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MODELLING SIMULATION AND DEVELOPMENT OF GRAVITATIONAL VORTEX FLOW HYDRAULIC POWER PLANT

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Abstract:

As we know energy demand is increasing day by day, so it is a dire need of this era to get know about new and modified sources of renewable energy. Renewable energy can be obtained by water, wind and solar energy etc. But our main focus is on hydro energy especially through Gravitational vortex hydro-turbine works on the principle of a vortex, it converts centrifugal head of vortex into shaft power. GVHT can generate electricity from renewable sources of energy. In a Gravitational vortex power plant, water enters a circular basin in tangential direction & energy is extracted from the free vortex using a turbine. The main advantages of GHVT are that it can generate electricity from the very low hydraulic head, it is environment friendly & it is economically & socially viable. It is a new and not well-developed technology to generate electricity from low-pressure water energy sources. Gravitational Water Vortex Hydropower Plant (GWVHP) is a new addition in the family of ultra-low head hydropower systems and is one of the emerging technologies that have special attention of academicians globally. In GWVHP, an artificially formed vortex rotates a co-axially placed turbine coupled with a generator thus producing electricity. The methodology includes performance analysis of GVHT, finding out the optimum shape of the basin & channel. The methods include both simulations on ANSYS fluent & manufacturing of a considerable amount of energy for the prototype based on the result obtained from the simulations for experimental analysis & testing. It also aims to study the feasibility of GVFHT in a country like India

Keywords: ultra-low head**,** Vortex Hydropower Plant, low-pressure, *GVFHT*

I. INTRODUCTION

Renewable energy such as hydropower has become one of the most demanded sources of energy for its clean generation. Low head hydropower plant is demanded in area which cannot see grid extension due to difficult geographical terrain and other reasons. Water vortex power plant is one of such low head turbine in which the mechanical energy of free surface flowing water is converted to kinetic energy by tangentially passing the water to a basin, which forms a water vortex. Water energy being a clean, cheap and environment friendly source of power generation is of great importance for sustainable future; however, designing such energy system to harness energy from water is usually a major challenge. Energy from water can be harnessed using different approaches, some of which include: hydrostatic and hydrokinetic methods. Hydrostatic approach is the conventional way of producing electricity by storing water in reservoirs to create a pressure head and extracting the potential energy of water through suitable turbo- machinery. In hydrokinetic approach, the kinetic energy inside the flowing water is directly converted into electricity by relatively small scale turbines without impoundment and with almost no head, which is usually placed inside a river and activated by the water current. Gravitational water vortex turbine is an ultra-low head turbine which can operate in a low head range of 0.7–2 m.

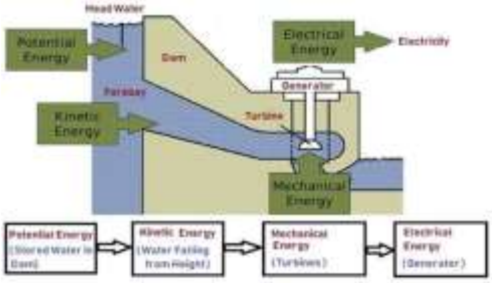
1.1 Hydro power

Hydropower has been the main source of renewable electrical energy for more than a hundred years, and will continue to be equally, or even more, important in the future, certainly for another 100 years. Though the hydropower of today is a mature technology, there is still room for technological improvements and a need for adaptation to many new challenges: New market conditions, new environmental policies, the water-food-energy-ecosystem nexus, and how to adapt to a changing climate with its impacts on water resources. Hydropower offers significant potential for carbon emission reductions. With 16% of worldwide electricity generation, hydropower today remains the largest source of renewable energy in the electricity sector, and, still, there is a potential to increase global hydropower generation by 200%–300%.

1.2 Hydroelectric Power Plant

Hydroelectric Power Plant is a system in dams and works by obstructing the river flow which causes to increase and store water in the Dams. This is Potential Energy. The water is made to fall from a height which constitutes Kinetic Energy. This Kinetic Energy is then converted to Mechanical Energy by the Turbines. Generator is responsible in converting this

Mechanical Energy from the Turbine into Electrical Energy. Hydroelectric Power Plants generates electricity for home consumption or business needs. The flexibility of generating the electricity usually is either in a large scale or in a smaller scale depending on the usage. In 1879, the first commercial Hydroelectric Power Plant was built at Niagara Falls. Although every passing year, there has been continuous improvements doing rounds for safer and efficient utilization.



II. MICRO HYDRO POWER (MHP) PLANTS

A **micro hydro power (MHP)'**plant′ is a type of hydroelectric power scheme that produces up to 100 KW of electricity using a flowing steam or a water flow. The electricity from such systems is used to power up isolated homes or communities and is sometimes connected to the public grid.

Micro hydro systems are generally used in developing countries to provide electricity to isolated communities or rural villages where electricity grid is not available. Feeding back into the national grid when electricity production is in surplus is also evident in some cases. The micro hydro scheme design can be approached as per household basis or at the village level often involving local materials and labour.

In 1995, the micro-hydro capacity in the world was estimated at 28 GW, supplying about 115 TWh of electricity. About 60% of this capacity was in the developed world, with 40% in developing areas. Micro hydro plants that are found in the developing world are mostly in mountainous regions for instance in the some places in the Himalayas as well as in Nepal where there are around 2,000 schemes, including both mechanical and electrical power generation. In South America, there are micro-hydro programs in the countries along the Andes, such as Peru and Bolivia. Smaller programs have also been set up in the hilly areas of Sri Lanka, Philippines and some parts of China.

