# Development of Vertical Axis Wind Turbine - The Way Towards Fuel Replacement of Diesel Pump


**Project Members:**

| | |
|---|---|
| Utsav N. Patel | Enroll No.:100780119059 |
| Yash P. Patel | Enroll No.:100780119011 |
| Amit H. Prajapati | Enroll No.:100780119060 |
| Vishal R. Dave | Enroll No.:100780119044 |

**Under Guidance of : Prof. A. G. Barad**

**Department of Mechanical engineering,**
**Smt. S. R. Patel Engineering College,**
**Dabhi,Unjha-384170**

# CONTENTS OF PRESENTATION

# FUTURE WORK CONSIDERATION

- Calculations regarding the centrifugal pump configurations used in Diesel pump.
- Fabrication of the Helix VAWT blades using FRP.
- Complete assembly of the VAWT pump and make sheet for the suction and delivery of pump outlet for various wind speeds.
- The real implementation of this project in a way towards successful replacement of diesel with wind energy.
- Contribute to nation to utilize wind energy conversion methods for sustainable energy development in future.

# METHODOLOGY

| Month | Work sequence |
| --- | --- |
| 1. **January** | 1. Selection of the blade profile as a helix shaped and with FRP material<br>2. Manufacturing of the blade at Ahmedabad Kathwada GIDC , with the wooden mould.<br>3. Noted the wind speed at the different elevations of our college. |
| 2. **February** | 4. Barrel pump is to be brought for the pumping purpose as a first attempt to chose the pump criteria.<br>5. Testing procedure for the barrel pump with the cutting oil and water in the fluid power laboratory.<br>6. Trouble in the testing of the barrel pump as the effort required for the pumping is very higher. |

| Month | Work sequence |
|---|---|
| 3. **March** | 7. Differential is to be connected to the VAWT rotor as the power transmission to right angle for the pump attachment.<br>8. Use of the pedestal for the blade support to bolt it to main frame.<br>9. Use of the crank mechanism for the conversion of the rotary motion of the shaft to reciprocating motion of the pump.<br>10. Trial of the hand pump with the rotor to check the speed of the stroke. |
| 4. **April** | 11. Development of the piston pump at workshop for the last trial purpose to fit the requirements.<br>12. Making the full assembly of the VAWT pump with trial and error with the pump and finally select the hand pump with the 30 cm of the displacement of the piston inside. |

# DEVELOPMENT OF VAWT

- Vertical Axis Wind Turbine Rotor Blades
- Mechanical Shaft
- Bearings pedestal for support
- Gear Box Arrangement(Bevel gear)
- Crank mechanism
- Barrel Pump / Hand Pump / Piston Pump
- Coupling
- Frame

# FABRICATION VAWT HELIX BLADE

- The fabrication methods used for the designing and fabrication of the VAWT blade using FRP material are simply the mould formation of the required blade specification.
- The mould specifications are as per the helix shaped blade profile as below:

| | | |
|---|---|---|
| **SWEPT AREA** | **:** | 0.1589625 $M^2$ (1.711058 $FT^2$) |
| **ROTOR DIMENSIONS** | **:** | 1M W X 1M H |
| **DIAMETER** | **:** | **1**M |
| **ROTOR LENGTH** | **:** | **1**M |
| **OVERALL HEIGHT** | **:** | **1**M |
| **ROTOR CONSTRUCTION** | **:** | FIBER REINFORCED PLASTIC SHEET |

# FIBER REINFORCED PLASTIC VAWT BLADE MANUFACTURING PROCESSES STEPS..

1. Produce an original blade from which to make copies. This would usually be carved from wood.

2. A fibre-glass female mould is then taken from the original. This mould is in three halves. This mould can be used a number of times.

3. The three halves of the blade are then made separately using a number of layers of glass fibre mat and resin.

4. When dry, these blade halves are then carefully cut and the edges tapered to that the two halves fit carefully together.

5. A wooden insert is fitted into the root of the blade. This provides material for which to screw into and provides some compressive strength.

6.A fibre-glass ‘stringer’ is fixed into one blade half. This is carefully cut down so that the other blade half fits exactly on top. This ‘stringer’ gives strength to the blade from root to tip.

7.Additional pieces of fibre glass mat are stuck to the ‘stringer’ using resin. This gives a large area onto which the other blade half can be stuck.

8. The other blade half is stuck onto the first. This is then fitted back into the mould and clamped together to ensure it dries in the correct shape.

9. A three-part expanding foam is then used to fill the blades.

10.Any imperfections in the blade are then filled with good quality filler which is then sanded back. A thin veil is added to the leading edge to join the two halves and for protection (this edge will be worn away in time due to the wind). The blade is then sanded to a smooth finish.

11. Depending upon the surface quality and desired finish, the blades may need to be painted.

# FIBER REINFORCED PLASTIC BLADE MANUFACTURING EQUIPMENTS

- The blades are made from what is commonly referred to as fibre glass. This is mixture of glass fibre (maybe this is obvious) which has great strength in tension and compression, resin, which provides rigidity when set, and a number of other chemicals. The various chemicals required are listed here along with their use and any special precautions required.

- The various tools required are also listed here. Ensure that you have all this equipment before starting the manufacturing process. Fibre glass product suppliers will typically stock all the materials and chemicals required.

# Chemicals required

## Resin

There are many different types of resin, each with different properties. To keep the design relatively simple, only two types of resin have been used for the blade manufacture:

1. *Resin Type 'R 10-03'*

This is a general purpose rigid orthopthalic (FRP) polyester resin. (Type 'R 10- 03' is a local manufacturer's code number). It is relatively inexpensive and is used for the majority of the wind turbine blades.

*2. Resin Type 'Polymer 31-441'*

This is called a 'gel coat' polyester resin. (Again, type 'Polymer 31-441' is a local manufacturer's code number)  It is 100% isophthalic with Neo- Pentyl Glycol (NPG). It is very hard wearing and is scratch and chemical resistant. It is more expensive than the other type of resin therefore its use is limited to just the outer layers of the blade.

## Styrene Monomer

This is mixed with the resin to reduce the viscosity of the resin. This makes the resulting mixture more workable and easier to ‘paint’ onto the fibre glass cloth.

