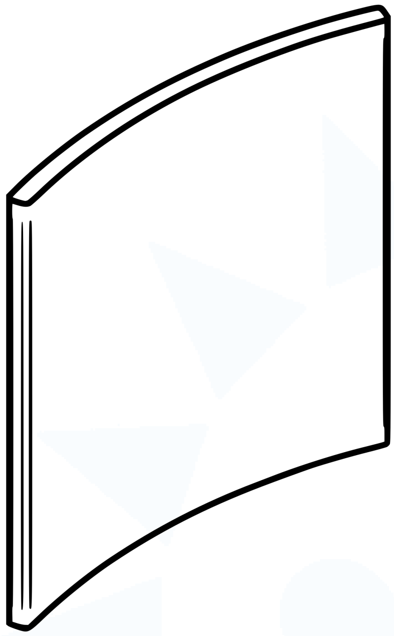


Fig. A.18.: The vanes guide water inside the flow channel

Requirements	
Tools:	• Saw and rasp
Material: 2x Steel pipe 43 mm	Ø(in) 121 mm Ø(out) 125 mm

1. If necessary, use a lathe to bring your pipe into the right dimensions. The diameters are very important for the turbine's efficiency.
2. Mark 39° sections on the two steel pipes. Leave space for the saw between the sections. In the technical drawing, you can find control dimensions in parenthesis. You should fit 6 section on one pipe.
3. Use a saw to cut out the sections. You should have 12 pieces.
4. Use the file to generously round the freshly cut edges of the sections.

Flow channel subassembly

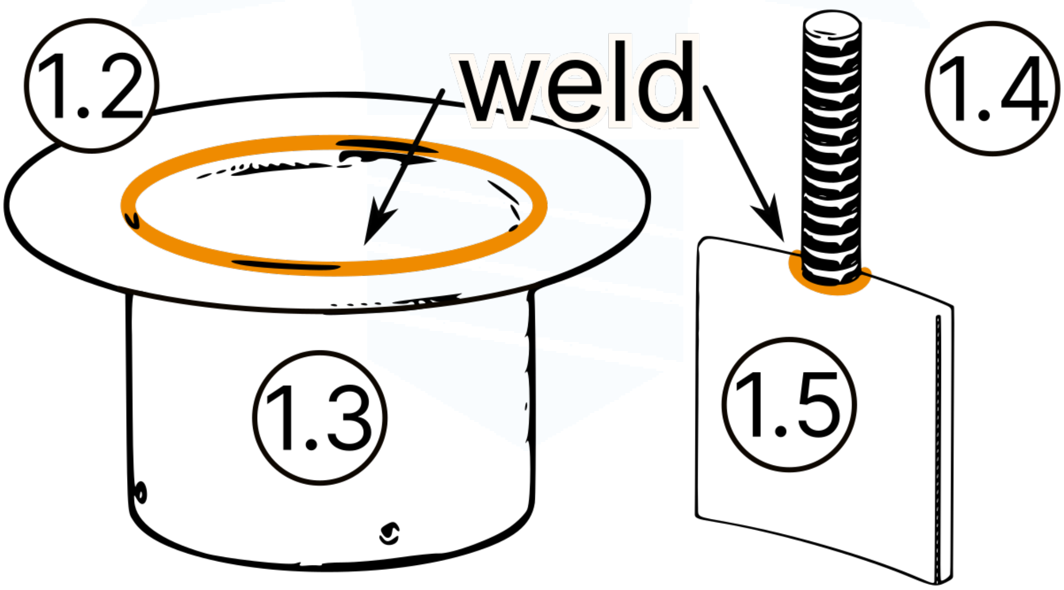


Fig. A.19.: Welding job for the outflow pipe and four vanes

1. Weld outflow pipe (1.3) and upper Feed stream ring (1.2) together.

2. Weld thread shafts (1.4) to the vanes (1.5)
   Note: For easy positioning of the thread shafts, mark the middle of the vanes.

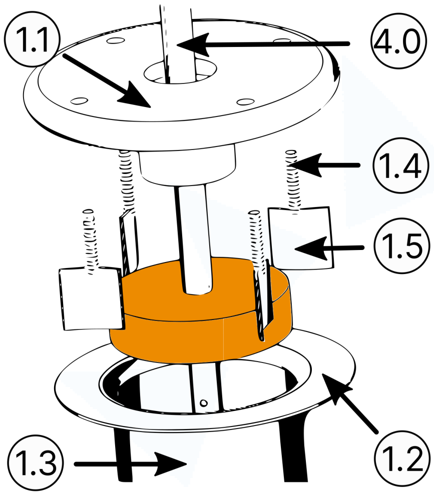
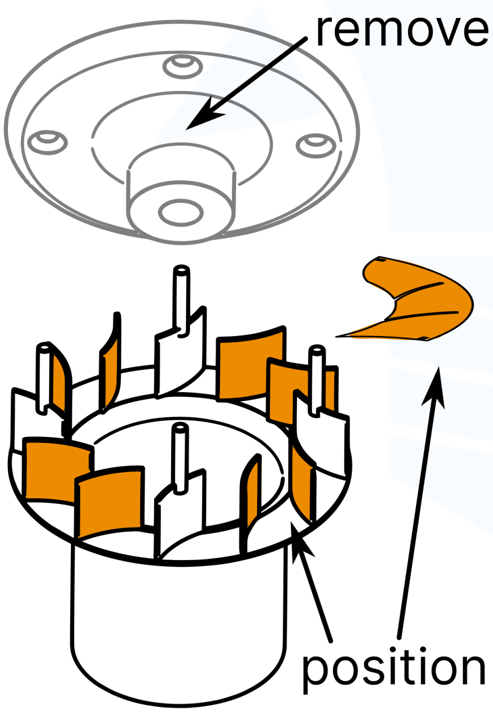


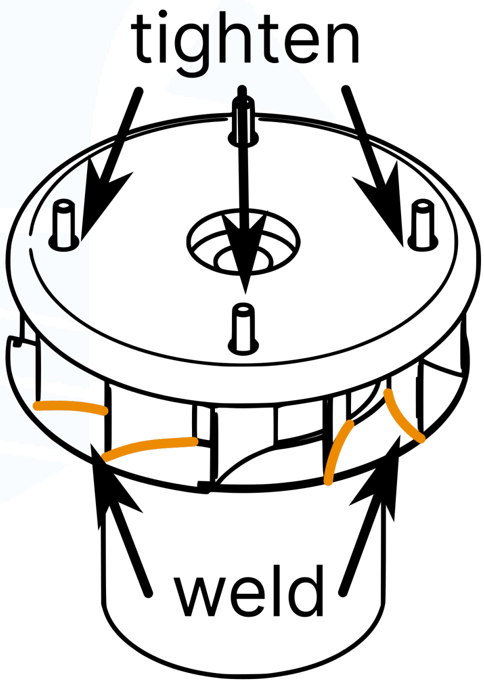
Fig. A.20.: Assembly of previously welded parts. Use the centring tool (orange).

3. Put the thread shafts (1.4) and already welded together vanes (1.5) through the holes of the lead ring (1.1) and screw them together. Put them into correct position with the vanes template (S_1.1). Use the centring tool!
   a) Screw lead ring and thread shafts together.
   b) Position the Vanes with the Template. Mind the angles!
   c) Use the centring tool to centre the lead ring and shaft (or the Ø20 mm pipe) with the flow channel before welding the 4 blades with threaded rod in the correct position. With this you will get the propeller to run with a constant gap of 0.5 - 1.0 mm. The smaller the gap, the higher the turbine output and efficiency.

4. Unscrew Nuts from step 3. Position the remaining Vanes with the Template and tighten the nuts again (now the Vanes will be hold in position)
   Note: It's much easier if you only weld one vane and then repeat step 4.



(a) Remove the lead ring and position remaining vanes with the template.



(b) Reattach the lead ring firmly and weld the remaining vanes to the upper feed stream ring.

A.5.2. Propeller

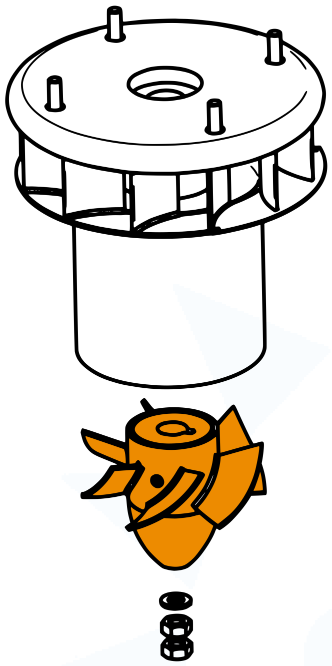


Fig. A.22.: Flow channel and propeller assembly highlighted in orange.

Requirements

Tools:

- Welding equipment
- Angle grinder (thin new blade)
- Jig saw (thin saw blade)
- Pipe wrench
- Metal drill
- Centre punch tool

Material:

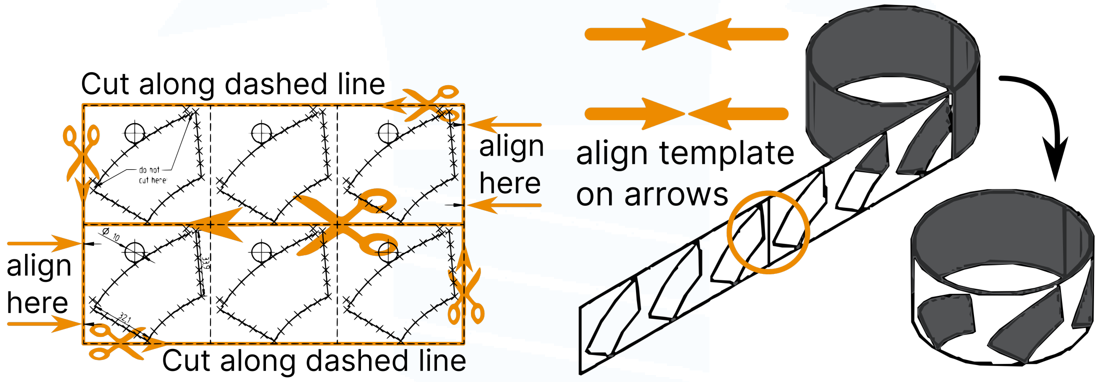
1x 2”-Pipe ØM 60.3 mm Øi 54.5 mm H 50 mm

1x Pipe ØM 125 mm Øi 121 mm H 70 mm

1x Propeller hub

1. Cut the blade receiver pipe to the length of 50 mm and burr the edges. The measurements of the outer (ØM 62 mm) and inner diameter (Øi 58 mm) need to be precise.
2. Now you need the bigger pipe (ØM 125 Øi 121). If you choose to use a jig saw, it is easier to cut the blades while the pipe is a longer piece (e.g. one meter). If you use a hack or hand saw instead, it is advised to cut the pipe to a length of 70 mm.

4. Apply the template onto the pipe and use a nail or centre punch on the points marked with an x (see Fig.A.23). Make sure, that the template is oriented the right way and in the right scale. The propeller’s shape is very important for the efficiency of the turbine.