2.1 Head and flow characteristics

- Microhydro systems are typically set up in areas capable of producing up to 100 kilowatts of electricity. This can be enough to power a home or small business facility. This production range is calculated in terms of "head" and "flow". The higher each of these are, the more power available.
- "**Head**" is the pressure measurement of falling water expressed as a function of the vertical distance the water falls.This change in elevation is usually measured in feet or meters. A drop of at least 2 feet is required or the system may not be feasible.
- When quantifying head, both gross and net head must be considered. Gross head approximates power accessibility through the vertical distance measurement alone whereas net head subtracts pressure lost due to friction in piping from the gross head.
- "**Flow**" is the actual quantity of water falling from a site and is usually measured in gallons per minute, cubic feet per second, or liters per second.

2.2 SUITABLE CONDITIONS FOR MICRO HYDRO POWER PLANTS:

The ideal geographical areas for exploiting small scale hydro schemes is where there are steep rivers flowing all year round. Islands with moist marine climates are also suitable. Low-head turbines have been developed for small-scale exploitation of rivers or irrigation canals where there is a small head but sufficient flow to provide adequate power.

To understand more about a suitable potential site, the hydrology of the site needs to be known and a site survey carried out so as to determine the actual flow and head data. Hydrological information is easily accessible from the metrological or irrigation department of the particular national government. Site surveys usually give a more detailed information of the site conditions to allow power calculation to be done and design work to begin. Flow data should however be collected over a period of one year where possible, this is to ascertain on the fluctuation in the river flow over the various seasons.

2.3 TYPES OF TURBINES

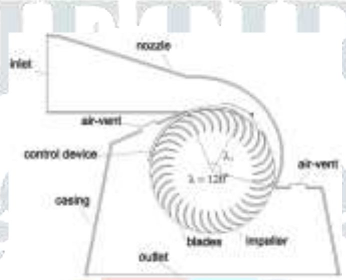
2.3.1 IMPULSE TURBINE

Impulse turbine changes the velocity of a water jet. The jet impinges on the turbine's curved blades which change the direction of the flow. The resulting changes in momentum (impulse) causes a force on the turbine blades. Since the turbine is spinning, the force acts through a distance (work) and the diverted water flow is left with diminished energy. Prior to hitting the turbine blades, the water's pressure (potential energy) is converted to kinetic energy by a nozzle and focused on the turbine. No pressure change occurs at the turbine blades, and the turbine doesn't require hosing for operation

2.3.1.1 Pelton Turbines: In a Pelton turbine as shown, water jets from nozzles strike cups or buckets arranged on a circumference of a runner or wheel, causing the wheel to rotate. A Pelton wheel has one or multi free jets. Pelton turbines are suited for high head, low flow applications, recently Pelton turbines can also be used for small and Micro hydropower systems. For these systems, a single water jet is typically used.

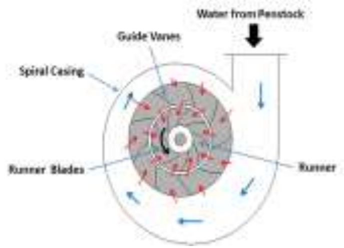
2.3.1.2 Cross Flow Turbines

A cross-flow turbine is designed by Ossberger Co, so it known as an Ossberger turbine, is shaped like a drum and uses an extended, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. The cross-flow turbine allows the water to flow through the blades twice. During the first pass, water flows from the outside of the blades to the inside; the second pass is from the inside back out. These types of turbines can be used both in horizontal and vertical orientations. These turbines can familiar with micro hydro, higher water flow and lower head than the Pelton turbine



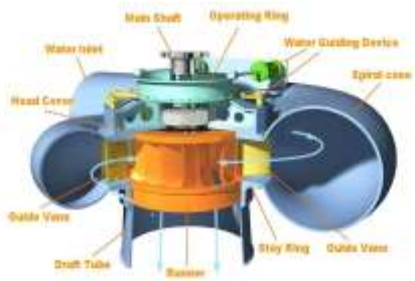
2.3.2 REACTION TURBINES

Reaction Turbines have a better performance in low head and high flow sites. They have not nozzles, the blades project radially from the periphery of the runner are formed and mounted so that the spaces between the blades have, in cross section, the shape of nozzles. A reaction turbine generates power from the combined action of pressure and moving water. In the slow operating speed, the efficiency of reaction turbines is better than the impulse turbines. Also Reaction turbines are generally preferred over impulse turbines when a lower head but higher flow is available.



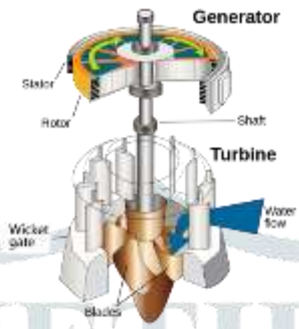
2.3.2.1 Francis Turbines

A Francis turbine has a runner with fixed buckets (vanes), usually nine or more. Water is introduced just above the runner and all around it and then falls through, causing it to spin. Besides the runner, the other major components are a scroll case, wicket gates, and a draft tube the cross-sectional view of a Francis turbine is shown in .The Francis turbines have a good performance for micro hydropower sites.



