HYDRO POWERED IRRIGATION PUMP

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DEPARTMENT OF MECHANICAL ENGINEERING

HITEC UNIVERSITY, TAXILA

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FINAL YEAR PROJECT REPORT

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Bachelors of Science in Mechanical Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

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Submitted By:

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Abstract

The target audience for this initiative is farmers who work in irrigation fields. They need to move less water because of this pump. The main goal was to create a fuel-free, low-cost pump that can pump water to a certain head for irrigation needs.

A prototype is first created, and it is subsequently put to numerous tests. A complete working model is later created, which can be applied in many contexts and used for more research. It should be mentioned that our pump is capable of handling water that is flowing at any pace. This could be a man-made reservoir, river, or canal. The graphs produced corresponded to the anticipated outcomes that were anticipated throughout the prototype's testing for faults

List of Tables

List of Figures

Nomenclature

P	Power
ρ	Density of water
g	Gravitational
H	AccelerationHead
V	Volumetric Flow rate
ω	Angular Acceleration
T	Torque
E	Kinetic Energy
r_{wheel}	Radius of the wheel
m	Mass of the wheel
v	Velocity of flowing water
W	Work done on the wheel
F	Force on the wheel
Q	Volumetric Flow rate

Table of Contents

Chapter 1

1. Introduction

1.1.Background

Ancient Egypt is where the concept of water wheels originally appeared. Due to the fact that the majority of the men were farmers, they used a water wheel powered by the Nile's water to solve their irrigation problems. Different civilizations devised methods to increase their access to the waterwheels and eventually found a way to the spiral and coil pumps. These pumps performed more effectively. The easiest of all the pumps then appeared, the barsha pump. Project statement.

As the name implies, a hydro-powered irrigation pump is a water pump used for irrigation as well as other things. It combines the functions of a spiral pump and a water wheel. A water wheel is attached on both sides by spirals of pipe. The two rotating discs of the wheel are joined at the surface by water paddles. This pump runs on the kinetic energy of water flowing through a canal, stream, or river instead of using any fuel. It can operate at any RPM and will change its speed to match the stream's flow.

1.2.Project statement

As the name implies, a hydro-powered irrigation pump is a water pump used for irrigation as well as other things. It combines the functions of a spiral pump and a water wheel. A water wheel is attached on both sides by spirals of pipe. The two rotating discs of the wheel are joined at the surface by water paddles. This pump runs on the kinetic energy of water flowing through a canal, stream, or river instead of using any fuel. It can operate at any RPM and will change its speed to match the stream's flow.

1.3.Project Motivation

As is well known, Pakistan is mostly an agricultural nation, and this is how our economy is based. We needed a method that allowed a constant flow of water in order to better irrigate crops in mountainous areas or places where water streams are far from the farms. Farmers in those regions collect water in buckets or another container to provide water to their crops, reducing crop productivity overall and risking the loss of some harvests. Our idea had to have a minimal maintenance and operating cost given the financial circumstances of our farmers so that they could pay it on their own even if the government were unhelpful. There have been many more identical pumps created around the world, but none in Pakistan. We have praised the design employed by aQysta in the creation of the Barsha pump and have primarily drawn inspiration from that project for our project

1.4.Minimum requirements

There are basic working prerequisites for our project. It simply requires running water to function, therefore it may operate at low flow rates. By taking into account the stream's flow rate, the design can be changed. If we examine its construction, only a small number of machining machines and fundamental tools are required.

To correctly comprehend the construction, design, and operation of the pump, it is necessary to have a basic understanding of a few topics. Subjects needed for designing and fabrication

1.4.1. Basic Physics
1.4.2. Design of Machine Elements
1.4.3. Engineering Mechanics
1.4.4. Fluid Mechanics
1.4.5. Instrumentation and Measurements
1.4.6. Workshop technology

Helpful machines and software tools

1. Lathe machine
2. Shaper machine
3. Drill machine
4. SOLIDWORKS software
5. Microsoft Excel

Chapter#2

Literature Review

2.1. Witz Spiral pump:

This pump has a high lift and slow rotation (as shown in figure 2) Invention date: 1746. The spiral pump was made with inexpensive, lightweight materials. 160 feet of polyethylene pipe with a diameter of 1-1/4 inches are spirally joined to the 6 foot diameter wheel. With a working speed of 3 feet per second, it can pump about 3900 gallons of water per day and provide about 40 feet of head. The pump can readily operate in a stream with a flow velocity of at least 2 feet per second due to its low torque. The pedals mounted on the wheel are propelled by the stream flow. The pump is relatively simple to construct, requires no fuel or power to operate, and may be used anywhere there is a flowing stream or river. It also requires very little maintenance.

The Wirtz spiral pump was constructed in such a way that the outer end of the pipe opened into a scoop. The inner coil of the pipe settles into the center of the wheel where it joined a rotary fitting at the axis of the machine.

2.2. Airlift Effect:

This pump can generate water columns in its coils by using the airlift effect. It also absorbs air and water sections, which tends to raise the pressure head. As it ascends to the delivery end of the pipe from the center of the wheel, the compressed air expands, giving the water a lift effect. The air lift effect and blow-back were both tied to wheel speed, which was also connected to them. The air was able to ascend through the water in the delivery pipe more efficiently at very low speeds for the wheel with a larger distance across coils pushing into the larger delivery pipe... This lessened its lifting effect and caused the pump's output pressure to increase until blow-back occurred. This only occurred when pumping to heads higher than what could be pumped with just water at the blow-back pressure. Air lift allowed the larger pipe to pump to heads higher than those indicated by the blow-back pressure at greater wheel speeds

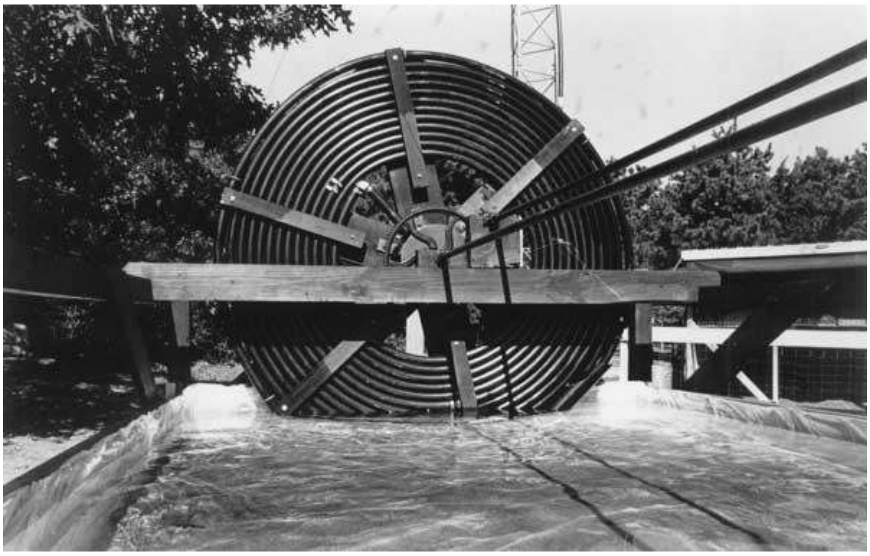


Figure 2: *Witz Spiral pump*

2.3. The Spiral tube water wheel pump

In order to specifically employ the kinetic energy of flowing water to pump water under pressure to a higher point where it may be used for residential use, lab staff designed the spiral tube water wheel pump in 1979. The researchers at Blair have created a variety of wheels with diameters ranging from 0.5 meters to 4 meters.