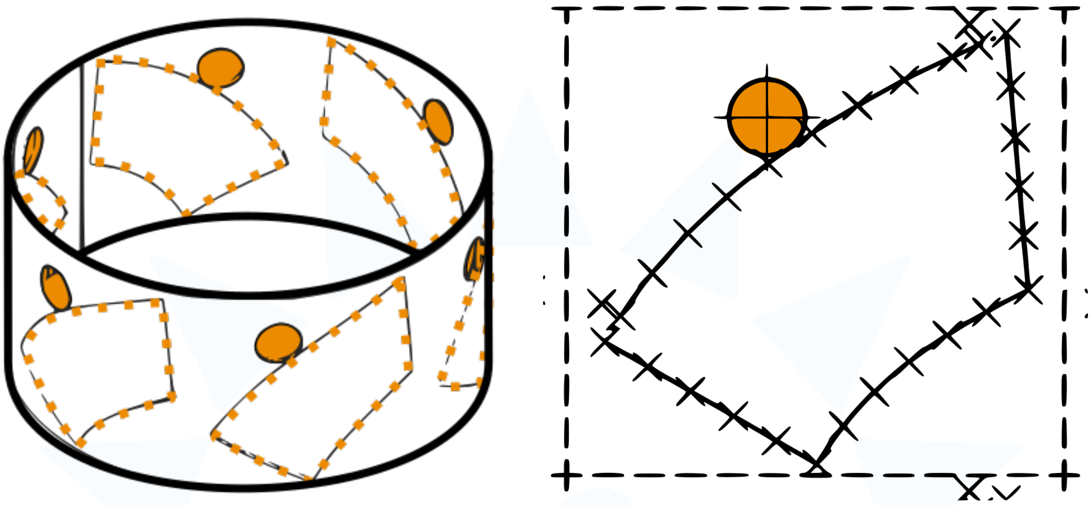


(a) Double check for right dimensions and cut out the square shape and the inside area of the blades in the template

(b) Wrap the cut out template sheet around the bigger pipe. The template needs to be in line with the edges of the pipe.

Fig. A.23.: To transfer the template’s shape onto the pipe, use a centre punch or nail on the marked points.

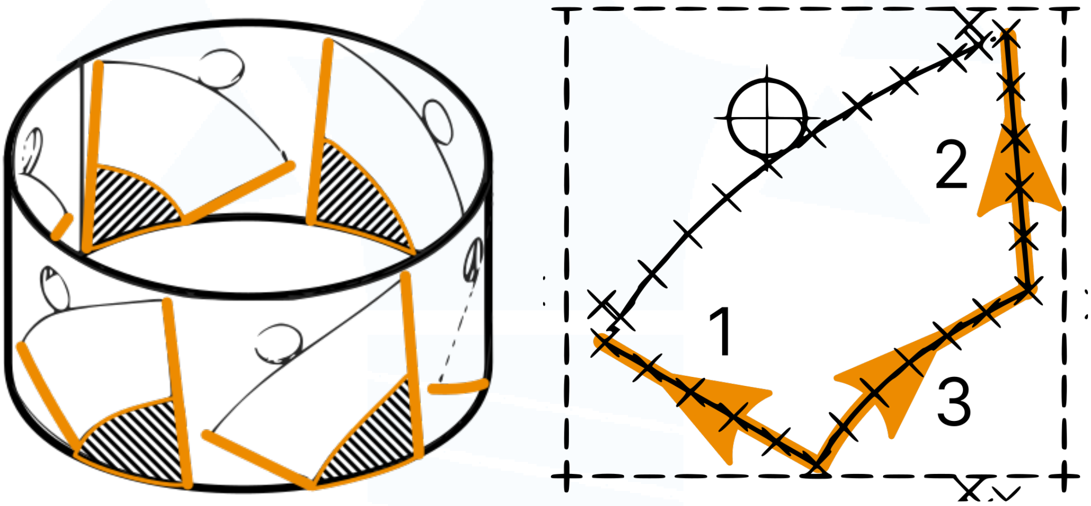
5. Drill a hole of minimum 10 mm so you can reach the longer bow with the jig saw. Be sure it is well outside the area of the marked blade.



(a) Pipe with marked blade shape and drill hole (b) Sketch positioning of drill hole

Fig. A.24.: Pipe blade shade and drill hole

6. Then, first cut the three edges with the jig saw or with the hack saw (both side edges and the shorter bow), as shown below. Be precise with the cutting.

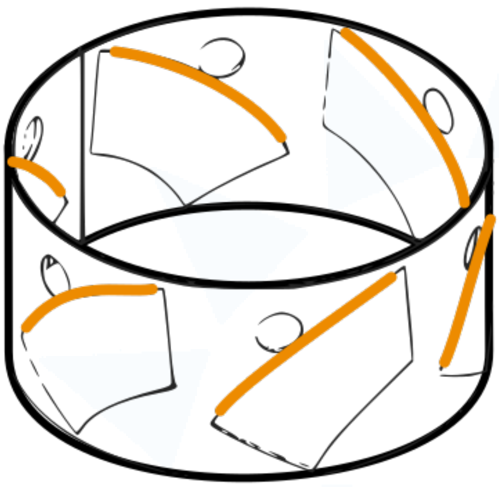


(a) Pipe with first three saw cuts (b) Sketch order of saw cuts

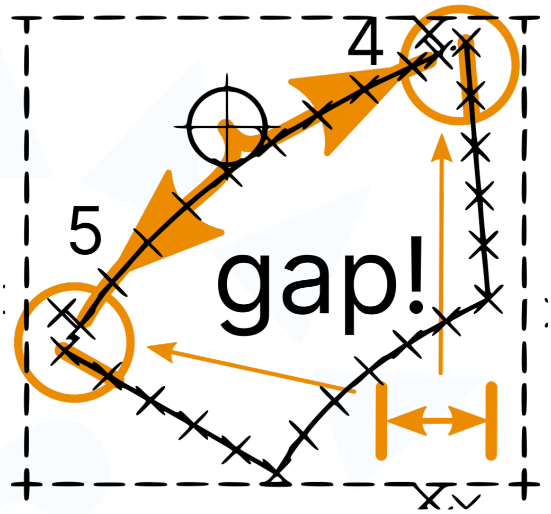
Fig. A.25.: Pipe with first three saw cuts and order of saw cuts

7. Then, cut from the hole along the marking until there are only about 2 mm left over to the right and left cut.

ATTENTION: Do not cut the whole shape!



(a) Pipe with saw cuts and speared bending positions

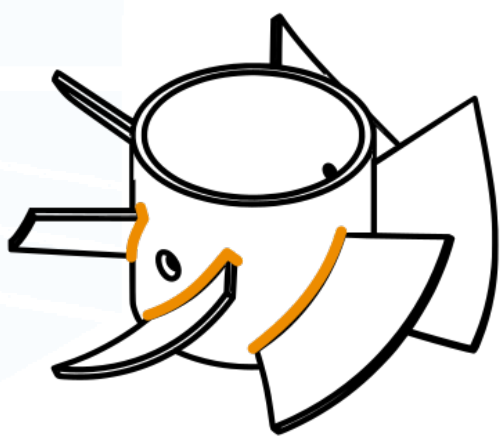


(b) Order and placement of saw cuts

Fig. A.26.: Last cuts on the outer pipe. Make sure to leave a gap!

8. Bend the six blades to the inside. Be careful and wear gloves! The edges can be very sharp. Fit the smaller, 50 mm long pipe inside the bigger pipe with the inwards bended blades. Centre the inner pipe and position it height-wise, so that the blades fully touch the inner pipe. You can use the dummy magnets to prop up the inner pipe. Check another time if the pipes are concentric and levelled. If they are not, the turbine would be unbalanced, which causes heavy damage. Weld the blades to the inner pipe carefully on the side with the spikes.

(a) Pipe with bended blades and centred, positioned inner pipe



(b) Weld the blades to the inner pipe, along the orange area.

Fig. A.27.: Attaching the blades to the inner pipe. Make sure the weld is durable and goes across the entire length of the blades.

9. Now cut off the outer pipe by using the angle grinder. Just cut the 12 bending positions careful. Make sure to not cut anything off the blades.

Adjusting the propeller on a lathe

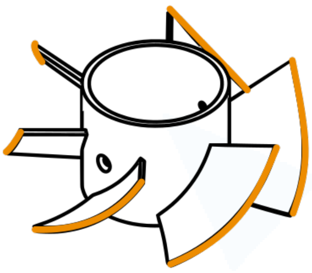


Fig. A.28.: Turn the propeller to the specified diameter

Lathe parameters

- Rotation: 150 rpm
- Feed: 0.16 mm/rev
- Cut depth: 0.1-0.2 mm
- Cutting tool: Lathe bit

The propeller needs to have a very tight clearance to the inside of the outflow pipe. For this, the outer edges of the propeller need to be adjusted on a lathe. Use little feed and low number of revolutions. Take your time, be very careful with the turning job!

Propeller Hub

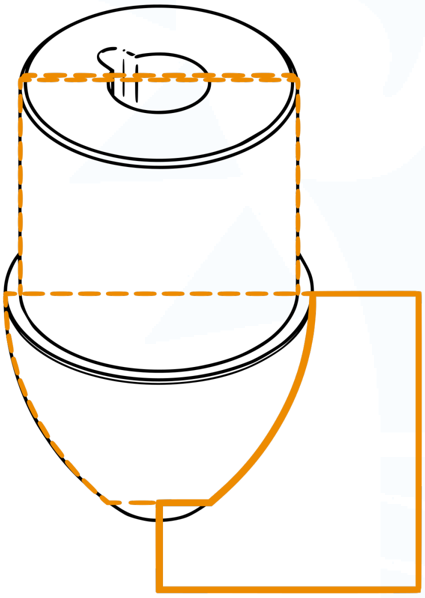


Fig. A.29.: Propeller hub with template

Requirements

Tools:

- Lathe
- Oil
- Hub template

Material: 1x Hardwood 70 x 70 x 110 mm

ATTENTION: Make sure you print the stencils in the right scale.

The propeller hub can be manufactured without any fixation tool, i.e. using the normal clamps of the lathe. For manufacturing it, follow the earlier advice on turning wood. Check the overall shape with the stencil in the drawing set.

A.5.3. Housing

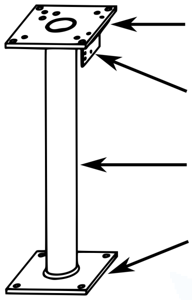


Fig. A.30.: Parts of the housing

Requirements

Tools:

- Lathe and equipment
- Welding equipment

2x Screw M6x10 mm

Material:

1x Pipe ØM 50 Øi 40 L 474 mm

1x Steel sheet 75 x 75 x 3 mm

2x Steel sheet 140 x 140 x 8 mm

Connection pipe

Lathe parameters

- Rotation: 900 rpm
- Feed: 0.2 mm/rev
- Cut depth: 0.2-0.8 mm
- Cutting tool: Lathe bit and boring bar

Fig. A.31.: The ends of the connection pipe's inner and outer diameter need to be adjusted on a lathe. The fit on these parts has to be very tight.

Stator receiver

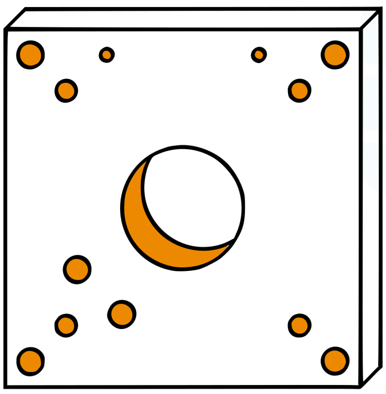


Fig. A.32.: The stator receiver plate is manufactured on a lathe

Lathe parameters

- Rotation: 900 rpm
- Feed: 0.2 mm/rev
- Cut depth: 0.2-0.7 mm
- Cutting tool: boring bar, centric drill, drill of 10, 15, 20, 25 mm

Use the 4-jaw chuck to turn a hole of 48 mm

1. Use the drill up to a diameter of 20 mm
2. Use the inner turning tool

Terminal bracket

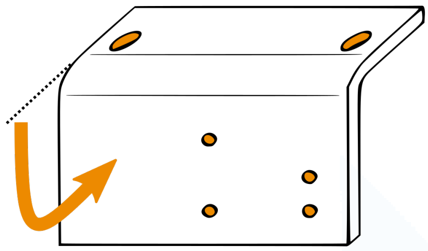


Fig. A.33.: Bend and drill the sheet.