## Hardener

Hardener is added to the resin mix to start the solidification (or curing) process. The time taken before the resin sets is controlled by the amount of hardener and accelerator (cobalt) added. Once the hardener is added to the resin it must be worked quickly into the fibre glass as the resin will solidify quickly.

An imported MEKP hardener is used due to its more reliable properties and hence more reliable resin setting time.

## Cobalt

Cobalt is an 'accelerator' that speeds up the hardening process when added to the resin. This can be used to help control the setting time of the resin.

**Toner**

This only adds colour to the resin. It has no structural properties. It is used to colour the outer layers of resin, rather than paint the blades afterwards. This can be obtained in many different colours. Approx 5 to 10% by weight is added to the resin mixture until the correct colour is reached. Adding a greater amount than this may inhibit the solidification process. Adding toner makes the lay-up stage easier as you can clearly see where the resin is, however this makes the foam filling stage more difficult as the blade is then opaque.

**Durawax**

This is a release agent. It is applied to the mould before each ‘lay-up’ to ensure that the item produced does not stick to the mould.

Sometimes a thin non-stick film is added to moulds to avoid the part sticking – given the complex curved shape of the moulds a wax release agent was selected.

# Fibre glass

1. *Chopped strand fibre glass mat (CSM)*

The fibers within CSM are in random orientation. This means that it has the same strength in every direction. It is the cheapest and easy to work with, as its orientation does not matter. It is available in different weights. 300gsm (grams per square meter) is used to produce the moulds and a thin ‘veil’ of 100gsm is used to join the sides and protect the leading edge.

*2. Woven cloth fibre glass (WC)*

This consists of woven strands. It is very strong in the direction of the weave but is slightly more expensive and harder to work with as the orientation of the weave when the piece is cut must be carefully chosen. The cut weave has a tendency to unravel when it is handled in a dry state.

**Thinners**

Lacquer thinners are required to remove excess resin and to clean up any spills, paint brushes, pots and tools. It is extremely flammable.

**Expanding foam**

A two-part expanding polyurethane low density foam is used to fill the air gaps within the blade.

The foam is initially two liquids which must be mixed in a ratio of 1:1. This will then expand to 25 times its initial volume.

Such foam is used in boat building and construction. It may require a specialist supplier to source the product.

This foam may not be required and the structure can be left empty but we have found significantly improves the rigidity and strength of the blade.

# Materials required: For ONE blade

| | Windward face | Backward face | Units | Total |
|---|---|---|---|---|
| WC (200gsm) | 2.5 | 2.5 | kg | 5 kg |
| Resin 31 441 | 0.5 | 0.75 | litres | 1.25 l |
| Resin 10 03 | 0.75 | 0.75 | litres | 1.5 l |
| Cobalt | 5 | 10 | cc | 15 cc |
| Styrene Monomer | 0.11 | 0.13 | litres | 0.25 l |
| Toner | 0.05 | 0.05 | kg | 0.1 kg |
| Lowilite | 2 | 3 | g | 5 g |
| Hardener | 17 | 20 | cc | 40 cc |
| Dura wax | some | some | | some |

**Blade joining**

When set, the three halves of the blade need to be joined to form a single unit. To do this they need to be accurately cut so that the two pieces fit together. The join should be made with minimal impact on the blades aerodynamic shape. The final piece should appear as close to the original wooden mould as possible.

Also additional strength and rigidity is added to the blade through the use of a 'stringer' from the root to the tip.

**Blade trimming**

The dust from cutting fibre glass is TOXIC. A dust mask must be worn during this operation - ensure others around the blade do not inhale the dust.

Firstly the excess (over lap from the mould) must be cut off. This was done with a circular cutting saw. A jigsaw or a mini-cutter could also be used. A line should be visible at the edge of the part, distinctly showing the smooth section from the mould and the excess overlap. Take care not to remove any of the final blade part.

# IMAGES THAT WE TAKEN FOR THE BLADE MANUFACTURING…


Accelerator


Polymer 31-441 Resin


Hardener

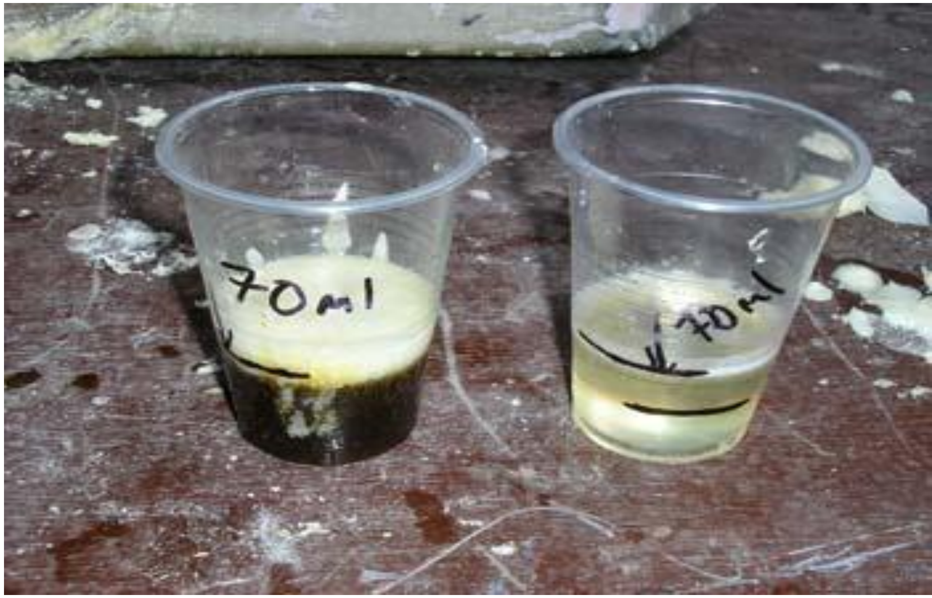

Styrene Monomer


R 10-03 Resin


Release agent

Chopped strand fiber glass mat

Woven cloth fiber glass




Expanding polyurethane foam

# PUMP CALCULATIONS

## 1. SPECIFICATION OF BARREL PUMP:

| | | |
|---|---|---|
| **THEORY** | : | HAND PUMP |
| **USAGE** | : | OIL / WATER |
| **POWER** | : | MANUAL HAND POWER |
| **PRESSURE** | : | LOW PRESSURE |
| **SIZE** | : | 1 M. |
| **MIN. FLOW RATE** | : | 10L/MIN |
| **MAX. FLOW RATE** | : | 100L/MIN |
| **MAX. SUCTION PRESSURE** | : | 10 BAR |