As the wheel revolves each paddle successively becomes submerged within the water passing around it. Thus once per revolution each watercollector also dips into the water. Just after the water collector passes the horizontal position and begins to rise it takes during a "gulp" of water, expelling air previously contained within it. When the collector rises out of the canal it is stuffed with water. This charge of water runs back to the primary spiral of the tube pump and is followed by a charge of air. As it dips again into the water the collector picks up another charge of water and so the cycle is repeated. As the wheel revolves, a pressure head develops within each coil of the spiral tube, water within the ascending coils being higher than the descending coils. Cores of water contained within the spiral compress air between them as they travel round the tube and both water and air are expelled struggling into the hollow axle of the wheel. The water which is struggling rises up the pipe and this process is assisted by the compressed gas which lifts water above in its try to escape through the pipe (as shown in figure 3) The water is discharged out in a series of bursts, jets ofwater followed by jets of compressed gas.

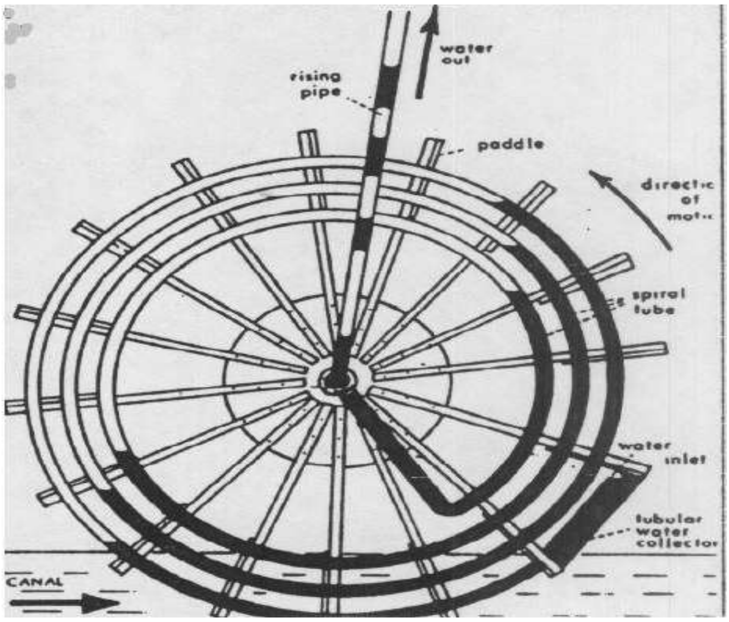


Figure 3: *Spiral tube water wheel pump*

2.4. The coil Pump:

This pump is simple both in construction and operation. It consists of a length of flexible tube wound around the inside or outside of a cylindrical drum which is partly submerged in water with the axis of the drum parallel to the water surface. One end of the pipe is secured to the drum and left open and this forms the inlet. The other end of the pipe is connected via a sealed rotary joint to the delivery pipe.

Rotation of the drum causes the inlet end of the pipe to take in alternate plugs of air and water. The ratio of the lengths of these plugs is determined by the depth of the immersion of the drum. The plugs then move along the helical pipe towards the outlet and after passing through the rotary joint they travel up the delivery pipe to the header tank.(as shown in figure 4) The pressure that is required to force the plugs up the delivery pipe is developed by each water plug acting as a manometer and sustaining a pressure difference across the plug. The sum of allthese pressure differences equals the pumping head.

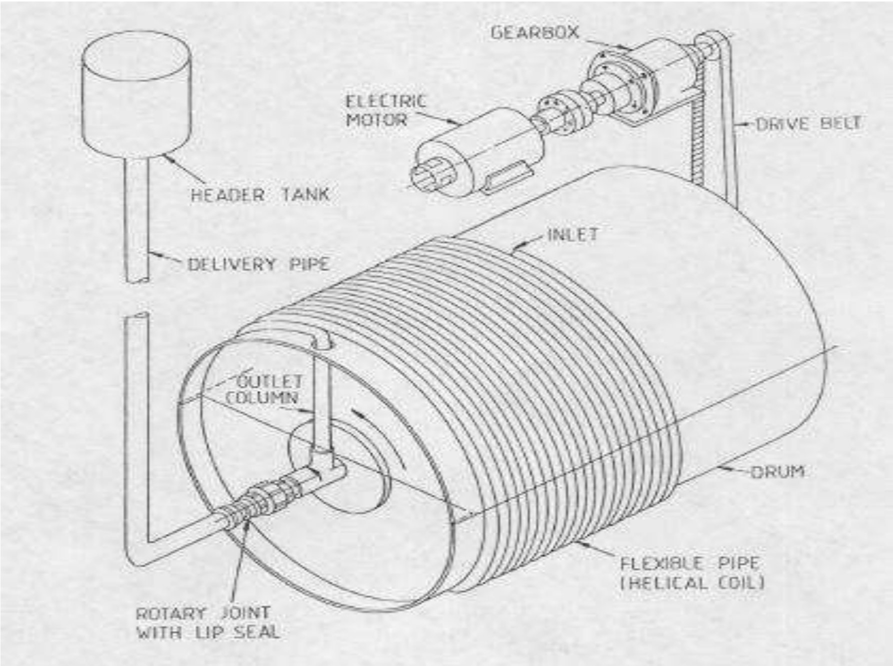


Figure 4: *The coil Pump*

2.5. Barsha Pump

A German business named aQyata created the Barsha pump.(as shown in figure 5) The pump is one of the most effective irrigation pumps used in rural areas with local water streams. The pump operates without the usage of electricity or fossil fuels. The Barsha pump transports water from a moving stream to potential agricultural regions entirely by hydropower. It combines the functions of a water wheel and a spiral pump. It is made simply and easily, has few mechanical parts, and is very simple to use.

The name barsha was given to it looking at the word "Barish" which means rain in the Hindi language. Name was set in this language as it was first tested in the South Asian region i.e. Nepal, Bhutan, Afghanistan. As the name suggests the pump requires a minimal flow speed to function and it can give an output head of 20 meters approximately. The pump has a one-time investment and setup

Cost. Later in the running, this pump has a very low running and maintenance cost as it uses no fuel but water or stream itself. It’s a pretty simple design such that even the farmers themselves can fix and maintain it.