The bracket can be manufactured with hand tools only:

- Bend the sheet to a 90° angle. The sheet piece is purposely larger, so you have a bigger margin of error for the bending job.
- Measure the dimensions of the newly bent faces and adjust according to the drawings.
- Drill the bore holes into the bracket

Upper feed stream sheet

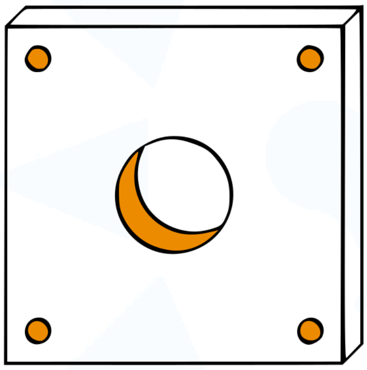


Fig. A.34.: The upper feed stream plate is manufactured on a lathe

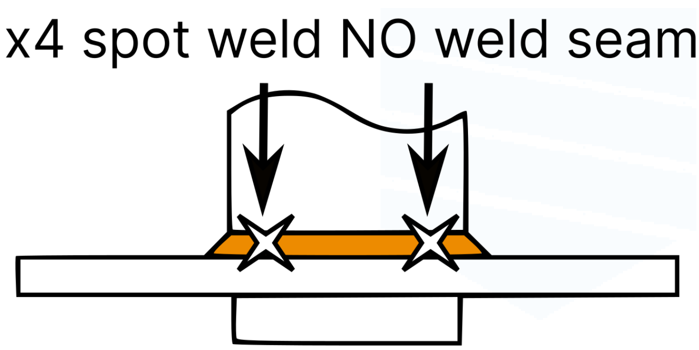
Lathe parameters

- Rotation: 900 rpm
- Feed: 0.2 mm/rev
- Cut depth: 0.2-0.7 mm
- Cutting tool: boring bar, centric drill, drill of 10, 15, 20, 25 mm

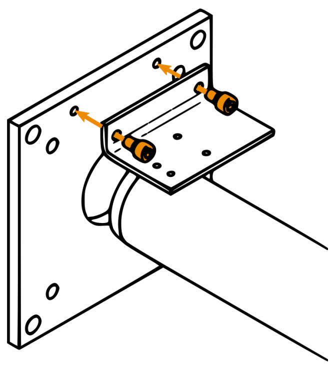
Use the 4-jaw chuck to turn a hole of 48 mm

1. Use the drill up to a diameter of 25 mm
2. Use the inner turning tool

Housing subassembly



(a) Weld the connection pipe to the two sheet plates.



(b) Attach the terminal bracket.

Fig. A.35.: The housing subassembly is simple. First weld the sheet plates onto the pipe. Do not seam weld, as this would deform the connection pipe. Afterwards, screw the terminal bracket on the stator receiver. You may also spray paint the housing now.

A.5.4. Turbine shaft

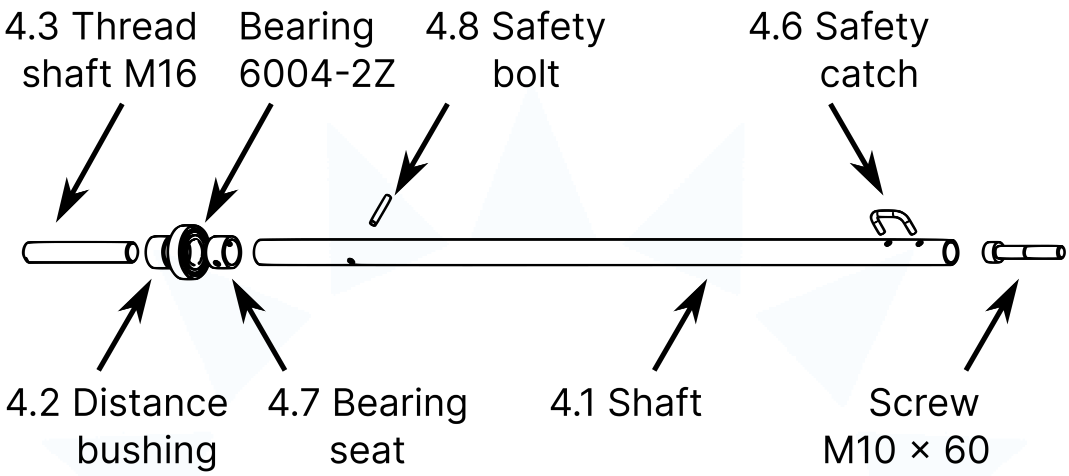


Fig. A.36.: Parts of the shaft. Please be very careful when working on the shaft. Any deformation can heavily reduce the lifespan of your turbine.

Distance bushing and thread shaft

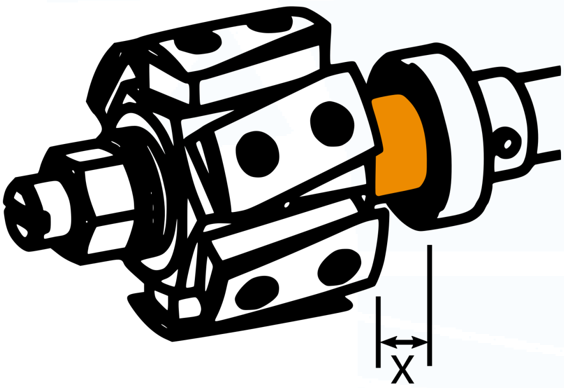


Fig. A.37.: The distance bushing (orange)

Fig. A.38.: Notched thread shaft

The distance bushing sits between the upper shaft bearing ant the rotor. In the technical drawings, we suggest a height of 16 mm, although you need to adjust this dimension for every turbine. The magnets and generator sheets need to align on the bottom side, thus the bushing's dimension depends on multiple parts and cannot be determined in advance. Keep that in mind, when cutting the bushing. If it's to0 short, you'll need to cut a new one. The thread shaft needs to be notched on one side. This gives you a place to wedge e.g. a screwdriver on the shaft, to fixate it while tightening or loosening nuts later on.

Safety catch

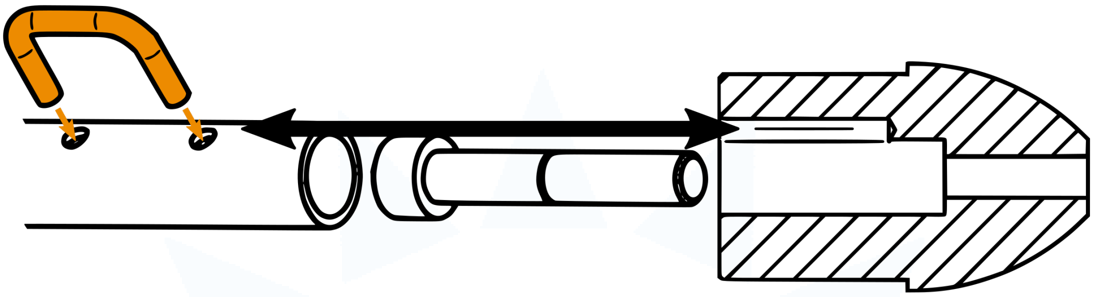


Fig. A.39.: Safety catch with pocket in the propeller hub.

The safety catch is a bent piece of bar that locks the propeller in place. While the nuts fixate the propeller along the shaft's axis, the catch and pocket prevent any free rotation of the propeller. This means, that all rotational energy is transferred to the catch, then shaft and lastly the generator.

Bearing seat and safety bolt

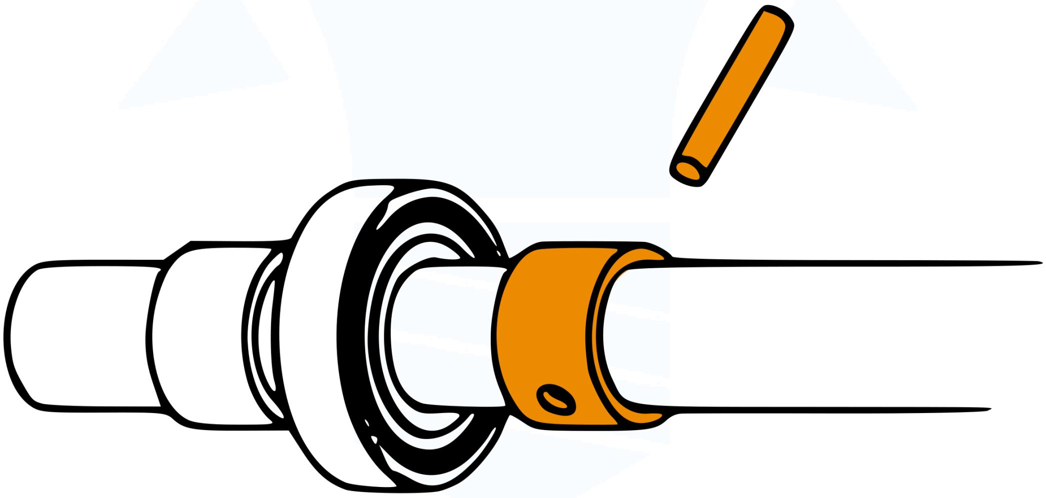


Fig. A.40.: Bearing seat and safety bolt on the shaft.

The bearing seat provides a resting surface for the bearing, while the safety bolt locks the seat in place. You might need to adjust the height of the seat, so that the bearing sits properly in the assembly.

Shaft subassembly

Fig. A.41.: Weld the two thread shafts onto the shaft

ATTENTION: Welding can deform the shaft! The shaft is very sensitive to bending or derounding. Weld only at the upper side of the shaft to fixate the M16 thread bar. Do not weld the bearing fixation ring. Use the metal pin to fix the bearing ring axially.

After the welding, check the shaft for deformations. Rework the surface area on the shaft, where the lower bearing and seal sits, with fine sanding paper. The surface has to be free of grooves or spins, to seal properly. The welding seam on the lower thread bar needs to be reworked on the lathe. Make sure the thread bar is properly aligned to the shaft and the weld seam is not rising over the shaft's end too much.

A.5.5. Stator

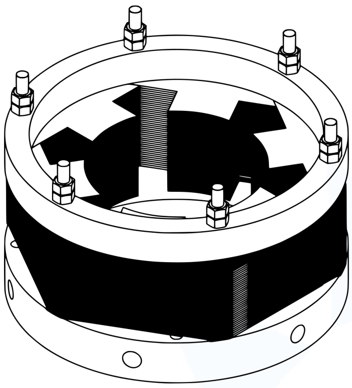


Fig. A.42.: Finished Stator

Requirements

Tools:

- Band saw
- Cutting tools
- Lathe
- Metal drill: 4.2; 5 mm
- Thread drill: M5; M6
- Rasp

Material:

480x Transformer Sheets
6x Thread bar and screw M5x80 (both)
1x Upper Lamination Ring
1x Lower Lamination Ring

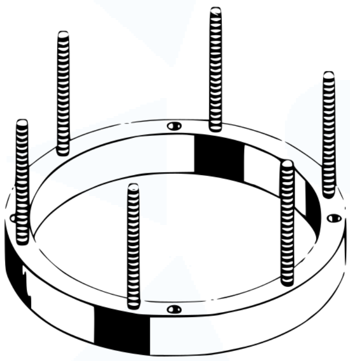


Fig. A.43.: Lower lamination ring and thread bars

1. Cut the thread bars to 80 mm and burr the edges. If you use screws, cut their heads off and burr the edges so the Screw Nuts fit. Screw them about 7 mm deep into the M5 borings.

2. The next step is to cut the lamination sheets. You will need 480 pieces of the cut sheets. Precision is very important, the better the sheets are cut, the more electrical power will be generated. Take your time to prepare the sheets. Due to the large number of sheets you should work in a group of 5 or 6 people. Each person is doing one of the following steps so that a production row is created:

   a) Cut with pair of snips
      i. Drill the 5 mm holes
      ii. Mark the cutting lines for flanks and middle part
      iii. Cut the flanks and middle part
      iv. Mark the angle cut
      v. Cut the angle
      vi. Flatten the sheets

   b) Cut with the angle grinder and the Appliances: (take a look in the drawings)
      i. Drill the 5 mm holes
      ii. Do step 1 with the Angle Grinder Appliance I
      iii. Do step 2 with the Angle Grinder Appliance II

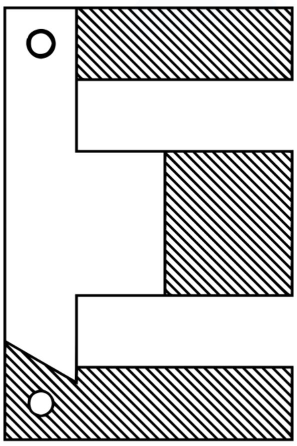


Fig. A.44.: Transformer sheet cut

ATTENTION: Check for precision every 20 pieces!