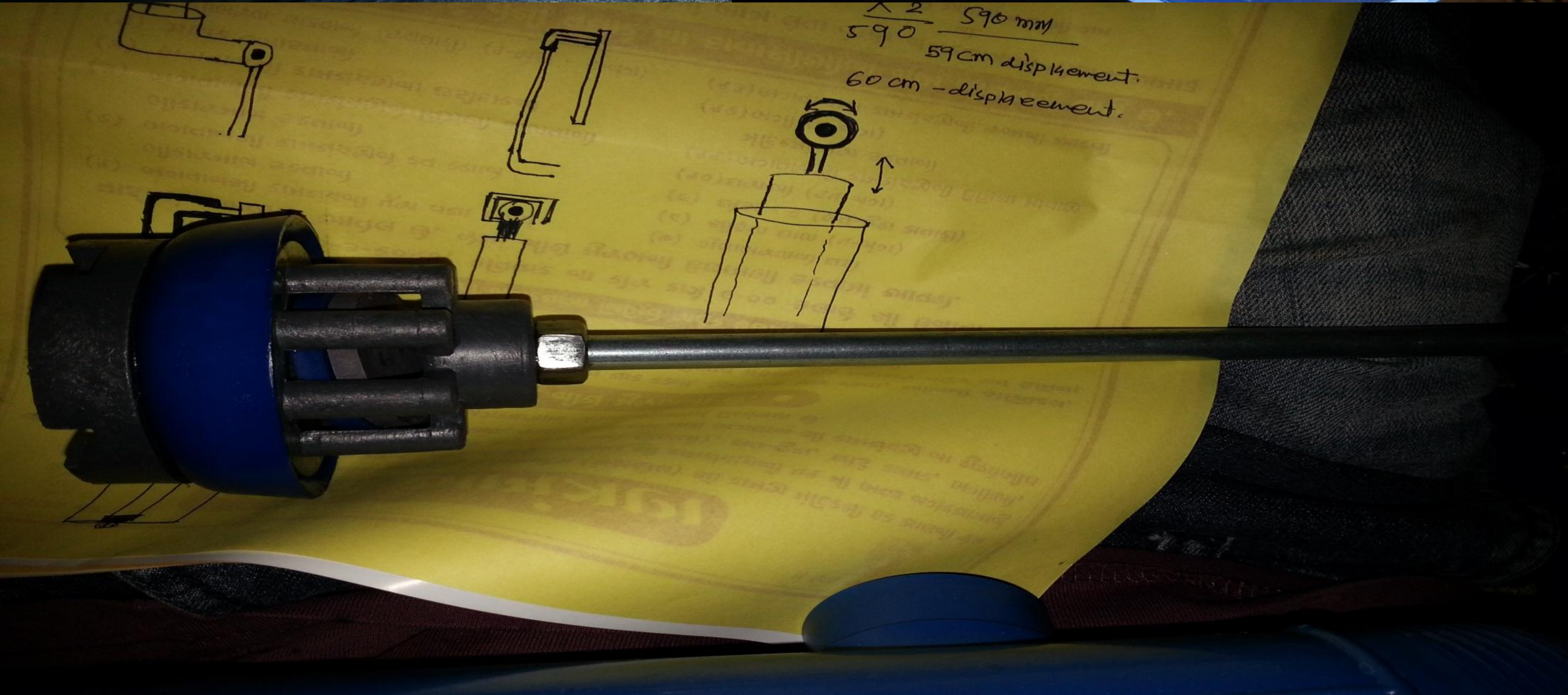
Testing with oil



Barrel pump

# 2. SPECIFICATION OF HAND PUMP:

| | | |
|---|---|---|
| **THEORY** | : | HAND PUMP |
| **USAGE** | : | WATER |
| **POWER** | : | MANUAL HAND POWER |
| **PRESSURE** | : | LOW PRESSURE |
| **SIZE** | : | 30CM |
| **MIN. FLOW RATE** | : | 25L/MIN |
| **MAX. FLOW RATE** | : | 200L/MIN |
| **MAX. SUCTION PRESSURE** | : | 8 BAR |


x 2
590
590 mm
59cm displacement.
60 cm -displacement.

# 3. SPECIFICATION OF PISTON PUMP:

| | | |
|---|---|---|
| **THEORY** | : | PISTON PUMP |
| **USAGE** | : | WATER |
| **POWER** | : | MANUAL HAND POWER |
| **PRESSURE** | : | MEDIUM PRESSURE |
| **SIZE** | : | 300MM |
| **MIN. FLOW RATE** | : | 40L/MIN |
| **MAX. FLOW RATE** | : | 300L/MIN |
| **MAX. SUCTION PRESSURE** | : | 15 BAR |