Figure 5: Barsha Pump

2.6. Primary goal or targeted site

A little overview of the area of our target where the pump can be installed, priority all the tribal areas and sites where the water body is close and running as shown in *Figure06.*

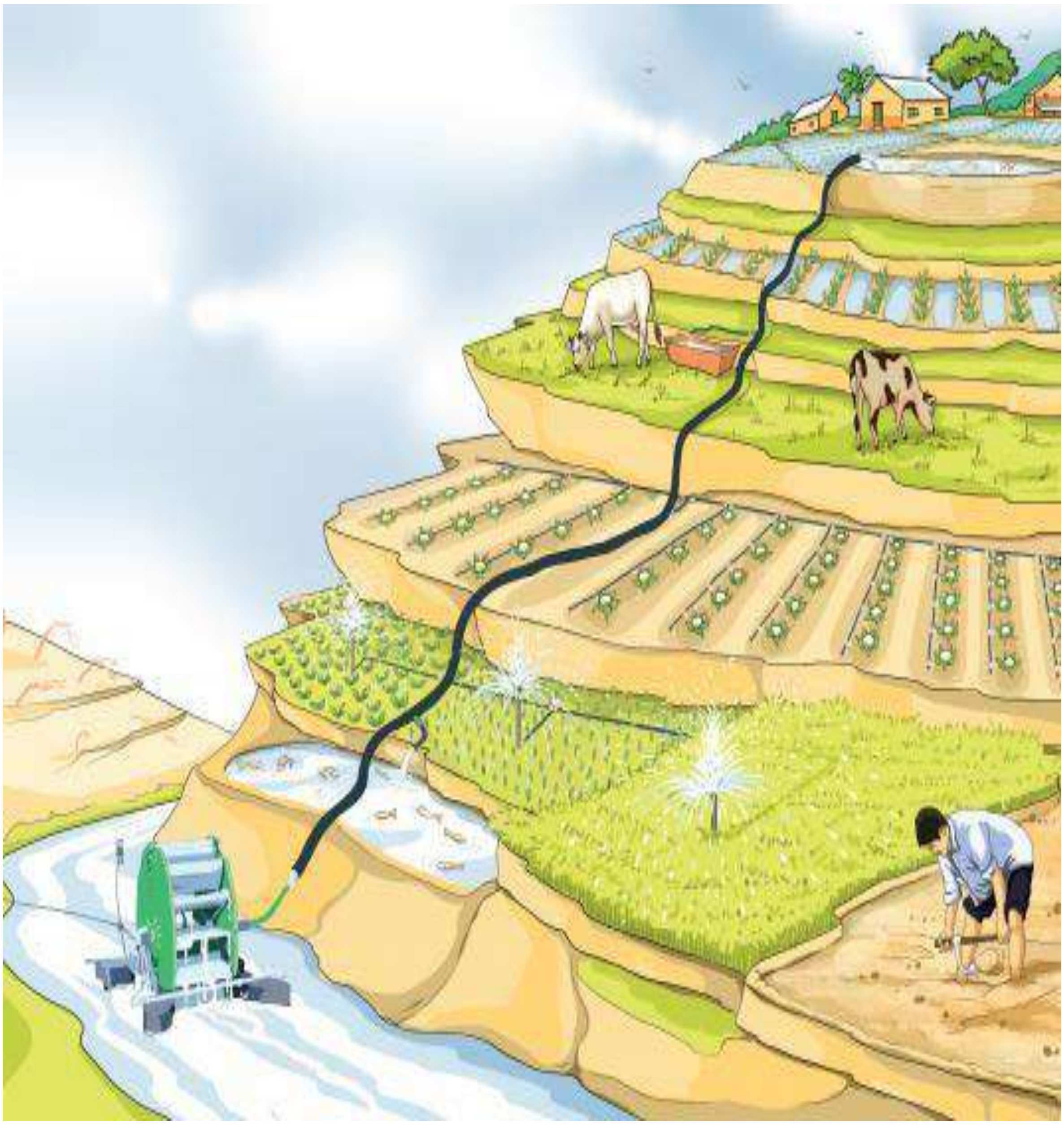


Figure06: Barsha Pump pumping water at a hill station

2.7. Project management

2.7.1. Project schedule

Various parts of the project were divided into small parts in order to complete them in time.

Task Name	Start Date	End Date	Days
Literature review	10/07/2022	25/10/2022	75
Methodology Development	06/11/2022	12/03/2023	102
Development Techniques	23/09/2022	01/01/2023	90
Fabrication	01/03/2023	30/04/2023	120
Troubleshooting	15/05/2023	25/06/2023	32
Thesis writing	23/06/2023	24/07/2023	30

Table 1: *Project Schedule1.5.2 Work breakdown structure*

2.7.2. Work breakdown Structure

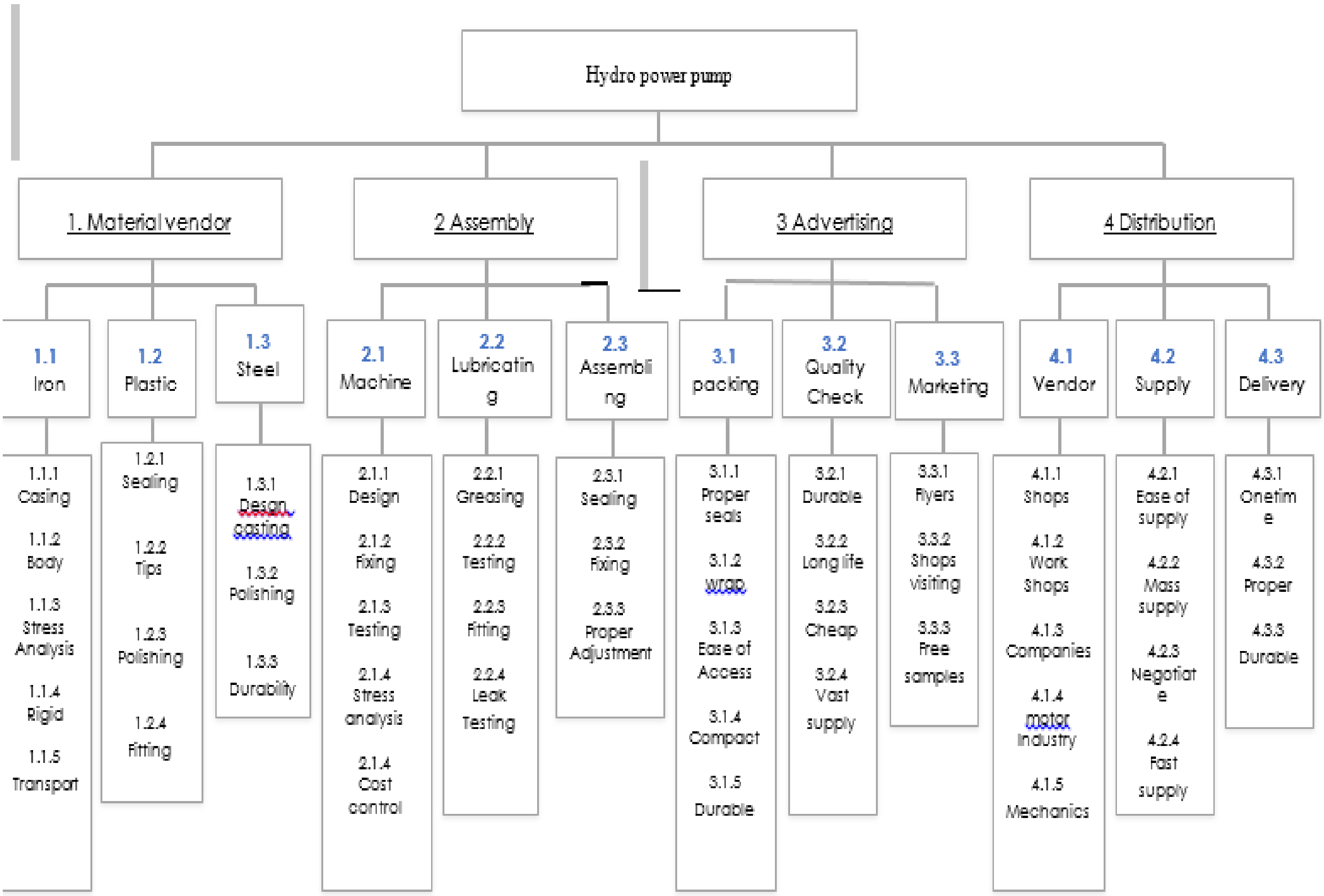


Figure 1: Work breakdown Structure

Chapter 3

Design Methodology

3.1. Basic Design Concepts

The main working principle as described earlier is basically the kinetic energy of the water, which drives the wheel. The blades on the wheel are impacted by the water i.e. the velocity of stream comes into play to drive the pedals hence rotating the wheel.