2.3.2.2 Axial Flow Turbines (Propeller and Kaplan Turbines)

Most of the reaction turbines are a propeller type turbine. A propeller turbine generally has a runner with three to six blades in which water impinges continuously at a constant rate. The pitch of the blades may be fixed or adjustable. The major components besides the runner are a scroll case, wicket gates, and a draft tube see figure. The propeller turbine design was originally motivated by the need to develop high specific speed machines for use in relatively low head situations where it would be uneconomic to use a Francis turbine. Viktor Kaplan, an Austrian engineer, realized that changing the pitch of the blades could make a turbine with a greater range of applicability. In 1913, Kaplan designed a variable pitch propeller turbine, the Kaplan turbine. Since that time, the operating head of the Kaplan turbine has been increased, and smaller Kaplan turbines have been used for heads as high as 65 m. The Kaplan turbine runner is hydraulically similar to the propeller turbine runner except that the hub is larger to accommodate the mechanism for blade angle shifting. The servomotor to accomplish this is located in the hub in some designs. References presented an axial hydro turbine with low heads micro potential flow ranged from 1 m to 5 m



2.3.2.3 Pump as Turbine (PAT)

In pumping mode, the fluid enters at suction side of pump at low pressure and gets energized by the impeller, which is rotated by some external means, and leaves the casing at high pressure. Whereas in case of PAT in figure, the pump rotates in reverse direction, water enters in the pump at very high pressure from the casing and moves through the impeller blades and releases its pressure and kinetic energy to the impeller shaft as mechanical energy and fluid comes out from the eye of pump at low pressure.

The research on using PAT started around 1930 and the main challenge in PAT usage was the selection of a proper PAT for a small and Micro hydro-site. The main problem of using a pump as turbine is still the difficulty of predicting accurately the turbine performance, pump manufacturers do not normally provide the characteristic curves of their pumps working as turbines. Hence references presented methods to predict the performance of PAT which based on the data for pump performance at best efficiency a wide range of results.

2.4 Micro Hydropower Plant Turbines

Several types of water turbines can be used in micro hydro installations, selection depending on the head of water, the volume of flow, and such factors as availability of local maintenance and transport of equipment to the site. For hilly regions where a waterfall of 50 meters or more may be available, a Pelton wheel can be used. For low head installations, Francis or propeller-type turbines are used. Very low head installations of only a few meters may use propeller-type turbines in a pit, or water wheels and Archimedes screws. Small micro hydro installations may successfully use industrial centrifugal pumps, run in reverse as prime movers; while the efficiency may not be as high as a purpose-built runner, the relatively low cost makes the projects economically feasible.

In low-head installations, maintenance and mechanism costs can be relatively high. A low-head system moves larger amounts of water, and is more likely to encounter surface debris. For this reason a Banki turbine also called Ossberger turbine, a pressurized self-cleaning crossflow waterwheel, is often preferred for low-head micro hydro systems. Though less efficient, its simpler structure is less expensive than other low-head turbines of the same capacity. Since the water flows in, then out of it, it cleans itself and is less prone to jam with debris.

- **GRAVITATIONAL WATER VORTEX POWER PLANT :** part of the river flow at a weir or natural water fall is diverted into a round basin with a central bottom exit that creates a vortex. A simple rotor (and connected generator) is moved by the kinetic energy. Efficiencies of 83% down to 64% at 1/3 part flow.

- **SCREW TURBINE** (Reverse Archimedes' screw): two low-head schemes in England, Settle Hydro and Torrs Hydro use an Archimedes' screw which is another debris-tolerant design. Efficiency 85%.

- **GORLOV**: the Gorlov helical turbine free stream or constrained flow with or without a dam

- **FRANCIS AND PROPELLER TURBINES.**

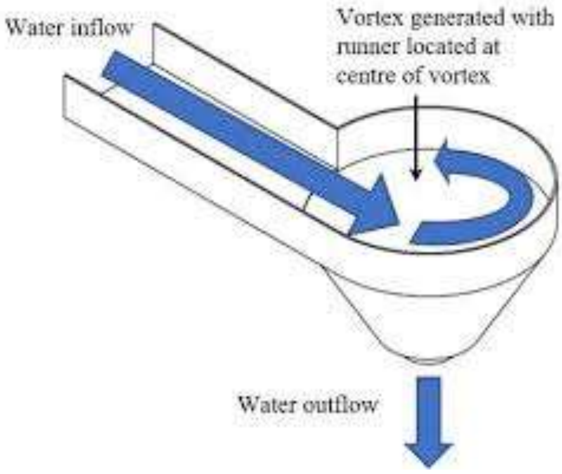
- **KAPLAN TURBINE** : Is a high flow, low head, propeller-type turbine. An alternative to the traditional Kaplan turbine is a large diameter, slow turning, permanent magnet, sloped open flow VLH turbine with efficiencies of 90%.
- **WATER WHEEL** : Advanced hydraulic water wheels and hydraulic wheel-part reaction turbine can have hydraulic efficiencies of 67% and 85% respectively. Overshot water wheel maximum efficiency (hydraulic efficiency) is 85%. Undershot water wheels can operate with very low head, but also have efficiencies below 30%.

III. GRAVITATION WATER VORTEX POWER PLANT

The **gravitation water vortex power plant** is a type of micro hydro vortex turbine system which is capable of converting energy in a moving fluid to rotational energy using a low hydraulic head of 0.7–3 metres (2 ft. 4 in–9 ft. 10 in). The technology is based on a round basin with a central drain. Above the drain the water forms a stable line vortex which drives a water turbine. The operation of the turbine is quite simple. It has only one moving part, extending its operating life, energy production and thus requiring very little maintenance. A self-cleaning screen holds large debris out of the turbine. The flow is guided into a vortex through optimized concrete basin. The vortex turns a specially designed impeller. The water flows back into the stream with all debris gone through and all fish unharmed

It was first patented by Greek-Australian Lawyer & Inventor Paul Kouris in 1996, who was searching for a way to harness the power inherent in a vortex.