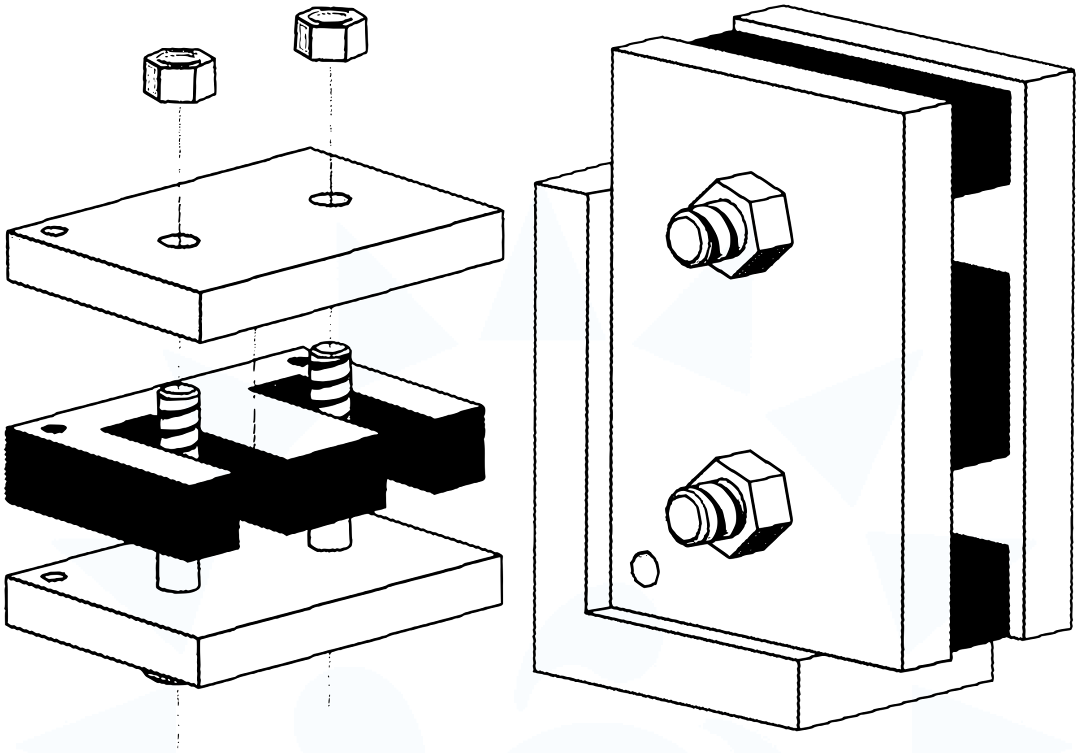


Fig. A.45.: Left: Drill Tool assembled with Sheets and Right: Drill Tool in combination with Angle Tool to straighten the Sheets

3. Due to the fact that the borings in the sheets are not big enough, one side needs to be expanded to 5 mm. Here we use a tool which makes it easy to widen the borings. Span a pack of 30 sheets into the Drill Tool and straighten them up by using the Angle Tool. Make sure the edges are in line with the edges of the tool and the hole in the sheets is exactly in line with the slightly bigger hole in the tool. Span the sheets together very tight, then drill through the 5 mm hole in the Drill Tool using a 5 mm drill

4. Release all the sheets after drilling; for the next steps, the sheets will be processed piece by piece.

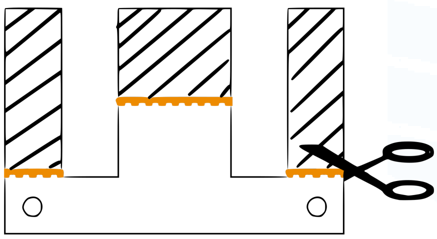
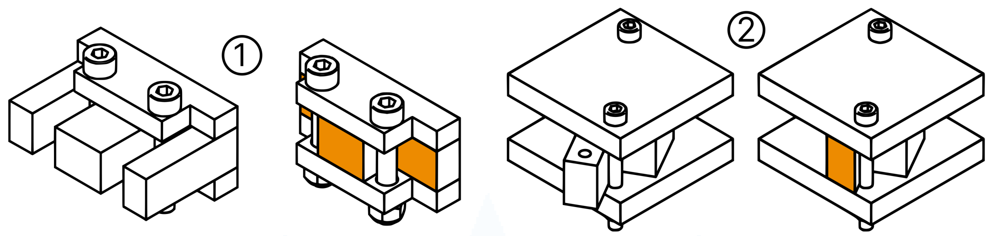


Fig. A.46.: Cutting positions on full sheet

5. Cut the flanks and the middle part using tin snips to the measurements seen below. Be precise! For both, 4. and 5., it is advised that one person is doing the marking, another person is doing the actual cutting. Use Templates made out of strong cardboard.

6. Now you need to cut the side with **the smaller (4.5 mm) holes**. Be accurate with the measurement of the bottom side of 60 mm, the angle needs to be exactly 60°. You can also use the angle grinder appliance for the cuts in the transformer sheets:



(a) First step (b) Second step

Fig. A.47.: The transformer sheets are cut in two steps, using the two angle grinder appliances

7. Fit the transformer sheets into angle grinder appliance 1 and cut them down according fig.A.47. On the second step, make sure that the transformer sheets firmly touch the screw! This is very important to get the important 60° angle. This angle is the reason for the uncomfortable bore dimension of this appliance and is very important for the fit inside the generator cover, later.

   Alternative transformer sheet shape: A laser cut stator sheet can be used instead. Exact measurements are inside the technical drawing set in the annex. You can either order the sheet yourself, f.e. from a Chinese manufacturer, or contact us. We can send you the starter sheets.

8. Place the first layer of 6 sheets clockwise on the lower Lamination Ring. The next layer will be placed anticlockwise. Change direction with every layer. Do not compress the sheets yet. Just keep them in position.

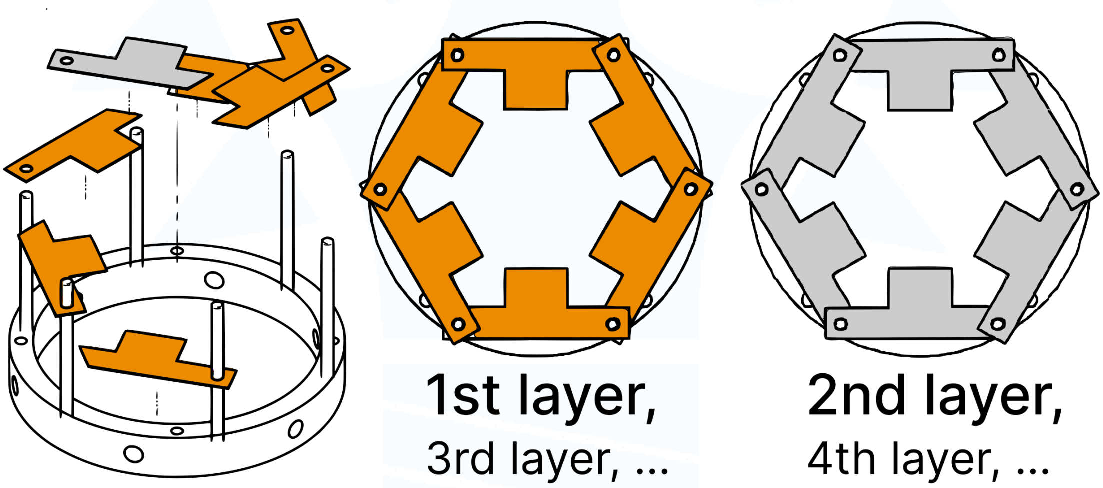


Fig. A.48.: Direction and order of the layers

9. Cut 480 Lamination Sheets and place them as described above.

10. When you got all layers in position, place the upper lamination ring on top and start compressing by tightening the screw nuts consistently. After compressing, the height of the transformer sheet pack **needs to be exactly 40 mm**. Remove or add more sheets if necessary until the required height is reached. After this, do not open the sheet pack again, to prevent damage.

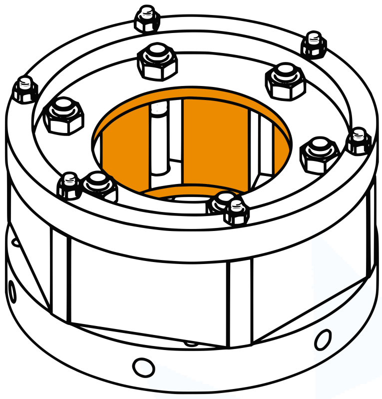


Fig. A.49.: Highlighted areas to be machined on the lathe

11. Place the Stator Support Tool in the middle of the Stator. Make sure the tool is centred and the screws are tightened strongly.
12. Cut out the middle of the stator to a diameter of **75 mm**.
13. Take the stator support tool off and rasp the sharp edges carefully.
14. Cover the six inner surfaces of the stator core (those that are freshly cut), with tape and spray-paint the whole body at least 3 times, to reduce damage on coils and prevent corrosion.

Parameters for the lathe

- Number of revolutions: 150 min^{-1}
- Feed: 0,2 mm/revolution
- Infeed: 0,2-0,3 mm (Depends on the quality of the lathe chisel)

ATTENTION: Sufficient experience with lathe and adequately sharp tools are required!

Coils and Wiring

Fig. A.50.: Finished wiring of the coils (numbered)

Requirements

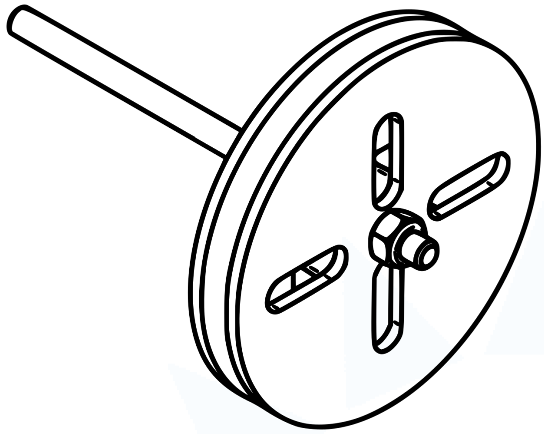
Tools:

- Coiling Tool
- Soldering equipment
- Battery
- Metal drill: 8 mm
- Knife
- Compass

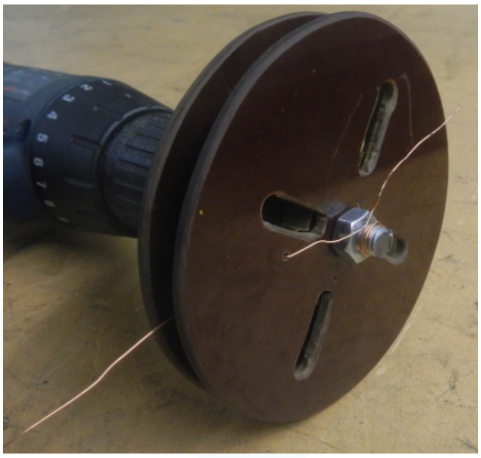
Material:

250 m Enamelled copper wire: Ø 0.5 mm
2 m Electric cable
1x Fixation String
1x Insulation tape

1. Prepare the coil tool by attaching the assembled coil tool to a drill or battery drill. Make sure the tool is tightened up and the side plate holes match the holes of the centre piece. Attach the wire by going in between the two plates and coming out of one of the four holes. Leave about 100 mm wire coming out of the holes and wrap it to the thread bar to fasten it.