$$K.E = \frac{1}{2}mv^2$$ *Equation 1: Kinetic Energy Formula*

As the velocity increases we get more energy to drive the wheel. Hence increasing the velocity increases the force,

$$F \; \alpha \; v^2$$ *Equation 2: Force velocity Relation*

Since force is in direct relation with the torque keeping the radius of the wheel constant,

$$r = F \times r$$ *Equation 3: Torque Formula*

Where, r= radius of the wheel

As we know

$$P = \omega \mathrm{T}$$ *Equation 4: Power Formula 1*

Since r and ω are in direct relation with the K.E of water which also makes power directly proportional to torque and ω

We know that,

As,

$$P = \rho g H Q$$ Equation 5: Power Formula 2

Using equations 4 and 5

$$\omega \mathrm{T} = \rho g H Q$$

$$H = \frac{\omega \ x \ T}{\rho \ x \ g \ x \ Q}$$ Equation 6: Head Derived

Also,

$$\omega = \frac{2x\pi}{60} N$$ Equation 7: Angular Velocity

From above relations we conclude that,

As RPM increases, ω increases and therefore head increases.

As diameter and radius increase r increases and therefore head increases

now, for flow rate

$$Q = AV$$ Equation 8: Flow rate Formula

$$A = \pi r^2$$ Equation 9: Area of circle

As r increases the area of pipe increases which further increases the flow rate

$$Q = \frac{1}{H} \ (keeping\ other\ parameters\ constan$$

Now concluding,

As,

$$\mathrm{H} = \frac{\omega \ x \ T}{\rho \ x \ g \ x \ Q}$$

The following parameters can be changed to get the desired head.

For torque, we have to increase/decrease diameter of the wheel by adjusting no. of spirals of pipe

For rotational velocity, we have to adjust RPM by water speed of flowing water channel.

The flow rate of output also plays a vital role in maintaining head. If we keep other parameters constant the flow rate decreases and head increases.

Using above formulas we have assumed the values and solved it considering it numerical problem

3.1.1 Calculations for Desired Head

Available Data

$$Vstream = 0.5\frac{m}{s}$$

$$r_{wheel} = 0.795\, m$$

$$Q_{output} = 0.0005\, m^3/s$$

$$\rho = 1000\frac{kg}{m^3}$$

$$g = 9.81\, m/s^2$$

Calculations

$$RPM = N = \frac{v_{stream} \times 60}{2 \times \pi \times r} = \frac{0.5 \times 60}{2 \times \pi \times 0.795} = 6$$

Now concluding,

$$F = \frac{1}{2} x\ mx\ v_{stream}^2 = \frac{1}{2}\ x\ (300)\ x\ 0.5^2 = 37.5$$

$$r = F \times r_{wheel}$$

$$=37.5\times0.795=29.8Nm$$

$$Head=\ \frac{r\times2\times\pi\times N}{\rho\times g\times60\times Q}=\frac{29.8\times2\times\pi\times6}{1000\times9.8\times60\times0.0005}=3.822\ \ \mathrm{m}$$

3.2 Components

Depending on the above formulas and equation we have deduced to a design conclusion.

1. Spiral pipes
2. Axle
3. Bearings
4. Peddles
5. Frame
6. Floating body/fixing panels (variable)

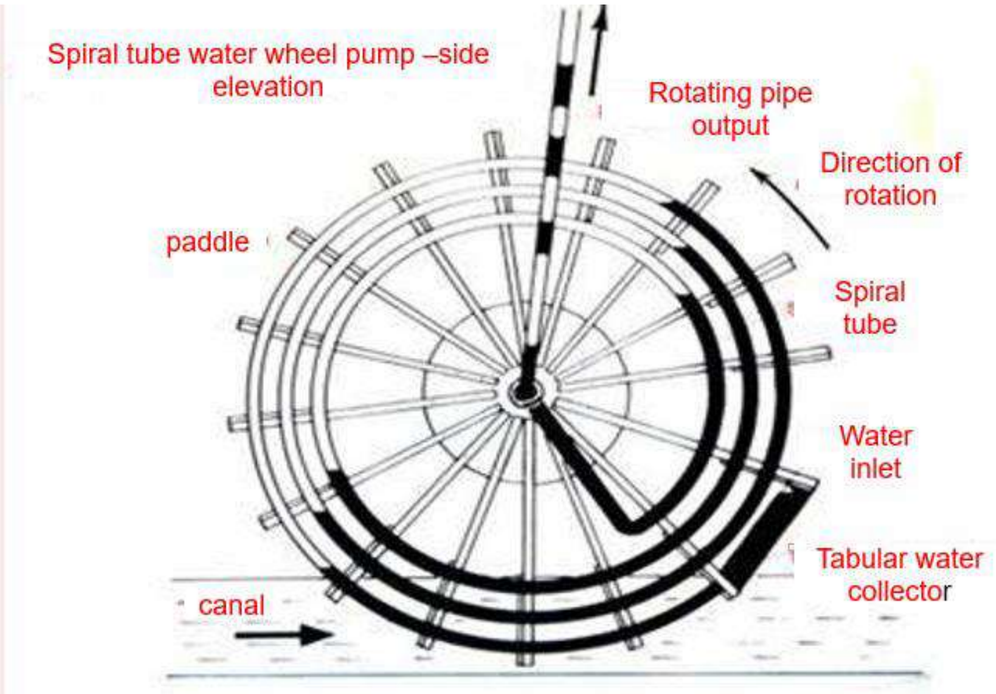


Figure 7: Pump Components

3.3 CAD Model

Before moving to fabrication we have used solid works software for simulation and cad model designing

Figure8:CADModel(side view)

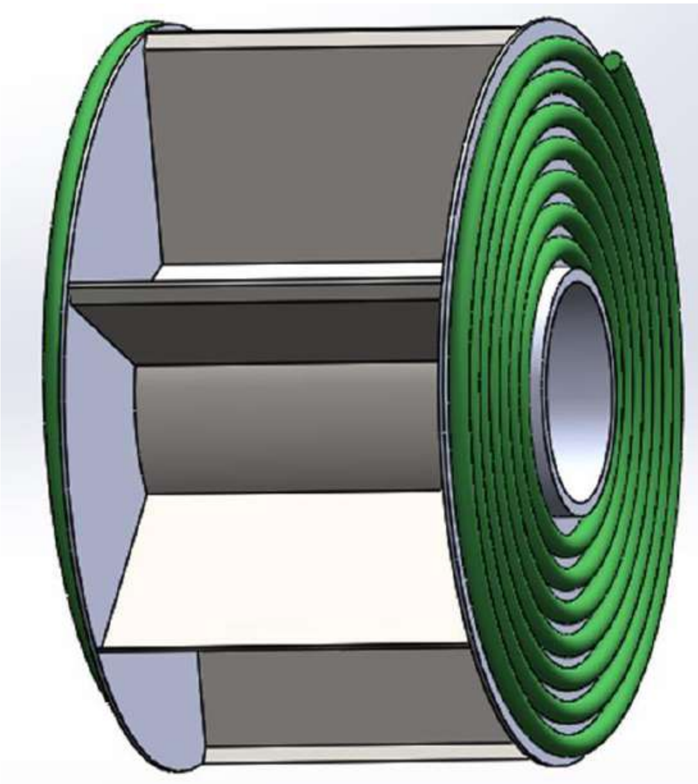


Figure 9: CAD Model (isometric)