SUPERFLO

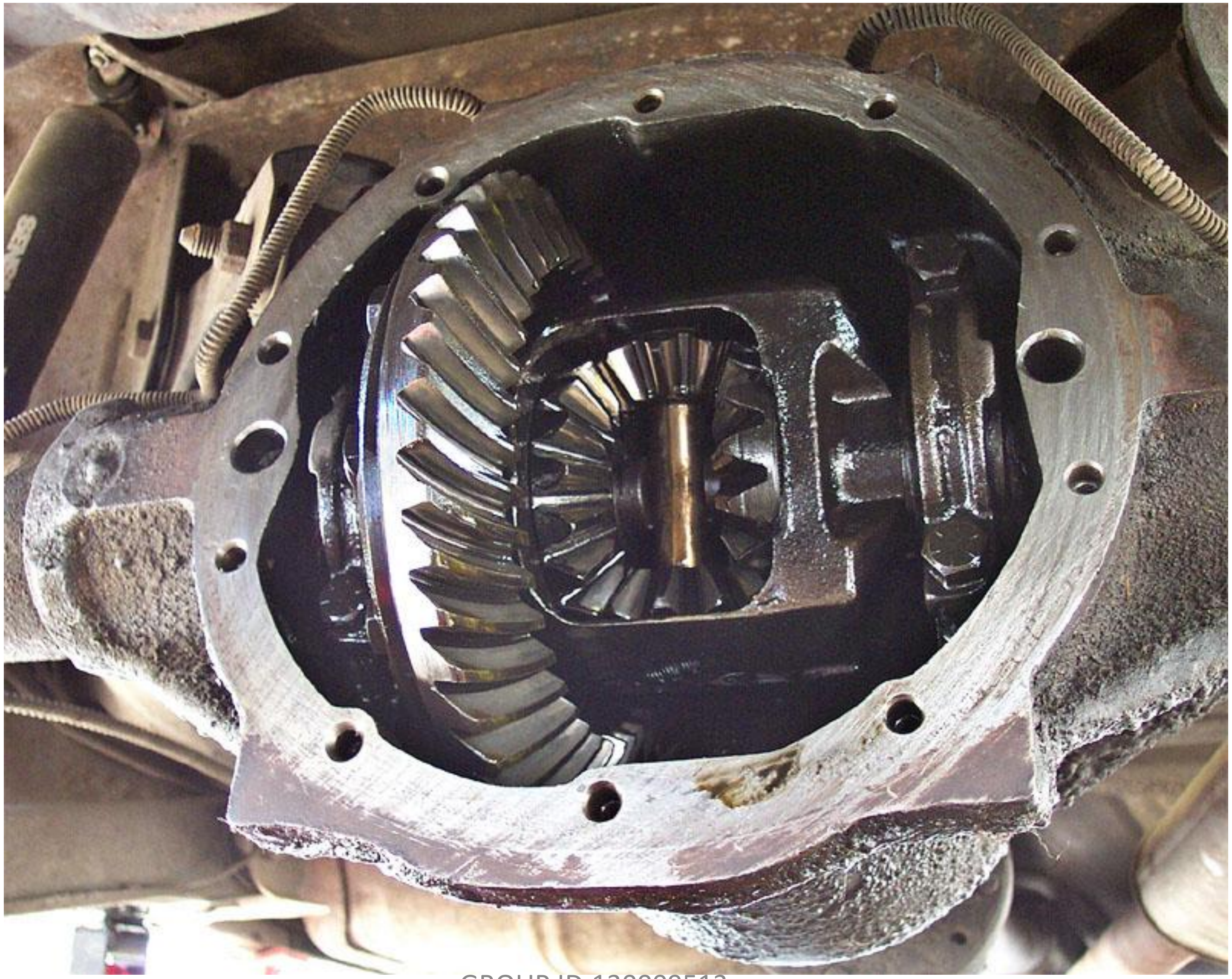

1" Slip Tee
2 x 1" Slip Caps
1-1/4" Slip Cap
1" PVC Pipe (26" long)
#320 O-ring
1-1/4" PVC Pipe (24" long)
2 x #219 O-rings
1-1/4" Slip Coupling
1" Plug
1-1/4 in. x 3/4 in. PVC Bushing
3/4" PVC Close Riser
3/4 in. PVC FIPT x FIPT x FIPT Tee

# GEARING ARRANGEMENT

Gearbox is required for the purpose of maximum efficiency. The VAWT rotor if at the vertical axis and the aim is to transfer the power of the VAWT rotor to its perpendicular direction . So, this is only possible with the bevel gear arrangement.

| | | |
|---|---|---|
| **GEAR TYPE** | : | Bevel gear |
| **ARRANGEMENT** | : | Sun and Planetary type |
| **MODE TO SELECT** | : | Car differential |
| **POWER TRANSMISSION RATIO** | : | 1:5 |
| **AXEL INPUT DIAMETER** | : | 25mm |
| **SELECTION CRITERIA** | : | Easily available |

# DIFFERENTIAL



- **Differential** is a device capable of transmitting torque and rotation through three shafts, almost always used in one of two ways. In one of these, it receives one input and provides two outputs; this is found in most automobiles. In an automobile and other wheeled vehicles, the differential allows each of the driving wheels to rotate at different speeds, while supplying equal torque to each of them.

**Parts**

**Pinion Drive Gear:**

Transfers power from the driveshaft to the ring gear.

**Ring Gear:**

Transfers power to the Differential case assembly.

**Differential case assembly:**

Holds the Ring gear and other components that drive the rear axle.

**Rear drive axles:**

Steel shafts that transfer torque from the differential assembly to the drive wheels.

**Rear axle bearings:**

Ball or roller bearings that fit between the axles and the inside of the axle housing.

**Axle housing:**

Metal body that encloses and supports parts of the rear axle assembly.