(a) Individual parts of the coil tool



(b) Assembled coil tool

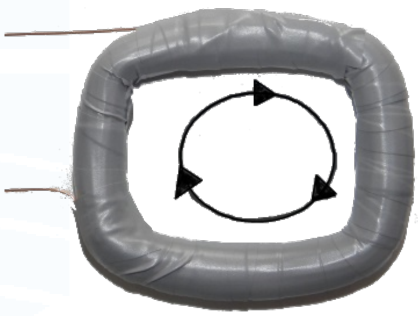
Fig. A.51.: Assembled coil tool A.51a attaches to a battery drill A.51b. The wire attaches to the central thread bar.

2. Get another person to help you start winding coils. Person 1 sticks something (e.g. Screwdriver) through the wire drum and hold tight to it so the wire is always on tension while winding. Person 2 carefully activates the drill/battery drill and coils the wire onto the middle part of the coil tool. It is important to guide the wire constantly so a homogeneous distribution while winding is reached. (The thickness of the coil must be equal at all points). It is advised that at least two persons are counting the windings while processing. Keep the tension on the wire when finished.

   ATTENTION: Each coil needs exactly 230 windings.

3. After winding a coil, you need to dismantle the coil tool. To prevent the finished coil from falling apart, wrap a piece of insulation tape around each side of the coil through the holes along the sides of the Coil Tool. Now the tension on the wire can be relieved and the tool can be opened.

(a) Coil fixated on all 4 edges by insulation tape.



(b) Fully insulated coil.

Fig. A.52.: Figure A.52a shows the wound coil after step 3. Figure A.52b shows the insulated coil after the following step. The arrows in the middle indicate the winding direction of this example coil.

4. Insulate the coil completely and let the end bits stand out on the top side so you still can see the direction of winding. Get a double layer of tape to the inner side of the corners where the

friction will be very heavy due to sharp edges. Use a knife to thoroughly scrap the isolation lacquer of about 10 mm of the wire endings to make them electrically conducting. Make sure you can always figure out the winding direction of each individual coil.

5. Repeat step 1 to 4 until you get 6 consistent and fully insulated coils

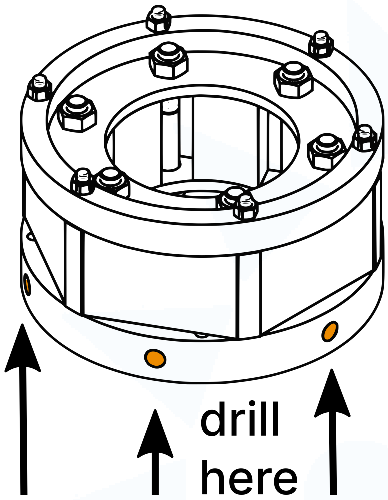


Fig. A.53.: Stator with marked boring positions

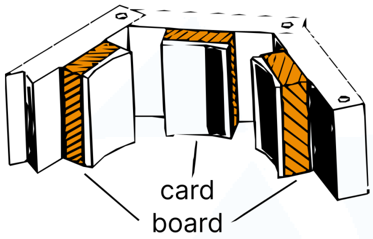


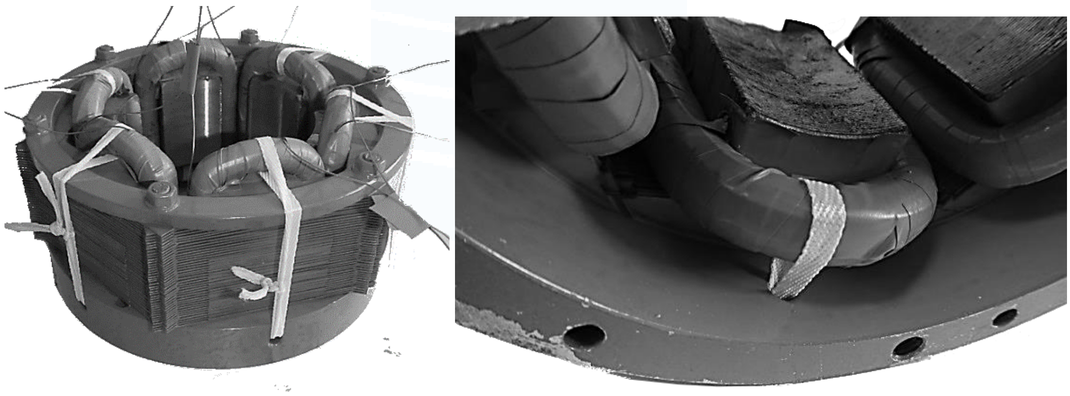
Fig. A.54.: Schematic of the safety insulation positioning

6. To prepare the stator, mark 6 spots on the lower lamination ring for later drilling. The horizontal position is in the middle of the Lower Lamination Ring, the vertical position is the centre in between the screws fixating the Lamination Sheets.

7. Now drill 8 mm holes at the marked positions. Burr the holes carefully. The next step is to cover the sharp edges of the inner blocks of the Lamination Sheets (where the coils will sit on) using cardboard or multiple layers of paper. Cut some cardboard to the measurement of 150x10 mm and glue them to the Lamination Sheets. It must not be thicker than 0.5 mm.

8. Fit the coils onto the stator (Loose ends up!) and make sure that they don't get damaged during the process. Do not use force! Once damaged, a coil cannot be used any more. A new one has to be coiled.

9. Fixate the fitted coils. Tighten each coil to the stator as seen on the pictures below. The string goes through the hole at the bottom of the Lower Lamination Ring as well as over the top of the Upper Lamination Ring. This prevents the coils from moving around during the turbine's operation.



(a) Total view (b) Detailed View

Fig. A.55.: Stator with fixated coils

10. Check for damaged coils. To check for damaged coils by measuring the resistance between the two copper wire endings using a multimeter. Each coil must have a resistance of approximately 3.2 to 3.4 Ω. If the resistance is beyond that margin, the coil is assumed to be damaged or the wrong number of windings is applied. Additionally, check each coil for a short circuit by connecting the sensing elements to one wire ending and to the body of the stator. If the multimeter shows any value below infinite Ω, the coil must be assumed as damaged. Damaged coils must be replaced by new coils. They cannot be reused.

11. Assembling and soldering of the coils. The coils need to be connected exactly the way shown in the schematics below. The winding direction of the coil must the opposite direction of the previous coil. Connecting the coils in another way will lead to extreme damage at the generator unit. First just connect the wires by twisting them together. The connection must be checked by someone else before soldering the wires.

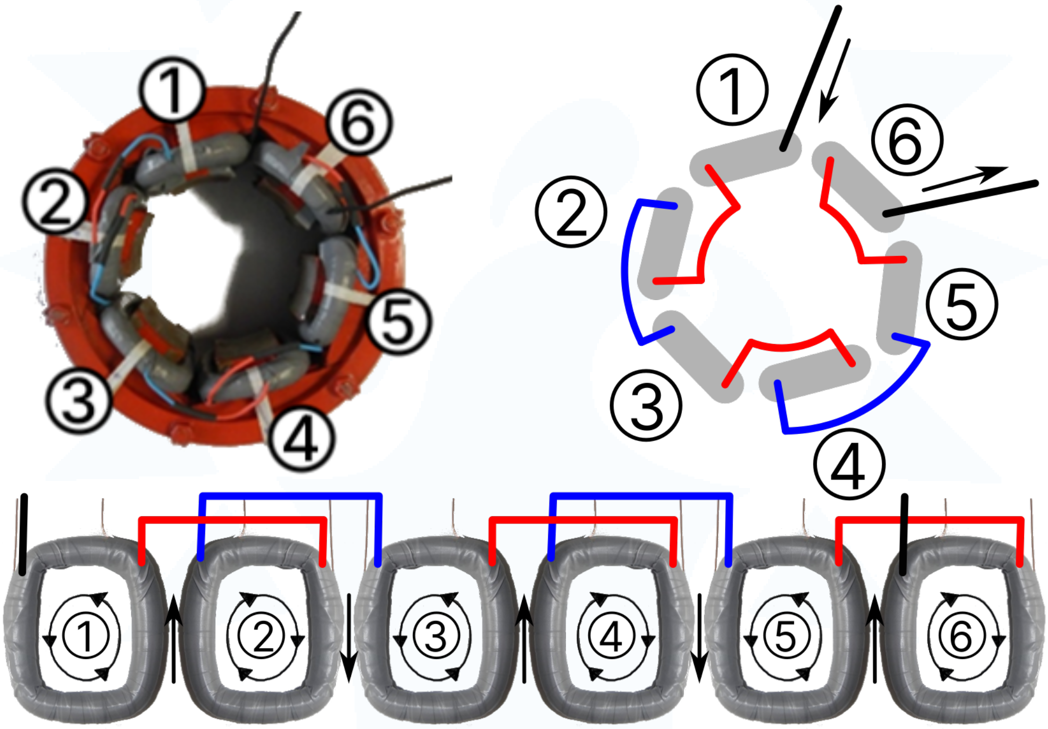


Fig. A.56.: Schematic for coil assembling. Arrows indicate the direction of the electrical current. The cross marks current inflow points, the dot marks current outflow points.

12. To check for damaged coils by measuring the resistance between the two copper wire endings using a multimeter. The whole bunch must have a resistance of approximately 19.2 Ω. If the resistance is beyond this margin by more than 1 Ω, one or more coils of the bunch must be assumed damaged. Additionally, check the bunch for a short circuit by connecting the sensing elements to one wire ending and to the body of the stator. If the multimeter shows any value below infinite Ω, one or more coils of the bunch must be assumed damaged. Go back to Step 9. Damaged coils must be replaced by new coils. They cannot be reused.

13. (if possible): Check for correct assembly. Apply a maximum 5 V DC Voltage to the generator coils. Check the direction of the magnetic field by holding a compass right on top of the coil. The magnetic field of a coil must always have the opposite direction compared to the neighbouring coils.

14. Use insulation tape to insulate all connection wires of the generator. There must not be any open wire beside the two end tails.

15. Apply each phase of a 1 meter electric cable to one end of the stator wiring. Make sure the connection is very strong, so the cable does not get ripped off easily.

A.5.6. Rotor

Requirements

Tools:

- Lathe drill 20 mm
- Welding equipment
- Compass
- Metal drill 3,3 mm
- Thread drill M4
- Dummy magnet
- Rotor lathe appliance

Material:

- 12x A4 stainless steel screws M4x18 (Non-magnetic!)
- 1x Thread bar M30x60
- 2x Screw nut M30
- 1x Metal sheets 300x25x5[a]
- 6x Magnets N40

[a] will be cut in 6 trapezoid parts

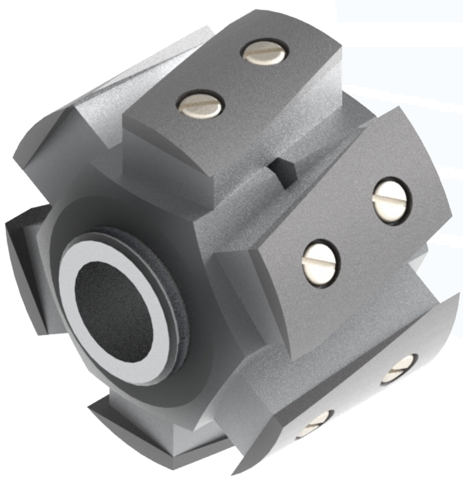


Fig. A.57.: Finished Rotor

1. Cut the thread bar to 60 mm and burr the edges. Build the pole shoes and the dummy magnets according to the drawings (see Fig.A.57).

2. Drill the bore with a diameter of 20 mm into the thread bar. Use the Lathe for this work and start with smaller diameters!

3. Put the two nuts on the 60 mm thread-shaft, side to side, minimum distance and axially centred to the mid of the shaft. The surfaces of the nuts must be in exact parallel position. If not, the magnets can break. Use screw clamps for aligning them.