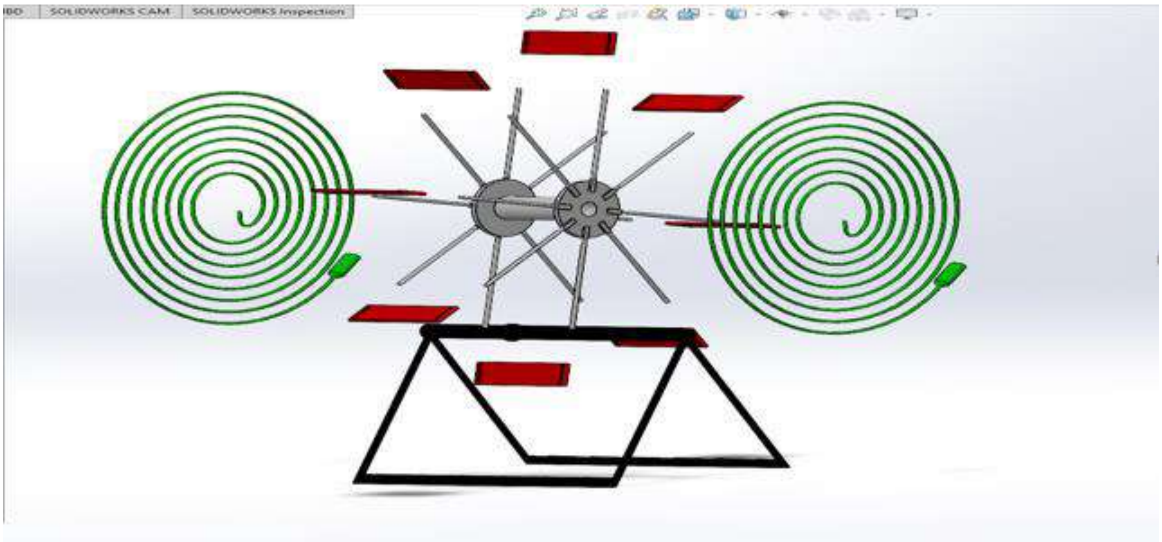


Figure 10: CAD Model (exploded view)

3.4. Prototype

Before building the actual pump, a prototype shown in *Figure 11* was built to ensure that our concepts could be implemented. To start looking for the ideal design, we used a hit-and-miss approach. The revolving disc surfaces of the real pump are designed to have spirals on both sides. We initially built the testing prototype with a spiral on one side. We made the decision to test our prototype while changing a number of factors. For this, we utilized the fluid mechanics lab at the HITEC University's Mechanical Engineering Department. We employed hydraulic benches and basic tools and instruments for the majority of the tests...

Figure 11: Prototype

3.4.1 Machines and apparatus used

1. Hydraulic bench
2. Tachometer
3. Flow rate measuring device
4. Venire caliper
5. Rulers
6. Stopwatch
7. Glue gun and cable ties
8. Nuts, screws etc.

3.4.2 Components of the prototype

1. Plastic can
2. Rubber pipes
3. Inlet valves
4. Axle rod
5. Plastic fiber rotating coil (disc like on either end)
6. Metal bearings
7. Iron frame
8. Movable metal handle

3.4.3. Construction of the prototype

To create a water bed on which the wheel could move, shown in *Figure 12* a plastic can was sliced. To make it stable for rotation, thin shafts were used to attach a plastic wheel. To enable rotation, a shaft was inserted from one side of the wheel through the other. (as shown in figure 12 & 13)To facilitate the rotational action, bearings were installed. The plastic wheel was attached with glue using thin-diameter rubber pipes.

Figure 12: Construction

Figure 13: Construction

3.4.4 Specifications of the prototype

Perimeter	Value
Diameter of the rotating wheel	0.27 m
Total length of prototype	0.39 m
Total height of prototype	0.34 m
Total width of prototype	0.27 m
Length of water container	0.39 m
Height of water container	0.11 m
Width of water container	0.27

***Table 2**: Measurements of the prototype*

Figure 14: Spiral Pipes

Figure 15: Prototype (3D view)

Figure 16: Prototype (Top view)

3.5 Scheduled Tests

After some tests on the prototype we have left with some test that will be done on the software and we have used Microsoft excel

1. Varying diameter of the spirals
2. Varying diameter of the rotating wheel
3. RPM of the rotating wheel
4. No. of pedals

3.5.1. Test1: Varying diameter of the spirals

For this test RPM of the rotating wheel was kept constant and the length of pipes was chosen to cover the face of the disc on the wheel. No pedals were attached as this test was just to test spiral with the better outflow. A plastic pipe was used to make the spirals in such a way that the pipes covers all the surface area of the wheel.

	Spiral A	**Spiral B**
Length	4.26 m	3.01 m
Diameter	0.006 m	0.008 m
No. of coils	6	4
RPM	111	111

***Table 3**: Test 1 parameters*

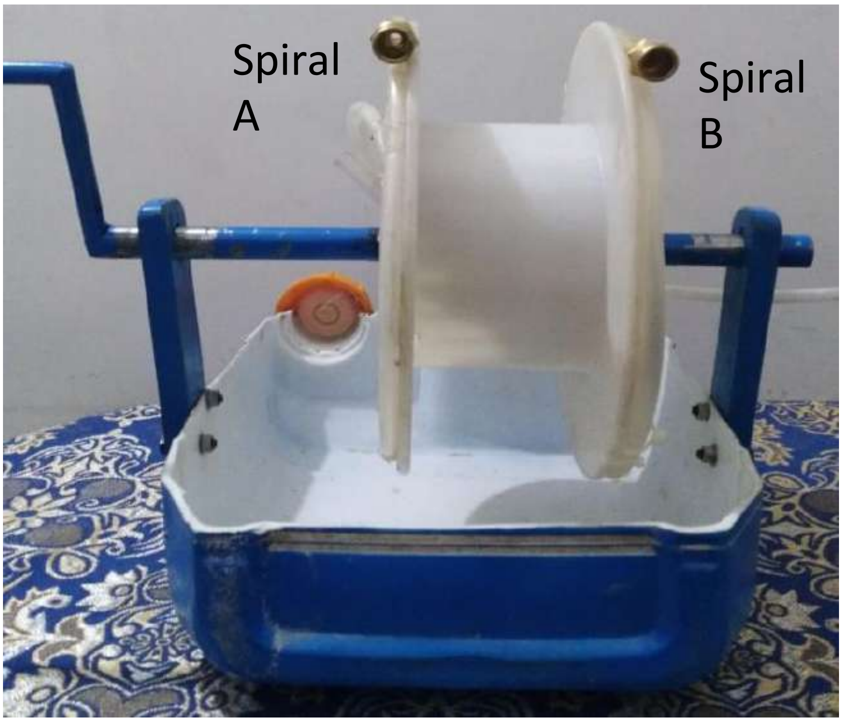


***Figure 17**: Prototype (side view)*

Water was filled inside the container and the wheel was rotated to gather the amount of water at the output.