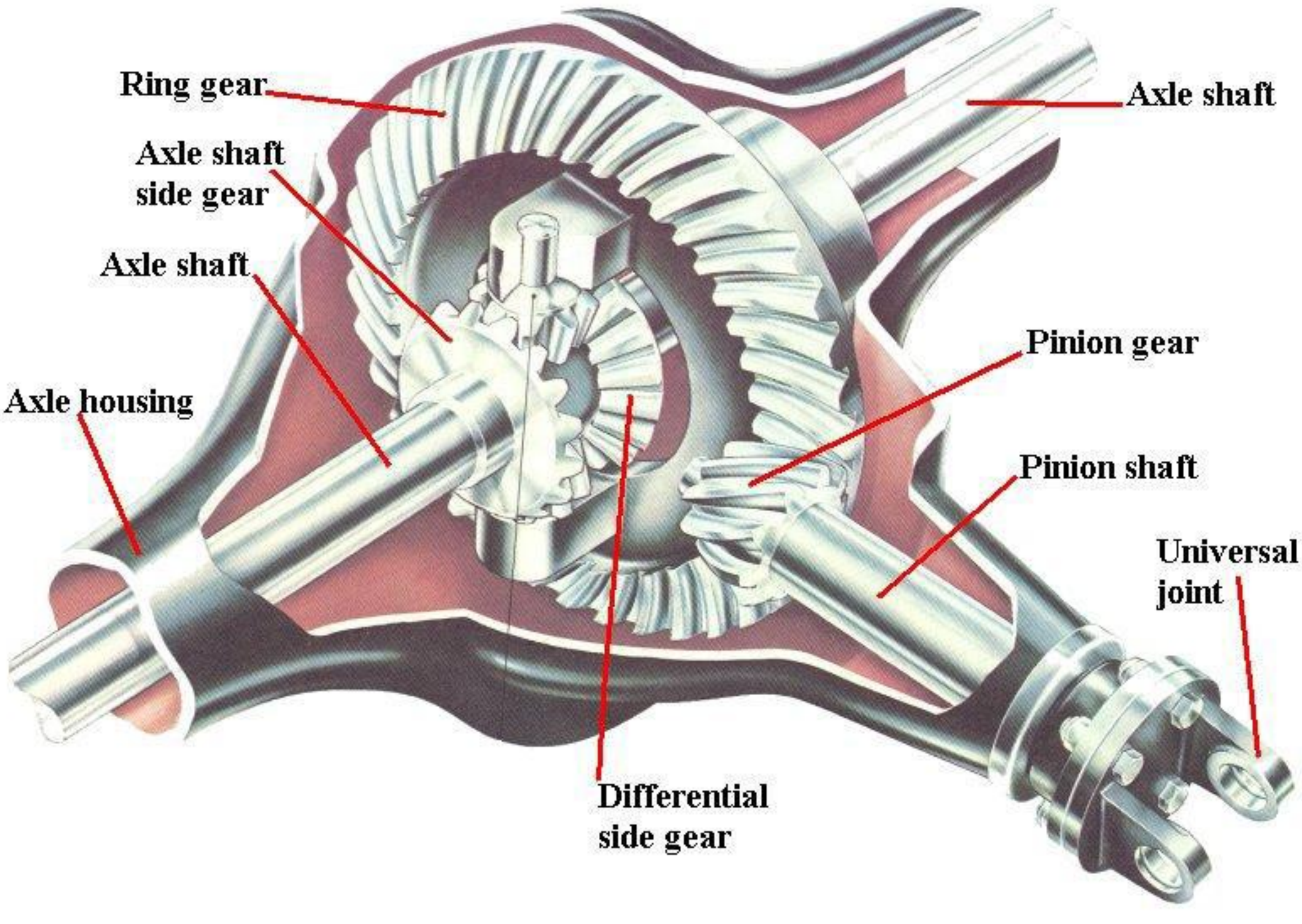



Fig. Differential with two-axle

# POWER TRANSMISSION

- Drive shaft spins the Pinion gear.
- Pinion gear turns the larger ring gear to produce gear reduction.
- Ring gear attached to differential case, hence it rotates with the ring gear.
- Differential case spins the sun gears which are attached to the axles.
- Axles transfer the power to the wheels.

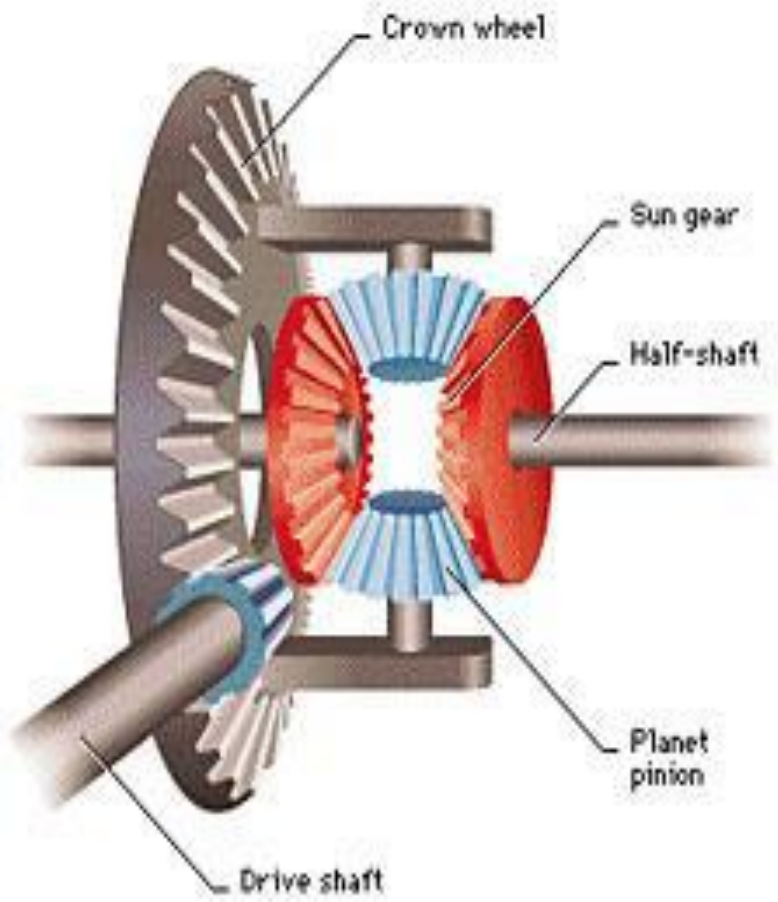



Fig. Power transmission in differential

# Why we have to use differential in place of Bevel Gear arrangement?

- When we use bevel gear arrangement to transfer the rotary motion of the vertical shaft to perpendicular horizontal shaft at that time the meshing of the gears is done but effort required to rotate the gears is more.
- Now in this project our main aim in manufacturing is to reduce the effort so we can get better efficiency.
- Bevel gear arrangement is also one of the bulky process so we cannot be satisfied with this arrangement.
- Now its time to find another way to transmit the motion in similar way.

At that time we enlighten with the new concept named ”DIFFERENTIAL”

It is a device which is generally used in automobiles to get turn the vehicle.

Now here we used a differential in vertical axis wind turbine pump to transmit a rotary motion of vertical shaft to get perpendicular rotary motion on a horizontal shaft.