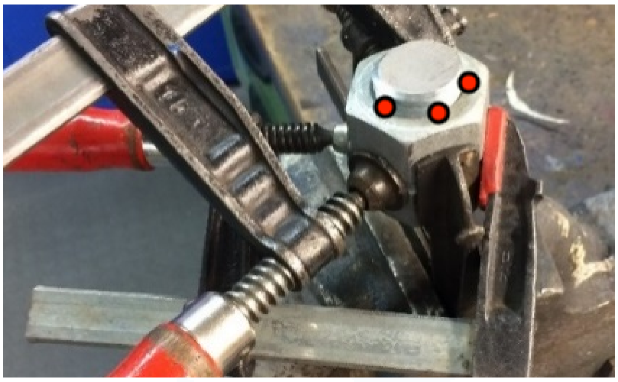


Fig. A.58.: Align and weld the nuts on the thread shaft

4. Weld the nuts on the thread bar. On the picture below, you can see where the welding points are located (red dots). Mount the 2 Nuts on the Threat Shaft. Again, pay attention: The surfaces of the Nuts have to be exact parallel and the position of the nuts has to be very precise. Use a ready pole shoe and mount it to see if you already have the right diameter.

5. Fixation of magnets: Magnets and pole-shoes are mounted with an angle (see 6.0_Rotor in drawing). You may mark the exact position of the threat-holes according the drawing. Another simple way of marking the holes is like this: use one magnet and position it angular in a way, that the edges of the magnets align exactly to the edges of the nuts. The magnetic force is strong enough to allow marking the hole-position with a 4.2 mm drill (holes of the magnets are 4.3 mm). After marking all the six sides of the nuts you can drill 3.3 mm holes and finally cut the M4 threats.

6. Fixation of the pole-shoes: Like the magnets, the pole-shoes are also mounted with an angle on the magnets. With this double angle you reach a maximum slop of the pole-shoes on the rotor. To position the holes on the pole-shoes you can again use two ways: either marking according to the drawing, or use the real magnets to position the pole-shoes in maximal angular position to mark them with a 4.2 mm drill.

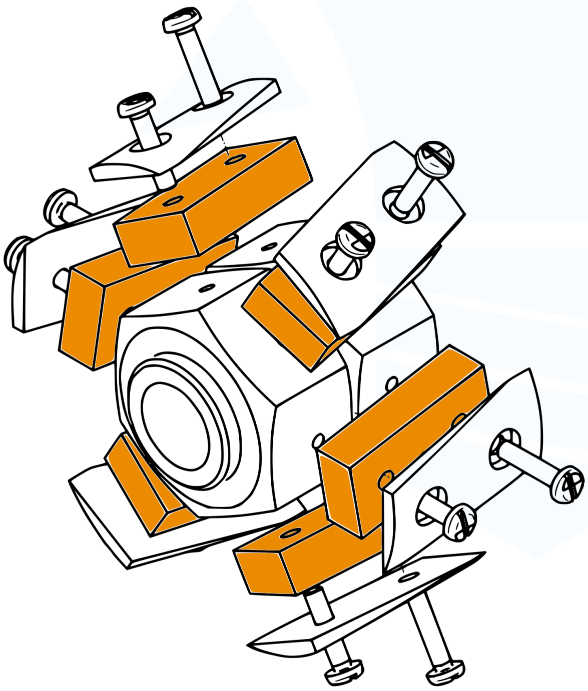


Fig. A.59.: Rotor with mounted dummy magnets

7. After marking both holes on each of the six pole-shoes, continue with exact drilling and cutting the stepped holes according to the drawing.

8. Now mount the dummy-magnets and the pole-shoes to the rotor-core using regular metal screws. You do the major part of the turning using those regular screws because they will not break as easily as the high-grade Screws. Also, we are using the dummy-magnets for the major turning because they will not get the iron dust adhering while turning.

Fig. A.60.: Positioning and numbering of the pole shoes

9. Chuck the rotor to the lathe using the rotor lathe appliance and trim the major diameter to a measurement of 73 mm. Now remove the rotor from the lathe and clean it carefully. Mark one side of the rotor core and the same side of the Pole Shoes with the numbers 1 - 6. This helps us keeping the position and direction of turning. Unscrew the Pole Shoes and the Dummy Magnets.

Parameters for the lathe

- Number of revolutions: 500 min^{-1}
- Feed: 0.16 mm/revolution
- Infeed: 0.1 to 0.2 mm

ATTENTION: If you can hear a loud knocking, you should check the screws again!

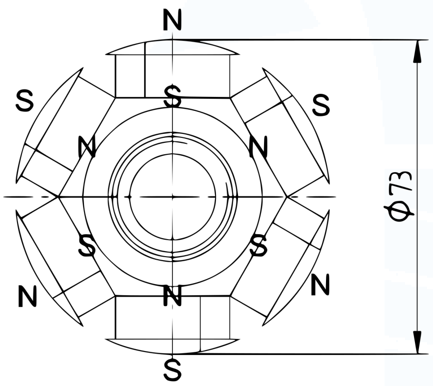


Fig. A.61.: Rotor shape and dimensions

Start with the diameter 74 mm for the rotor. Assemble it into the stator. If it's already turning freely, there is no need to turn it down to 73 mm. You can reach a better efficiency with a bigger diameter of the rotor, but it's only possible if you have produced the parts very accurate! Carefully attach the magnets and the pole shoes in the right order, this time using the stainless steel screws. The North-South direction of the magnets needs to alternate with each element. The stainless steel screws are somehow fragile so do not overbold them! Check with a compass if the North-South direction is alternating by doing a slow circle around the rotor. When finished, wrap the rotor with cardboard and store it in a save place until the final assembly of the turbine.

ATTENTION: The magnets are very strong and fragile. Handle with care to avoid injuries!

A.5.7. Generator cover

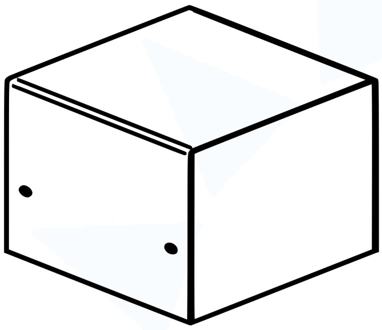


Fig. A.62.: Generator cover

The generator cover shields the generator from water and dust. It can be fabricated from any non-flammable material, e.g. metal or plastic. We suggest sheet metal, since this allows easy welding of the side pieces. As long, as the dimensions are correct and the cover does not impose a fire thread, it can be fabricated however you wish. Keep in mind, that the generator produces significant heat that might melt or burn the wrong material.

A.5.8. Downpipe

Componets

1x Sheet of galvanised steel 1.0 m x 2.0 m x 0,8 mm

Tools

- scissors for 0.8 mm steel
- hammer
- pair of pliers
- silicone to seal connections

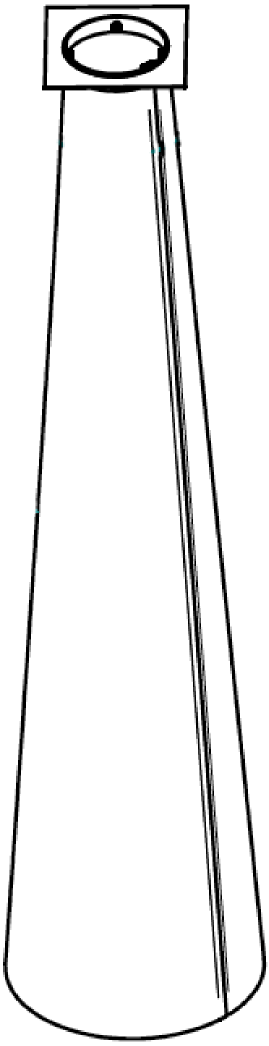


Fig. A.63.: Finished draft tube (Sheet metal version)

The draft tube can be manufactured in two versions. You either have to construct the tube yourself or have to source a specific tube. The first Version consists of a conical tube out of a bent 0.8 mm metal sheet. The sheet metal version can be build out of easily available material but has to be manufactured.

The advantage of the conical sheet metal version is a slightly better efficiency. The outflow velocity is reduced along the flow and the remaining kinetic energy at the tube exit is smaller. For the alternative version, you'll need a straight PVC-tube of 160 mm diameter. This is a much simpler method but requires the specific tube, which might not always be available.

For both solutions, conical or strait, it is essential to create an air-tight connection to the turbine. As there is under-pressure within the draft tube, air would be sucked in, which results in a drastically reduced efficiency of the system.

Therefor the connection between draft tube and turbine is important. We propose a solution where the turbine is just put in the upper collar of the tube without any further fixation. The under pressure will press both parts together. This allows easy disassembly for maintenance, as the sealing is in the water, so no air can get into the system.

In the following chapters, we are going over the step to construct both versions of the draft tube, so the choice is yours. Consider both options and chose to one that suits your current situation best.

Sheet Metal Draft Tube

1. Mark the shape of the draft tube, using the measurements as seen in the drawing

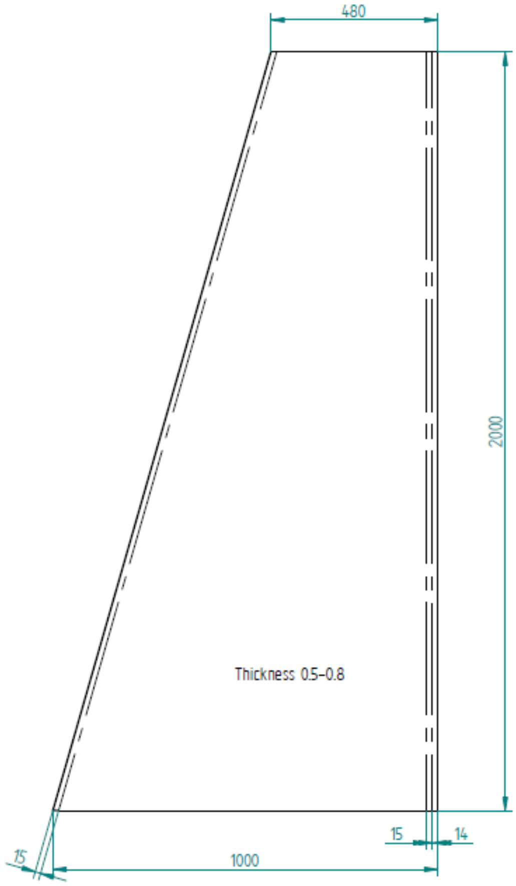


Fig. A.64.: Draft tube sheet dimensions

2. Mark a 15 mm edge on one and a 30 mm edge on the other side. They are used as overleap material.

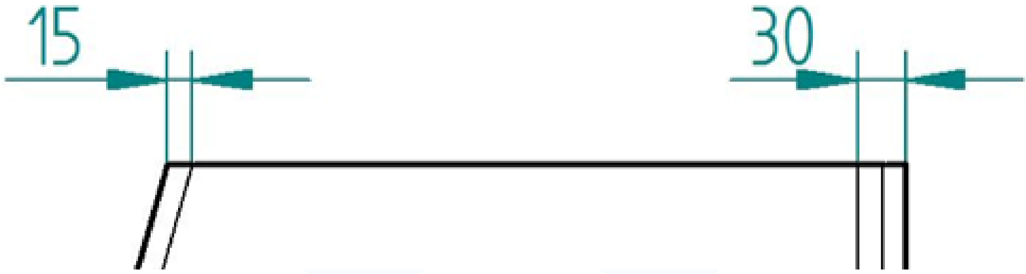


Fig. A.65.: Draft tube sheet positioning of the overlap edges

3. Cut the shape using tin snips (metal scissors)

4. Next comes the bending of the edges. The 12 mm side needs to be bended upright. You can do this - for example - using the sharp edge of a table. Place the bending line at the edge and use a rubber mullet.