Rpm = 111

Diameter of bottle = 66 mm = 0.066 m

t = 60 sec

For spiral A

Height of water collected = 30 mm = 0.03 m

$$Volume\ of\ water\ collected = \pi \left(\frac{d}{2}\right)^2 h = 1.026 \times 10^{-4}\ m^3$$

$$Q = \left(\frac{volume}{time}\right) = \left(\frac{1.026 \times 10^{-4}}{60}\right) = 1.71 \times 10^{-6}\ m^3/sec$$

$$Q = 1.70 \times 10^{-6}\ l/sec$$

For spiral B

Height of water collected = 40 mm = 0.04 m

$$Volume\ of\ water\ collected = \pi \left(\frac{d}{2}\right)^2 h = 1.368 \times 10^{-4}\ m^3$$

$$Q = \left(\frac{volume}{time}\right) = \left(\frac{1.368 \times 10^{-4}}{60}\right) = 2.28 \times 10^{-6}\ m^3/sec$$

$$Q = 2.28 \times 10^{-3}\ l/sec$$

Figure 18: Testing

The remaining exams were meant to be conducted in a similar setting, but we simulated them using Microsoft Excel.

3.6 Factors affecting the Design

Following are some factors that when changed might affect the overall head at the output of the pump:-

1. Diameter of the wheel
2. Diameter of the spirals
3. RPM of the rotating wheel
4. Velocity of the water stream
5. Flow rate of water