# PURPOSE OF A DIFFERENTIAL

- Now the purpose of using in place of bevel gear arrangement is to reduce the effort required to transmit torque and rotation.
- In VAWT pump the differential is exactly located below the vertical shaft of the helix blades.
- In this arrangement we require total three shafts to get the complete work from the differential. So, the three required shafts are mentioned below:-
  1) The input shaft coming from the wind blades
  2) The output shaft of the differential
  3) The third shaft which is used to rotate differential

# SET UP OF DIFFERENTIAL

- Here we used two axles in the differential so, we can also get power on two different shafts. Now, mainly differential works here is to transfer the rotation perpendicularly.
- We require the horizontal rotating motion of the shaft and by the differential arrangement we get the perpendicular motion as well as the another motion which also be produced on the same shaft so two motions we got so, we can work on the two different phenomena of the VAWT pump.

# DIFFERENTIAL PROBLEMS

Ring and Pinion Problems

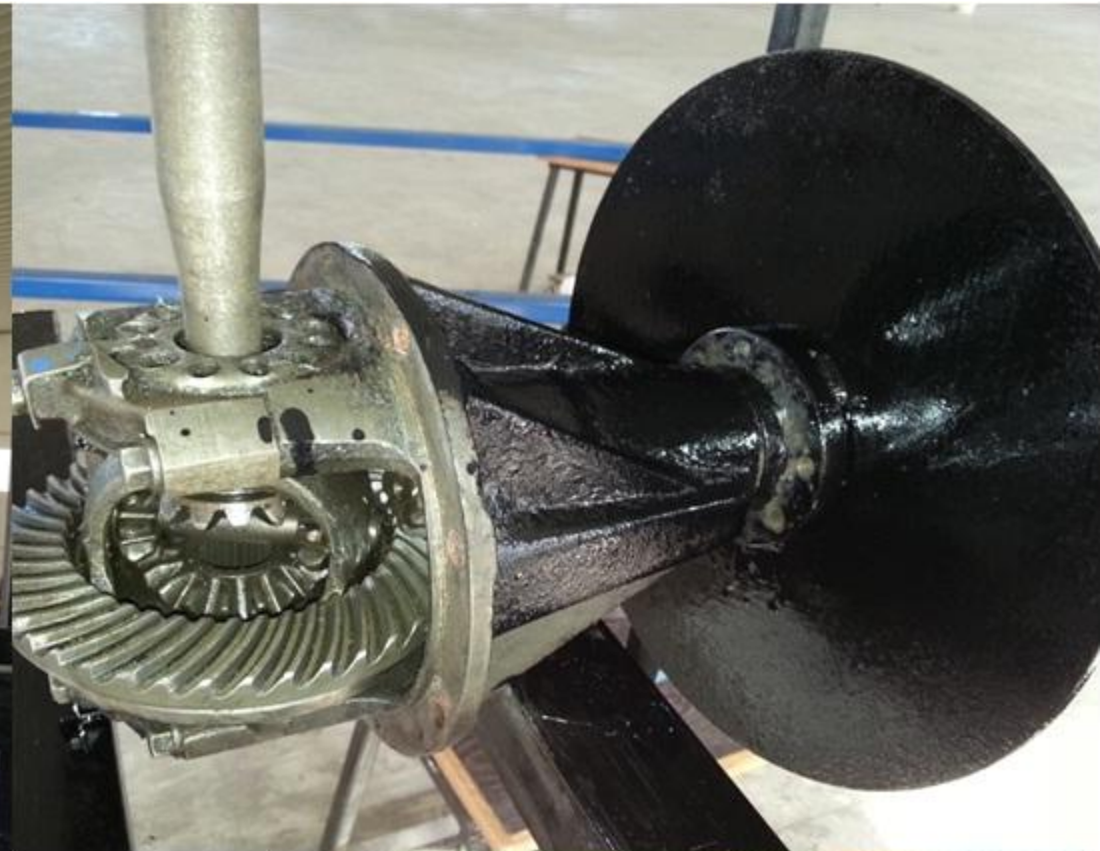
- Will show up as whining or howling noise that changes when going from acceleration to deceleration.
- Lack of service or low fluid can cause this problem.
- If backlash (clearance) between ring gear and pinion gear is too great, a clunking sound can be produced, especially when an automatic transmission is shifted into gear.

# DIFFERENTIAL ADJUSTMENT

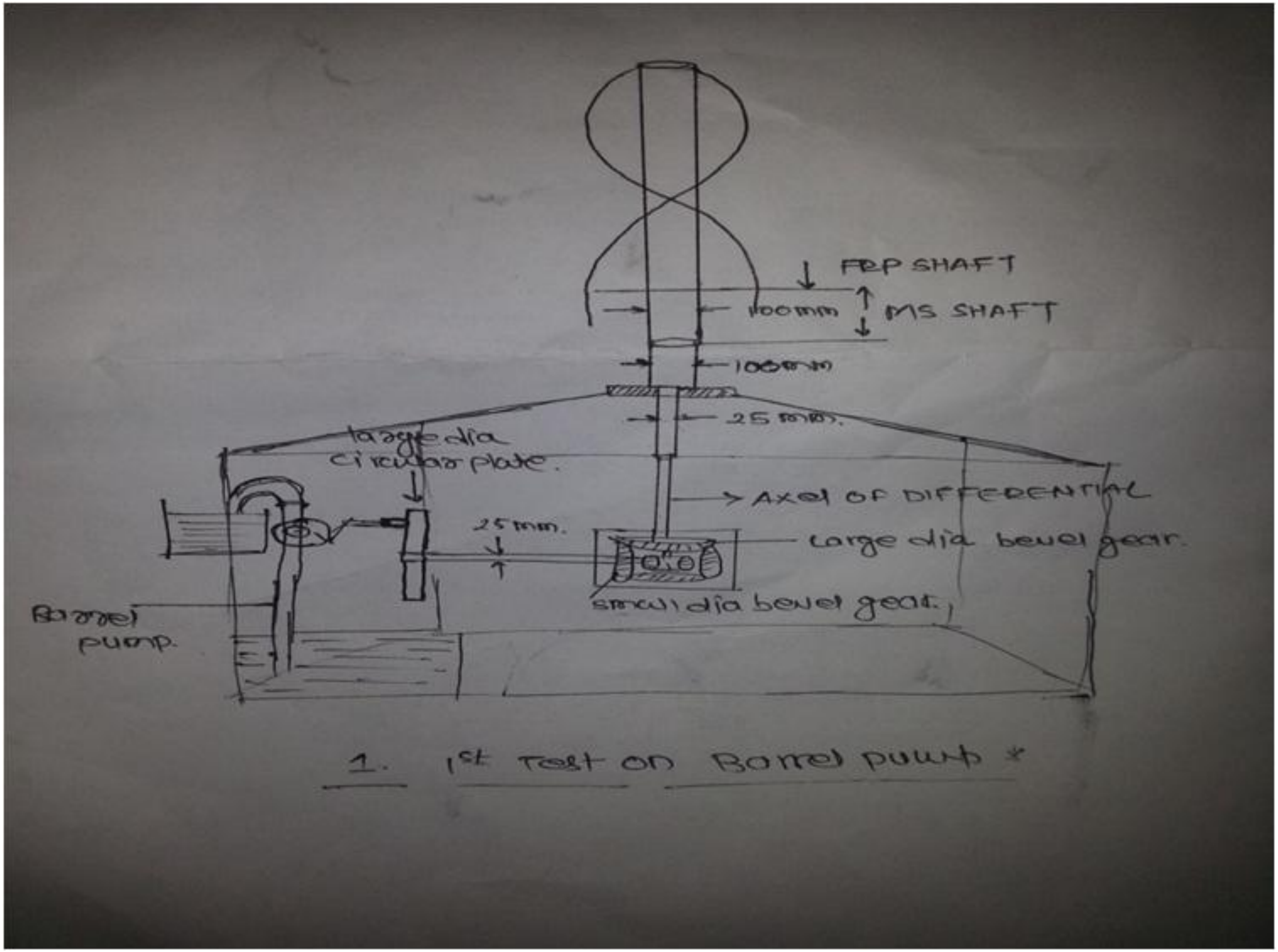
Ring and pinion gear backlash refers to the amount of space between the meshing teeth of the gears.