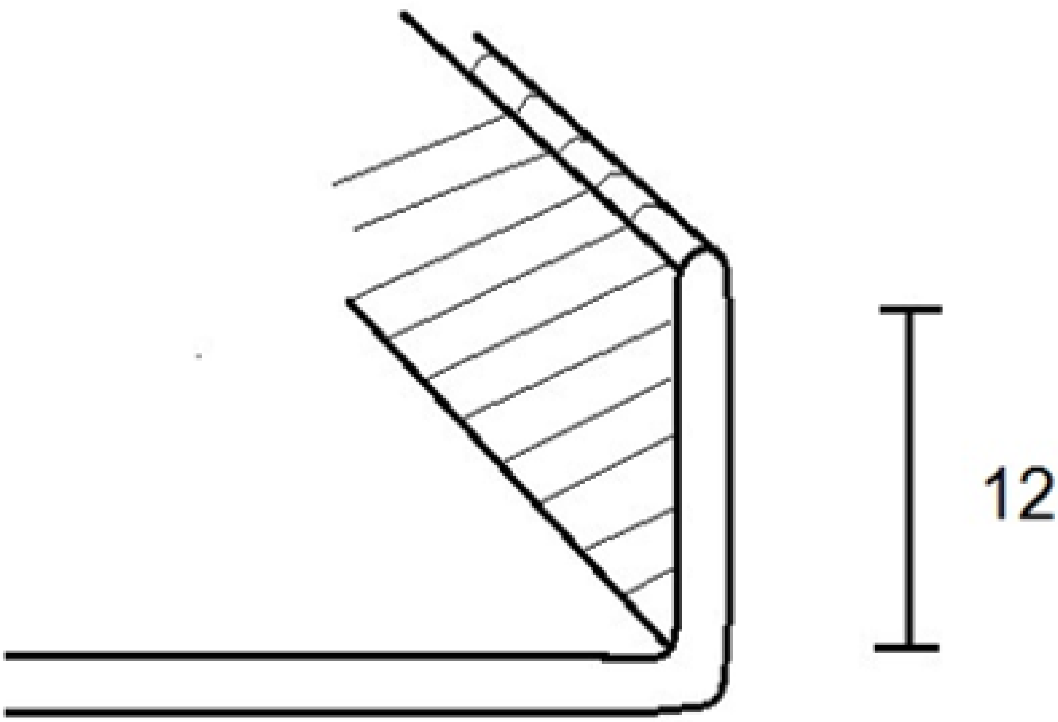


Fig. A.66.: Left edge bending position and height

5. The 30 mm edge is first bended upright, then like a U downright. Make sure it is on the same side as the other one. You have to be very precise here to get the needed diameter.

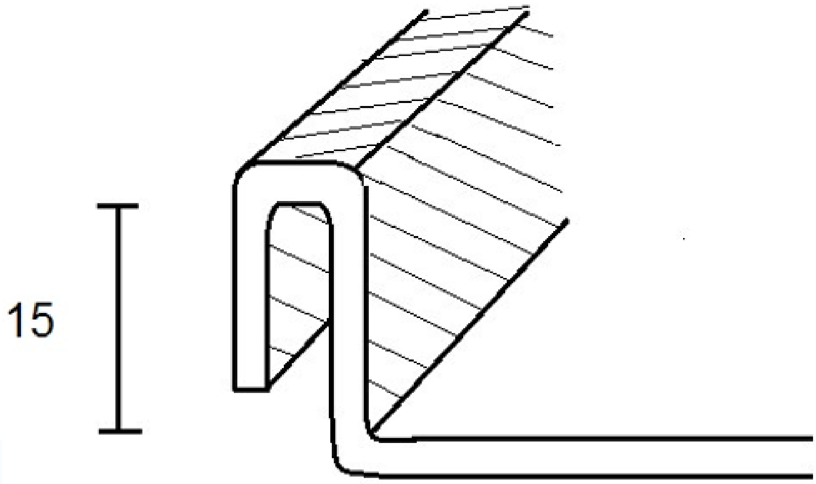
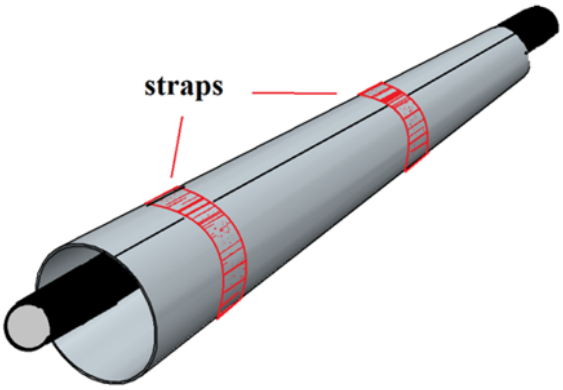
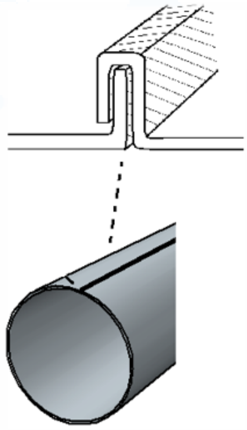


Fig. A.67.: Right edge bending position and height

6. Then you must bend the sheet with the hands over the pipe until it is possible to put the U over the edge. Now the sheet is rolled, and the edges hooked into each other. Use some straps or some rope do keep the tube rolled.



(a) Draft Tube with straps



(b) Connection of the sheet edges

Fig. A.68.: Draft tube with straps and its connection

7. Stick something robust underneath the seam, e.g. a long 100 mm pipe. Bend the seam over by using a hammer, so it cannot get open again.

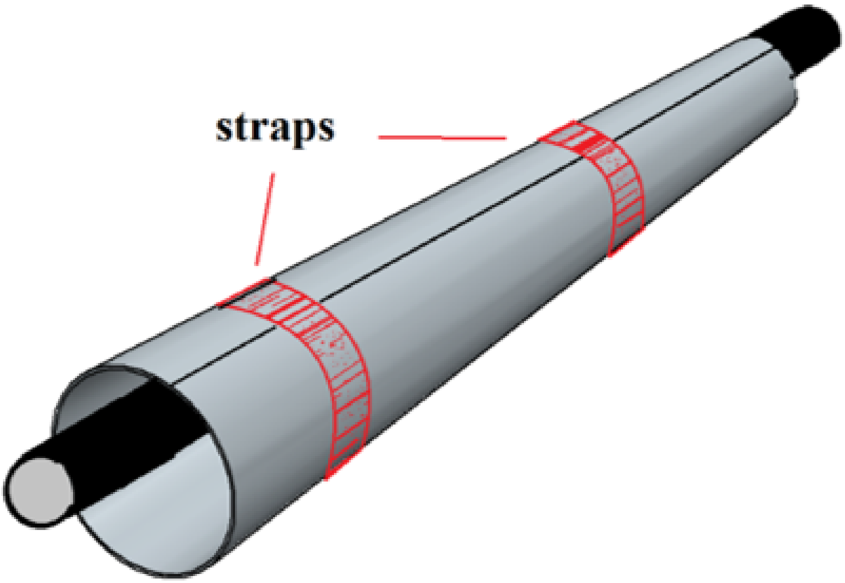


Fig. A.69.: Draft Tube with straps and counter pressure material

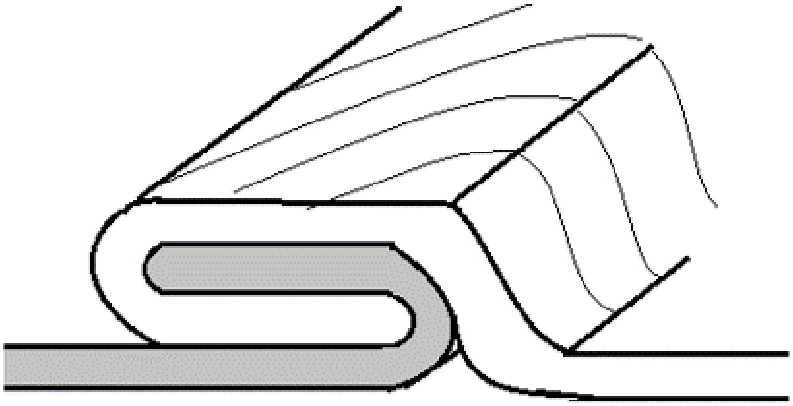
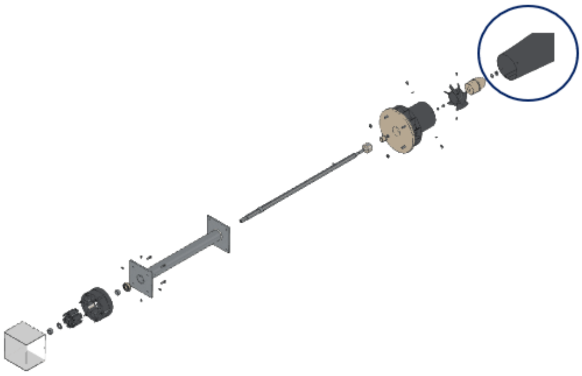


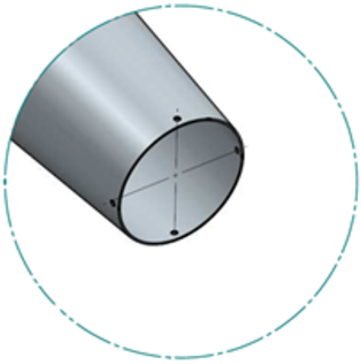
Fig. A.70.: Draft tube seam after bending

8. Put a stove pipe with the same diameter as the flow channel into the draft tube. Then cut the overlapping sheet away. Cut the bottom of the draft tube until you get a cylindrical shape

9. Put the turbine foot into the pipe and drill four holes with the diameter 6.5 mm through the sheet and the turbine. Now mark the position of the holes from the tube and the turbine so you can find the right position for mounting it again. Take care that they are not too close to the edge. 20 mm distance minimum)



(a) Assembly



(b) Positions of the D 5 mm bores

Fig. A.71.: Assembly of the tube and positions of the D 5 mm bores

Keep in mind! Screwing the draft tube directly on the turbine requires you to disassemble the tube every maintenance cycle. Optionally, you can build a flange to rest the draft tube on the inlet basin. This way, the turbine can be serviced without disassembling the draft tube. Further steps are given after the instruction for the straight draft tube.

10. Silicone the seam very carefully and give time to dry out. The seam needs to be completely tight!

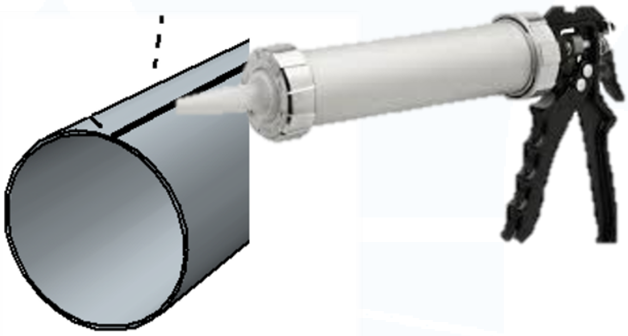


Fig. A.72.: Sealing of the draft tube

Straight Pipe Draft Tube

Fig. A.73.: Common PVC-Pipe

A commonly found PCV pipe in Germany and Europe is the "KG-pipe". This pipe features a small flange on one side. If you can find a pipe with such a flange and a diameter of 160 mm, you can use the pipe directly as is. The flange supports the pipe on the inlet basin and the outflow pipe of the turbine can be placed inside, without any screws. The generated under-pressure inside the running turbine presses the pipe and turbine firmly against the basin. Make sure to properly seal the connection between the pipe and basin with silicone

Should you be worried that the flange is not big enough or you can only find pipes without any flange, you can construct the flange yourself. This flange is identically used on the sheet metal draft tube. In the net chapter, you can read more about how to build this flange.

Draft Tube Flange

Componets

1x Steelplate 200 mm x 200 mm x 2 mm

Tools

- silicone to seal connections
- Something to cut the plate

For the Flange, you'll need the stove pipe piece you prepared in chapter A.5.8 point Nine. This piece is also necessary for the straight pipe solution.