Gravitational water vortex power plant is a green technology that generates electricity from alternative or renewable energy source. In the vortex power plant, water is introduced into a circular basin tangentially that creates a free vortex and energy is extracted from the free vortex by using a turbine. The main advantages of this type of power plant is the generation of electricity from ultra-low hydraulic pressure and it is also environmental friendly. Since the hydraulic head requirement is as low as 3m, this type of power plant can be installed at a river or a stream to generate electricity for few houses. It is a new and not well-developed technology to harvest electricity from low pressure water energy sources. Vortices are formed at the outlet of hydraulic structures, where a large amount of water is drained into the outlet. This flow into the outlet causes a vortex to initiate at the free surface. This vortex gradually intensifies, causing the water rotation to speed which, in turn, causes the pressure at the centre of the vortex to decrease. This pressure gradually decreases until, ultimately, it is lower than the atmospheric pressure and sucks the air into the intake, so forming an air core. The radius of the air core reduces gradually while moving from the free surface to the outlet.



IV DESIGN OF GRAVITATION WATER VORTEX POWER PLANT

- Basic Components in Gravitational **Water Vortex Power Plant**
  - Inlet Canal/Inlet Pipe
  - Casing
  - Turbine/Runner
  - Generator
  - Electrical Control Unit

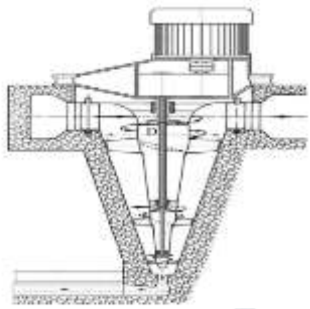
4.1 DESIGN OF RUNNER BLADE

A majority of runner used in GWVPP turbine is in rectangular shape which converts the kinetic energy of water into electricity. The design is widely celebrated due to its simplistic yet effective approach. A majority of runner used in GWVPP turbine is in rectangular shape which converts the kinetic energy of water into electricity. The design is widely celebrated due to its simplistic yet effective approach.

The water vortex striking the turbine blades has been modelled as a jet of water striking the turbine blades like in cross-flow or other impulse turbines. Taking the inlet jet angle to be 16° [10] and assuming no outlet whirl velocity, the design proceeds with the calculation of the inlet and outlet blade angles using velocity triangles.

4.2 BASIN CONSTRUCTION

Basins and feeder channels are generally constructed on-site from concrete or other construction materials, but it is possible to construct small transportable systems with steel basins, as the pressure is in the center of the vortex and not on the exterior. Such transportable systems use pipelines instead of a channel to feed water into the vortex. Two types of basin are encountered, respectively of cylindrical and conical design.



V SIMULATION OF GRAVITATIONAL WATER VORTEX POWER PLANT

5.1 COMPUTATIONAL FLUID DYNAMICS

A CFD analysis basically consists of the following three phases:

a) **Pre-processing:** In this phase the problem statement is transformed into an idealized and discretized computer model. Assumptions are made concerning the type of flow to be modeled (viscous/inviscid, compressible/incompressible, steady/non steady). Other processes involved are mesh generation and application of initial- and boundary conditions.

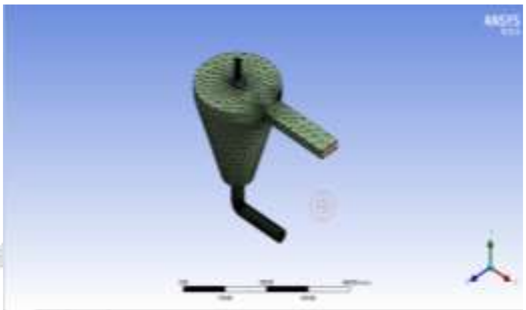
b) **Solving:** The actual computations are performed by the solver, and in this solving phase computational power is required. There are multiple solvers available, varying in efficiency and capability of solving certain physical phenomena.

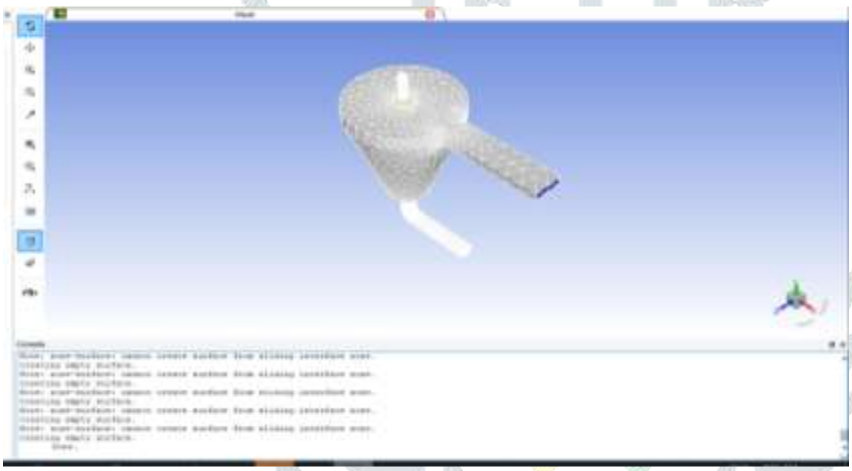
c) **Post-processing:** Finally, the obtained results are visualized and analyzed in the post processing phase. At this stage the analyst can verify the results and conclusions can be drawn based on the obtained results. Ways of presenting the obtained results are for example static or moving pictures, graphs or tables.