- Backlash is needed to allow for the heat expansion and lubrication.
- Too little back lash will cause the gears to jam and too much backlash will cause gear noise (whirring, roaring, or clunking).
- Hydrate ferric oxide (yellow oxide of iron) is used to check the contact pattern between pinion and ring gear.
- To increase move the ring gear away from the pinion gear. To decrease move the ring gear toward the pinion gear (controlled by case bearing nuts or shims).

# IMAGES THAT WE TAKEN FOR DIFFERENTIAL ARRANGEMENT…



# PURPOSE OF DIFFERENTIAL



# COUPLING

Coupling is required for the temporary joining the two different diameter shaft.
Here also there would be requirement of the coupling for joining the VAWT rotor shaft to the axel shaft of the differential.

## Specification of coupling :

| | | |
|---|---|---|
| MATERIAL | : | MS ROUND BAR |
| DIAMETER | : | 100 MM |
| LENGTH | : | 10 INCH |

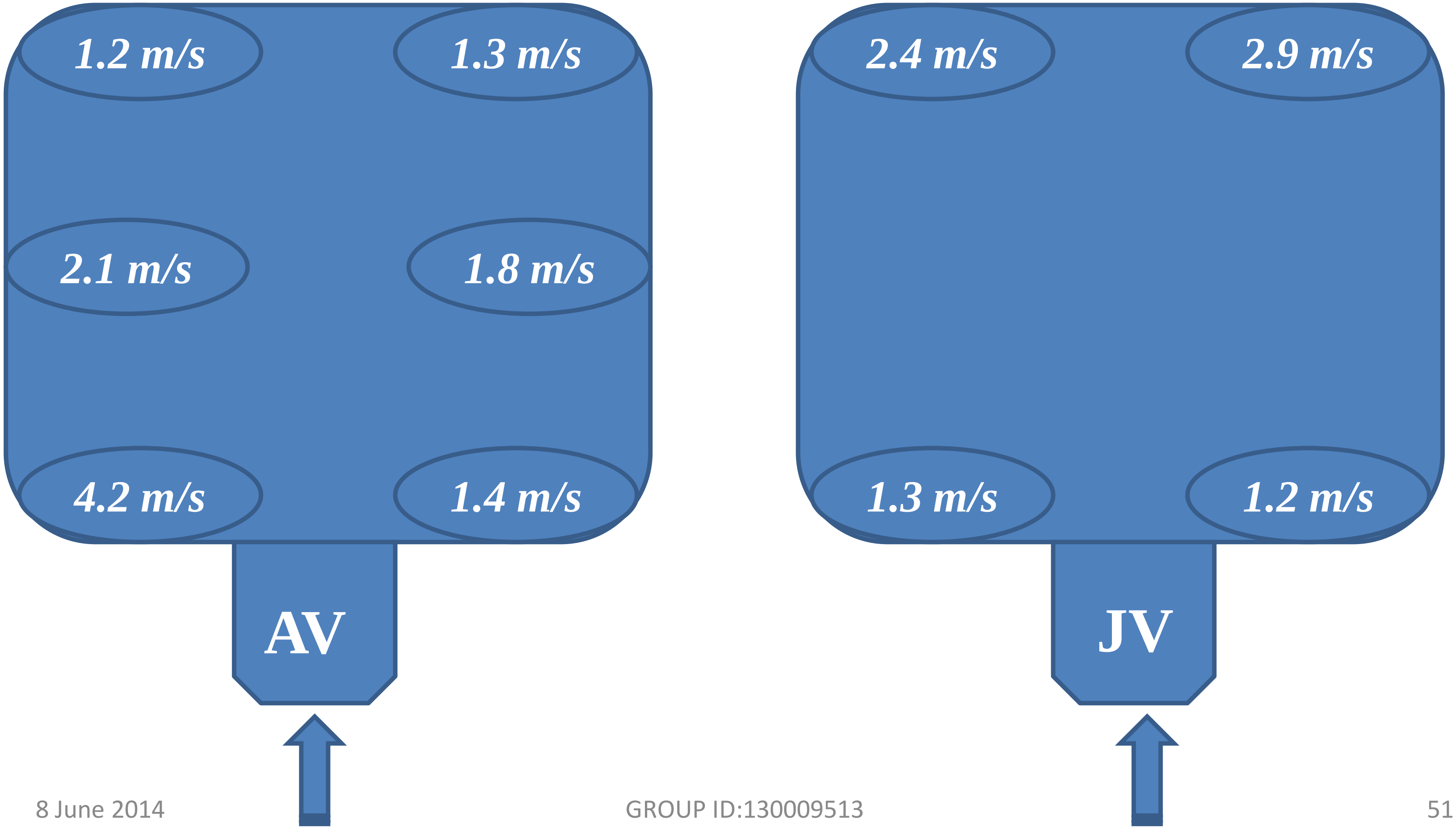
**NOTE:**
For the weight reduction up to 5 inch there would be a boring operation to make a bore of 80 mm. and after 5 inch there would be reduction of the 100 mm dia. To 35 mm by turning on lathe. There would be also weight reduction in 35 mm solid shaft to make bore of 25 mm that we required for coupling the axel shaft of the differential.