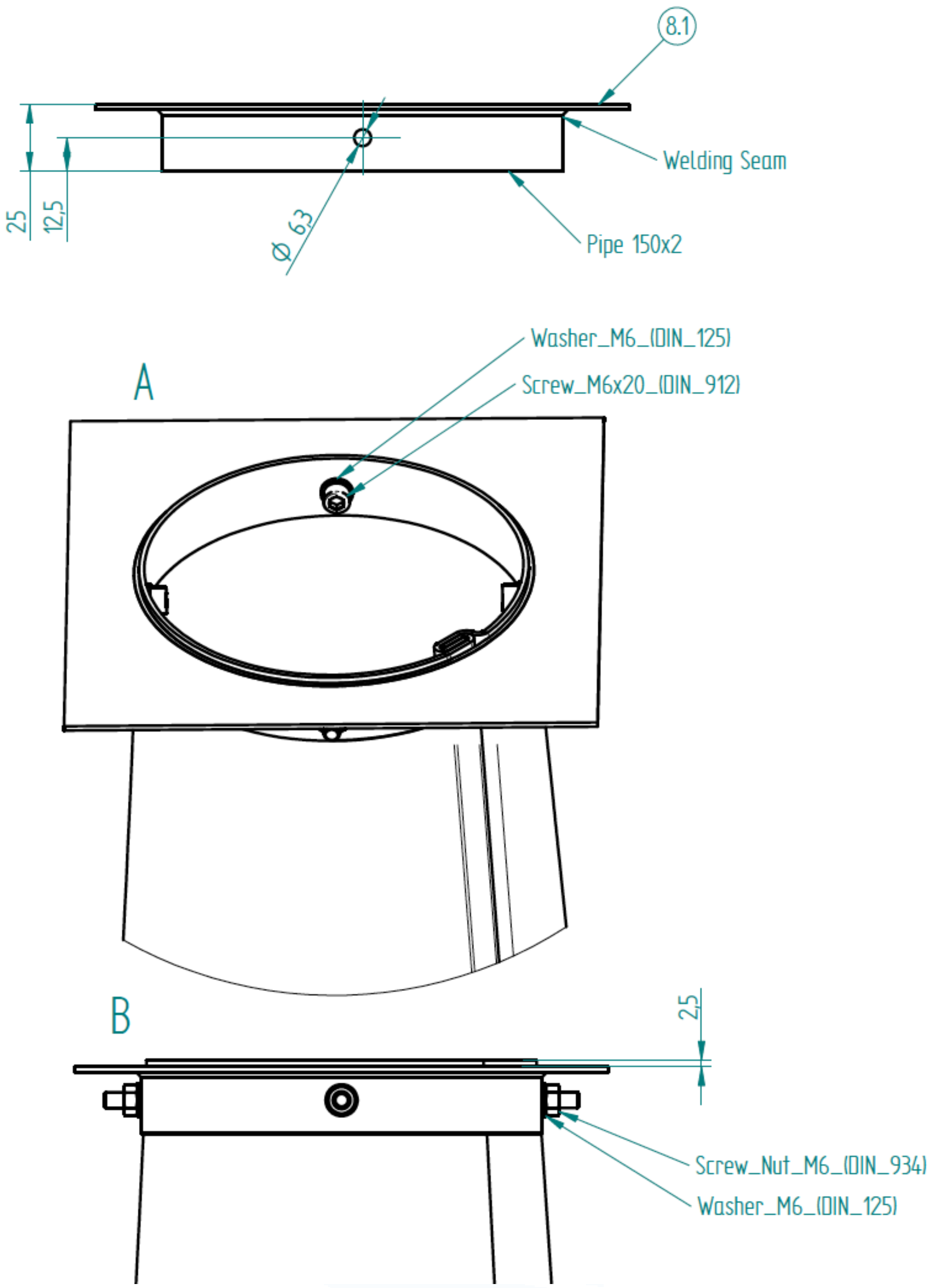
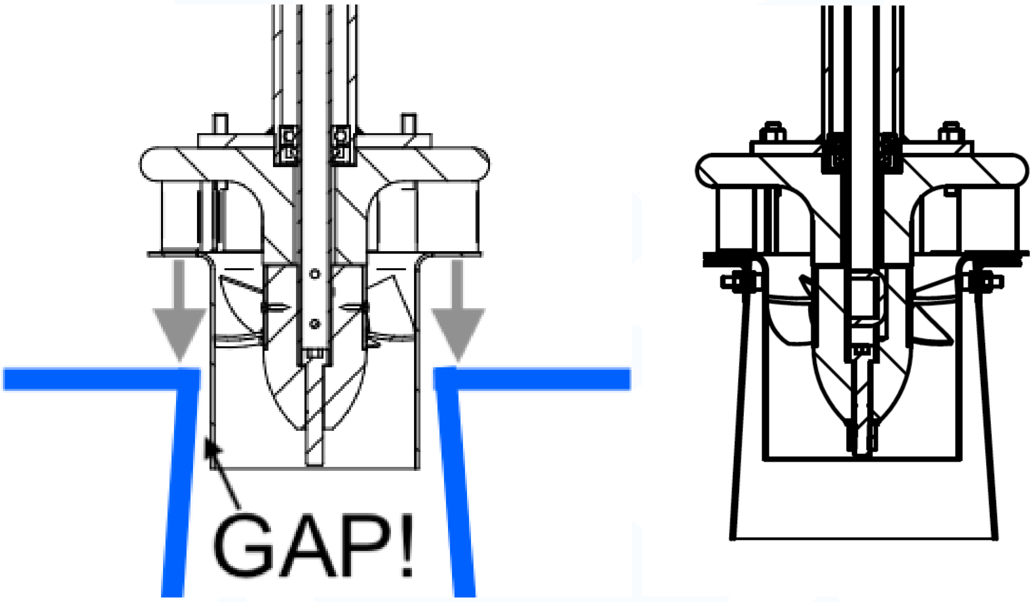


Fig. A.74.: Draft tube with flange

The construction itself is very straight forward. You have to cut a hole with a 150 mm diameter in the centre of the plate. Refer to the drawing 8.1 on page 43 of the drawing set. The cut plate is then welded onto the prepared stove pipe. To fix the flange onto the draft tube, you use four screws and nuts to press the flange onto the tube. You might need to drill holes into the draft tube. For this, please agin refer to chapter A.5.8 point Nine.

Make sure to use enough silicone on every connection point so the draft tube is air- (and water-) tight around the flange. A leak makes you lose a significant amount of power and can reduce the lifetime of the propeller and other components.



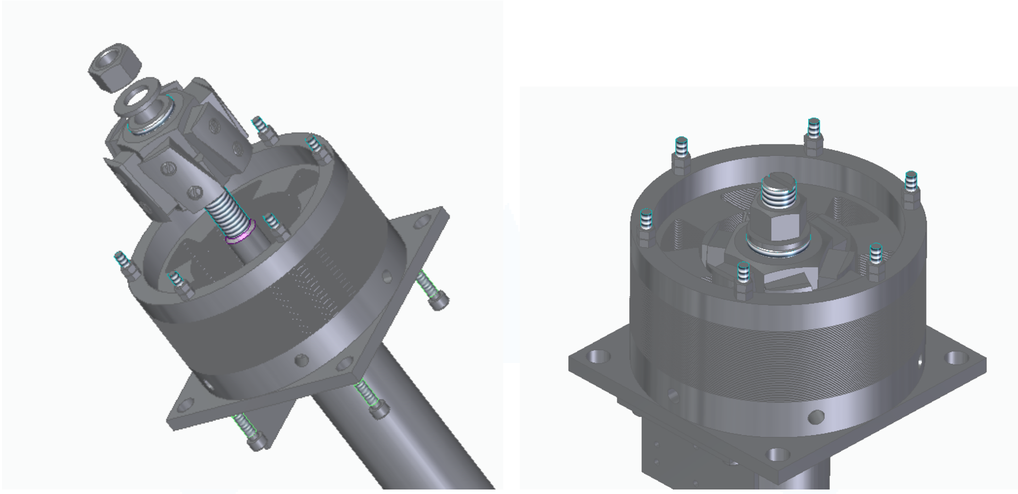
The flange of the draft tube sits on the inlet basin and the turbine on the draft tube. The generated under-pressure then presses the whole construction together. As you can see in the figures above, there has to be a gap between the draft tube and the outflow pipe. This is, so the screw heads fit between the turbine and the draft tube. Make sure there is enough space beforehand!

A.6. Main Assembly

Material		
1x Screw M16	4x Screw M6 x 20	1x Housing
1x Nut M16	1x Stator	1x Rotor

Tools

- Mallet
- Screw driver



(a) Explosion drawing (b) Assembly of the generator

Fig. A.75.: Assembly of the generator and explosion drawing

1. Screw the stator onto the chassis using M6x20 screws. Then get the Rotor onto the turbine shaft using a pair of pliers. Fix it with an M16 screw nut. Use a Rotor with dummy magnets!

2. Now you need to release the four M6x20 screws again. Adjust the stator so far that the rotor can turn freely. There needs to be half of a millimetre space between each pole shoe and the stator! Tighten the four screws very good as soon as it is adjusted!

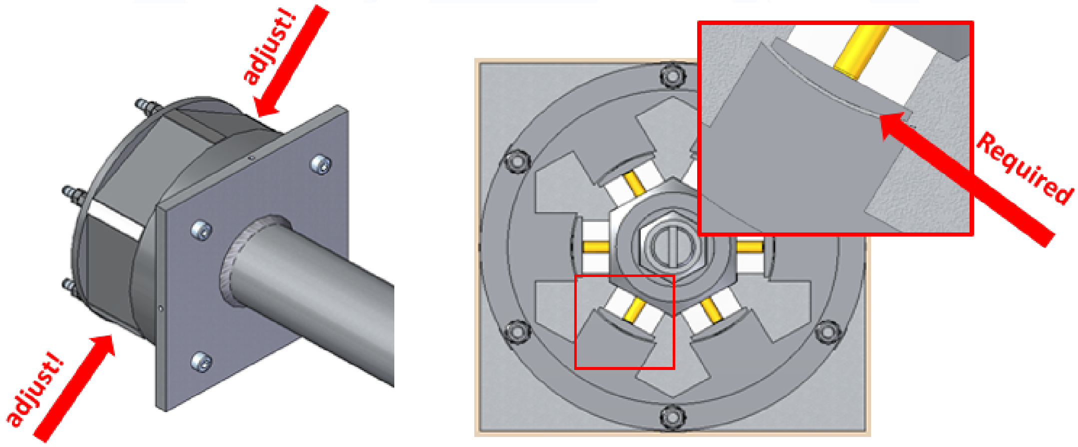


Fig. A.76.: Generating the necessary gap

3. Now we need to connect the power cable which leads to the Load Controller. For that work you can remove the Rotor using some pliers. Just insert the cable through the designated hole in the Stator Receiver, pull it up in between two Coils and solder it to the two end wires of the coils.
   ATTENTION: Make sure the cable can not be damaged in any way and it is not affecting the rotation of the Rotor.

4. Then change the Dummy Magnets for the real Magnets and assemble the Rotor again. Mark the Pole Shoes, so you can mount it again on the correct nut area.

ATTENTION: Be careful with the strong magnets! Use a pair of pliers for the mounting of the Rotor and tighten the M16 nut.

1. To assemble the propeller to the turbine, you need to grind some material off the blades. Drill the holes for the wood screws and fixate the propeller on the propeller hub. Use the finished turbine for this work. Screw a M10 nut into the lower end of the shaft and fit the Propeller onto it. Now, looking directly onto it, you can mark how much you have to take off the blades to make it fit. Do not take off too much at once! The air space between turbine and propeller needs to be as small as possible, so work step by step. Now attach the Propeller as supposed and make sure it can be turned freely. If you prefer, you can also turn the Propeller in the lathe for a better accuracy.

2. If the propeller fits, spray paint it at least 3 times to reduce damage due to corrosion. Attach it to the turbine using the M8 x 50 screw.