Design and Fabrication of Water Car using Experimental and FEA Technique

Bilal Mapkar, Abu Talib, Aaqib Shariff, Abdullah Marwan, Mohammed Sajid Khan, Yassar Qureshi, Jatin Mendiratta, Sampath Suranjan, Rajiv Selvam, Chitrai Pon Selvan

Abstract: ***This project deals with the design and fabrication of a water powered car. The sustainable energy system plays a very important role nowadays because of various limitations in the exhaustible fuels and the pollution. The proposed car incorporates a water turbine which is rotated by the high pressure developed by the powerful pump and specially designed nozzle. The work produced by the turbine is stored in the batteries and the same work is used to run the overall system. Maximum rotation of the turbine power and efficiency is calculated by both theoretical and experimentation. Both the results and compared and validated. The system is modeled in CREO software and tested in Ansys Workbench to obtain structural stability. The system is fabricated using Aluminum for the cups of the turbine and Mild Steel for the chassis.***

Keywords: Sustainable Energy, Water Turbine, Power, Mechanical Efficiency & Velocity.

INTRODUCTION:

Practical improvement is the sorting out rule for supportability which incorporates four interconnected areas: biology, financial matters, governmental issues culture and furthermore involves the utilization of vitality that is expended at unimportant rates contrasted with its supply alongside sensible security and natural impacts. Reasonable vitality can likewise be vitality framework that helps the requirements of the present without bargaining the capacity of upcoming ages to address their issues. As opposed to prevalent thinking, sustainable power source does not compare to supportable vitality. Renewable vitality is normally recharged on a human timescale not at all like the previous. Maintainability science is the investigation of feasible improvement and ecological science. The contemporary urban life demands a unique set of requirements for day to day transportation. These demands are satisfied by the production and use of a large number of automobiles in today's world which in turn creates excessive amounts of pollution of different kinds. The carbon emissions from these vehicles deplete the density of the ozone layer exposing mankind to harmful ultraviolet radiations apart from causing phenomenon such as the greenhouse effect and global warming. This increase in pollution has led to demand of a means of transportation that is cheap and eco-friendly. Earlier, attempts were made to use water as a source of energy to run cars by separating hydrogen and oxygen atoms in the water and use the former to charge batteries which is in turn is used by the engine instead of petrol or diesel as a form of energy.

Through this project, attempts have been made to use the energy generated by water to run this concept water car. Water, a natural resource, has been chosen as it is readily available and is an eco-friendly option. It is not burned implying that there is no carbon emission. The main objective of this project is to provide a breakthrough in the direction of building a healthy environment and sustainable use of natural resources. The 'Water Car' shall work on the principle of using hydro energy to rotate the in-built Pelton turbine which in turn would create mechanical energy which ultimately will be used for running the car. An impulsive force is induced due to the high-speed water jet hitting against the buckets of the Pelton wheel. This force in turns rotates the turbine and the rotating shaft runs the differential of the car and produces rotational movement. Therefore, Pelton turbine results in the transformation of the kinetic energy of water jet to rotational energy of the turbine.

PROBLEM DEFINITION:

To design a sustainable energy system which can eliminate the use of fuel and drives the car move totally with the pressure of water with the help of Pelton wheel.

RELATED STUDY:

This chapter gives an elaborate discussion of the various projects, papers & relevant research/ industry articles that have been referred to, to aid and enhance the project. This section also defines the problem for which a literary survey was conducted that helped in developing ideas to reach the goals of this project. This project is a new concept in the field of water filtration because from the project, the water can be filtered at the same time as when it is transported from one place to another that results in saving time and effort. This project is manufactured using simple equipment and only requires the need of one-man power [1]. The processed stream designs show great concurrence with the stream representations amid the first and last phases of the pail cycle. Results with respect to the slice fly are more hard