3.5.4 Graphs on several parameters

RPM vs. Head

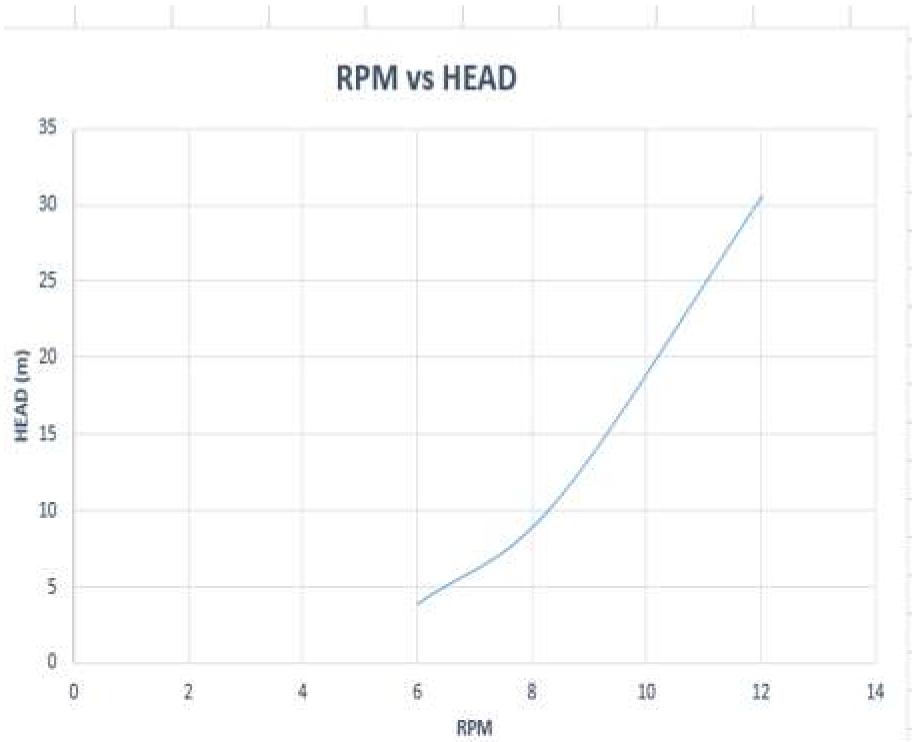


Figure 19: RPM vs. Head Grap

RPM vs. Flow rate

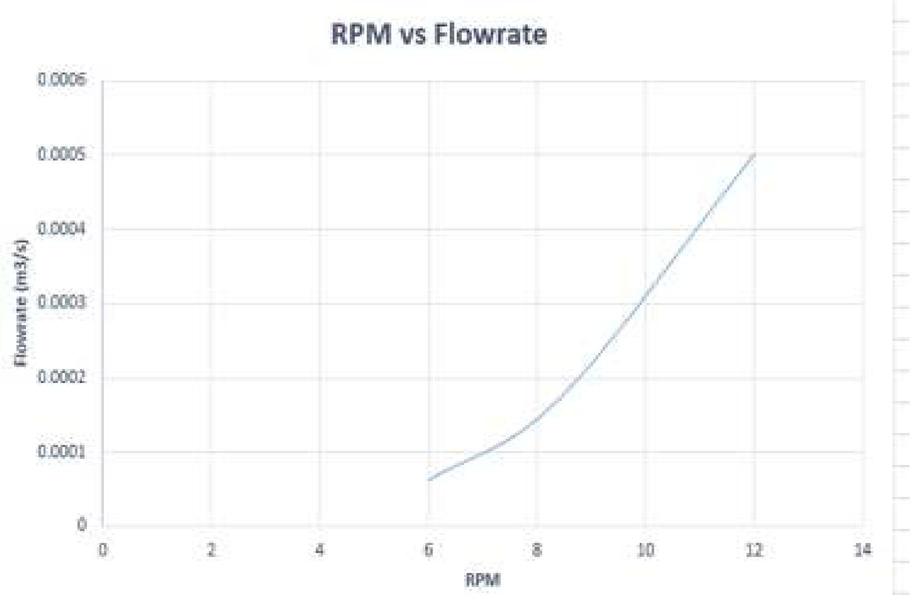


Figure 20: RPM vs. Flow rate Graph

Radius vs. Flow rate

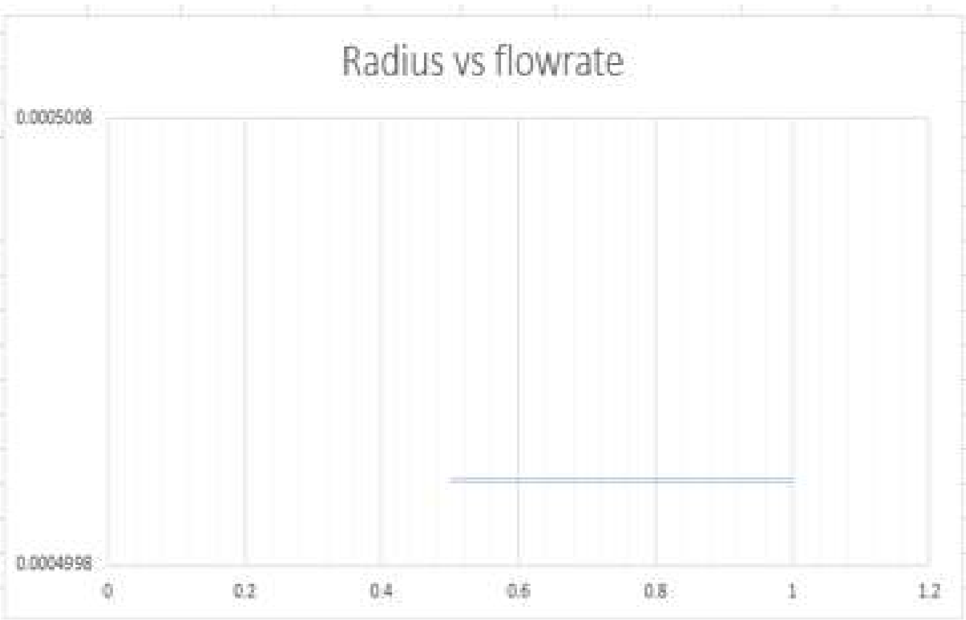


Figure 21: Radius vs. Flow rate Graph

Radius vs. Head

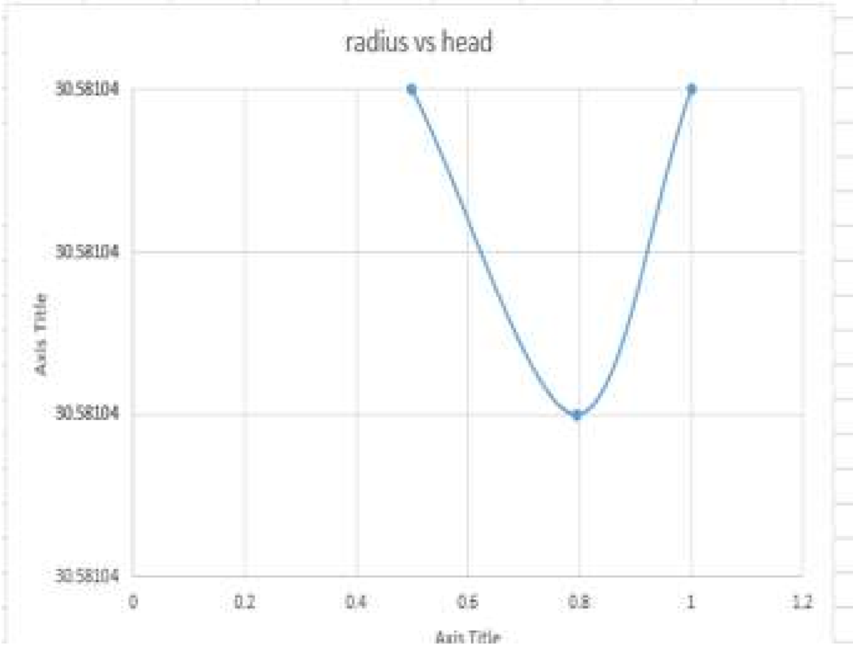


Figure 22: Radius vs. Head Graph

Flow rate vs. Head

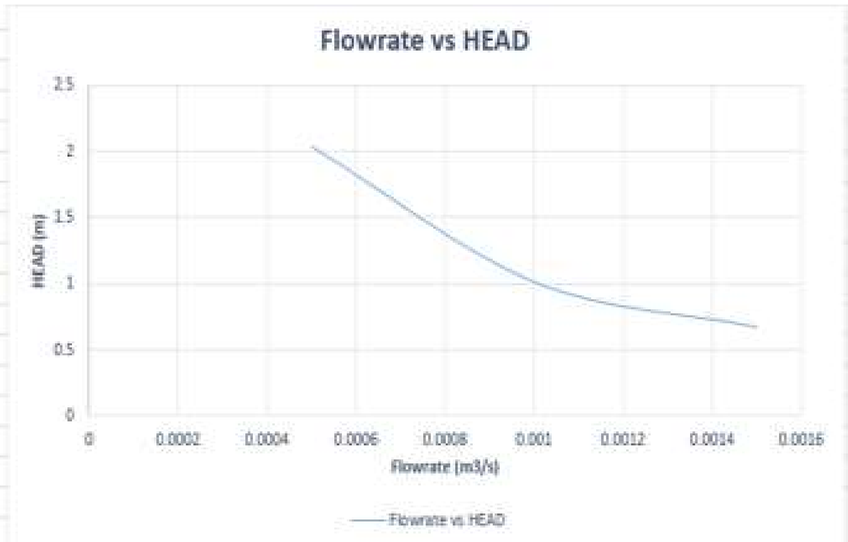


Figure 23: Flow rate vs. Head Graph

RPM vs. Head

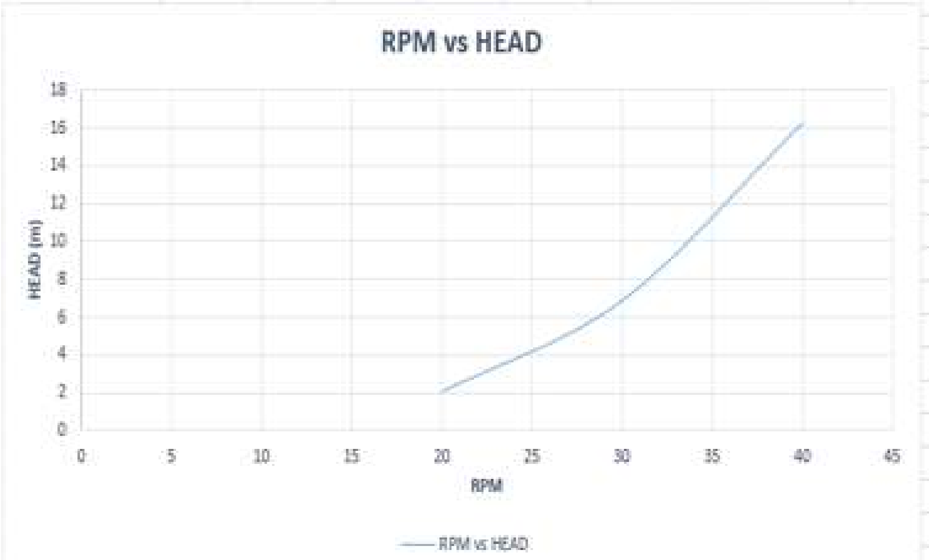


Figure 24: RPM vs. Head Graph

Diameter vs. Head

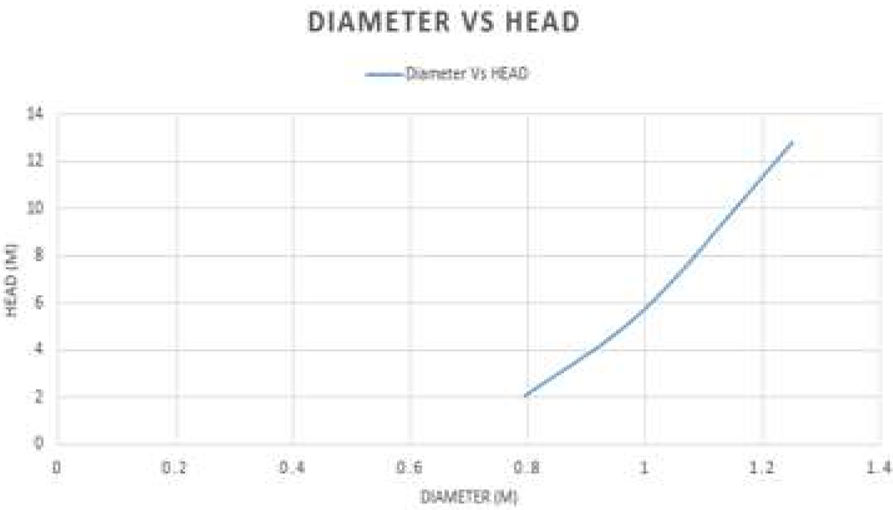


Figure 25: Diameter vs. Head Graph

3.7. Analysis

The analysis that follows was determined after the analysis and conducting test of modifying factors on MS Excel. The following observations were made when our software was running for the designing factors:-