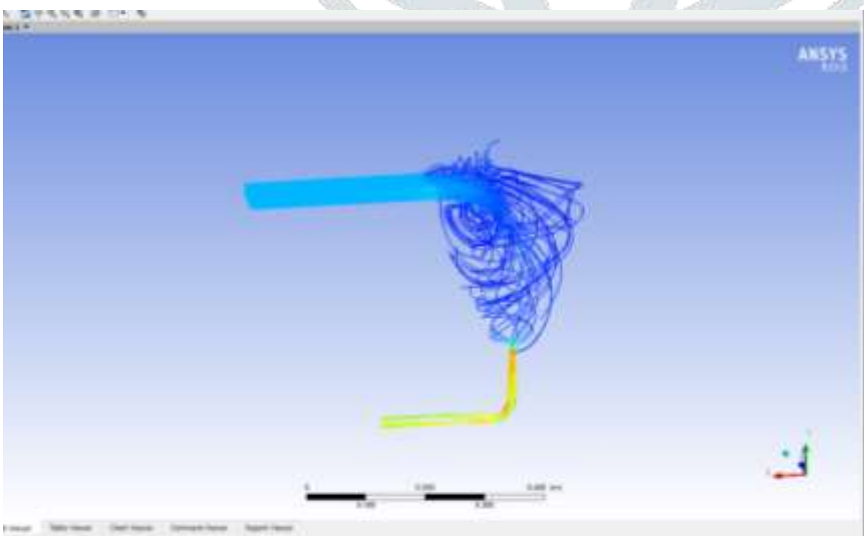
In the first phase topic was selected as "Computational and Experimental Study of Gravitational Water Vortex Turbine". Literature review was done over the topic keywords and past researches over the topic was commenced. The literature review was continued throughout the course of the project. Moving into the calculation and design part, parameters such as cone inlet diameter etc. was acquired based on the past researches and some parameters were assumed on our own. Then a CAD model of the prototype was designed in SolidWorks based on the collected parameters. Then it was carried onto material selection where mild steel was selected as core material for our prototype. After acquiring parameters and material selection, fabrication and assembly was proceeded. The prototype was fabricated using technical level manpower and no advanced fabrication like casting, machining etc. was performed. The fabricated parts were then finally assembled for experimental testing. The prototype geometry was exported to ANSYS CFX for computational analysis. Torque and efficiency was then calculated for three different runner positions. The experimental setup was adjusted so as to resemble setup as for computational analysis. Then using rope brake dynamometer, torque was calculated for three different runner positions and finally efficiency was derived.

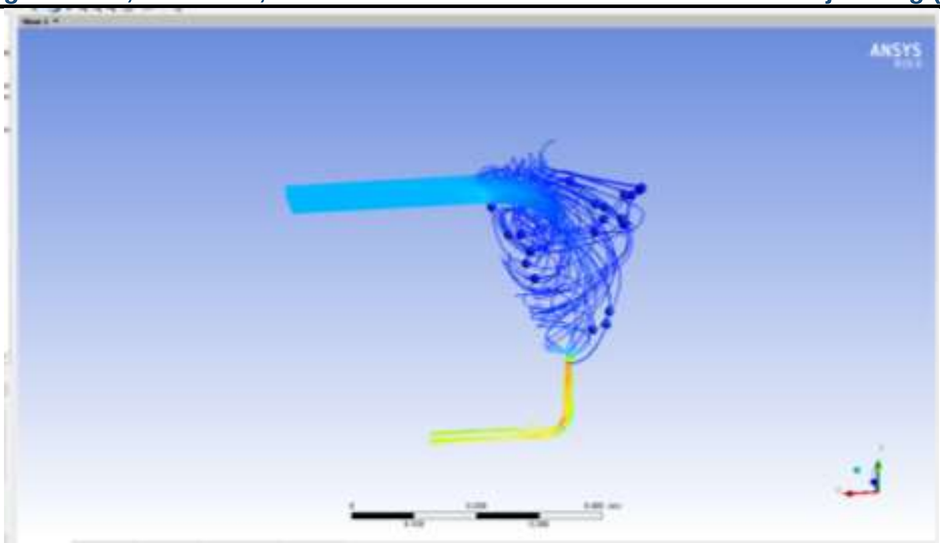
5.1.1 COMPUTATIONAL ANALYSIS OF CONICAL BASIN WITHOUT RUNNER

Firstly, the fluid domain (geometry) for the flow simulation without runner was created with CAD software using Solid works 2016. Then the domain was imported into the ANSYS R15.0 in the CFX solver for the computational analysis. Various meshes were created starting from minimum of 2195 to maximum of 26710 numbers of nodes through refinement by changing the mesh element sizes. Finally the mesh having 148403 nodes was used for the simulation whose minimum size was default (2.6479e-4 m) and maximum size of 11e-3 m. The solver preference was CFX. The analysis type was made transient where simulation was run for 30 seconds with time steps 0.5 second and having the convergence criteria of residual target 1e-4. The minimum and maximum coefficient of loops for convergence control was 1 and 5 respectively. The working fluids were taken as air and water at 25oC. The reference pressure of 1 atm and buoyancy reference density of 1.12 kg/m3, surface tension coefficient 0.072 N/m and the domain was of stationary type. The fluid model was of standard homogeneous model with turbulence model of Epsilon which gives great analysis in fully developed flow and having scalable wall function. The simulation was run with no-slip conditions at the wall; bulk mass flow rate of 6.2 kg/s normal to both inlet and outlet boundary. The upper surface of water channel was subjected to the atmosphere and the whole domain was assumed to be filled with water.