Coupling Manufacturing

# Assembly of Whole System Structure

# Experimental procedure of the project…

# Wind velocity calculation in **SRPEC**



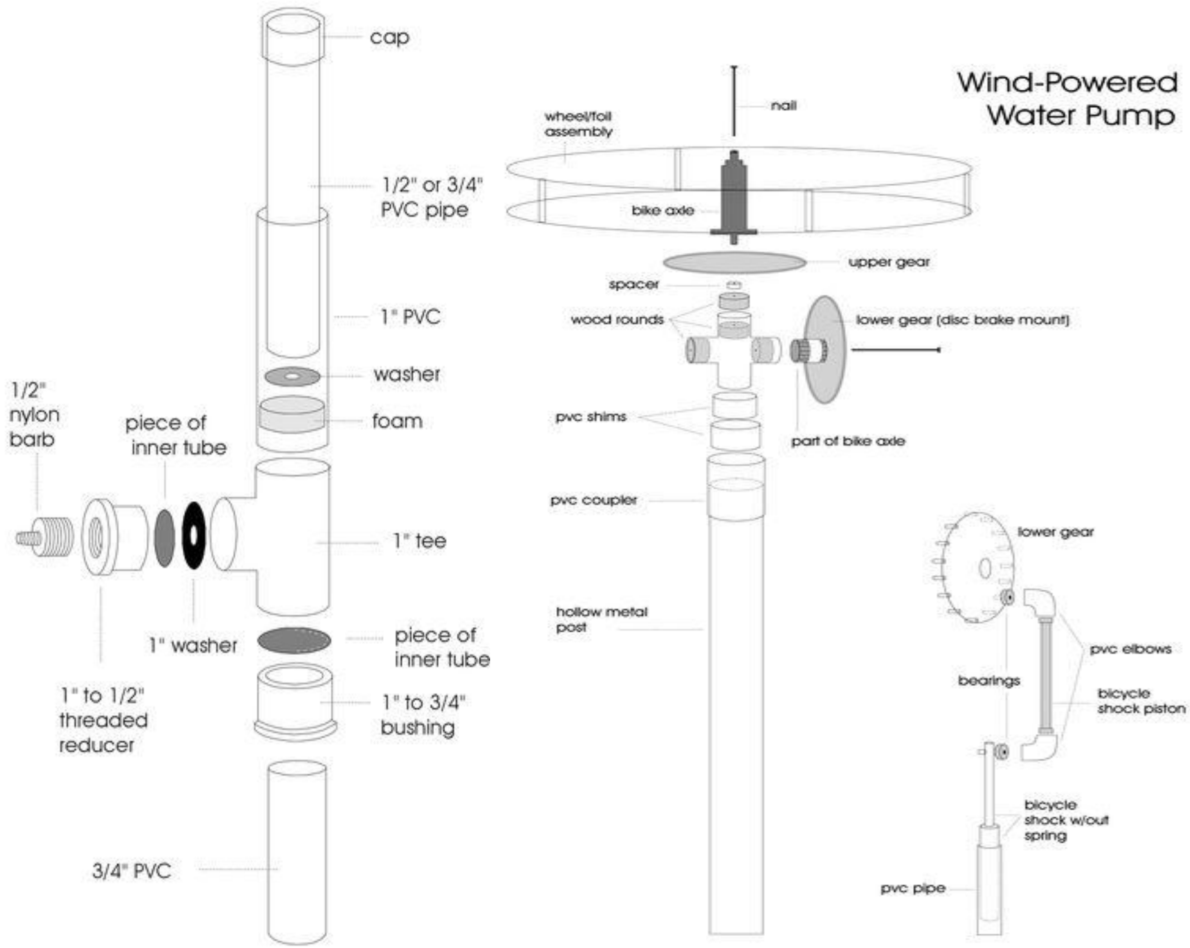
# VAWT ROTOR SPEED CALCULATION

| Wind speed in m/s | Rotor speed result | RPM |
|---|---|---|
| 3 | No | - |
| 5 | No | - |
| 10 | Low | 800 |
| 15 | Moderate | 1500 |
| 25 | High | 2200 |
| 30 | Very high | 2880 |

# ALTERNATIVES WE HAVE….

1. PUMP:

After checking the working of the barrel pump if it is to be required that the effort required for the rotation of the barrel pump is greater then we have an alternative that is the piston pump. The piston pump is to be made from plastic hence it to be remains cheaply and easy to manufacture at domestic workshops.



# CONCLUSION

Our work and the results obtained so far are very encouraging and reinforce the conviction that vertical axis wind energy conversion systems are practical and potentially very contributive to convey water from one place to another place in the salt pans. It is hoped that they may be constructed used high-strength, low-weight materials for deployment in more developed nations and settings or with very low tech local materials and local skills in less developed countries.

# REFERENCES

1.Wind Powered Water Pumping

windmillhttp://www.ironmanwindmill.com/windmill-history.htm

2. Wind Energy Technology

www.kidwind.org

3. Textbook for Wind Turbines, by T. Al. Shemmeri.

http://bookboon.com/en/wind-turbines-ebook

4. **Fibre glass wind turbine blade manufacturing guide** Produced by Engineers Without Borders (EWB - UK) & Sibolng Agham at Teknolohiya (SIBAT - Philippines)Version 1.41st May 2008Authors: Andrew Corbyn & Matthew Little.

5. Manufacture the  Wind pump.

http://www.tribology.co.uk/poldaw.htm

HAVE ANY QUESTION ???

# *Thank You*