1. Tests showed that the bigger pipe diameter gives a better flow rate
2. Increased RPM increases the overall head
3. Increased RPM increases the flow rate at the output
4. Increase in internal pipe flow rate decreases the head
5. Increase in wheel diameter has a minimal effect on the output flow
6. Diameter of the wheel has a minimal effect on flow rate
7. Diameter of the when has almost negligible effect on the head

Chapter 4

Fabrication

After all the conclusions made from the above simulations and experiment we have deduced the optimal values for the project

4.1 Components

1. Peddles (Trays)
2. Frame (Angle iron)
3. Floating body/fixing panels (variable)
4. Spiral pipes
5. Axle
6. Bearings

4.2 Specifications

Parameters	Measurement
Diameter of wheel	3ft x 2
Diameter of floats	1ft x 2
Length of floats	3ft x 2
Diameter of spirals	1 in
Length of paddles	1ft x 6

Table 5: Specifications

4.3 Material Suggested

Component	Material
Rotating wheel	Cradling sheet
Paddles	Stainless steel / Mild steel (powder coated)
Fixing stand	Stainless steel
Spirals	UPVC
Floaters	PVC
Bearings	Stainless steel

Table 6: Material Suggested

4.4 Procedure

1. Cutting a comb like structure from metal sheets
2. Using PVC pipes for the structure support
3. Fixation of UPVC pipes on the wheels
4. Fixation of two wheels together using an axel shaft
5. Bearings are attached for movement of wheel
6. Addition of paddles using rivets, cable ties etc.
7. Fixation of floats under the frame usually empty cans

4.5 Processes Involved

1. Cutting
2. Welding
3. Drilling
4. Material removal
5. Attachment of bearings
6. Hammering
7. Riveting
8. Plastic welding

4.6 Helpful machinery

1. Lathe machine
2. PVC pipe cutting machine
3. Riveting gun
4. Pipe swirling machine

4.7. Final product

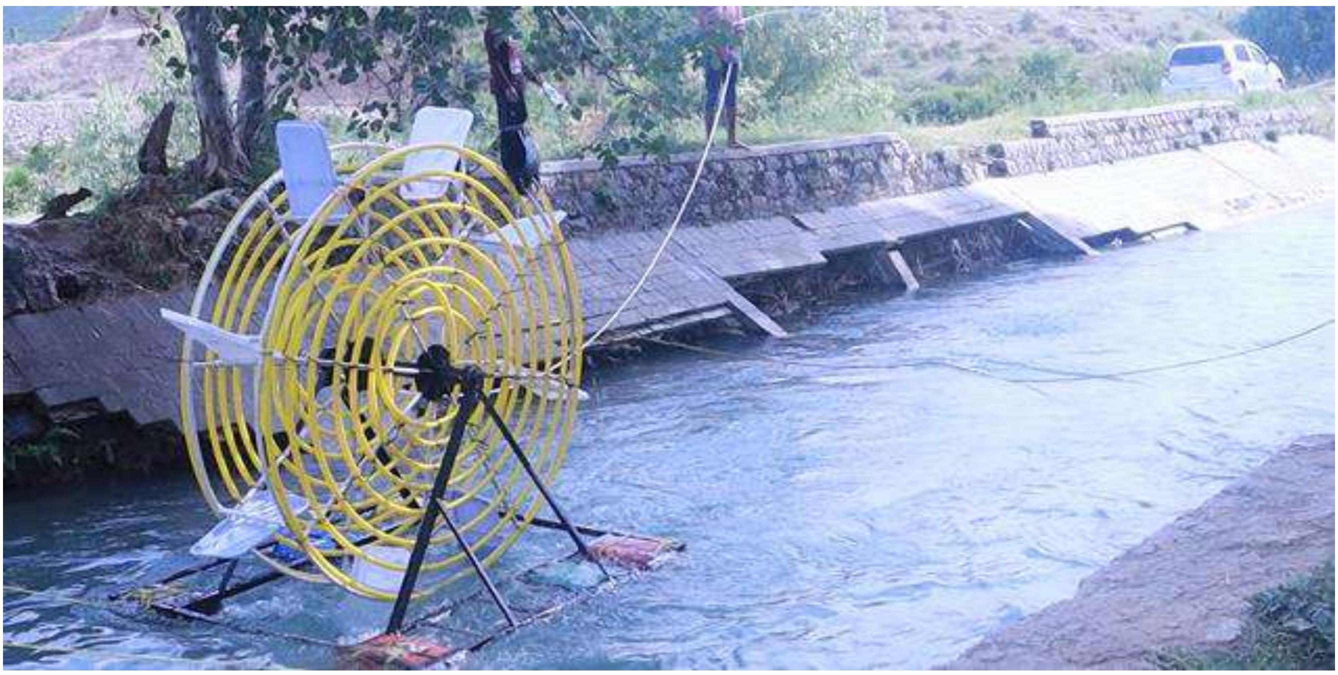
4.8 Final model (1st Attempt)

Conclusion:

We have used plastic can as fins and attached them at some angle , but these fins or blade were not enough to make the wheel rotate so the 1st attempt generate a HEAD o 13 feet only

4.9 Final model (2nd Attempt)

In second attempt we have used plastic trays as fins or blade and the HEAD turns out to be 80 feets approx..



Conclusion and Results

Variables	Theoretical	1 st attempt	2nd attempt
HEAD	51.9 feet	13 feet (approx.)	26 feet (approx.)
FLOWRATE	0.00074 m^3/s	1.5litre / 30sec = 0.00005 m^3/s	1.5litre / 18sec = 0.000083 m^3/s
RPM	7.8 rpm	3.5	6
VELOCITY OF WATER	0.65 m/s	0.5 m/s	0.5 m/s
NO. OF Fins	8	8 (curved)	8 (straight)
SCOOP OPENING	2	Funnels	Half cut cans
Diameter of wheel	0.795 m	0.795 m	0.795 m
Diameter of spiral	¾ inch	¾ inch	¾ inch

Chapter 5

Conclusion and Results

5.1 Conclusion

The Hydro Power Spiral Pump project has been an ambitious and innovative endeavor that aimed to harness the potential of hydrokinetic energy to address water pumping challenges in rural and off-grid regions. Throughout the project's development, we have successfully designed, constructed, and tested a novel spiral pump system drive by hydro power, showcasing its viability as a sustainable and environmentally friendly water pumping solution. Practically any Pakistani water stream is suitable for the project. The information and the results of our calculations indicate that this project will probably work well enough to provide irrigation water.

5.2 Future Prospects

The hydro power spiral pump have promising potential in harnessing water energy for various applications. As we look into the future, several prospects and developments can be anticipated for this technology:

- Advancements in Efficiency
- Integration with Renewable Energy Systems
- Micro and Decentralized Applications
- Water Supply and Irrigation
- Aquaculture and Eco-Friendly Farming
- Research and Investment
- Environmental Impact
- Global Applications:

In future anyone with an interest in farming or irrigation can study and make the design even simpler and more successful. Cost cutting parameters can also be over looked as some times availability of a certain material is limited. Morework that can be done is to find another equation that relates all the factors affecting the overall head output.

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