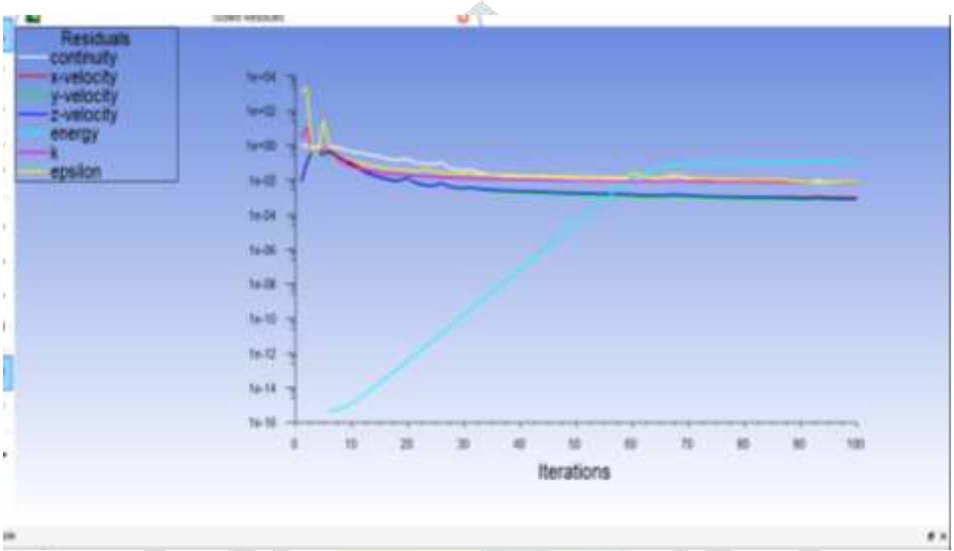






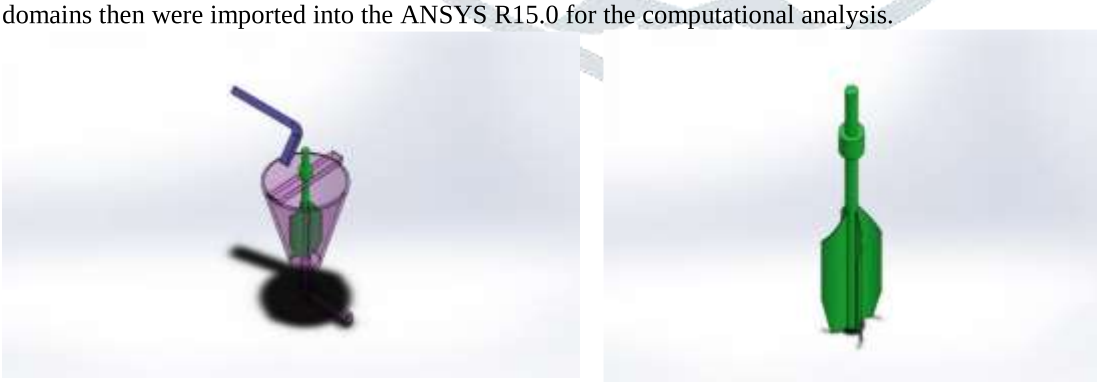


WATER VELOCITY STREAMLINE



5.1.2 COMPUTATIONAL ANALYSIS OF CONICAL BASIN WITH RUNNER

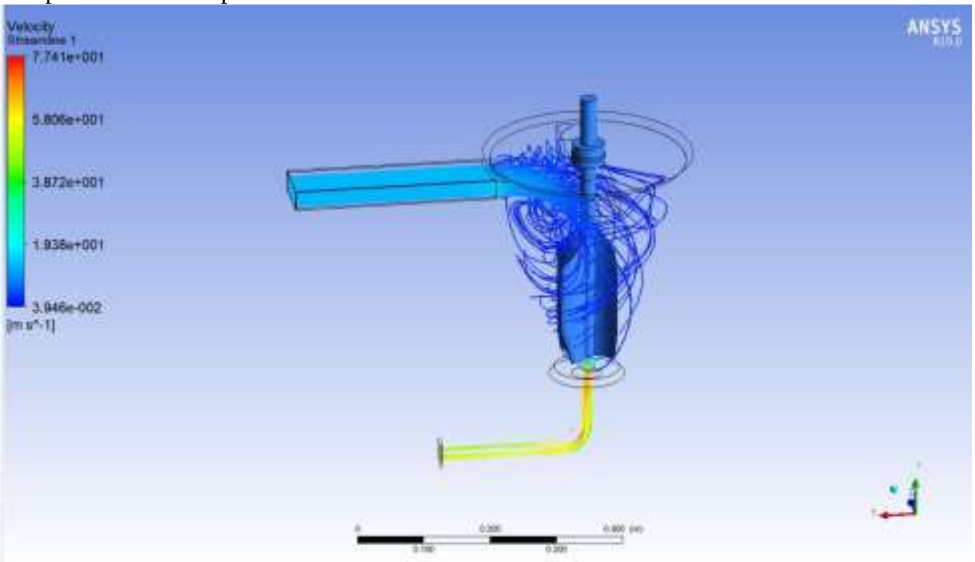
Similar to the computational analysis of conical basin without runner, the stationary and rotating fluid domains (geometry) for the simulation with runner at different position were created with CAD software using Solidworks 2016. The domains then were imported into the ANSYS R15.0 for the computational analysis.