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Bilal Mapkar, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Abu Talib, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Aaqib Shariff, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Abdullah Marwan, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Mohammed Sajid Khan, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Yassar Qureshi, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Jatin Mendiratta, Undergrduate students, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Sampath Suranjan, Assistant Professors, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Rajiv Selvam, Assistant Professors, Mechanical Engineering, Manipal Academy of Higher Education Dubai
Chitrai Pon Selvan, Head of School, School of Science and Engineering, Curtin University Dubai, UAE

to survey since representations of this segment of the cycle are not yet accessible. An examination of the power move in the five pail locales demonstrates that the external areas, amongst D1 and the pattern, contribute the most to the basin control. These regions collaborate ahead of schedule with the stream and, therefore, get water particles with a high energy [2]. In the investigation, there is a need to perceive the framework fly sprinter packaging. The proficiency of the turbine can be resolved from the turbine trademark. Quantification of the measurement of the fly is done utilizing an Advanced Picture Handling Framework (Plunge). A decent inexact estimation of the productivity of the sprinter can be assessed from the geometry of the pail and the speed triangles at the channel and the outlet [4]. Pedal fueled water pumping and sanitization lessens the rising vitality costs. Pedal controlled water pumping and cleaning is plan as a compact one which can be utilized for water system in different spots. The trial examination was executed and execution of the pedal controlled water pumping and refinement had completed at various rpm. So this paper suggests that, the pedal fueled water pumping and purging will give a lot of release and head [5].The resulted experimental vehicle is a concept that tries to use the idea of using electrical surplus energy generated from solar and wind power, transform and stalled in shape of nitrogen compressed gas. Only in this circumstance it is feasible and cost efficient for common urban, non-polluting and people transportation [6]. Hydropower is a clean source of energy. It does not consume but only uses the water, and after use the water is accessible for other purposes (although on a lower horizontal level). Cross flow water turbine is used in micro hydro power plant in case of low head and stream rate. This paper gives a complete study of cross flow turbine and necessary fulfill condition for using in micro hydro power plant[7]. The outline was centered on every one of the procedures of origination, innovation, representation, computation, refinement and determination of points of interest that decide the type of the framework. The outline has gone under power examination with the goal that its execution measure won't flop in any sense. The principle physical parameters of the plan are resolved through the proper figuring and functional observations with sensible suspicions [8]. The pneumatic-mixture vehicle is one of the fortunes to car industry. It guarantees a superior blend of various power sources alongside commitment to the field of green innovation. The air-cross breeds are anything but difficult to produce and can be effortlessly determined with no carbon impressions. Along these lines, for a superior tomorrow, pneumatic-cross breed has its part. In this manner, for green innovation, pneumatic-half breed is a help. This accomplishment is an amazing achievement in fight to make greener and less expensive motoring. The outcome is new minimal effort pneumatic-half and half which altogether cuts discharge of carbon-dioxide [9]. The undertaking is to ponder the new pneumatic half and half idea and its distinctive methods of motor activity. The goal was to altogether explore the distinctive parameters influencing the pneumatic half and half motor execution and to inspect the capability of lessening in fuel utilization for a pneumatic crossover vehicle [9].

METHODOLOGY:

Before beginning the design, motivated to use chassis that would provide excellent strength but at a very low weight. In other words, an excellent strength to weight relation.

MATERIALS AND METHODS:

Requirement to design and fabricate the model of the concept was as follows**,** Able to maintain high strength to weight ratio**,** Disperse vibration well**,** Hold a good stiffness rating**,** Easy to machine**,** Cheap and affordable**,** Shouldn't be extremely brittle, The chassis of the vehicle must be capable of holding a weight of a normal person (80kg),Weight of the chassis was between 65-75 kg, Enough space on the vehicle to install all the procured parts.**,** Steering mechanism and the gear system were well working. In this project, the methodology is to design a sustainable energy system that eliminates the use of fuel. Water is used as it is readily available for everyone. It is not burned therefore, there is no carbon emission and as a result, it is safe for the environment. CREO is used for modeling & ANSYS work bench for analysis. Parts are assembled by using processes like – drilling, welding, bending etc. The system was tested and inspected by a trial run and modifications were done as required. The work done by the team was systematically documented in a report upon completion.

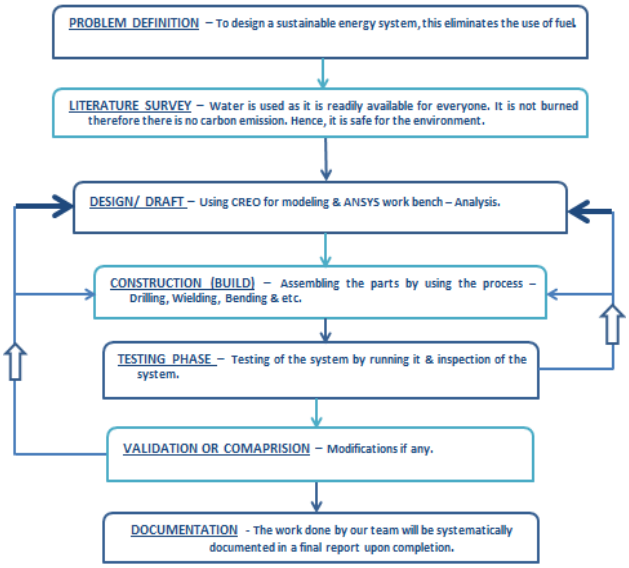


Figure1- Methodology

DESIGN AND CONSTRUCTION:

Creo Elements is a software which uses 3D computer aided design to portray various minute details of any particular mechanical part. This software was used to model various parts of the concept car such as the water tank, the pelton wheel and structure of the turbine including its blades. While considering the type of chassis required, there were a plethora of ideas to choose from and begun with the

most basic requirements. The shaft carrying the Pelton wheel should have enough strength that it is able to carry the load, which makes the design safe to use. Analysis was done on the shaft to find the stress and strain applied on the shaft by the load of Pelton and bearings. Water Tank design is also safe, as it will be carrying 25 liters of water

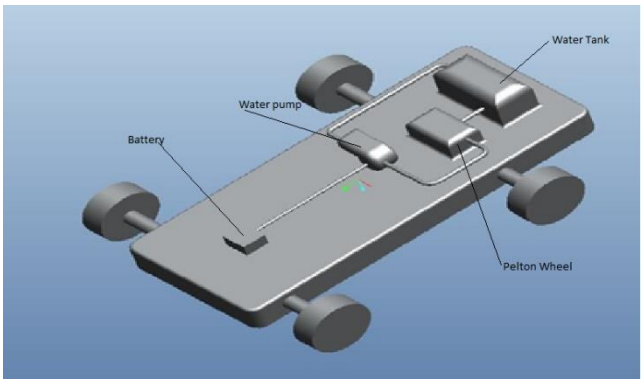


Figure 2- Initial (Idea) model of the setup

Selection of Parts with its specifications:

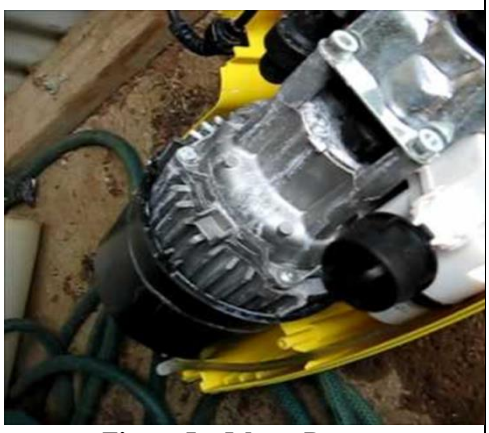
PARTS	SPECIFICATIONS
 **Figure 3 – Pelton Wheel**	Material – Aluminum Diameter – 20 cm Blade length – 10 cm No. of Blades – 11
 **Figure 4 - Reservoir**	Length – 29 cm Thickness – 22 cm Inlet Valve – 1.5 cm Outlet Valve – 0.5 cm
 **Figure 5 – Water Pump**	Voltage - 220-240 V Frequency - 50-60 Hz Weight without accessories - 2.5kg Pressure – 140 bar

Figure 6: Initial stage of car

Figure 7: Final Stage of car

CONSTRUCTION:

The car will be designed in such a way that the high-power battery shall supply electrical power to water pump connected to a high-pressure nozzle that will further increase the pressure of water hitting the blades of the turbine due to which the differential will lead to rotation of the wheels resulting in displacement of the car from its

position. The above-mentioned nozzles shall direct, high-speed streams that are forced against a rotary series of spoon-shaped buckets, otherwise known as impulse blades. These blades are mounted on the rim of a drive wheel around its circumference (i.e. runner). As the water jet exerts itself upon the impulse blade, it causes the direction of velocity of water to change and follows the contours of the blade, the direction of water velocity is changed to follow the contours of the bucket. Water impulse energy exerts a force which creates torque within the bucket-and-wheel system that causes the wheel to spin; the water stream turns into the opposite direction and exits at the outer sides through the outer side of the bucket at a lower velocity. This process causes water jet's momentum to be transferred to the wheel and in turn to a turbine. Thus, "impulse" energy does work on the turbine. To yield maximum power and efficiency, the wheel and turbine system is designed in way that the velocity of water jet velocity is twice as much as that of the rotating buckets. A very small percentage of the water jet's original kinetic energy remains in the water, that causes the bucket to be emptied at the same rate it is filled, and thereby un interrupted high pressure flow to continue without waste of energy. Generally, the buckets are mounted adjacent to each other that causes then water to split in two equal streams on the wheel, which splits the water jet into two equal streams. This helps in maintaining the balance of the side load forces of the wheel and ensures efficient transfer of momentum of the water jet to the turbine wheel.