FLUID DOMAIN RUNNER

Various meshes were created for stationary and rotating domains and refinements were made by changing the mesh element sizes. Finally the mesh having 131864, 133404 and 205139 nodes was used for the simulation of conical basin with runner position 1st, 2nd and 3rd respectively. The minimum size was default (2.6479e-4 m) and maximum size was 13e-3 m for stationary domain and 5e-3 m for rotating domain of 1st and 2nd runner position simulation respectively whereas the minimum size was default (2.6479e-4 m) and maximum size was 10e-3 m for stationary domain and rotating domain of 3rd runner position simulation.

The solver preference was CFX. The analysis type was made transient where simulation was run for 30 seconds with time steps 0.5 second and having the convergence criteria of residual target 1e-4. The minimum and maximum coefficient of loops for convergence control was 1 and 5 respectively. The working fluids were taken as air and water at 25^{o} C. The reference pressure of 1 atm and buoyancy reference density of 1.12 kg/m^3, surface tension coefficient 0.072 N/m and the domain was of stationary type. The fluid model was of standard homogeneous model with turbulence model of kepsilon which gives great analysis in fully developed flow and having scalable wall function. The interface model between the stationary and rotating domain was general connection with frozen rotor and specified pitch angle of 360^o. The simulation was run with no-slip conditions at the wall; bulk mass flow rate of 6.2 kg/s normal to both inlet and outlet boundary. The upper surface of water channel was subjected to the atmosphere and the whole domain was assumed to be filled with water. The black arrows normal to the inlet channel and the outlet shows the bulk mass flow rate normal to the boundary whereas the blue double head arrow shows the channel is open to the atmosphere.



WATER VELOCITY STREAMLINE AT 1ST RUNNER POSITION

VI FABRICATION OF GRAVITATIONAL WATER VORTEX POWER PLANT

Basic Components in Gravitational **Water Vortex Power Plant**

- Inlet Canal/Inlet Pipe
- Conical Basin
- Turbine/Runner
- Generator
- Centrifugal pump
- Electrical Control Unit

- **INLET CANAL/ INLET PIPE**

For GWVPP, the inlet flow rates are the water that is released into a channel connected to the basin. The channel is responsible to direct the water flow into the basin tangentially. It can be horizontal or slanted at desired angle. The channel width between two ends could be different or the same. One of the study that will be mentioned below also shows that the inlet of GWVPP could be in the form of pipe instead of channel.

- **CONICAL BASIN**

In Gravitational water vortex turbine, water assuming to be non-rotational and inviscid passes through an inlet channel and enters the basin tangentially where it forms a powerful vortex.

The conical basin design attempts to exploit the fact that water moves down the vortex in a circular motion, and energy can be extracted at every level (see Fig. 5.2.2(iii)). Whereas in the basin design, water passes through the blades once, it passes through a series of blades on the way to the outlet in the conical design.

- **TURBINE/RUNNER**

A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced by a turbine can be used for generating electrical power when combined with a generator.

- **GENERATOR/ STEPPER MOTOR**

Electric generators, also known as dynamos is an electric machine that converts mechanical energy into electrical energy. The electric generator's mechanical energy is usually provided by steam turbines, hydraulic turbines, gas turbines, and wind turbines. Electrical generators provide nearly all the power that is required for electric power grids

In contrast to other generators, a stepper motor produces a large induced voltage even at low rotational speeds. ... The type used here, with a DC resistance of 2×60 Ω per winding, can generate more than 20 V when turned by hand, without any gearing. Any stepper motor can be used as a generator.

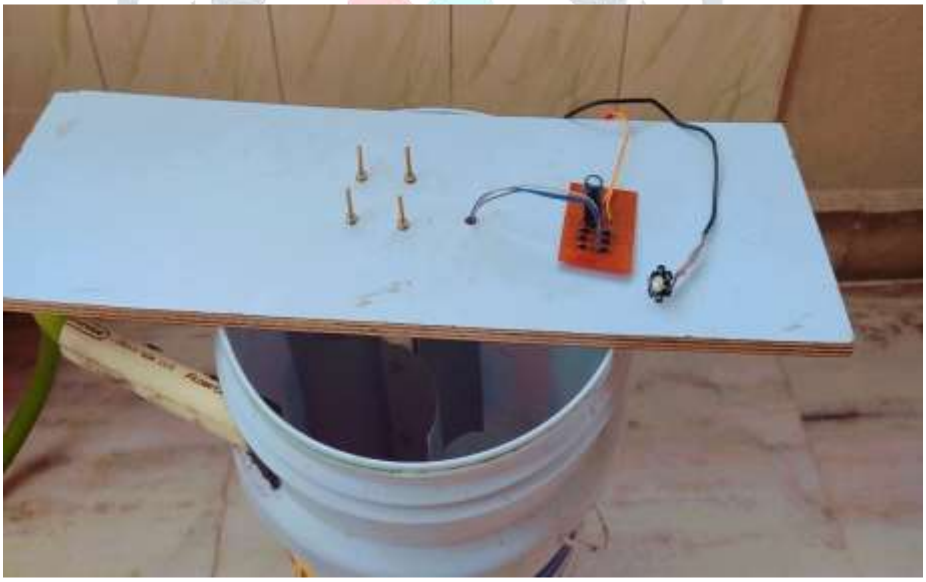
- **CENTRIFUGAL PUMP**

A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips. The action of the impeller increases the fluid's velocity and pressure and also directs it towards the pump outlet. The pump casing is specially designed to constrict the fluid from the pump inlet, direct it into the impeller and then slow and control the fluid before discharge. The titling fumes equipment uses the centrifugal pump for its movement of fluids.

➢ **ELECTRICAL CONTROL UNIT AND LED LIGHTS**

LED lights are used as a measure of electricity produced during the operation of Gravitational vortex hydraulic turbine

➢ **FINAL MODEL OF VORTEX POWER PLANT**



CALCULATIONS

- Shaft diameter =28mm
- Total height of conical basin =375 mm
- Height of inlet from base = 305 mm
- Basin top diameter =296mm
- Lower base diameter =265 mm
- Out let hole diameter = 28mm
- Number of Blades =3

- Height of blade = 200mm
- Width of blade =110mm
- Outer diameter of runner = 206mm
- Inner diameter of runner =40mm

- Flow rate at inlet (Q_i)= 0.66 Lit/sec------------(FULL GATE OPENED)

  From continuity Equation Q= AV

  A --- Area of inlet = $\pi d^2/4$

  d--- Diameter of inlet pipe = 25.4mm= 0.0254m

  V= Q/A = $0.66\times10^{-3}/0.00005123$ =12.88 m/sec--------- (FULL GATE OPENED)

- Flow rate at inlet (Q_i)= 0.4 Lit/sec------------(HALF GATE OPENED)

  From continuity Equation Q= AV

  A --- Area of inlet = $\pi d^2/4$

  d--- Diameter of inlet pipe = 25.4mm= 0.0254m

  V= Q/A = $0.4\times10^{-3}/0.00005123$ =7.80 m/sec--------- (HALF GATE OPENED)
- Flow rate at outlet (Q_o) =0.48 Lit/sec (FULL GATE OPENED)
- Flow rate at outlet (Q_o) =0.25 Lit/sec (HALF GATE OPENED)
- Inlet velocity at full gate opening = 12.88 m/sec
- Inlet velocity at half gate opening =7.80 m/sec
- Outlet velocity at full gate opening = 9.36 m/sec
- Outlet velocity at half gate opening =4.87 m/sec
- Voltage generated at Full gate opening = 6V
- Voltage generated at Half gate opening = 5V

ADVANTAGES

The gravitational water vortex power plant is an economic and clean energy system allowing for the conservation of low head streams for generation of power.

- Gravitational water vortex power plant is considered a "run-of-river" system meaning that water diverted from the stream or river is redirected back into the same watercourse. Adding to the potential economic benefits of micro hydro is efficiency, reliability, and cost effectiveness.
- With only a small stream needed, remote areas can access lighting and communications for homes, medical clinics, schools, and other facilities. Micro hydro can even run a certain level of machinery supporting small businesses.
- These hydro power plants have good potential for providing electricity to remote communities.
- Imagine you could use any kind of small head difference in a river or canal. The power produced by this turbine might surprise you.
- It requires simple maintenance cares
- Checking and cleaning are easy, because of the main parts are screwed.
- Handling is easy.
- Manual power not required
- Repairing is easy.
- Replacement of parts is easy

Applications

Each type of hydro power plant has a specific application area relating to head and flow rate. Gravitation water vortex power plants are suitable for the very low head area between 0,7m and up to 3m at a flow rate up to 20m³/s. At higher flow rates several turbines operate in parallel mode.

- **Agricultural** The water supplied to fields via motors and pumps can be used to generate electricity using GVHT. Once the GVHT is situated at the water inlet, if given enough, it may produce enough power to run the motor that pulls up the water and even light the lamps in the near vicinity.

- . **Rainwater Harvesting** The water stored at the time of rains can be helpful to generate the electricity from a very low head. The wastewater that may not be used, can give a low yet definite rate of power generation.

- **High Towers in load shedding regions** Areas in which face load shedding can use the water stored in the compound tanks, which are located at the top of the buildings. The GVHT may be situated by modifying the pipeline, as water is supplied from the tanks. Obviously, this would be the excess amount of water that may be unused due to the regular fulfillment of water that the tanks.
- **Drainage Water** The drainage water from buildings can be used to generate electricity utilizing GVHT. The sewage will bounce off of the turbine, thus protecting the turbine and increasing its life. This may be situated underground, thus occupying no extra space in the compound.

CONCLUSION

Gravitational vortex hydraulic turbine power plant is capable of generating power from low water head. Therefore, this type of power plant is suitable for the areas with rivers. Since the fossil fuels reserves are declining, GVHTPP can be an alternative energy source which is environmentally friendly as well as cost effective. In this project the following results were obtained by designing, fabricating and varying the parameters of the system to determine the performance analysis of the gravitational vortex hydraulic turbine; by doing this analysis we determine that the power produced by this turbine is of W, which helps in use of domestic purpose.

The head (m) varies inversely with the power (W), discharge (L/s), hydraulic, volumetric and mechanical efficiency.

The turbine is tolerant of muddy and polluted water, as the vortex action carries small solid particles through the turbine. So the maintenance of this kind of turbine is less as compared to other type of turbines. The turbine, which operates at a low speed does not cut the natural stream of water so does not harm aquatic and marine life.

As a fact that 11% of renewable energy contributes to our primary energy. If this project is deployed then not only, we can overcome the energy crisis problem but this also contributes to create a healthy global environmental change.

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