EXPERIMENTATION:

A hand held water pump was used to supply a continuous flow of water with a pressure of 80 bars upon the blades of the turbine which was attached to the chassis of the concept car. The experiment was successful and it was inferred that the conversion of energy was taking place as ensured by the rotation of the wheels. However, this experiment was carried out without any load or resistance of the vehicle. When the load was applied on the differential enough torque wasn't produced to move the vehicle. This was because the turbine was directly connected to the differential through a chain drive due to enough inertia was not being produced. From the observation of the ***first experiment***, it was clear that we needed to install am engaging and disengaging mechanism to cause displacement of the wheels with on the ground. In this case, the turbine was connected to the differential with an engaging and disengaging medium (i.e. FNR Gearbox) in order to be able to produce more inertia with the same pressure. At the end of this experiment, it was inferred that the car was moving successfully on the surface but the movement was slow and the car would stop abruptly with the application of even a small load. This experiment proved to be successful because the issue of the last experiment was resolved and it paved way for more detailed research. Upon further research, we came to the conclusion that the turbine was not moving continuously with the applied pressure so in order to establish continuous periodic rotations; we added a fly wheel on either side of the pelton wheel. Upon mechanical execution of this idea, it was observed that the car was moving on the surface over considerably long distances but with very low velocity (7-8 km/h). Therefore, our team had to work towards attaining higher velocity and smoothness over further experimentation. ***Upon further research***, we came to the conclusion that the turbine was not moving continuously with the applied pressure so in order to establish continuous periodic rotations; we added a fly wheel on either side of the pelton wheel. Upon mechanical execution of this idea, it was observed that the car was moving on the surface over considerably long distances but with very low velocity (7-8 km/h). Therefore, our team had to work towards attaining higher velocity and smoothness over further experimentation. In order to ***attain higher velocity***, we had to work towards reducing the overall weight of the car by using lighter parts in order to increase the efficiency of the system which had been tested earlier. Initially, the car weighed 120 kg and we bought it down to 70 kg. This was done by changing the chassis of the car along with installation of the same mechanical system. Also, we invested in a water pump of pressure 100 bars and then 140 bars, the pressure of which is substantially higher than the one used in the beginning which was 80 bars. Therefore, at the end of this experiment, the velocity of the car came up to (11-12 km/h at 1000 Rpm). Apart from this, our team concentrated in improving the aesthetics of the car.

SHAFT DESIGN USING FEA:

ANSYS Analysis was done on the shaft, to find out the total deformation, equivalent elastic strain, normal stress and equivalent stress.

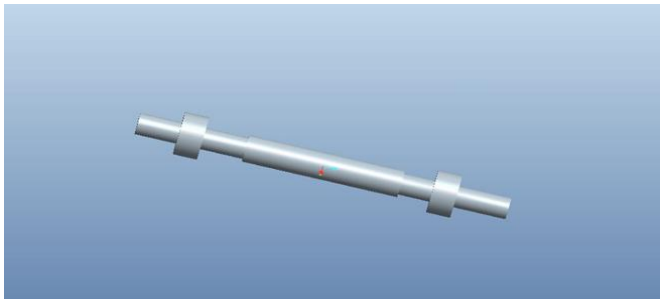


Figure 8 – Creo model of the shaft

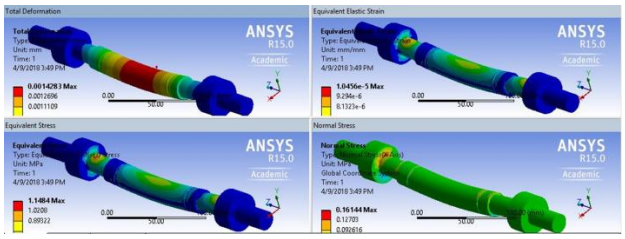


Figure 9 – ANSYS Analysis of the shaft

RESULTS & DISCUSSIONS:

FEA analysis indicates that the stresses developed in the shaft are less than the yield stress. There the FOS is greater than 1, thus the design is safe

Table 1- Results obtained by analysis of shaft

Total Deformation (mm) • **0.0014 (max)** • **0 (min)**	**Equivalent Elastic Strain** • **1.0456e - 5 (max)** • **1.0554e – 13 (min)**
Equivalent Stress (MPa) • **1.1484 (max)** • **8.345e – 9 (min)**	**Normal Stress (MPa)** • **0.16144 (max)** • **-0.14828 (min)**

EQUATIONS USED:

Case 1 – Input power of the pelton wheel:

The Force of the turbine $\mathbf{F_T = m \times a}$

where 'm' is the mass and 'a' is the acceleration of the turbine.

The Torque (T) of the vehicle $\mathbf{T = F_T \times R}$

where R is the radius of pelton wheel.

The acceleration of the turbine **a = velocity (v) / time (t)**

The power of the turbine which is the input power $\mathbf{P = 2\pi NT}$

where 'T' is the torque and 'N' is the speed of the pelton wheel

Case 2 – Output power of the car wheel:

The acceleration of the car wheel **a = v/t**

Torque (T) of the vehicle $\mathbf{T = F_T \times R}$

where R is the radius of the car wheel.

The Force of the car wheel is equal to $\mathbf{F_T = m \times a}$

where 'm' is the mass and 'a' is the acceleration of the car wheel.

The power of the car wheel which is the output power $P = 2\pi NT$

where 'T' is the torque and 'N' is the speed of the car wheel.

The mechanical efficiency can be determined by the ratio of output to the input power.

Table 2 - Results obtained by the experiment

Model	Speed of rotation (N)	Acceleration (m/s^2)	Torque (N-m)	Power (W)	Efficiency (%)
Pelton Wheel (Final Model)	1000	0.26	0.15	Input power=15.98	20.51
Wheel (Four)	110	0.055	0.072	Output power= 3.28	

As observed by the calculation, the efficiency produced is 20.51%. There are lot of friction and mechanical losses which have to be eliminated in order to improve the mechanical efficiency. The car is able to achieve the maximum velocity 12 to 15 km/hr in one minute. Also Ansys analysis showed that FOS is greater than 1, hence the design is safe.

CONCLUSIONS:

The aim of the project was to design a sustainable energy system which eliminates the use of fuel. Sustainable energy can also be the alternate energy system that serves the needs of the present without compromising the ability of future generations to meet their needs. Contrary to popular belief, renewable energy does not equate to sustainable energy as it is naturally replenished on a human timescale whereas the latter doesn't. The concept of the car was to improve the output (efficiency) in terms of speed, load resistance and smoothness. The goal was to reduce the number of moving parts leading to lesser mechanical complexities. CAD tools were used to reduce the complexity of the design. It was also found that appropriate design of Pelton cups can increase the speed. Water is used as it is readily available for everyone. As it is not burned, there is no carbon emission, therefore it is safe for the environment. The modeling and analysis of the system was done by using CREO for modeling and ANSYS work bench for analysis. Mechanical processes such as drilling, welding, bending & milling were utilized for assembling the parts. On a regular basis, the car was tested and the system was inspected until the final output was achieved. Modifications were made on the basis of comparisons with other projects related to converting hydro energy to mechanical energy. In conclusion, the car was able to move by the pressure of water with the help of flywheels which were connected to the shaft on either side of the Pelton wheel. Due to lack of efficiency, the Impulse turbine was then changed to a Pelton wheel. The installation of the gear box helped in generating torque that resulted in higher rpm of the vehicle. Overall, the ANSYS workbench analysis revealed that the shaft design is safe. The overall mechanical efficiency can be improved by making appropriate changes. Adding more than one nozzle, the rpm of the turbine can be increased. Composite materials can be used in order to reduce the weight of the vehicle (turbine and vehicle). Due to the low velocity, more than one Pelton turbine can be suggested for the vehicle to improve the speed.

NOMENCLATURE:

V=Velocity, m/s
T = Torque, N-m
F_T = Tangential Force, N
R = Radius of pelton wheel, m
m = Mass, Kg
a = Acceleration, m/s^2
P = Power, W
N = Speed of rotation, rpm
ɳ = Efficiency, %

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